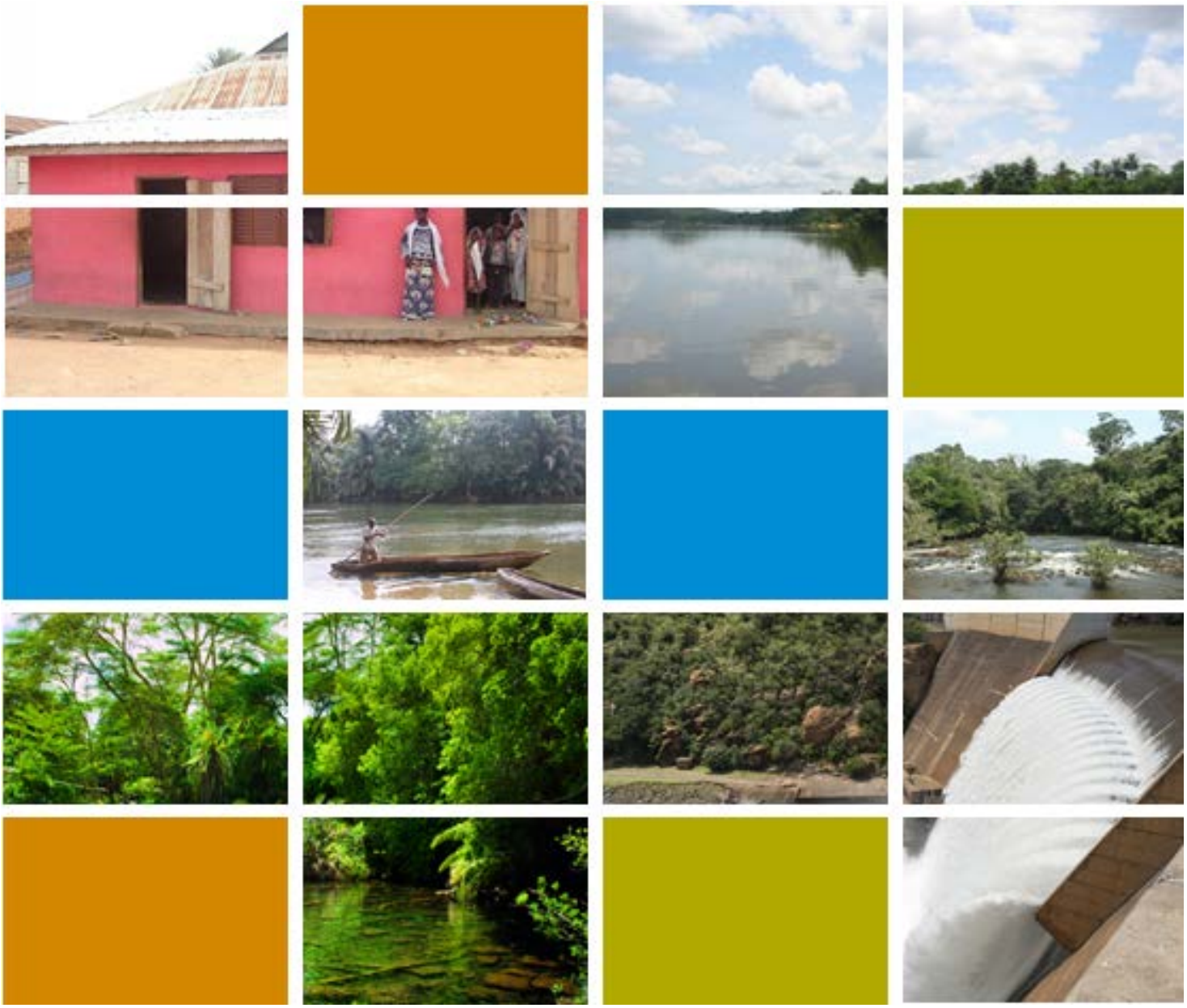

Environmental, Social and Health Impact Assessment for Bumbuna II Hydroelectric Project

Volume 1 – ESIA Report

02 February 2017

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Prepared for: Joule Africa

The business of sustainability

ERM

Joule Africa

Environmental, Social and Health Impact Assessment for the Bumbuna II Hydroelectric Project: *Volume 1 – ESIA Report*

February 2017

Reference 339594

For and on behalf of
Environmental Resources Management

Approved by: Tunde Morakinyo

Signed:

Position: Partner

Date: 2 February 2017

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ACRONYMS AND ABBREVIATIONS

AC	Air Conditioning
AOO	Area of Occupancy
AS	Australian Standard
AfDB	African Development Bank
AfDB OS	AfDB Operational Safeguard
AoI	Area of Influence
ALARP	As Low As Reasonably Practicable
ARD	Acid Rock Drainage
ARI	Acute Respiratory Infections
ASL	Above Sea Level
ASM	Artisanal and Small Scale Mining
AQIA	Air Quality Impact Assessment
AQMP	Air Quality Management Plan
AQS	Air Quality Standard
BCA	Bumbuna Conservation Area
BHP	Bumbuna Hydroelectric Project
BS	British Standard
BTO	British Trust for Ornithology
BWMA	Bumbuna Watershed Management Authority
CBO	Community Based Organisation
CEC	Community Education Centre
CFP	Chance Find Procedure
CH	Cultural Heritage
CHA	Critical Habitat Assessment
CLO	Community Liaison Officer
CLSG	Côte D'Ivoire, Liberia, Sierra Leone and Guinea
CMP	Construction Management Plan
CMR	Child Mortality Rate
CR	Critically Endangered
CRA	Climate Risk Assessment
CSSL	Conservation Society of Sierra Leone
DD	Data Deficient
DDC	Dalan Development Consulting
DDC	District Development Committee
DMRB	UK Highways Agency Design Manual for Roads and Bridges
DO	Dissolved Oxygen
EBRD	European Bank for Reconstruction and Development
EC	Electrical Conductivity
ECOWAS	Economic Community of West African States
EFA	Environmental Flow Assessment
EFR	Environmental Flow Requirements
EHS	Environment, Health & Safety
EIA	Environmental Impact Assessment

EIB	European Investment Bank
EIS	Ecological Importance and Sensitivity
EITI	Extractive Industries Transparency Initiative
EN	Endangered
EMAD	Environmental Mitigation and Area Development
EOO	Extent of Occurrence
EP	Equator Principles
EPA	Environmental Protection Agency
EPAA 2008	Environment Protection Agency Act, 2008
EPA-SL	Environmental Protection Agency Sierra Leone
EPC	Engineering, Procurement and Construction
EPFI	Equator Principles Financial Institutions
EPRP	Emergency Preparedness and Response Plan
ERBD	European Bank for Reconstruction and Development
ERM	Environmental Resources Management Ltd
ERP	Emergency Response Plan
ESAP	Environmental and Social Advisory Panel
ESHIA	Environmental, Social and Health Impact Assessment
ESHMP	Environmental, Social and Health Management Plan
ESMS	Environmental and Social Management System
ESPS	Environmental and Social Policy Statement
EU	European Union
FAO	Food and Agriculture Organisation of the United Nations
FDI	Foreign Direct Investment
FGD	Focus Discussion Group
FSL	Full Supply Level
GDP	Gross Domestic Product
GFRA	Global Forest Resources Assessments
GGBFS	Grand Granulated Blast-Furnace Slag
GHG	Greenhouse Gas
GII	Gender Inequality Index
GIIP	Good International Industry Practice
GIS	Geographical Information Systems
GO	Grievance Officer
GoSL	Government of Sierra Leone
GPa	Gigapascals
HDI	Human Development Index
HEP	Hydroelectric Power
HGV	Heavy Goods Vehicle
HTP	Health Transformation Program
HV	High Voltage
IA	Impact Assessment
IAQM	Institute of Air Quality Management
IBA	Important Bird and Biodiversity Area

IBIS	Chapter 5 Page 5-7
ICP	Informed Consultation and Participation
ICZ	Intertropical Convergence Zone
IEZ	Inshore Exclusive Zone
IFC	International Finance Corporation
IFC PS	IFC Performance Standard
IMF	International Monetary Fund
IMR	Infant Mortality Rate
IPCC	Intergovernmental Panel on Climate Change
IRR	Internal Rate of Return
ITCZ	Inter-Tropical Conversion Zone
IUCN	International Union for Conservation of Nature
JA	Joule Africa
JCI	Joint Commission International
JSS	Junior Secondary School
KII	Key Informant Interview
LC	Least Concern
LRP	Livelihoods Resettlement Plan
LULUCF	Land Use, Land Use Change and Forestry
MAFFS	The Ministry of Agriculture Forestry and Food Security
MCE	Maximum Considered Earthquake
ME	Ministry of Energy
MFMR	Ministry of Fisheries and Marine Resources
mg/L	Milligrams per litre
MIA	Ministry of Internal Affairs
MIC	Maximum Instantaneous Charge
MIGA	Multilateral Investment Guarantee Agency
MLCPE	Ministry of Lands, Country Planning and the Environment
MOL	Minimum Operating Level
MOU	Memorandum of Understanding
MPs	Members of Parliament
$MtCO_2e$	Megatonnes of Carbon Dioxide Equivalent
MW	Megawatt
MWL	Maximum Water Level
MWR	Ministry of Water Resources
NA	Not Applicable
NBSAP	National Biodiversity Strategy and Action Plan
NGOs	Non-Governmental Organisations
NO_2	Nitrogen dioxide
NO_x	Oxides of Nitrogen
NPA	National Power Authority
NPA	National Power Authority (Amendment)
NPV	Net Present Value
NSADP	The National Sustainable Agriculture Development Plan
NSR	Noise and Vibration Sensitive Receptor

NSRs	Noise Sensitive Receptors
NTFPs	Non-Timber Forest Products
NT	Near Threatened
NTS	Non Technical Summary
NTU	Nephelometric Turbidity Units
NVIA	Noise and Vibration Impact Assessment
OBE	Operating basis earthquake
OECD	Organisation for Economic Co-operation and Development
OHS	Occupational Health and Safety
OP	Operational Policy
OPIC	Overseas Private Investment Corporation
OSs	Operational Safeguards
PADCs	Project Area Development Committees
PC	Process Contribution
PCDP	Public Disclosure and Consultation Plan
PEC	Predicted Environmental Concentration
PFS	Pre-Feasibility Study
PGA	Peak Ground Acceleration
PM_x	Particulate Matter with aerodynamic diameter not exceeding x μm
PMF	Probable Maximum Flood
POL	Planned Operating Elevation
PPE	Personal Protective Equipment
PPP	Purchasing Power Parity
PPV	Peak Particle Velocity
PR	Performance Requirement
PRA	Proposed Reservoir Area
PS	Environmental and Social Performance Standard
RAMSAR	Chapter 4 Page 4-6
RAP	Resettlement Action Plan
RCC	Roller Compacted Concrete
RCC	Roller Compacted Dam
RCP	Representative Concentration Pathway
RDRM	Revised Desktop Reserve Model
RF	Resettlement Framework
ROSCA	Rotating Savings and Credits Association
RoW	Right of Way
RPF	Resettlement Policy Framework
RR	Range Restricted
SALWACO	Sierra Leone Water Company
SEP	Stakeholder Engagement Plan
SLDHS	Sierra Leone Demographic and Health Survey 2013
SMP	Soil Management Plan
SNAP	Sustainable Nutrition and Agriculture Promotion
SO_2	Sulpur dioxide
SRDA	Seli River Development Authority

SSS	Senior Secondary School
STH	Soil Transmitted Helminths
STIs	Sexual Transmitted Infections
TA-Luft	Technical Instructions on Air Quality Control" (Technische Anleitung zur Reinhaltung der Luft)
TB	Tuberculosis
TBA	Traditional Birth Attendant
TDS	Total Dissolved Solids
TFR	Total Fertility Rate
TL	Transmission Line
TN	Total Nitrogen
TOBB	The Türkiye Odalar Ve Borsalar Birliği
ToR	Terms of Reference
TRL	Transport Research Laboratory
TSI	Trophic State Index
TTMP	Traffic and Transportation Management Plan
U5MR	Under Five Mortality Rate
ug/l	Micrograms per litre
UK	United Kingdom
UKAS	United Kingdom Accreditation Service
UN	United Nations
UNAIDS	Joint United Nations Programme on HIV/AIDS
UNCBD	United Nations Convention on Biological Diversity
UNFCCC	United Nations Framework Convention on Climate Change
UNICEF	United Nations Children's Fund
UNDP	United Nations Development Program
UNOCHA	United Nations Office for the Coordination of Humanitarian Affairs
USACE	United States Army Corps of Engineers
USEPA	United States Environmental Protection Agency
VDC	Village Development Committee
VOC	Volatile Organic Component
VU	Vulnerable
WAPP	West Africa Power Pool
WASH	Water Sanitation and Hygiene
WB	World Bank
WHO	World Health Organisation
WMP	Waste Management Plan
WNW-ESE	West to North West – East to South East
WRI	World Resources Institute
YIZ	Yiben Inundation Zone
YR	Yiben Reservoir

1 INTRODUCTION

1.1 PROJECT BACKGROUND

1.1.1 Bumbuna Hydroelectric Power Development

Phase I of the Bumbuna Hydroelectric Power (HEP) scheme consisted of the development of a run-of-river project, comprising a 50 MW dam and power generation facility near to Bumbuna village on the Upper Seli River, 200 km northeast of Freetown in Sierra Leone (see *Figure 1.1*). This phase has been completed and is currently operational and is referred to as Bumbuna I.

Figure 1.1 Project Location

Phase II of the Bumbuna II scheme will have a total gross power output of 143 MW and consist of the following elements:

- Bumbuna Extension HEP (referred to hereafter as Bumbuna Extension): This will have a gross power output of 88 MW and comprise a power intake structure, a main headrace tunnel, a new powerhouse (consisting of 2 x 42.15 MW turbine units, a tailrace canal, a 3.7 MW environmental flow power turbine (located at the Bumbuna I Environmental Flow outlet) and a new Transmission Line between the Bumbuna Extension switchyard and Yiben HEP and between Bumbuna Extension switchyard and the proposed West African Power Pool (WAPP) Substation, a total distance of around 36 km of 225 kV line. The Bumbuna Extension will utilise the same reservoir as the existing Bumbuna I with separate waterways and a separate powerhouse.

- Yiben HEP (referred to hereafter as Yiben): A new dam will be constructed upstream of Bumbuna, at Yiben, to regulate inflow into the Bumbuna reservoir in order to increase the power output from Bumbuna I. The dam will have a gross power output of 55 MW (2*27.7 MW).

The development of Phase II of the Bumbuna scheme is being undertaken by Joule Africa (JA) in partnership with the Government of Sierra Leone (GoSL). The Project is referred to hereafter as Bumbuna II.

In 2011 and 2012 a Scoping Report and an Environmental and Social Impact Assessment (ESIA) for Bumbuna II was prepared by Lahmeyer International and CEMMATS Group Ltd. According to the final report, the ESIA aimed to "meet the local requirements for securing the EIA license from the Environmental Protection Agency Sierra Leone (EPA-SL)". This ESIA was submitted to GoSL for consultation purposes only; a formal approval was not sought.

Environmental Resources Management Ltd (ERM) was contracted by JA in October 2012 to undertake a Gap Analysis of the ESIA for Phase II, comparing it against the requirements of international standards for potential lenders to Phase II. ERM was further commissioned in April 2014 to upgrade the ESIA to meet both national requirements and international standards.

ERM conducted supplementary baseline surveys in the field from the 16th May to 10th June 2014 and in March, April, June and July 2016, focussing on the area to be inundated by the reservoir behind the dam at Yiben, the proposed transmission line (between Bumbuna Extension and Yiben) and Bumbuna Extension area.

JA have commissioned ERM to assist in the completion of the Bumbuna II ESIA including the Bumbuna Extension, the new transmission lines, Yiben and associated reservoir and infrastructure.

A Scoping Report for the Bumbuna II ESIA (the *Project*) was submitted to the EPA-SL on the 22nd August 2016. EPA-SL, with the support of an independent consultant (The Southern African Institute for Environmental Assessment) undertook a review and the comments of the Scoping Report have been addressed in the updated ESHIA.

JA are seeking financing from development finance institutions to fund the development of the Project and is in discussions with the European Investment Bank (EIB), the African Development Bank (AfDB), International Finance Corporation (IFC), World Bank Group, Commonwealth Development Corporation (CDC), the Emerging Africa Infrastructure Fund (EAIF) and the Islamic Development Bank (IDB), and may engage with others.

Under the Equator Principles (1), a project of this size and nature in a non-Organisation for Economic Co-operation and Development (OECD) country is considered to be a Category A project. For such projects, an environmental analysis must be prepared. To comply with this requirement, a full Environmental, Social and Health Impact Assessment (ESHIA) has been undertaken to present the risks and impacts associated with Bumbuna II. This approach has been accepted by the principal lenders.

(1)http://www.equator-principles.com/resources/equator_principles_III.pdf

1.2 THE ESHIA PROCESS

The ESHIA has been undertaken in accordance with Sierra Leonean legislative requirements, EIB, IFC and AfDB requirements. The ESHIA process has included the following steps:

1. ***Scoping***: this phase presented a description of the proposed Project, the ESHIA process, relevant legislation and Project standards, the physical, biological and socio-economic characteristics of the Project Study Area (following a Gap Analysis of all previous studies of the Project area), perceived issues and an outline of the Terms of Reference (ToR) for the specialist studies to be included in the ESHIA. Key stakeholders, including interested and affected parties, were identified during this phase and provided with an opportunity to raise any interim comments, concerns, and/or queries that they might have had on the proposed Project.

2. ***Environmental, Social and Health Impact Assessment***: this study functioned as the main document for the ESHIA study and provided a detailed analysis of the potential environmental and social impacts, supported by in depth objective specialist scientific studies.

3. ***Environmental, Social and Health Management Plan (ESHMP):*** this provides a concise tabular framework of all the high level mitigation measures, key performance indicators, responsibilities and related Project Plans and / or Procedures aligned with the assessment of environmental and social impacts.

4. ***Stakeholder Engagement***: stakeholders have been engaged throughout the ESHIA process. Key findings from the Scoping process have been presented to government officials, local communities and key interest groups.

1.3 PURPOSE OF THIS DOCUMENT

The main objective of this ESHIA report is to present the following:

- A detailed description of the proposed Project and considered alternatives;

- The ESHIA process and methodology including a register of legislation, standards, guidelines and strategies (both national and international) pertinent to the Project and this ESHIA;

- The outcomes of stakeholder engagement activities carried out throughout the ESHIA process;

- A detailed baseline review of the physical, biological and socio-economic characteristics of the Project area and surrounds;

- An assessment of impacts to the physical, biological and socio-economic environments during construction and operation of the Project;

- An assessment of cumulative impacts associated with the other planned, existing or project-related developments in the broader area of the proposed Project; and

- Mitigation measures and associated management plans that aim to avoid or minimise or manage the identified impacts.

1.4 STRUCTURE OF THIS REPORT

This ESHIA is provided in two Volumes;

- ***Volume I:*** the main Environmental, Social and Health Impact Assessment (ESHIA) Report, which outlines the key findings and conclusions of the ESHIA process; and

- ***Volume II:*** Technical Annexes that provide extensive detail covering each technical discipline involved in the ESHIA assessment and supports the conclusions summarised in *Volume I*.

The detailed structure of *Volumes I* and *II* is outlined in *Table 1.1* and *Table 1.2* below.

Table 1.1 Volume I – ESHIA Report

Chapter	Contents
Non-Technical Summary	Non-Technical Summary (NTS) to provide an overview of the full ESHIA and can be used as a stand-alone document during the stakeholder engagement process.
Chapter 1; Introduction	This Chapter.
Chapter 2; Project Description	Describes the Project and its geographical and temporal context. Including a site description, an overview of the Project Design, details of project inputs and outputs and an overview of ancillary infrastructure.
Chapter 3; Alternatives	Describes the Project alternatives that have been considered in the ESHIA process.
Chapter 4; Legal and Administrative Framework	Describes national environmental and social legislative, policy and administrative requirements, as well as international good practice and guidelines applicable to the Project.
Chapter 5; Stakeholder Engagement	Provides the results of consultation undertaken as part of the ESHIA, plus plans for future consultation, including during operation. It identifies key project stakeholders and presents their feedback on the Project.
Chapter 6; ESHIA Methodology	Describes the overall ESHIA approach and methodology for the technical assessments with consideration of national and international guidelines and requirements.
Chapter 7; Analysis of Impacts	Provides an overview of key baseline findings, sensitive receptors and significant construction and operational

Chapter	Contents
	impacts, mitigation measures and residual impacts. Cumulative impacts are also presented.
Chapter 8; Environmental ,Social and Health Management Plans (ESHMP)	Provides a summary of the ESMS and presents the Environmental, Social and Health Management Plans (ESHMPs) that are to be implemented to manage identified significant impacts.
Bibliography and References	Lists references made in the report and documents drawn upon during the course of the assessment are presented within each of the individual Annexes of Volume II.

Table 1.2 Volume II – Technical Annexes

Annex	Contents
Introduction	Presents a brief overview of the ESHIA Technical Annexes and their role in the overall ESHIA report, including an overview of the general Area of Influence for the ESHIA.
Annex A; Air Quality	Presents the Air Quality Area of Influence, scope of work, baseline, impact assessment, mitigation and all associated technical data.
Annex B; Greenhouse Gas and Climate Change	Presents the Greenhouse Gas and Climate Change Area of Influence, scope of work, baseline, impact assessment, mitigation and all associated technical data.
Annex C; Ambient Noise and Vibration.	Presents the Noise and Vibration Area of Influence, scope of work, baseline, impact assessment, mitigation and all associated technical data.
Annex D; Geology and Soils	Presents the Geology and Soils Area of Influence, scope of work, baseline, impact assessment, mitigation and all associated technical data.
Annex E; Water Resources and Ecological Flows	Presents the Water Resources Area of Influence, scope of work, baseline, impact assessment, mitigation and all associated technical data.
Annex F; Biodiversity	Presents the Biodiversity Area of Influence, scope of work, baseline, impact assessment, mitigation and all associated technical data.
Annex G; Ecosystem Services	Presents the Ecosystem Services Area of Influence, scope of work, baseline, impact assessment, mitigation and all associated technical data.
Annex H ; Social	Presents the Social Area of Influence, scope of work, baseline, impact assessment, mitigation and all associated technical data.
Annex I; Resettlement Framework	Presents the Resettlement Framework Plan for the Project
Annex J; Stakeholder Engagement Plan (SEP)	Presents the Stakeholder Engagement Plan for the Project
Annex K; Traffic	Presents the Traffic Area of Influence, scope of work, baseline, impact assessment, mitigation and all associated technical data.
Annex L; Dam Stability Analysis	Presents the Dam Stability Analysis work completed by Lahmeyer as part of the Yiben Feasibility Study in 2012.

2 PROJECT DESCRIPTION

2.1 THE EXISTING SCHEME BUMBUNA I SCHEME

The Bumbuna I scheme is a hydro scheme on the upper Seli River, about 2 km upstream of the town of Bumbuna in Kalansogoia chiefdom, Tonkolili District. The existing dam is 88 m high and constructed of asphalt rockfill. The Full Supply Level (FSL) is at 240.0 masl (1) and the maximum flood water level is 241.75 masl.

Two conical 'morning glory' spillways are located close to the left and right banks just upstream of the dam. The right "morning glory" has an intake of 236 masl and is connected to the power house and an auxiliary spillway tunnel under the right bank. The left spillway with a maximum level of 238 masl is connected to a 9 m diameter primary spillway tunnel that passes under the left bank of the dam. The spillways have a combined discharge of 3,000 m^3/s at maximum capacity which is almost three times the maximum flood flow of 1,052 m^3/s recorded in 1970.

The power station situated immediately downstream of the dam holds 2 Francis turbines with individual gross outputs of 25 MW. A 161 kV switchyard is located close to the powerhouse. The maximum design powerhouse discharge is 78 m^3/s. Current power output ranges between around 10 to 36MW depending on the water and plant availability.

The reservoir is I-shaped, with a length of 30 km and an estimated surface area of 15.4 km^2 (the volume of which is 445 million m^3) at 242 masl.

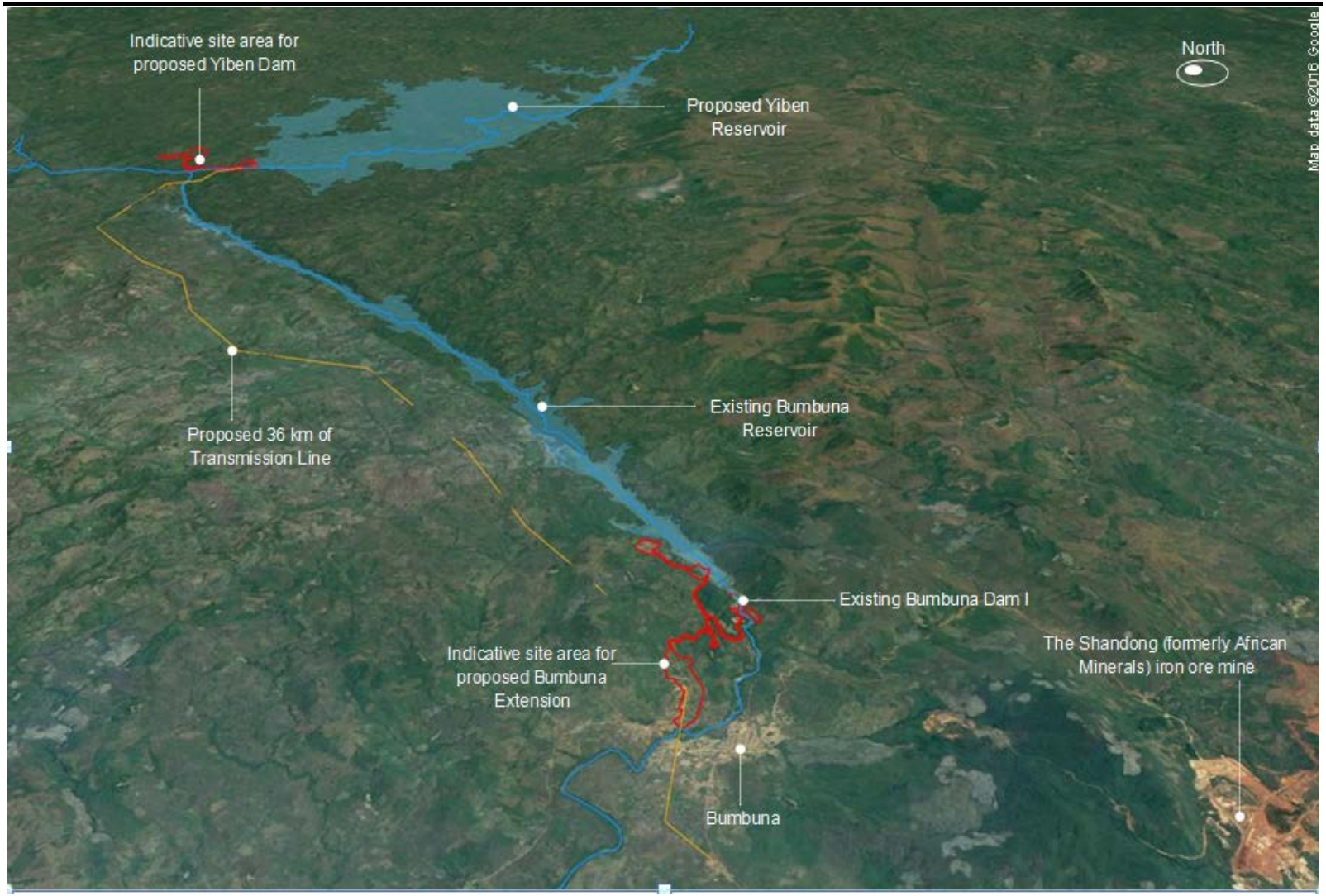
Beyond the Mawoloko confluence, approximately 30 km upstream of the Bumbuna dam, the reservoir stretches for between 7 to 11 km into the Mawoloko and Seli Rivers, respectively. The width of the reservoir ranges between 200 m and 1 km (2).

2.2 THE PROJECT

As mentioned in *Chapter 1* the Project comprises the Bumbuna II HEP (referred to hereafter as Bumbuna II) which includes the development of the Bumbuna Extension HEP (referred to hereafter as Bumbuna Extension) adjacent to the existing Bumbuna I, Yiben HEP (referred to hereafter as Yiben) and new transmission lines between Bumbuna Extension and Yiben. The transmission lines will be developed and built by the GoSL. The key project components are illustrated in *Figure 2.1*.

(1) masl (meters above sea level)
(2) Lahmeyer International (2011) Yiben - Bumbuna HEP Complex Pre-Feasibility Study

Figure 2.1 The Bumbuna II Project



The Project will have a total installed capacity of 143 MW gross power which will be made up of the 2 x 42.15 MW turbines at the Bumbuna Extension, 1 x 3.7 MW turbine at the Environmental Flow Powerhouse which will be located within the existing Bumbuna I dam and 2 x 27.7MW turbines at Yiben.

The key components are described individually in specific sections of this chapter ie the Bumbuna Extension, Yiben and the transmission line. Linked to these, a range of supporting ancillary facilities and activities may be required including road upgrades, development of quarries and the construction of a new landfill waste management facility. Where details of these are known they are described below under the relevant key component, in other cases details of these ancillary works are yet to be finalised.

A number of factors such as the nature of construction phase activities, labour management, resource use and pollution prevention will be similar across the two main construction sites. As such these are outlined in the ESHIA for the whole project unless specific details specific to each site are required.

The approximate footprint of the three key project areas is summarised in *Table 2.1*. The individual components are described within this Chapter.

Table 2.1 Footprint of the Bumbuna II

Project Area	Area (km^2)
Bumbuna Extension including existing reservoir (15.4 km^2)	16.14
Yiben including the dam and inundation area	117.19
Transmission line	1.90

2.3 BUMBUNA EXTENSION PROJECT COMPONENTS

2.3.1 Overview and Key Structures

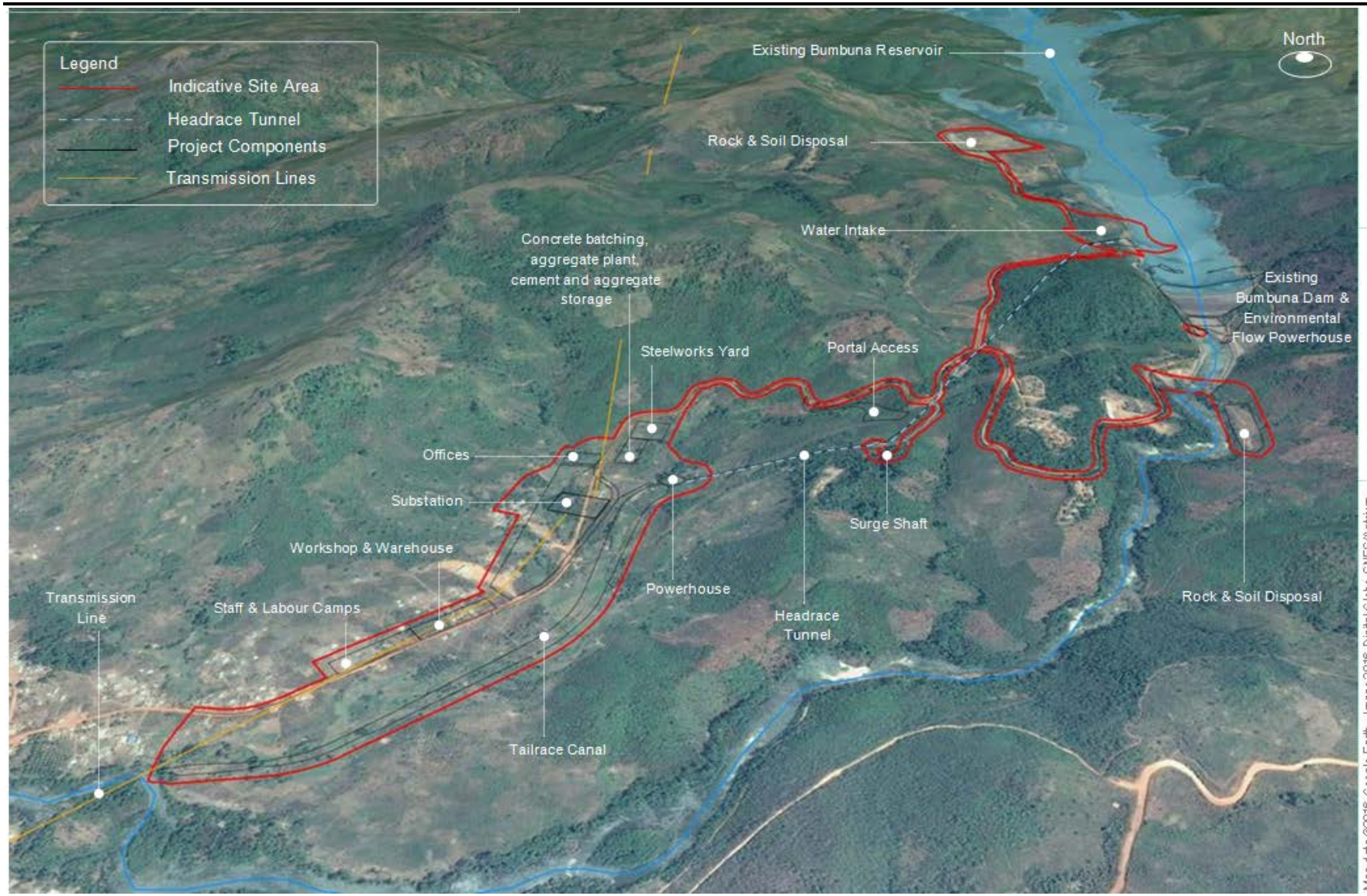
The Bumbuna Extension project components will comprise a power intake structure, a main headrace tunnel, a new powerhouse (consisting of 2 x 42.15 MW (gross) turbine units, a tailrace canal, a 3.7 MW (gross) environmental flow power turbine (located at the Bumbuna I Environmental Flow outlet) and a new transmission line between the Bumbuna Extension switchyard and Yiben and between Bumbuna Extension switchyard and the proposed WAPP Substation, a total distance of around 36 km of 225kV line.

The existing Bumbuna I will still be used for energy generation, but will generally be utilised during the rainy season for a limited period when the full capacity of the Bumbuna Extension will be exceeded, during maintenance of Bumbuna Extension units or as required by the Offtaker (1).

Bumbuna Extension will utilise the same reservoir as Bumbuna I with separate waterways and a separate powerhouse. The project components are illustrated in *Figure 2.2*.

(1) The offtaker of Bumbuna I is the Government of Sierra Leone.

Figure 2.2 Bumbuna Extension Project Components



2.3.2 *Power Intake*

The dedicated power intake structure will be located on the western bank of the Seli River, approximately 400 m upstream of the existing dam. The intake structure will be made of reinforced concrete comprising the bell-mouthed intake with trash racks. The bottom sill of the intake is 14 m below the full supply level of Bumbuna I.

The new power intake will allow for the new powerhouse to operate completely independent of the existing powerhouse. During construction, a small cofferdam and sheet piling or grouting may be required to minimise and protect the construction pit from water seepage depending on the geotechnical conditions encountered during construction. The new power intake structure will not affect the operation of the existing reservoir when complete.

2.3.3 *Headrace Tunnels*

A headrace tunnel will connect the intake structure with the new powerhouse underground. The headrace tunnel, with a diameter of 4.8 m and length of approximately 1.9 km at a 1.58% gradient, will carry water from the intake to the Bumbuna Extension surge tank. The surge tank will consist of a 53 m deep concrete lined surge shaft at the transition from the headrace tunnel to the penstock via a bend connecting to the penstock. Adjacent to this will be a 63 m access tunnel.

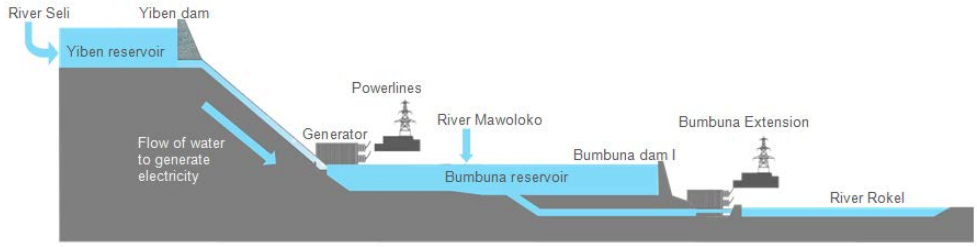
The surge tank will be used to reduce impacts on the system due to sudden shut down or start-up of one or both of the generating units. From the surge tank, a 511 m long steel lined penstock with a diameter of 3.8 m will transfer water with an incline of 20.25% to manifolds in the powerhouse. The headrace tunnel and penstock will most likely be excavated by conventional drill and blast method.

2.3.4 *Powerhouse and Switchyard*

The open-air powerhouse will be approximately 53.8 m long and 21.6 m wide. It will be located adjacent to the manifold and will accommodate two vertically mounted generating units with Francis-turbines, each with a rated capacity of 41 MW resulting from a net head of 112.8 m and a turbine discharge capacity of 41 m^3/s at 300 rpm. Surface runoff in the vicinity of the powerhouse will be dealt with through typical building drainage systems.

Figure 2.3 provides a schematic to illustrate the layout of the Bumbuna II scheme which includes the Yiben and Bumbuna Extension components along with the Bumbuna I and Yiben reservoirs. This figure is for illustration only and does not accurately reflect the relative sizes of each respective reservoir.

Figure 2.3 Schematic diagram of the Bumbuna II Scheme



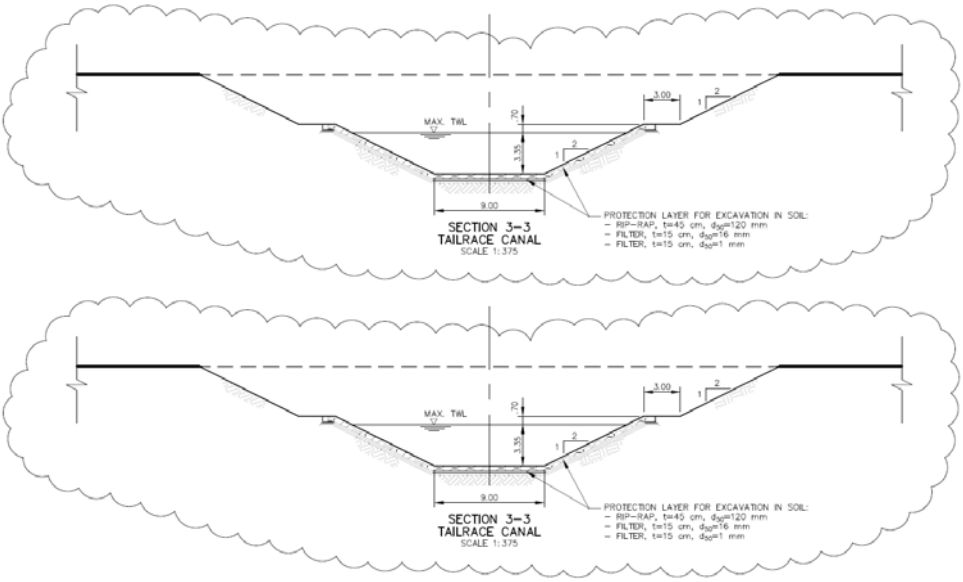
Source: ERM

2.3.5 Tailrace Canal

A 1.67 km long tailrace canal (with a bottom width of 9 m, maximum water depth of 3.35 m and 2:1 sloped embankments) will convey the powerhouse discharge water back to the river just upstream of a bridge at Bumbuna village. (N.B. At this point the river is known as the Rokel River whereas upstream of the dam the river is known as the Seli River - for the avoidance of confusion the overall river is referred to as the Seli River throughout this report.

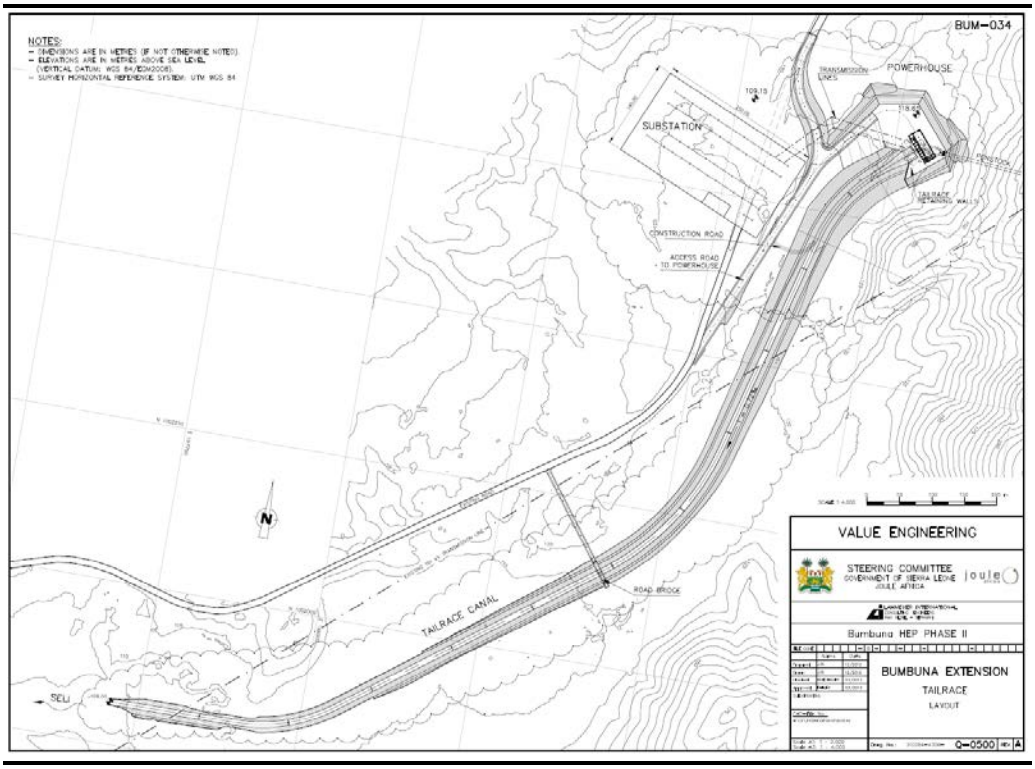
The tailrace channel will have a protection layer or rip rap and will also act as a drainage course, discharging surface runoff to the Rokel River. *Figure 2.4* and *Figure 2.5* illustrate a cross-section and the layout of the tailrace canal.

Figure 2.4 Tailrace Canal Cross-Section



Source: Lahmeyer (2012) Engineering Drawings

Figure 2.5 Layout of Bumbuna Extension Tailrace



Source: Lahmeyer (2012) Engineering Drawings

2.3.6 Existing Powerhouse

Due to the higher energy yield of the Bumbuna Extension compared to Bumbuna I, water will usually be diverted through the new system for the purposes of generation. Water will only pass through Bumbuna I during periods of excess flow when the supply level rises above 236 masl. If there is no capacity in the grid to absorb the additional power that running Bumbuna I alongside the Bumbuna Extension would generate, the excess water will be spilled via the existing system. The existing system might also be used if there is a complete shutdown of the Bumbuna Extension for maintenance of turbine units or in an emergency. Dispatch of the two facilities will be controlled by the Offtaker (the Electricity Distribution and Supply Authority, EDSA).

2.3.7 Project Footprint

There will be four site installation areas at the following sites and the components listed are illustrated on *Figure 2.2*:

- The main site installation area will be approximately 45,000 m² in area and will be located around the powerhouse and tailrace canal, comprising concrete batching plant and aggregates storage, laboratories, workshops, warehouses, offices, a canteen and camps for the labour and staff.

- An installation area of less than 500 m² will be located on top of the hill for the construction of the surge shaft, comprising of a limited number of containers for tools and materials and a small office.

- Another site installation area of between 1,000 and 1,500 m² will be located at the tunnel portal of the access tunnel facilitating the construction of the access tunnel, the headrace tunnel and the installation of the penstock. It will consist of a limited number of containers for tools and materials, and a small office.

- A site installation area will be located at the intake area and will consist of offices, stores, depots and a small workshop.

It is planned that concrete/shotcrete (approximately 104,000 m³) for all components of Bumbuna Extension will be produced at the batching plant close to the powerhouse site. From there it can easily be transported by trucks to the appropriate locations for placing. The maximum driving distance during construction will be 2-3 km along existing permanent roads, except where immediate access to new facilities is required (less than 100 m in length).

The main workshops for construction equipment and the steel lining will be located at a distance of less than 1 km from the powerhouse site and the access tunnel to the penstock/manifold. The offices will also be located within the vicinity of the powerhouse site.

The total permanent footprint of Bumbuna Extension is outlined in *Table 2.2*.

Table 2.2 Project footprint at Bumbuna Extension

Project Component	Footprint (km²)
Bumbuna existing reservoir plus existing reservoir (15.4 km²)	15.396
Existing dam	0.079
Intake, powerhouse, headrace tunnel, penstock, surge shaft, substation , portal access entrance, and offices	0.085
Ancillary facilities including:	
Concrete batching plant and cement storage area	0.001
Rock and spoil disposal areas	0.187
Access roads to site	0.368 (7.366 km)
Staff and labour camp	0.01
Workshop and warehouse	0.01
Total	16.14

2.3.8 Bumbuna Extension Construction Camps

Camps for the labour and staff will be spatially separated from the construction activities away from the noise and dust from the site, as construction activities will run continuously over 24 hours per day at certain times. The camps will be located close to the road that leads to Bumbuna village and close to the village of Kamankay which is located within 500 m of

the main construction areas (see *Figure 2.2*). This would enable easy access for workers.

A single construction camp will be required for Bumbuna Extension. The camp will house around 1,200 construction workers at peak requirement.

2.3.9 *Other Bumbuna Extension Infrastructure*

The Project will use the existing road network around Bumbuna I. Within the Project footprint at this site other infrastructure will include; site offices, warehouse and storage areas and a steel works yard. Rock and soil will be deposited at the locations depicted in *Figure 2.2* along with all other ancillary infrastructure.

2.4 YIBEN PROJECT COMPONENTS

2.4.1 *Overview*

Yiben will comprise a dam and additional facilities comparable to Bumbuna Extension and described further below. Although part of the same Project, the distance between Yiben and Bumbuna Extension means that many construction activities will need to be carried out independently, although there will be one overall EPC Contractor who will to undertake construction in as efficient a manner as possible, which may include sharing certain resources between the two projects where this is possible. One of the most significant differences is that the inundated area will be much greater relative to storage volume due to the topography of the affected area.

A 730 m wide dam with a crest level of 322.5 masl (83.5 m crest height) will impound an area of approximately 115 km^2 based on a full supply level of 320 masl. The active storage volume will be 1,303 Mm^3. At the minimum operating level (300 masl) the inundated surface area will be approximately 43 km^2. As such the operating dam may experience water level fluctuations of around 20 m and large changes in the inundated area. The operation will ensure a minimum environmental downstream release of 11 m^3/s.

The dam will have a gross installed capacity of 55 MW (2*27.7 MW gross) generating an average of 304.9 GWh/yr of energy.

During the construction phase there will be a range of environmental and social impacts associated with construction activities and typical of large scale civil engineering projects and in line with the assessment methodology outlined in *Chapter 6; ESHIA Methodology,* these will therefore be 'short term'.

The construction of the dam and ancillary facilities will require approximately 1.5 Mm^3 of concrete with associated resource requirements.

During commissioning, inundation of the operational flooded footprint will take place. The will result in the inundation of approximately 115 km^2.

During the operational phase of the Project, impacts will principally relate to the operational effects of reservoir water management. Upstream of Yiben this will principally relate to changes in the flooded area and any associated effects in the upper catchment and tributaries. Downstream this will principally relate to impacts associated with the maintenance of the environmental flow and any changes in the hydrographic regime of the downstream catchment. These will of course be closely related to and dependent on the operation of the Bumbuna Extension.

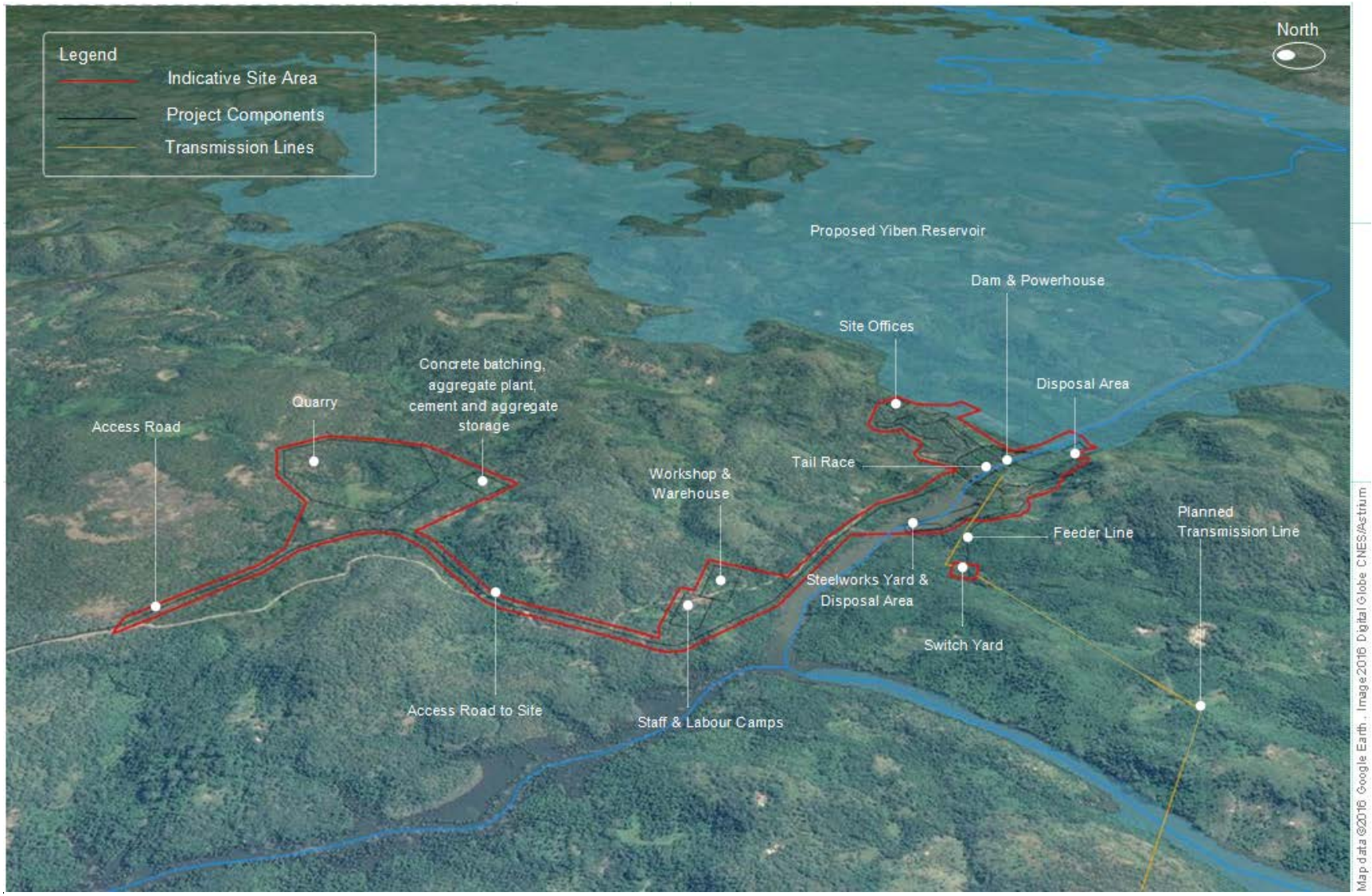
The total permanent footprint of the Yiben project components are outlined in *Table 2.3* below.

Table 2.3 Project footprint at Yiben and transmission lines

Project Component	Footprint (km^2)
Yiben dam, tailrace, power house, switchyard, spillway and offices	0.048
Inundation area	115.171
Ancillary facilities including:	
Quarry including aggregate plant and storage area, concrete batching plant and cement storage area	0.284
Waste disposal areas	0.025
Access roads to site	0.529 (10.588km)
Staff and labour camp	0.02
Workshop and warehouse	0.02
Transmission lines	1.347
Total	117.32

The key components of the Project and the inundated area are illustrated in *Figure 2.6*.

Figure 2.6 Yiben Project Components



2.4.2 *Dam Stability Analysis at Yiben*

A Dam Stability Analysis was carried out in 2012 by Lahmeyer as part of the Yiben Feasibility Study [(1)]. The full analysis from this study is presented in *Volume II, Annex L; Dam Stability Analysis* and the results are summarised below.

It is assumed that the dam will rely on its gravity and form to resist any loads acting on it and transmit into the foundation rock. The following paragraphs describe at first the basic design data, parameters, design loads, loading conditions and load combinations as well as design requirements. Subsequently, the two-dimensional calculation models and results are reported. Both static and seismic loading are covered. In the present stability analysis, the pseudo-static method for seismic analysis of gravity dams is used for the analysis under seismic loading, because the dam is situated in a low seismic hazard region and the earthquake loads are insignificant to the dam stability. The following basic data and assumptions were applied.

Table 2.4 Dam Data Assumptions for Stability Analysis

Structure Data of the Dam	
Type of dam	RCC Gravity
Nominal crest length	665 m
Nominal height of the dam	86 m
Height of the dam above riverbed	84 m
Crest width (thickness)	7.0 m
Foundation elevation	239 masl
Crest elevation	325 masl
Hydrological Data	
Upstream reservoir	
Full reservoir level	320.0 masl
Maximum water level (Q10,000)	320.0 masl
Minimum operating level	300.0 masl
Silt level	250.0 masl (conservative)
Downstream tail water:	
Tailwater level at MWL (Q10,000)	246.25 masl.
Tailwater level at Bumbuna Full Supply Level	239.06 masl.

(**Source**: Lahmeyer (2012) Bumbuna HEP Phase II Sierra Leone Feasibility Study)

Geological and Geotechnical Design Data

The dam site is characterised by a wide open valley in an asymmetrical shape with a gentle abutment. The dam will comprise a series of blocks founded on granite and gneiss rock. As the geological assessment for the dam foundation is not yet completed, the mechanical parameters of the foundation rock (Granite and Gneiss) may be conservatively assumed for the present stability analysis as follows.

- Angle of internal friction: 42°.

(1) Lahmeyer (2012) Bumbuna HEP Phase II Sierra Leone Feasibility Study

- Cohesion: 0.75 MPa.
- Bearing capacity bed rock 30 MPa.
- Bearing capacity foundation rock:
  - 7.5 MPa (usual loading, safety factor 4.0);
  - 11.1 MPa (unusual loading, safety factor 2.7); and
  - 17.6 MPa (extreme loading, safety factor 1.7).
- Unit weight 27 kN/m^3.
- Poisson's ratio 0.25.
- Young's modulus 15 GPa.
- Seismic activity OBE: PGA = $\alpha h1 \cdot g = 0.05g$
  MCE: PGA = $\alpha h2 \cdot g = 0.10g$.

The results of the stability analysis for different load cases is provided in *Box* 2.1 for the spillway section, but in principle applies also to other dam sections.

The stability and stress analysis was performed on the main components of the dam structure. This involved modelling the main components such as the dam-foundation interface, the dam body for the dam blocks of the non-overflow; and the spillway dam in the river channel with the maximum height.

The modelling concluded that the stability of the dam meets the requirements of the design criteria, and the factors of safety of the dam have a fair safety margin. The stability analysis demonstrated that in the usual and unusual loading cases, the dam will work normally.

In the case of extreme loads, the dam safety will be ensured and thus dam failure such as a total collapse of the dam or release of a large mass of uncontrolled water will not occur. However, cracks or other local damages may occur in the dam structure but this will not jeopardise the dam stability.

Based on the present knowledge and technical data of the Yiben dam, it can be concluded that the stability of the dam is verified. However, in accordance with Performance Standard 4 an updated Dam Safety Risk Assessment will be carried out prior to construction by an independent panel of experts.

Box 2.1 Calculation Results of Stability Analysis for Spillway Section at Level of Dam-Foundation Interface

Load Conditions	Designation	Factor of Safety (FS) against Sliding		Resultant Location at Base (m)		Stress at Dam Heel (MPa)		Stress at Dam Toe (MPa)		Comment
		Calculated value	Allowable value	Calculated value	Allowable value	Calculated value	Allowable value	Calculated value	Allowable value	
1	US	3.17	≥ 2.0	7.83	< 12.2	0.254	> 0	1.168	< 7.50	OK
2	UN	—	—	8.79	< 18.30	1.852	< 11.11	0.265	>-0.1	OK
3	EX	34.92	≥ 1.3	10.83	< 36.60	1.797	< 17.65	0.106	—	OK
4	UN	3.01	≥ 1.7	8.56	< 18.30	0.200	—	1.145	< 11.11	OK
5	UN	2.83	≥ 1.7	11.49	< 18.30	0.040	—	1.318	< 11.11	OK
6	EX	2.52	≥ 1.3	18.80	< 36.60	-0.175	—	1.468	< 17.65	OK
7	UN	2.74	≥ 1.7	13.27	< 18.30	-0.047	—	1.120	< 11.11	OK

(**Source:** Laymeyer (2012) Yiben Feasibility Study)

2.4.3 Key Structures

Roller Compacted Dam

As summarised in the introduction, the Roller Compacted Concrete (RCC) dam will be a 730 m wide dam with a crest level of 322.5 masl (83.5 m crest height) and will require 1.38 Mm^3 of concrete (dam only).

The RCC dam technology is state-of-the –art and provides several advantages over the conventional rock-fill dams. Although being more expensive on a unit rate basis, the required volume of concrete is smaller. RCC allows for a leaner design and also considerably increases the speed of construction in comparison to traditional methods. The dam is also overtoppable (can have an overflow), which adds a considerable safety margin over rock fill dams. However, a continuous construction process is required, which requires dedicated logistics on the construction site and also in terms of materials supply.

River Diversion

The concept includes a dedicated diversion tunnel for diverting the dry season flow a couple of months after start of construction. During the first dry season, the river section, amongst others, will be excavated and dam foundation at level 241.0 masl will be prepared. A retaining wall on the left embankment will also be constructed in both an upstream and downstream direction. Once this is completed, the upstream cofferdam diverting the river flow through the tunnel will be removed and the second flood period can be safely discharged along the original route of the river. Excavation and concrete back-fill at the left bank can continue undisturbed.

After the flood has passed, the upstream cofferdam will be placed again in order to commence with RCC placement above 241.0 masl. Just before the

third flood season, the diversion tunnel will be plugged and the cofferdam removed to start impounding. There will be a very limited period of time (5-10 days) when no water can pass the dam site until the level upstream of the dam has reached the bottom outlets. Then, then bottom outlets will further control the impounding.

Once the conversion is complete, partial impounding of the reservoir will be able to commence, conditional on other factors including the progress of the dam construction, the time of the year (impounding should only take place in the wet period), and the progress of the Resettlement Action Plan (RAP) implementation (people living in or using the impoundment area must be relocated prior to land take).

Spillway

In addition to the four bottom outlets that will also allow for sluicing of sediments, six roller gate overflow spillways will be constructed. These can cope with the Probable Maximum Flood (PMF) estimated to be 2,463 m^3/s. The spillway will discharge to the original river bed through flip buckets at the end of the chute in order to dissipate most of the energy. The rapids will remain in place in order to increase the water depth just behind the spillway.

Bottom Outlet

The four bottom outlets shall be the Howell Bunger valve type with a bi-plane butterfly valve for emergency closure and a cap-type closure of the intake. One bottom outlet will be sufficient to serve for both regulated release during impounding as well as provision of environmental flow, if required.

Powerhouse

The powerhouse on the left bank will contain two Francis turbine units each with a gross installed capacity of 27.7 MW. Each unit will have its own power intake and penstock connected with the reservoir. A tailrace canal with a bottom bed width of 10 m will connect the powerhouse with the river downstream.

Due to the backwater of the Bumbuna reservoir reaching the Yiben Powerhouse, the tailwater level will be influenced by the Bumbuna reservoir water level exceeding 235.0 masl (existing dam reference). Due to the general reservoir operation procedure keeping Bumbuna reservoir at full supply level, this will likely be a permanent impact.

2.4.4 *Project Footprint*

Generally site installation areas should be located in as much as possible flat areas. For Yiben there are minimal such areas in the near vicinity. The presented project footprint has been selected on the basis of the existing

topographic information, trying to identify those locations which are more or less flat.

There will be four site installation areas at the following sites as illustrated in *Figure 2.6*.

- An area of approximately 20,000 m² about 4 km north of the dam site and 500 m from the quarry, for the aggregate plant (crushing plant), the aggregate storage, the concrete batching plants, cement storages, laboratories etc.

- An area of about 20,000 m² each for staff/labour camps and workshop/ware-house respectively will be available on the right bank of the river about half way to the quarry, 2 km away from the dam site.

- For contractor and employer site offices, an exposed area on the right side of the future dam crest will be available, enabling a good overview on the site activities.

- The workshops for the steel works will be established on the disposal area on the left bank of the river about 500 m downstream of the dam structure. This area will only be available after completion of the works on the diversion canal, when the excavation material from the canal will be deposited at the left side of the wide river basin there. A minimum separation distance of 50 m will be observed from the edge of the river bank to avoid any materials being deposited in the river.

It is planned that all concrete (RCC, conventional concrete and shotcrete – approximately 1,493,000 m³) for all components of Yiben will be produced by aid of one crushing plant and two batching plants (one for RCC, one for conventional concrete) located close to the quarry.

2.4.5 Yiben Construction Camps

Camps for the labour and staff will be spatially separated from the construction activities away from the noise and dust from the site, as construction activities will run continuously over 24 hours per day at times.

The camps will be located close to the workshops and warehouses approximately 2 km from site to enable easy access for workers.

The camp will house in the order of around 1,150 construction workers at peak requirement.

2.4.6 *Other Yiben Infrastructure*

Quarries

As described above with reference to resources, a quarry will be required to provide aggregate for the Project. The chosen location approximately 4 km away from the dam site has been identified by aid of the available topographic information and impressions gained during engineer site visits.

This location is indicative; there may be other adequate locations in the vicinity of the site. The final quarry location will be subject to the findings of the geotechnical investigation work undertaken by the EPC Contractor.

Road Upgrades

A number of upgrades may be required to allow suitable bearing capacity and carriageway width for the volumes and weight of traffic likely to be associated with the Project construction.

2.5 *TRANSMISSION LINE*

The 203 km long 161 kV existing transmission line connects the Bumbuna powerhouse to the substation at the Kingtom Thermal Power station in Freetown. The existing transmission line was constructed in the mid-90s. The line is not sufficient to transmit the maximum power output once Bumbuna Extension is complete. Therefore a 225 kV line is proposed to run in two directions.

1. A 225kV double circuit line will run from Bumbuna Extension to the proposed WAPP Substation (1), to be located around ~4km to South West of the Bumbuna Extension.

2. A 225kV single circuit line will run from Bumbuna Extension to Yiben which will be approximately 34 km in length.

The environmental flow powerhouse will be connected by an 11 kV line to the Bumbuna Extension switchyard either directly or via the Bumbuna Extension powerhouse.

The Government of Sierra Leone (GoSL) will be responsible for the provision of this transmission line which will form part of the 225kV single circuit transmission line that will run from Yiben to Port Loko. This is considered to be an associated facility and as such GoSL will be required to undertake an Environmental and Social Impact Assessment and Resettlement Action Plan

(1) The "WAPP Substation" relates to the planned CLSG line that is being developed by Transco CLSG, a company established by the countries of Cote D'Ivoire, Liberia, Sierra Leone and Guinea, which will develop and build the line, before handing it over to a C

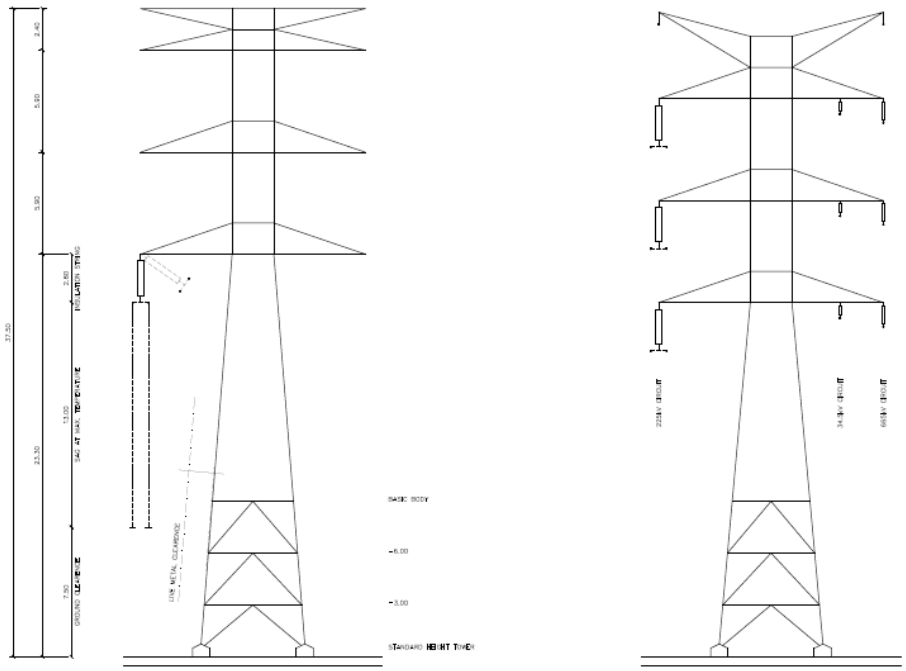
according to international standards. The transmission line is being financed for GoSL by the EXIM Bank of India.

The proposed transmission line will be required to accommodate a Right of Way (RoW) 50 m either side of the proposed route. A full range of tower heights shall be designed from -6 m level to +12 m level based on the standard tower.

A range of hill-side extensions shall also be designed to cater for the installation of the towers on hilly terrain. The range of towers shall be designed according to the maximum loads in "normal conditions" (maximum wind pressure and maximum conductor/earthwire tension), additionally "exceptional loading" such as broken wire conditions will be considered. A standard tower design is illustrated in *Figure 2.7;* however, a final tower design will be completed once the EPC Contractor is confirmed.

The design of the foundations will be subject to the nature of the soil and the forces (uplift and compression) transmitted by the tower. Soil investigations will be undertaken at each tower location to determine the soil characteristics. The exact locations of the towers will be identified during a spotting exercise to identify the optimum locations for the towers. Towers will be located approximately 360 m apart. A track along the length of the existing transmission line will be used for access during the construction of the new transmission line and its associated towers. Construction teams may use temporary mobile camps as construction works progress along the transmission line.

Figure 2.7 ***Standard Tower Design***



2.6 ACCESS

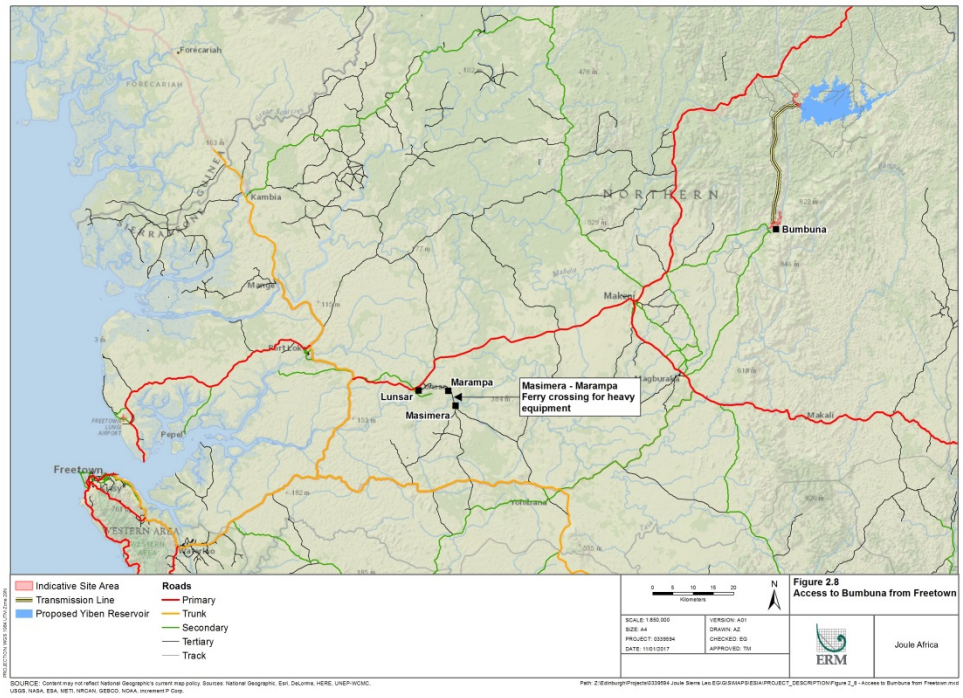
2.6.1 Bumbuna and General Site Access

Most access roads to the sites already exist. It may be required to upgrade some of the roads for intense site traffic with heavy construction machinery, considering the difficult conditions during the rainy period between June and October. The main road to Bumbuna village may need to be relocated for a stretch of about 500 m to create space for the site installation.

In terms of the delivery of materials to site, there are only two routes which could be used (from Freetown/Waterloo and Lungi/Port Loko) but both routes meet at Port Loko, and pass by Lunsar on route to Makeni. There are two options for transport of materials from Makeni, via Binkolo or via Magburaka.

For heavy/large equipment, the Masiaka-Lunsar highway bridge over the Rokel/Seli River may not be used, so a ferry over the Rokel River may be utilised (eg Masimera-Marampa).
Figure 2.8 identifies the location of the Masimera-Marampa River crossing where heavy equipment will be ferried across to reach Lunsar for onward haulage to Bumbuna.

Figure 2.8 Access to Bumbuna from Freetown



2.6.2 Yiben Access

An access road to the dam site for the execution of the geotechnical field investigations starting close to Fadugu village was previously developed.

Permission has also been granted to use this road during the construction works. It may be necessary to upgrade this road for large volumes of traffic transporting heavy construction machinery, especially considering the difficult travelling conditions during the rainy period between July and October.

A number of new roads within the site installation areas will need to be constructed, and some upgrading of existing roads from the dam crest to the toe of the dam will be required.

Due to the inundation of the area the Badala Bridge will become inundated, requiring the construction of a new replacement bridge further upstream along the Seli River and the construction of an access road to reconnect affected villages currently located to the north and south of Badala.

As the location of this new bridge and access road is currently under consideration the potential environmental and social impacts of this development will be subject to an addendum to this ESHIA, or the development of a separate ESIA entirely.

2.7 *RESOURCE USE AND WASTE MANAGEMENT*

Through the Project construction a range of wastes will be generated but in relatively small quantities:

- cleared vegetation that is unsuitable for reinstatement;
- excavated material that is unsuitable for reuse;
- workforce and administration waste; and
- occasional hazardous waste from equipment maintenance and accidental spills.

Treatment and disposal of hazardous wastes will be accomplished primarily by incineration or placement in a properly engineered and managed landfill near the Project in accordance with the Project Waste Management Plan. If large trees are to be removed, the beneficial use thereof by the community will be explored.

All wastes generated during construction will be characterised as either hazardous or non-hazardous. Any waste that cannot be recycled or treated onsite will be taken for offsite recycling or disposal in a properly engineered and managed landfill.

2.7.1 *Mineral waste at Bumbuna Extension Area*

For excavation material that cannot be reused there will be three locations for the disposal of this material. Final selection of the preferred disposal site will be made following the selection of the EPC Contractor. A Project Waste Management Plan (WMP) will be developed for the preferred site(s) by the

EPC Contractor prior to construction and the waste management activities within these areas will comply with IFC Environmental Health and Safety Guidelines for waste management (1). The proposed sites are described below.

- Disposal within the former quarry for the construction of the Bumbuna dam - this quarry, located 1.5 km away, has enough capacity for the disposal of approximately 170,000 m³ of material (soil and rock). Material will be gained by the excavation for the intake structure and the upstream waterways, including the surge shaft. However, it is assumed that 60% of the excavated rock (70,000 m³) will be reused and transported to the crushing plant and the aggregate storage at the main site installation area where it will be crushed, filtered, washed, stockpiled and batched.

- Disposal of rock on the left bank of the Seli River downstream of the Bumbuna dam - this area has previously been identified and used during construction of Bumbuna I. This area may be optionally used as a disposal area. The average distance from the excavation area is about 2 km. A minimum separation distance of 50 m will be observed between the disposal site and the bank of the river to avoid any materials being deposited in the river.

- Disposal area at the main road to Bumbuna village - this disposal area, with a surface area of 100,000 m², is adequate for the disposal of the soil and rock material which cannot be reused from the excavation of the penstock, powerhouse, manifold but mainly at the tailrace canal. Approximately 535,000 m³ of material, 30,000 m³ of rock, ie 60% of excavated rock from penstock and powerhouse, will be reused and transported to the crushing plant and the aggregate storage, 15,000 m³ of excavated rock shall serve as filter and riprap material for the protection of the tailrace canal. Maximum transport distance is limited to 1 km. In the final state the switchyard will be placed on the deposited material.

2.7.2 *Mineral waste disposal at Yiben*

Cut-fill and mineral waste

It will be necessary to dispose of material from excavation works which cannot be reused in the Project engineering as fill. Key sources of material will include the diversion/tailrace canal as well as the dam foundation. Two disposal areas are envisaged, namely:

- disposal area on the banks of the river downstream of the dam site;

  downstream, 500 m away from the dam site the Seli River forms a relatively wide river basin with shallow depths. It is planned to use the southern bank of the river at this point as a disposal area. A minimum

(1) IFC (2007) Environmental Health and Safety General Guidelines

separation distance of 50 m will be observed between any disposal site and the river bank to avoid material being deposited in the river;

- excavation material originating from parts of the diversion/tailrace canal can be disposed of there as well as material excavated at the right bank dam foundation; and

- disposal area upstream of the dam site: Upstream of the dam site on the left river bank there is a small terrace which can well be used as disposal area eg for excavation material from the left bank dam foundation works or material from the upper part of the diversion/tailrace canal. A minimum separation distance of 50 m will be observed between any disposal site and the river bank to avoid material being deposited in the river.

2.7.3 *Non-mineral Waste*

Construction waste

In common with any large scale civil engineering project activities this project will generate a wide range of waste streams which are likely to include both hazardous and non-hazardous materials. Whilst this is a large scale engineering project, these waste streams will be generated from only a limited period (construction).

As mentioned above treatment and disposal of hazardous wastes will be accomplished primarily by placement in a properly engineered and managed landfill near the Project in accordance with the Project Waste Management Plan. This will be designed and operated in line with the requirements of the Performance standards and EHS guidelines. The landfill design and location is yet to be confirmed. Once confirmed a supplementary ESIA will be carried out for the construction and operation of this landfill. If large trees are to be removed, the beneficial use thereof by the community will be explored.

As part of this a waste reception facility will be constructed to process all project waste. All wastes generated during construction will be characterised as either hazardous or non-hazardous. Waste will be minimised via application of the waste management hierarchy and the waste reception plan and facility will promote and support recycling. Any waste that cannot be recycled or treated onsite will be taken for offsite recycling or disposal

Operational waste

Operational waste streams from both operational areas ie Yiben and the Bumbuna Extension are anticipated to be limited. There will be a small operational workforce generating waste streams typical of office and engineering maintenance activities. These waste streams will include relatively small volumes (a few tonnes per annum) of both hazardous and non-hazardous wastes.

As mentioned above the Project will develop a Waste Management Plan for management of wastes in line with the IFC performance standards and EHS guidelines and Good Industry International Practice (GIIP).

Waste will be minimised via application of the waste management hierarchy and the waste reception plan and facility will promote and support recycling.

Non-hazardous wastes will be disposed of in the purpose built project landfill which will have been constructed during the construction phase. This will be designed and operated in line with the requirements of the Performance standards and EHS guidelines.

Hazardous wastes will be segregated, stored under appropriate conditions and then treated or disposed in a properly designed and managed landfill in line with the Performance Standards and project supply chain and contractor management procedures.

The predicted waste streams are as outlined below. Project volumes of waste streams were unavailable at the time of writing but will be estimated by the EPC Contractor as part of the development of the Waste and Resources Management Strategy prior to construction.

- Recyclable materials, sold to market.
- Non-hazardous waste, disposed of in project landfill.
- Hazardous waste, treated or disposed in a properly designed and managed landfill in line with the Project Waste Management Plan and supply chain and contractor management systems.

2.7.4 Mineral Resource use Bumbuna Extension

Based on analysis of the ground investigations to date, a large volume of excavation material is expected to be available, mostly granodiorite rock. This rock will be transported to the crushing plant at the main site installation area and crushed to the specific sizes for its reuse as coarse aggregate for concrete. However, it should be noted that reactive minerals could occur in some of the rocks and sediments of the area. Since there is no long history of large scale concrete works in the area with which to prove or otherwise the presence of reactive minerals, the aggregate sources will have to be carefully tested for reactivity with the cement. If the aggregates are found to be reactive, the concrete mix shall be proportioned using Ground Granulated Blast-Furnace Slag (GGBFS) to mitigate reaction of reactive aggregates. Sand will be produced by crushing the excavation material.

For protection measures along slopes and structures, fill material of almost every size is required. The slope and bed protection of the tailrace canal particularly requires large quantities (about 9,000 m^3) of relatively medium sized stones (average diameter about 30 cm). This material can also be gained from the excavation material.

Good quality stone for masonry work may not available in the Project region. Thus it will be transported to the site from Freetown or alternative sources. The required quantities are not very high; so no logistic problems are expected.

Cement and steel may not be available in sufficient quantity in the Project area, as required for the construction of the Project. Thus cement and steel will have to be obtained from Freetown.

2.7.5 *Mineral Resources Use Yiben*

Overview

For the construction of the RCC-dam around 1.4 Mm^3 of aggregate is required. This is much greater than the excavation of the diversion/tailrace canal and the excavation of the dam foundation will provide. For this reason a quarry must be operated which provides large quantities of material for the production of concrete and other materials such as fill material.

The chosen location approximately 4 km away from the dam site has been identified by aid of the available topographic information and rough impressions gained on a site visit.

This location is indicative; there may be other adequate locations in the vicinity of the site. The final quarry location will be subject to the findings of the geotechnical investigation.

Coarse Aggregates

Only a small quantity of excavation material will be available, mostly granodiorites rock.

As a result all the aggregates required for the concrete production must be gained in the quarry, transported to the nearby crushing plant and can then be used for concrete production.

If reactive minerals are identified the concrete mix shall be pro-portioned using careful concrete mix design and testing to mitigate reaction of reactive aggregates.

Excavation material which cannot be reused as fill will be disposed of in the disposal areas as described in *Section 2.8.2*.

Fine Aggregates

Sand may be available in the bed of the Seli River. However, the quantities available are unlikely to be sufficient and the quality might not be adequate as

a high organic content must be expected. It is therefore proposed to produce sand by crushing of the material gained in the quarry.

Fill Material

For protection measures along slopes and structures, fill material of almost every size will be required and this material will also be gained from the quarry.

Building Stone

Good quality stone for masonry work is not available in the Project region. It must be transported to the site from Freetown or elsewhere. An estimated 120 m^3 of such stone is predicted to be required.

Cement, Fly Ash and Steel

Cement and steel may not be available in sufficient quantity as required for the construction of the Project. Thus cement and steel will have to be obtained from Freetown. Class F fly ash for the RCC-production will need to be imported from other countries. The imported material may be transported by ships to the Port of Freetown, from where they will be further transported by trucks to the Project site. There is also a privately owned and operated railway from the estuary to a mine near Bumbuna, however using this method of transportation will also require truck transport for the remaining 50 km to the site and use of the railway may not be possible.

2.7.6 Power

Construction phase power will be provided by a range of mobile generating plant anticipated to be diesel powered. Generators will also provide the source of power required to enable black start capability of the plant (1). Storage buildings will be erected to store diesel required for the mobile generating plant. The storage units will be secure and adequately bunded to ensure that surrounding areas are protected in the event of a spill.

Operational power will be drawn from the grid.

2.7.7 Water

Construction Phase water supply will be obtained from the Bumbuna reservoir or the Seli River. The volume of water required during construction is unknown at the time of writing and there are no guideline or target rates. The volume will be determined following the selection of the EPC Contractor and in accordance with IFC Performance Standard 3.

The principal water uses are as follows.

(1) A black start is the process of restoring an electric power substation or a part of an electric grid to operation without relying on the external transmission network in this case through the use of generators.

- Concrete batching.
- Dampening down or exposed excavations for dust control.
- Potable and sanitary supply.

Operational water demand will be limited to potable and sanitary supply for the workforce, sourced from the Seli River and minor amounts of water used for operational purposes.

2.8 TRAFFIC

Construction traffic is, at times, anticipated to operate 24 hours a day, seven days a week throughout the construction period. The construction of the Bumbuna Extension and Yiben is anticipated to take three and four years respectively. No significant levels of traffic are anticipated during the operational phase of the Project than what already exists at present.

2.9 CONSTRUCTION ACTIVITIES

2.9.1 Overview

The construction phase activities are anticipated to be comparable to any major civil engineering and large hydro project. Key activities will include the following.

- Construction will include night-time operations and will, at times, be 24 hours a day, seven days a week.

- Ground clearance, drilling, blasting and excavation. Construction plant is anticipated to comply with Tier II emissions criteria (1) and the impact assessments in this ESHIA have been based on this assumption. It is not possible to source higher grade fuel to allow vehicles to meet higher emissions criteria.

- Large scale concrete batching and pouring.

- Resource consumption, particularly aggregate and water for concrete batching. Aggregate is likely to be produced on site wherever possible though some additional material may be imported.

- Power generation, temporary power supplies are likely to be required for camps, work sites etc. These are anticipated to be provided by diesel generators which will be designed and operated to comply with the

(1) Tier II standards were phased in between 2004 and 2009 and apply to cars and trucks up to 8,500 lbs GVWR. Emissions limits are fuel neutral (ie applicable to gasoline, diesel and all other fuels). 8 standard "bins" are available as long as the manufacture fleet averages 0.07 g/mi NOx. Bin 1 corresponds to 0.0 g/mi of all emission categories.

emissions guidelines for small combustion plant set out in the International Finance Corporation General EHS Guidelines (Air Emissions and Ambient Air Quality).

- Movement of labour and materials around the work site by diesel vehicle which are anticipated to comply with Tier II emissions criteria and the impact assessments in this ESHIA have been based on this assumption.

- Construction and operation of temporary camps for the construction labour force including water and power supply, sanitary provision, waste generation.

2.9.2 *Bumbuna Extension Construction*

Power Intake

The following construction methods will be used.

- Excavation of the pit and bulk excavation of the forebay - the excavation of soil and the top layer of weathered rock can easily be carried out by conventional excavators. Sound rock, however, required blasting (vertical drilling) prior to excavation. Some of the forebay excavation may be carried out underwater, as depending on construction schedule progress the excavation level may be below the minimum reservoir level. Excavation under these conditions will be undertaken using a dredger or an excavator placed on a pontoon.

- Excavation of the intake structure - the excavation of the intake structure will be carried out conventionally using excavators for soil removal and the drill and blast method (vertical drilling) to remove harder material, such as rock.

- Concrete works - concrete will be supplied by trucks from the batching plant at the main site installation.

Headrace Tunnel

The headrace tunnel and the access tunnel will be driven by means of the drill and blast method (horizontal drilling) with subsequent rock support.

The access tunnel hits the headrace tunnel close to the surge shaft. From there it is possible to excavate in both directions (in direction of the intake structure and in direction of the surge shaft). Additionally, excavation from the intake structure will also be possible.

Surge Shaft

The surge shaft will be driven down vertically from an exposed hill identified on *Figure 2.2*. At present on top of this hill a transmitter mast for mobile

telecommunication is installed which will need to be temporarily relocated to another location before beginning the works.

The construction of the surge shaft will be undertaken in two phases:

1. drilling a pilot hole approximately 30 cm diameter from top to bottom (headrace tunnel); and

2. installing a reamer of 2 to 3 m diameter in the headrace tunnel, excavating by pulling the reamer back from the headrace tunnel to the top. The rest of the excavation will be carried out conventionally by utilising the drill and blast method (vertical drilling) with subsequent rock support and concrete lining.

Penstock and Manifold

To enable independent working on the powerhouse and the penstock/manifold respectively, a short access tunnel to the transition penstock to manifold is required. Excavation of the penstock will be by drill and blast method (horizontal drilling) with subsequent rock support. Excavation of the manifold will be undertaken in the direction of the powerhouse after the breaking through of the penstock to the headrace tunnel.

Powerhouse

As a sum for the construction of the powerhouse, approximately 53,000 m^3 of soil and rock must be excavated prior to construction of the foundations of the powerhouse. Excavation will be done with excavators in soil and weathered rock and by the drill and blast method (vertical drilling) in sound rock. Once the foundation works are complete, the load bearing walls, columns, slabs and beams of the powerhouse will be raised as quickly as possible in order that the roof can be placed, the main crane installed and the building made weatherproof.

Tailrace Canal

The construction of the tailrace canal requires excessive bulk excavation for the canal. The canal will be dug into the ground to 24 m deep in the immediate vicinity of the powerhouse. The average excavation depth will be less than this, in the order of 5 to 10 m in depth. Excavation will be carried out by conventional excavators in soil and by blasting in rock.

Switchyard and Transmission Lines

The switchyard will be placed on disposal material close on the other side of the road to Bumbuna village. The disposal material will be thoroughly compacted in approximately 30 cm thick layers.

During the design of final alignment for the transmission line it will be routed parallel to any existing access tracks if present between Yiben and Bumbuna Extension. However, for the majority of this route access will be achieved

through the construction of new access tracks. It is therefore assumed that the accessibility of the tower locations will be sufficient and no or only minor road works will be required. Some limited concrete works for foundations will be required for the switchyard installations as well as for the towers of the transmission lines. The steel lattice towers will be transported to their destination in separate segments and erected on site on concrete foundations by aid of mobile cranes.

2.9.3 *Yiben Construction Activities*

This section outlines the main construction activities involved in the construction of Yiben.

River Diversion

The Seli River diversion will comprise four phases.

- Stage 1: Construction of the tailrace canal on the left bank including an upstream extension to form a bypass canal.
- Stage 2: Diversion of the Seli River discharge through the bypass canal. This is facilitated by a cofferdam with a crest elevation at 247 masl.
- Stage 3: During this phase a box culvert is built in the river, which exhibits 6 quadratic boxes with an edge length of 6 m, each.
- Stage 4: The cofferdam in the Seli River will been removed and the bypass canal is blocked by an upstream cofferdam with crest elevation at 249.0 masl for the protection of the dam and powerhouse foundation works, and a downstream dam with a crest elevation at 243.0 masl for the protection of the powerhouse construction pit from the Bumbuna reservoir backwater. In this phase the water flows through the box culverts while the powerhouse and the dam is being built.

Diversion/Tailrace Canal

The construction of the diversion/tailrace canal requires excessive bulk excavation for the canal carved up to 20 m deep in the ground. Excavation will be carried out by conventional excavators in soil and by blasting in rock.

Main Dam

Preparative Works

For the dam foundation sound rock is required. Thus soil cover and weathered rock must be excavated on the whole footprint of the dam before starting with the dam foundation works and the construction of the diversion culverts respectively. Most of the excavation will be done by aid of conventional excavators, however locally some blasting might be required.

The slopes on the left and right bank are usually quite steep so that a slope protection by shotcrete and rockbolts is required. Depending on the quality of the rock, in some areas even pre-stressed anchors might be necessary.

Full-Scale RCC-Trial

Prior to placing RCC in the dam body, a full-scale trial for placement of RCC and grout enriched vibrated RCC shall be carried out. The full-scale trial is an essential part of the RCC tests and construction program. It is considered as a transit step from construction preparation and actual construction of the RCC dam.

RCC Placement

For the Yiben RCC dam, no consolidation grouting is foreseen, and the foundation rock is considered to be quite sound. Therefore, it has been recommended by the engineering Feasibility Study (1) to place the RCC immediately on the excavated rock surface after the dental treatment to fill troughs and irregularities that are too small for a small dozer and a vibrating roller.

The whole procedure of batching, transporting, placing and compacting RCC should be performed in a continuous process. Therefore, it is recommended to use high speed conveyor belts which are more and more used for delivery of RCC mix to lift surfaces. Using conveyor belts, a continuous flow of large amounts of RCC mix can be created in a short time, so that the placing rate of RCC can be significantly increased and the construction period of the RCC dam can be reduced. The conveyor belt transports the concrete to an abutment of the lift surface and will then be distributed by trucks. Bulldozers will be used to spread the un-compacted RCC mix layer to a thickness of about 35 cm.

Curing of RCC

Like conventional concrete, the fresh RCC must also be properly cured and protected after placement and compaction. Properly curing the fresh RCC and conventional concrete is an important step to ensure the concrete quality.

Powerhouse

The powerhouse will be constructed in the former diversion channel. Therefore, most of the excavation works will already have been carried out by the time of starting the works on the powerhouse. Remaining excavation will be done with excavators in soil and weathered rock and by the drill and blast method (vertical drilling) in sound rock. The slopes will have to be protected by shotcrete and rockbolts and, in case of bad conditions, even by aid of pre-stressed anchors.

(1) Lahmeyer (2012) Bumbuna HEP Phase II Sierra Leone Feasibility Study

Once the foundation works have been finished the load bearing walls, columns, slabs and beams of the powerhouse will be raised as quickly as possible in order that the roof can be placed, the main crane installed and the building made weatherproof.

Switchyard and Transmission Lines

The switchyard will be placed in a cut on the left river bank next to the tailrace canal. As the cut is quite deep sound rock is expected to be present (1). Depending on the rock quality of the slopes some rock support with shotcrete and rockbolts might be required. However, this can only be determined after further geotechnical field investigations.

Some limited concrete works for foundations will be required for the switchyard installations as well as for the towers of the transmission lines. The steel lattice towers will be transported to their destination in separate segments and erected there on concrete foundations by aid of mobile cranes. The transmission line will be in parallel to the Bumbuna reservoir and in close vicinity on the right bank. Access in this area is difficult and will be established prior to construction. Access points are on either end of the transmission line, ie Bumbuna and Yiben, as well as at Kamandi (approximately at 28.5 km from Bumbuna). At the most narrow section of the Bumbuna reservoir, approx. 1 km downstream of the confluence with the Mawoloko River, the Seli River has to be crossed by an approximately 600 m wide span.

Impounding

Impounding of the reservoir may only start after the diversion culverts are backfilled. Furthermore, impounding will also be efficient only if sufficient water is available and the mandatory environmental downstream flow release of between 4 and 15 m^3/s is maintained. Thus, the impounding should take place during the months of July to November.

2.10 OVERARCHING CONSTRUCTION SCHEDULE

Most of the structures, such as intake structure, headrace tunnel, surge shaft, penstock and manifold, powerhouse, tailrace canal and transmission lines, can be constructed mostly independently from each other as there are only a few relevant interconnections between the structures' construction processes, Almost all relevant access roads are already existing and only need to be upgraded (if required).

The construction schedule, shown in *Figure 2.9* and *Figure 2.10*, is calculated to extend over three years from contract award to full commercial operation for

(1) Lahmeyer (2012) Bumbuna HEP Phase II Sierra Leone Feasibility Study

Bumbuna Extension and to approximately 3.5 years for Yiben. The schedule and timings have been estimated by the engineering company (Lahmeyer Group) and is subject to the submitted programme of the winning bidder.

Figure 2.9 Bumbuna Extension Schedule

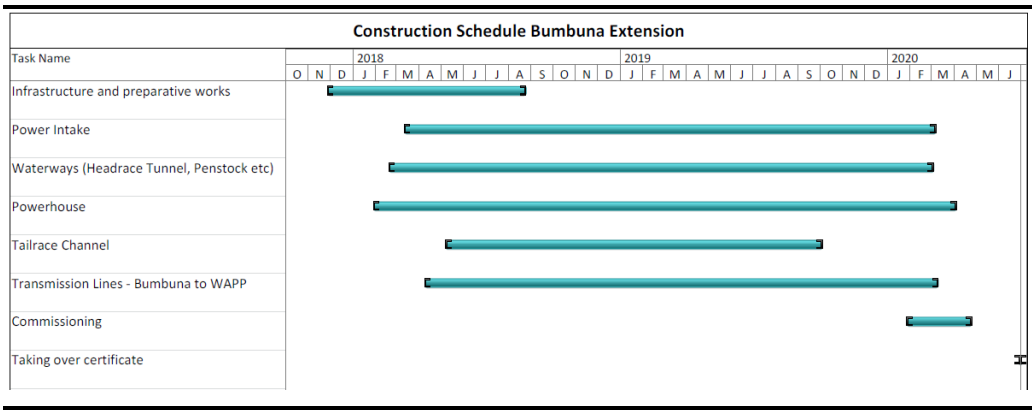
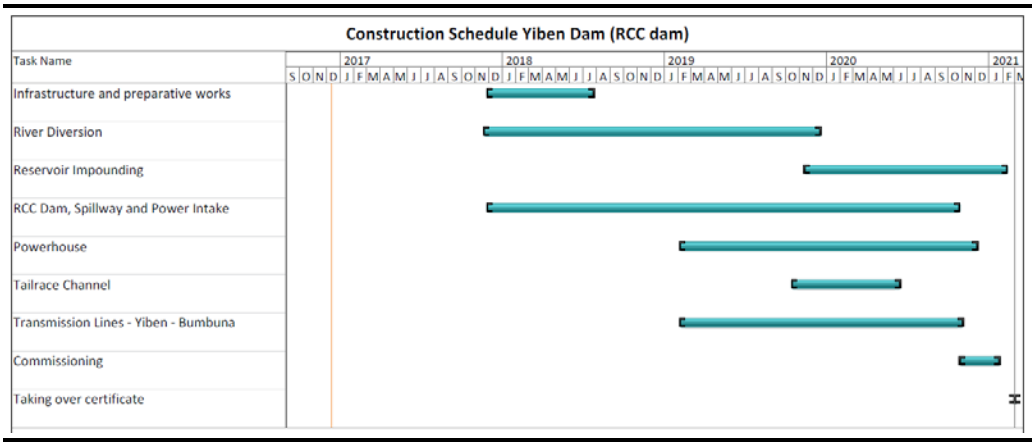


Figure 2.10 Yiben Schedule



2.11 LABOUR AND EMPLOYMENT

The construction phase peak will employ in the order of 1,200 people at the Bumbuna Extension, and another 1,150 at Yiben.

During construction, it is likely that employees will be sourced country-wide for higher level positions and from the local/regional area for other labour positions.

The skills mix is anticipated to be as follows.

- Management (skilled workforce) - 230.
- Semi-skilled workers - 1,020.
- Unskilled labour - 1,100.

The operations team will comprise in the order of 35 to 40 persons at Bumbuna Extension and 15 to 20 persons at Yiben.

The Project will develop a Labour Management Plan which is in line with the IFC Performance Standard 2 (Labour and Working Conditions) and the Sierra Leone Local Content Policy (as permitted by the lenders to the project). It will ensure that the Project will maximise local recruitment, the anticipated ratios are as outline below.

- Construction Phase, 550 Sierra Leone nationals: 800 international workforce.

- Operational Phase: the ratio of Sierra Leone nationals to international workforce is currently unknown but it is planned to maximise local recruitment.

The Labour Management Plan will be applied to the working conditions of direct, contracted and supply chain workers employed by the Project.

2.12 OPERATION

Following commissioning, the Project will be owned and operated (under a separate Operation and Maintenance Contract) by Joule Africa for a period of 25 years, at which point the asset will be transferred to the GoSL who will own and operate the asset until the Project is decommissioned.

2.12.1 *General Operation at Bumbuna Extension*

During the operation phase the Bumbuna reservoir water level will not change very much when compared to the current situation. The levels will be managed to remain the same as the current levels using a set of operation rules which are to be developed before the commissioning of the new powerhouse at Bumbuna Extension. At present, an optimised firm power generation is considered to be the primary target for the operation. This will result in constant releases throughout the course of the year.

2.12.2 *General Operation at Yiben*

The primary operational objective of Yiben is the generation of firm power and a more consistent supply of water year-round to Bumbuna I and Bumbuna Extension. Operational rule curves are the compilation of operating criteria, guidelines, and specifications that control the storage and release function of a reservoir. It may also be referred to as operating rules, flood control diagram, or water control schedule. These are usually expressed in the form of graphs and tabulations, supplemented by concise specifications and are often incorporated in computer programs. In general, they indicate limiting rates of reservoir releases required or allowed during various seasons

of the year to meet all functional objectives of the Project [(1)]. Operational rule curves will be set up for the operation of the dam before commissioning to help manage water levels, power generation, overspill and environmental releases.

2.12.3 *Environmental Flow Releases from the Bumbuna II Scheme*

Operation of Bumbuna II will result in an overall regulating effect of flows within the Seli River downstream of Bumbuna dam throughout the year. Due to the configuration of Bumbuna II, the majority of flow that currently discharges through Bumbuna I will no longer re-enter the Seli River immediately downstream of the Bumbuna dam, and instead will re-enter 4 km downstream at the outlet of the new tailrace. Only water discharging through Bumbuna I and the Environmental Flow Powerhouse will discharge into the Seli River immediately downstream of the Bumbuna dam. This configuration will result in a significantly different flow regime within the 4 km river reach between the Bumbuna dam and the Bumbuna Extension tailrace, compared to downstream of the Bumbuna Extension tailrace.

Based on the environmental flow assessment undertaken by Ecotone following field work in 2016 (see *Annex E*), which utilised the Revised Desktop Reserve Model (RDRM) it is recommended that the Environmental Flow Release (EFR) during the dry season should range from >11m^3s^{-1} to <84 m^3s^{-1}. Although the operational rules for the Project are still to be formalised, by varying the operational flow through Bumbuna I and the Environmental Flow Powerhouse, it will be possible to maintain flows that achieve the EFR within the 4 km reach between the Bumbuna dam and the tailrace.

Downstream of the tailrace however, flows from Bumbuna Extension will combine with flows from the 4 km reach between the Bumbuna dam and the tailrace, and are likely to exceed the EFR during the dry season.

During the wet season, it is anticipated that Bumbuna Extension, Bumbuna I, and the Environmental Flow Powerhouse will all be operational to their full capacity. The operation of all three of these project elements will result in a total combined flow of 138 m^3s^{-1} within the Seli River downstream of the tailrace, excluding any additional flow that may result from overtopping / bypassing through the spillway. Such overtopping / bypassing events are expected to become much less frequent, due to the flow control and storage capacity that will be provided by Yiben. This reduction in overtopping / bypassing events and introduction of the maximum operational flow of 138 m^3s^{-1} represents a significant reduction in typical wet season flows, which during the current scenario, range from 250 – 500 m^3s^{-1}.

Operation of Yiben will result in the long-term regulation of flows within the Seli River and the inundation of a large are upstream of the dam. Whereas at

(1) U.S. Department of Homeland Security, Federal Emergency Management Agency (2004) Federal Guidelines for Dam Safety, Glossary of Terms.

present, flows downstream of the Yiben dam site experience large fluctuation in flow between the wet and dry seasons, the storage of water within the Yiben reservoir will result in peak flows in the wet period being significantly reduced, whereas peak flows in the dry seasons will be increased. Subject to the operation of Yiben, the steady out flow is anticipated to be 84 m^3s^{-1}.

2.13 EMERGENCY SITUATIONS AND COMMUNITY HEALTH, SAFETY AND SECURITY

In accordance with Performance Standard 4 the Project will have a commitment to Community Health and Safety to ensure the safety of the communities local to the Project to mitigate any potential health and safety issues for the local communities.

In accordance with Performance Standard 4 the Project will engage experts with relevant and recognised experience in similar projects, separate from those responsible for the design and construction are commissioned to conduct independent assessments of the key structural elements or components of the Project such the dams, where their failure or malfunction may threaten the safety of communities. These assessments will be commissioned as early as possible before and during construction, operation, and decommissioning.

Safety measures will include safety campaigns, use of warning sirens, appropriate signage and fencing, traffic awareness programs and safety exclusion zones (including those to be maintained around fuel stores). Workers will be provided with training on community health and safety in order to mitigate any potential impacts caused particularly by the worker's living on site.

As part of the contract for the EPC Contractor, the successful bidder will be required to develop an Emergency Prevention and Response Plan (including spill prevention). This plan will ensure that communities living local to the Project are protected from loss of life, injury or damage to properties in the event of dam failure.

The plan will include the following.

- Actions the Project will take to moderate or alleviate a problem at the dam.
- Actions the Project will take, and in coordination with local emergency management authorities, to respond to incidents or emergencies related to the dam.
- Procedures the Project will follow to issue early warning and notification messages to responsible downstream emergency management authorities.
- Inundation maps to help the Project operations team and emergency management authorities identify critical infrastructure and population-at-

risk sites that may require protective measures, warning, and evacuation planning.

- Delineation of the responsibilities of all those involved in managing an incident or emergency and how the responsibilities should be coordinated.

2.14 DECOMMISSIONING ACTIVITIES

2.14.1 Overview

Decommissioning will entail the removal of any non-permanent features (ie temporary office and accommodation structures, generators and electrical sub-station). The proposed intake and tunnel will be closed and the tailrace canal backfilled. Flow will be through the existing dam as per the current arrangement.

The project lifespan is expected to be up to 90 years with careful operation and maintenance, and periodic replacement of electro-mechanical components. Due to the timelines involved, there is no firm decommissioning plan in place at present. In line with GIIP, the Project commits to the development of a decommissioning strategy and any required environmental and social assessment. This will be approved by the national regulator and the lender consortia prior to decommissioning work commencing.

3 ANALYSIS OF ALTERNATIVES

3.1 INTRODUCTION

This part of the ESHIA summarises the process by which the energy potential of the Bumbuna-Yiben hydropower complex (ie Bumbuna I and the proposed Bumbuna II Project) was identified and initially assessed, the policy and strategic framework within which potential development of both Bumbuna I and particularly Bumbuna II has been progressed, and alternatives that have been considered during the design and development process.

Throughout any consideration of options for power generation to support social and economic development in Sierra Leone, it is important to remember that for much of the critical period from the early 1990s onwards the country has been severely disrupted, at times to the point of being a failed state, initially by a prolonged civil war and most recently by the ravages of the Ebola Virus Disease ("EVD"). The resulting situation in the country and status of the power sector was summarised by the Overseas Development Institute (ODI) in 2015 (see *Box 3.1*). It is hard to over-emphasise the critical role that development of power generation capacity, with significant involvement of both development finance institutions and of the private sector, will play in Sierra Leon's social and economic progress in the future; and given the abundant water resource the country has, hydropower will play a key part in this.

3.2 POLICY AND STRATEGIC FRAMEWORK

3.2.1 GoSL Policy and Strategy

As stated by the Ministry of Energy (1) , although there have been various efforts over the last fifteen years Sierra Leone still lacks clear comprehensive policies and strategies for the energy sector; these are required to govern the process of energy provision and use in the country. Nevertheless, development of the power sector has been an important thread running through the GoSL's strategy in the aftermath of the protracted civil war, including the following:

- The three iterations of the five yearly Poverty Reduction Strategy Paper (PRSP) that have been part of the process for Sierra Leone to qualify for debt relief, the most recent covering the period 2013-2018 (2).
- The Overseas Development Institute (2015) examined the status of the power sector in Sierra Leone post-conflict and the Ebola outbreak and a summary of this study is presented in *Box 3.1*.

(1) http://www.energy.gov.sl/Energy_Policy.html. Accessed 07 December 2016.
(2)ttp://www.undp.org/content/dam/sierraleone/docs/projectdocuments/povreduction/undp_sle_The%20Agenda%20for%20Prosperity%20.pdf

Box 3.1 Status of the Power Sector in Sierra Leone, 2015

Fewer than 10% of the population has access to some form of power. The power sector in Sierra Leone has been a focus of many development programmes through donors such as DFID and the World Bank who have sought to support the Government of Sierra Leone (GoSL) in reforming the sector. Sierra Leone is one of the world's poorest countries. As of 2012, Sierra Leone ranked 177 out of 186 countries in the United Nations Human Development Index and had an estimated Gross National Income per capita of $580, placing it in the bottom third of countries in sub-Saharan Africa. The largest segment of the population is concentrated in the Freetown area, with one of the region's largest and poorest urban settlements. Poverty is even more severe in rural areas. Gradually, post-conflict recovery has been sustained, characterised by strong economic growth, infrastructure development, improvements in governance and public sector capacity building. Unfortunately, due to the recent Ebola outbreak, many of the development programmes in the energy sector, and indeed in other non-essential areas, have had to take a backseat to the Ebola response. Rural Sierra Leone suffered significantly by isolations posed by Ebola quarantines, which further hampered the gains that had been made before this devastating setback.

Electricity access and demand in Sierra Leone are among the lowest in Africa. Sierra Leone's limited power infrastructure base on generation, transmission and distribution is a major constraint to expanding electricity access. Public electricity services are limited to selected areas. Its sparse coverage and unreliable service exacerbate poverty conditions. The national distribution network extends to Freetown and the surrounding Western Area (Freetown Capital Western Area), covering about 40% of their residents. Two isolated systems (Bo-Kenema and Makeni systems) provide coverage in limited areas in the south-eastern and northern regions. In rural areas, where the bulk of the population reside, electricity access is practically non-existent. Electricity tariffs remain among the highest in Africa, constraining energy consumption…….high tariffs are mostly caused by the reliance on expensive thermal generation and high transmission and distribution losses. The tariff is not cost-recovering and the national electricity utility remains strongly dependent on government subsidies. Low connection rates and affordability issues keep electricity consumption rates among residents very low. Because of scarce supply and high costs, electricity represents only 7% of total energy consumption. The large majority of Sierra Leone's population is forced to rely on inefficient and polluting traditional fuels to meet their basic needs, such as kerosene for lighting and fuel-wood and charcoal for cooking. This results in adverse impacts on personal health and safety as well as on the environment.

Current power generation capacity, transmission and distribution remains inefficient and inadequate to accommodate the country's overall power requirements. Government-owned installed capacity is estimated to be approximately 90 MW, which includes the 50 MW Bumbuna hydroelectric power plant, two thermal power plants at Kingtom (10 MW) and Blackhall Road (16.5 MW), that serve the Freetown Capital Western area. Hydropower from Bumbuna is seasonal, producing less than 20 MW during the dry season often being out of action for days or even weeks. With no availability of a local fuel resource, all the thermal plants are supplied by expensive and imported heavy fuel oil or diesel, which further complicates the electricity supply situation during the dry season. Limited port facility and poor supply chain infrastructure often leads to periods of fuel crises, pushing up the price of diesel and creating fuel black-markets. One of the largest industries in the country, contributing to its economic growth, is the mining sector. This sector relies primarily on self-generation by using large diesel generators to meet its power needs. The power demand of these mining companies is vast and an essential part of their operations, thus not awarding them the flexibility to be able to rely on the (unreliable) national power supply. Other large power consumers who depend on power, such as businesses, also depend on diesel generators as their primary power supply option. This inability to supply industry with its power needs creates a missed revenue generation opportunity for the government. [The lack of] transmission and distribution, together with an appropriate electricity retailing mechanism, to allow for a financially sustainable sector, further exacerbates the situation.

Source: Overseas Development Institute, 2015. https://www.odi.org/sites/odi.org.uk/files/odi-assets/publications-opinion-files/10254.pdf . Accessed 7 December 2016.

- The strategic priorities and goals for the ten-year period 2006-2015 set out in the Ministry of Energy and Power (as was) document *The Sierra Leone Energy Sector: Prospects & Challenges (MoEP, 2006)*; and

- *Energy Sector Strategy and Action Plan, 2014 -2017. (MoE, 2014).*

All of the above strategic documents have recognised the key role of hydropower in the energy generation mix as Sierra Leone attempts to achieve low carbon economic development; with specific mention given to the importance of Bumbuna II. The MoE's Energy Sector Strategy identified the components that are collectively considered as Bumbuna II in this ESHIA as fundamental to a stated objective of achieving 1,000 MW of generating capacity by 2017, based mainly on a mix of large and smaller-scale hydropower that it identified to be the cheapest renewable energy source for Sierra Leone. Other renewables and new thermal generation capacity were also identified, but contributing to a lesser extent. Further actions included an enhanced transmission and distribution network and measures to strengthen the capacity of government institutions managing Sierra Leone's power sector. All of the above were part of a comprehensive plan with the involvement of development partners, including *inter alia* the World Bank, African Development Bank, and UK DFID.

The ambitious objective of such a significant increase in Sierra Leone's generating capacity was immediately behind schedule, but was then derailed by two events in 2014:

- the outbreak of the EVD, and the subsequent focus of a major part of donor aid efforts on containing and ultimately eradicating the epidemic; and

- the collapse of the iron ore price on the world market, with its impact on Sierra Leone mining companies' production (and in some cases their ability to survive); the mining sector had been identified as the major purchaser of the increased power planned to be generated.

In July 2015 the President of Sierra Leone announced the country's Ebola Recovery Plan, running from July 2015 to June 2017. The overarching objectives of the Plan set out to eradicate Ebola, restore basic socio-economic services across the country, and lift economic growth rates. The Plan focuses on three sequential steps: (i) getting to and maintaining zero Ebola cases; (ii) implementing immediate recovery priorities, including restoring health services, reopening schools, ensuring food security, and expand water and sanitation; and (iii) transitioning back into the Agenda for Prosperity (AfP) Plan (2013-2018 – also known as PRSP III). The AfP remains the defining document for the overall development of the country with a set of actions for Sierra Leone to become an inclusive middle income country by 2035, driving towards a low emissions, climate resilient, gender sensitive and sustainable growth trajectory. Also in 2015, the Ministry of Energy, in collaboration with ECOWAS / ECREEE, developed a framework for the deployment and

monitoring of National Renewable Energy Plans, National Energy Efficiency Action Plans and the Sustainable Energy for All (SE4ALL) Action Agenda.

The Integrated Resource Plan and Tariff Study (2015) (1) identified the prime importance of Bumbuna II in its scenarios for development of generation potential into the mid-term, ie to 2024: "There is considerable undeveloped hydropower capacity in Sierra Leone, most notably in the Bumbuna/Yiben cascade." (*Section 2.4.3*), whilst also noting the severe supply-side constraints that could prejudice Sierra Leone's future potential for strong economic growth. The study considered hydropower to be the to be the most economically viable option for major power generation in Sierra Leone over at least the next decade in comparison with other possible sources (such as coal or oil), considering the other sources either in isolation or in combination with hydropower.

In a recent letter to the World Bank (December 2016), the GoSL have confirmed its commitment to Bumbuna II, noting it being part of the Government's "long term sustainable and affordable development plan for the energy sector" and that it was the next Independent Power Producer ("IPP") in line following the recently finalised Western Area Power Generation Project ("WAPGP"), a 57MW HFO plant.

The President of Sierra Leone has therefore signalled the importance of energy in the nation's development, declaring energy as one of his highest priorities, with increasing hydropower and other renewable power generation and improvements in transmission and distribution as key elements. This commitment has been reinforced during 2016 by initiatives such as the "Energy Revolution" and Sierra Leone's active participation in the UK's "EnergyAfrica" programme. Sierra Leone also plans to connect to the West African Power Pool (WAPP), through the CLSG Transmission Line, due to start construction in 2017, to provide opportunities to trade energy with neighbouring countries, and to establish feed-in tariffs to harmonise the sale of power into the CLSG from Independent Power Producers (IPPs) that develop power generation capacity in Sierra Leone.

In general, development partners' efforts in the energy sector are now focused on three areas: (i) enhanced transmission and distribution to make power more available to the most energy poor, including those in rural areas; (ii) development of small-scale and off-grid generation (eg solar and mini-hydro); and (iii) institutional capacity building to improve management and governance of the sector (2) . It is the private sector that will manage the risks and raise the necessary finance for development of larger-scale generation capacity (such as Joule Africa, in the case of Bumbuna II).

(1) PPA Energy (UK), submitted to GoSL Ministry of Energy in February 2015

(2) Development partners involved in supporting power sector development include inter alia World Bank, African Development Bank, United Nations Development Programme, Millennium Challenge Corporation, Islamic Development Bank and Japan International Cooperation Agency.

3.2.2 *The Power Sector Master Plan*

Sierra Leone's energy generation potential was identified and evaluated in a systematic manner in the Power Sector Master Plan (Lahmeyer International, 1996). The Master Plan considered many options for power development including a large range of large and small hydropower schemes alongside wind, solar and more conventional thermal power generation. As well as considering many other forms of power generation at a wide range of locations, the Master Plan described 27 hydropower sites with a potential to generate over 2 MW (approximately 1,200 MW in total across all these sites). Sites with a smaller capacity were not considered. The viability of hydropower generation at some locations was deemed to be compromised to a greater or lesser extent by the extreme seasonality of Sierra Leone's rainfall and the consequent variation in guaranteed power between seasons, but the existence of a number of feasible productive locations for hydropower generation was confirmed. Bumbuna (ie Phase I, already partially constructed at the time the Master Plan was prepared, and the elements now included in Bumbuna II as described in this ESHIA) was indicated as one of the most productive and economically viable projects to generate power for Sierra Leone's future, not only by comparison with other hydropower schemes considered but also when considered against the other options for power generation mentioned above.

The comprehensive assessment of a range of power generation alternatives and sites in the 1996 Power Sector Master Plan was supplemented by the 2015 Integrated Resource Planning and Tariff Study prepared for the Ministry of Energy by PPA Energy. This provided a more up to date summary of the generation potential of hydropower in Sierra Leone by comparison with other sources of power generation. In the context of Sierra Leone's current situation and potential economic development trajectory over the next decade or more, the study's conclusions can be summarised as follows.

- **Coal**: in addition to noting the environmental impacts of pollutant emissions inherent in coal combustion, for which control technology adds significantly to project costs, PPA Energy also noted that there are no coal sources in the region. As a result transport costs would be high, which are stated as a reason why there are very few coal-fired power plants in most of Africa. Generation of power from coal combustion is also subject to economies of scale, and Sierra Leone's system would have the capacity to absorb only the smallest viable unit sizes, with extremely high unit costs per kWh compared to units many times the size in other parts of the world where the power market is very much larger.

- **Diesel**: this is not considered practical for more than small generating units of a few MW at most, and is generally not suited to baseload power generation. More complex technologies have a higher capital cost and O&M complexity and are not in PPA Energy's opinion suitable for the developing country context.

- **Gas**: although gas-powered plants are operated in several African countries, there is no indigenous gas resource and operating such plants on **Oil** is extremely expensive, and subject to price variability and security of supply risks (1) .

- **Solar**: the economics of solar photovoltaic (PV) technology has improved considerably in recent years and is starting to become competitive with conventional generation technologies in certain instances. The challenges for solar technology in Sierra Leone, however, are that: i) until large mining and industrial loads can be connected the system peak will remain during the early evening when solar plants cannot generate, and thus solar power could not contribute capacity towards meeting system peak demand; and b) the short-run marginal cost of solar is currently higher than the cost of diesel generation, so it can only have a limited role in the development of an economically optimal plant mix at present.

- **Biomass**: the biomass projects developed in Sierra Leone have generally been initiated by industrial stakeholders from the agriculture sector (eg ADDAX) to evacuate excess power rather than specifically to fill a gap in the electricity sector, resulting in very limited amount of power evacuated to the interconnected grid. In view of the feedstock supply risk this seems unlikely to change in the short- to medium-term.

- **Wind**: the wind resource is considered too unknown, the challenges of supply-demand balancing too challenging and the resource too intermittent for wind to be a practicable contributor to the energy generation mix in the short- to medium-term.

- **Geothermal** power was not mentioned in PPA Energy (2015) as a potential power generation **resource**; this was presumably because no potential resources have been identified within Sierra Leone.

- **Hydropower development's** merits and potential issues were also discussed in the 2015 Integrated Resource Plan and Tariff Study. Amongst various potential issues associated with hydropower development hydrological seasonality was highlighted as particularly relevant in the Sierra Leone context, where the high seasonality of rainfall results in 'firm' capacity typically being well below the installed capacity. This limits a hydropower plant's utility in satisfying peak system demand reliably. Bumbuna I was quoted as an example: although it has a large impounding dam it essentially operates as a run-of-river scheme for a large part of the year, with an output of only around 18MW compared with the installed capacity of 50MW. Yiben was identified as potentially providing Bumbuna as a whole with over-year storage that is more advantageous in contributing towards satisfying peak system demand.

(1) This strategy is generally only employed in countries that have an indigenous gas resource under development, but that wish to build generating capacity to fuel economic development whilst waiting for their indigenous gas resource to come on stream to provide longer-term fuel for power generation.

The likelihood of hydropower having high social and environmental costs inherent in the large impoundments necessary to provide year-round flows to overcome high seasonality were described, and it was noted that the resulting unit cost (US$/kW) could be less favourable than in many other countries. However, the 2015 study predates the design changes and mitigation discussed in the remainder of this chapter and elsewhere in this ESHIA. These have been developed specifically to reduce environmental and social impacts within the minimum impact on Project cost and operational efficiency.

3.3 DEVELOPMENT OF THE HYDROPOWER POTENTIAL OF THE BUMBUNA COMPLEX

3.3.1 Bumbuna I

The hydropower potential of the Seli River was first identified in 1970, with a suitable initial site for a hydropower plant located 230 km north-east of Freetown at the south-eastern edge of the Sula Mountains, upstream of the Bumbuna Falls. Following a detailed feasibility study and design development, construction of a 50MW plant (Bumbuna I) commenced at this site in 1986 but was interrupted by the increasing civil unrest in the lead-up to the civil war. Further progress towards completion of the partially-built project was halted throughout the civil war that ended in 2002. Work resumed two years later and Bumbuna I was eventually commissioned in 2009 after further delays due to funding issues. Bumbuna I is by some margin the largest power plant in Sierra Leone, providing approximately two-thirds of on-grid generating capacity.

From its inception, Bumbuna I was always perceived to be an initial part of a complex of developments to utilise the hydropower potential of the Seli River. Bumbuna I's design allowed for successive development of the full potential in one or more later stages without an interruption to generation of power from the original Bumbuna I plant.

3.3.2 Bumbuna II

Further development of Bumbuna, which as described above had been envisaged since prior to the start of construction of Bumbuna I in the 1980s, was initiated by GoSL in 2009 with the intention of involving the private sector. Bumbuna II was initially promoted at a Sierra Leone/UK trade and investment conference, and subsequently proposals from interested developers were solicited by the Sierra Leone Investment and Export Promotion Agency (SLIEPA). Following a competitive bidding procedure Joule Africa was named the preferred bidder and a Memorandum of Understanding signed in May 2011, with an independent pre-feasibility study (PFS) undertaken by Lahmeyer International later that year. Development of Bumbuna II was initially overseen by a Steering Committee whose membership was made from the GoSL and Joule Africa. More recently, the Energy Strategy Delivery Task Force has had this responsibility. In the period

up to the date of this ESHIA, work has progressed through the feasibility stage, design options, a value engineering study (which has resulted in a considerable cost reduction to the construction costs of approximately 25% with only a small (*circa* 1.1%) impact on the annual average energy) and other steps to create a "bankable" project attractive to potential sources of finance. These steps have included identification and analysis of various alternative configurations, location of components and designs (see below).

The Bumbuna II project as proposed consists of both the further parts of Bumbuna II that had been previously identified in the Power Sector Master Plan and incorporated into GoSL's post-conflict strategy for energy sector development. As described in *Chapter* 2, these components are:

- an extension at the Bumbuna I site to provide additional power generation capacity; and

- an impoundment further upstream at Yiben to generate additional power and regulate flow to the Bumbuna plant.

An associated facility to the new and extended generating capacity consists of the transmission line needed to evacuate power from Yiben, which connects to the existing transmission network at the Bumbuna I site. This transmission line is being provided by the GoSL as part of a separate project.

3.4 ALTERNATIVES TO BUMBUNA II

3.4.1 The "No Project Option"

As has been described in preceding sections of this chapter, Sierra Leone is one of the most energy-poor countries in the world. It is in the early stages of an ambitious programme to reach low emissions middle-income country status within twenty years. The development of Sierra Leone's hydropower generation potential is a fundamental part of this plan, and Bumbuna II is the first, most important step to unlock the remaining potential of the Seli River as an energy resource. It carries on the process started with the studies of the Seli River in the early 1970s and the construction of Bumbuna I which started in the mid-1980s. This long-established place at the heart of power sector development justifies Bumbuna II's classification as a major strategic project for GoSL which has the direct support of the country's President.

In light of the above, to abandon Bumbuna II in its entirety (ie "no project") is not considered a logical or feasible alternative. This major hydropower development's contribution to increasing Sierra Leone's access to electricity will be complemented, but could not be replaced, by small-scale and off-grid renewables generation. Thermal power generation will play a part in the energy mix but over-reliance on imported fuel, the availability and price of which could fluctuate markedly over short periods, would prejudice both GoSL's sustainable growth targets and its energy security. Given that only

around 10% of the population has access to electricity, other measures such as demand side management would not be appropriate, nor effective if they were attempted. Given these circumstances, further consideration of alternatives in the remainder of this chapter will therefore concentrate on alternatives considered within the overall Bumbuna II project, and on how environmental and/or social issues have been assessed within different alternatives identified.

3.4.2 *Alternatives for the Bumbuna Extension*

With the aim of increasing the generation potential of the existing Bumbuna plant, three options were considered in the Bumbuna II PFS (2011). These, as shown on *Figure 3.1,* were:

- extension of the existing powerhouse (Option A);
- development of a new powerhouse on the right bank of the dam toe (Option B); and
- development of a new powerhouse downstream of the existing dam and Bumbuna Falls (Option C).

Extension of the existing powerhouse was not perceived to create any environmental problems, but was ruled out on technical grounds because: a) it would have been necessary to shut down the existing power house for several months, with the resulting severe disruption to Sierra Leone's power creating social and economic problems (which would not be acceptable to GoSL); b) the relatively small additional power generation potential; and c) other administrative and technical problems.

The option of a new powerhouse on the right bank was also discounted, primarily for reasons similar to the above: a shut-down of at least two months would also have been necessary.

The third option that was considered takes advantage of the additional generating potential offered by the 40 m l head of water over the 2 km stretch of the Bumbuna Falls and rapids downstream of Bumbuna I. It would involve construction of a new powerhouse to release water just downstream of Bumbuna Falls via a tailrace canal of about 2.1 km. The existing powerhouse would then serve as a backup for replacement of generating capacity during scheduled maintenance or forced outage and for generation of secondary power.

The PFS concluded that the third option was preferable on engineering and economic grounds, as it would provide over 50% more firm power (at 99.5% reliability). This significant benefit in terms of energy yield was deemed to override: a) construction overall taking longer than other options; and b) potential environmental and socio-economic issues associated with loss of land to the tailrace canal that is currently used by local communities for year-round agriculture. The PFS proposed that the loss of communities' access to land, and the resultant impact on livelihoods, could be mitigated by use of the

tailrace canal to provide a reliable year-round irrigation water supply to farmers to increase their efficiency and thus yield.

Figure 3.1 Locations of Powerhouse Options

3.4.3 Yiben Dam and Reservoir

As described in *Section 3.2.1,* from early concepts of hydropower generation on the Seli River the value of maximising the energy yield through development of Bumbuna I and one or more subsequent phases was discussed. Thus by the time that construction of Bumbuna I commenced in

the 1980s, further development of an extension at Bumbuna and an additional component further upstream intended both to generate power in its own right and to regulate flow to Bumbuna to further increase the energy yield, was considered an integral part of Sierra Leone's power development planning.

Yiben I vs Yiben II

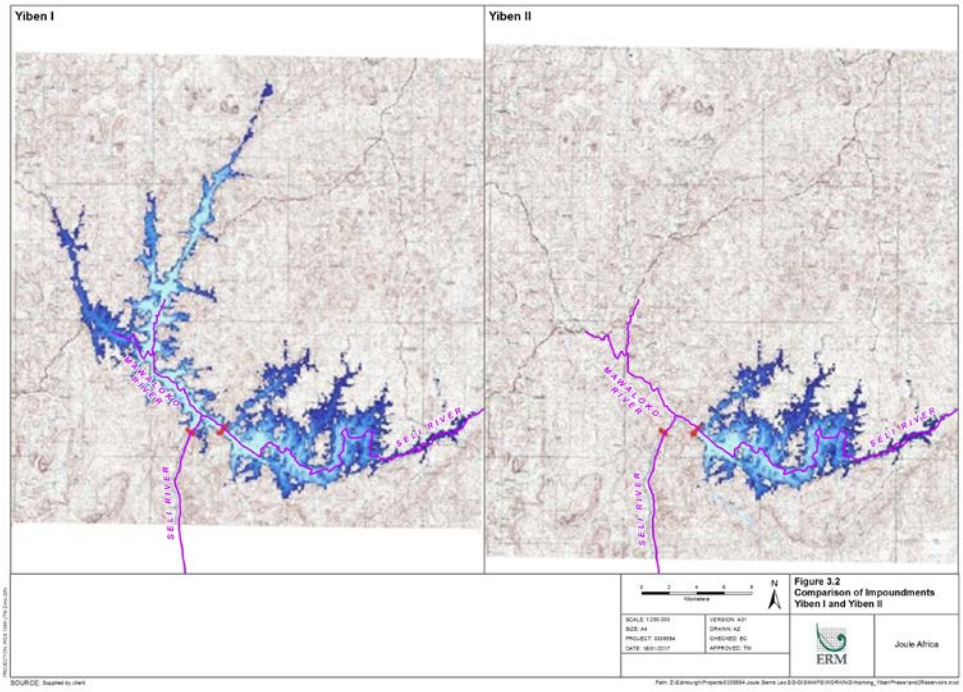
The independent PFS assessed two locations for the upstream dam and power plant, both situated near the village of Yiben, on economic, engineering and environmental and social grounds:

- Yiben I (the original option identified in early concepts of feasible development of the hydropower potential of the Seli River) at a location approximately 29 km above Bumbuna I and 1 km below the confluence of the Seli and Mawoloko Rivers; and

- Yiben II, first identified in the 1996 Power Sector Master Plan which is situated about 3 km further upstream (and therefore 2 km above the Mawoloko River confluence).

The siting of Yiben I below the Mawoloko confluence would create a significantly larger reservoir than the Yiben II location (approximately double the size: see *Figure 3.2*), the benefits being to maximise energy yield and regulation of the flow of water downstream to Bumbuna I, thereby providing greater assurance of year-round power generation including the dry season.

Figure 3.2 Comparison of Impoundments Yiben I and Yiben II



Yiben I is therefore a more 'productive' option in economic terms, but as a consequence of the much larger inundation area this option was deemed to cause significant social impacts. The preliminary analysis in the PFS suggested that 12 major settlements would be affected, of which seven would be completely inundated; in addition, 14 km of road infrastructure would be inundated along with several paths linking villages. By comparison, the PFS identified that the smaller Yiben II alternative would only inundate one settlement, with a further five affected to some degree, no impacts on road infrastructure and very few paths affected. The PFS completed a comparative assessment of the Yiben options and concluded that Yiben II was the preferred option due the lower social and environmental impact.

Yiben I was concluded to be more economically attractive in providing better flow regulation and thus more reliable generation of continuous power as described above, Yiben II was approved as the preferred option by both GoSL and Joule Africa members of the Steering Committee on the grounds that it would have less social impacts on the communities of the area. Yiben II will still provide an acceptably high regulation of flow to the Bumbuna generation facilities, and will both very significantly reduce socio-economic impacts, and in technical and financial terms avoid the logistical complexities, potential schedule delays and high costs of undertaking a major resettlement exercise compliant with international standards, compared to the Yiben I option.

It must be recognised, however, that the PFS provided only a high-level study of the social conditions of the Yiben Project area. The more recent, detailed social baseline studies undertaken as part of this ESHIA have yielded more precise information on the number of individuals and households in the Project area (see *Annex H: Social and Cultural Heritage*) which are significantly higher than was initially predicted by the PFS. There appears, however, not to be any reason to assume that the PFS population and infrastructure figures for the Yiben I inundation area are not also underestimates, not least because of the large population in and around the Fadugu area that would be impacted by the Yiben I impoundment.

As there were no biodiversity data for the wider (ie Yiben I) area at the time that Lahmeyer International carried out the study that recommended a smaller impoundment (ie Yiben II), the study focused on resettlement and infrastructure as the criteria for the recommendation. A case built on biodiversity grounds would have required extensive data collection that would have been more complex, time-consuming and costly, so the recommendation for a smaller impoundment was built on the socio-economic case which appeared strong in its own right. The fact that Yiben II is half the size of Yiben I could indicate that the impact on biodiversity was reduced somewhat, but without meaningful qualitative or systematic quantitative data the scale of the benefit cannot be stated with any confidence. More systematic studies in the Yiben area have focused on the Yiben II impoundment and surrounding area as part of this ESHIA (see *Chapter 7 Volume I* and *Annexes E; Water Resources, F; Biodiversity and H; Social*).

The "No Yiben" option

As has been mentioned in the preceding sections, the Yiben dam has been considered integral to achieving the full generation potential of the Seli River since prior to the start of construction of Bumbuna I. Yiben was identified in the 1996 Power Sector Master Plan as one of the most feasible options to increase exploitation of Sierra Leone's hydropower resources, even though Yiben is not as economically attractive a development in its own right; rather, its value lies primarily in the regulation of flows to Bumbuna (Bumbuna I plus the Bumbuna extension), with the incremental power generated at Yiben itself an additional benefit rather than being fundamental to the rationale for the construction of a dam at Yiben.

As discussed in detail in the 2016 Value Engineering Study (VES) [(1)] , by regulating the flow of the Seli River, Yiben significantly increases the average energy yield from Bumbuna in comparison to the yield from Bumbuna without a development at Yiben. In the VES, the simulated output at the existing Bumbuna Dam (ie Bumbuna I) averaged around 260 GWh/yr. With the addition of Bumbuna II (including Yiben) the combined generation at Bumbuna I plus the Bumbuna Extension increases to 756 GWh/yr (as per *Table 3.3* of the VES). Thus the generation added at Bumbuna by the Yiben reservoir (and the extension) of almost 500 GWh/yr is much more than the generation at Yiben (305 GWh/yr). Put simply, the flow regulation at Yiben will mean that the energy yield for Bumbuna as a whole will be greater than the sum of the individual parts, and Yiben is therefore considered integral to the viability of the whole Bumbuna II Project.

3.5 OTHER DESIGN CHANGES

Design changes have been considered, and in some cases adopted, as development of the Bumbuna II Project has gone through the normal project development stages over more than five years since the GoSL and Joule Africa signed an MoU. Such changes, for example those proposed as a result of the work carried out through the PFS, FS, and VES, have resulted from a process of considering options (eg for layout, engineering specification and operational regime) and assessing them against technical, economic, financial and social/environmental factors. They have subsequently been presented to the GoSL for its review and approval.

Further changes to mitigate impacts of the existing design that have been identified as necessary during preparation of the ESHIA are set out in the ESHMP (*Chapter 8)*.

(1) See Table 3.3 and supporting narrative in Bumbuna Phase II, Sierra Leone. Value Engineering (Lahmeyer International, 2016).

4 LEGAL AND ADMINISTRATIVE FRAMEWORK

4.1 INTRODUCTION

This section reviews the administrative framework, policies, legislation, regulations and institutions that are of relevance to the Project and the ESHIA.

4.2 INSTITUTIONAL CONTEXT: NATIONAL POLICIES, LEGISLATIONS, REGULATIONS AND INSTITUTIONS

4.2.1 Environment

Institutions

The Environmental Protection Agency

The Environmental Protection Agency (EPA) referred to hereafter in the document as EPA-SL was established in 2008 through the Environmental Protection Agency Act (2008) and became operational in 2009. The EPA-SL is housed within the President's Office and is the main government agency in charge of all issues concerning the environment and climate change. The EPA-SL was established with the goal of creating and enforcing a strict regulatory framework for environmental regulation in Sierra Leone. It has the mandate to coordinate, monitor and evaluate the implementation of national environmental policies, programmes and projects, including issuing Environmental Impact Assessment (EIA) licences (1).

EPA-SL liaises with the Forestry Division of the Ministry of Agriculture, Forestry and Food Security (MAFFS) when it comes to ensuring companies that acquire concessions in forest areas also carry out the required EIAs.

Bumbuna Watershed Management Authority

The Bumbuna Watershed Management Authority (BWMA) was established through the Bumbuna Conservation Area Act of 2008 with the aim to promote environmental management and biodiversity conservation in the Bumbuna Conservation Area (BCA) in order to address any negative impacts to the environment.

The purpose of this act was to create the BCA as an area of biodiversity conservation, to address environmental and social needs associated with the operation of the Bumbuna I dam. In relation to biodiversity, the primary aim of the BCA was to establish a protected area to safeguard West African Chimpanzees (*Pan troglodytes ssp. verus*) present in the area, the boundary of

(1) http://theredddesk.org/countries/actors/environmental-protection-agency-sierra-leone

the conservation area taking in the known range of a chimpanzee community present in the area.

Under this legislation the BCA has been defined as a 'strict nature reserve' (IUCN Protected Area Management Category Ia), to be managed by the BWMA. Provisions made under *The Act* include requirements for the control of certain activities within the BCA, such as hunting, removal of timber, movement of people and domestic animals along with overall protection measures for flora and fauna.

The BCA has been established in law; however the level of practical enforcement of this legislation is undetermined. The Environmental and Social Advisory Panel (ESAP) set up to oversee the implementation of the environmental and social commitments of the original Bumbuna dam, indicated that human settlement, farming and hunting inside the BCA would likely continue following the creation of the BCA and that management systems to regulate these controlled activities were not yet in place (1).

The BWMA are also responsible for addressing the social impacts of the dam. They do this by involving local communities in the management of the watershed area and including them in the development and implementation of the strategic action plan. The BWMA also works with local communities to ensure land is sustainably used and does not lead to degradation of the water catchment area.

Ministry of Energy

The Ministry of Energy is responsible for creating and implementing policies, projects and programmes on energy generation in Sierra Leone, and provide an oversight across the entire energy supply chain.

As mentioned in *Chapter 3* Sierra Leone lacks clear comprehensive policies and strategies for the energy sector; these are required to govern the process of energy provision and use in the country. Nevertheless, development of the power sector has been an important thread running through the GoSL's strategy in the aftermath of the protracted civil war. *Chapter 3* provides a summar of the key strategic documents developed by the Ministry of Energy over the last fifteen years including; The three iterations of the five yearly Poverty Reduction Strategy Paper (PRSP), The Overseas Development Institute Status of the Power Sector in Sierra Leone, 2015 and *The Sierra Leone Energy Sector: Prospects & Challenges (MoEP, 2006)* which sets out the strategic priorities and goals for the ten-year period 2006-2015 set out in the Ministry of Energy and Power.

The Ministry of Energy prepared the Sierra Leone Energy Sector Strategy and Action Plan (2014 – 2017) which seeks to address issues relating to power

(1) Jenness, J., Klimt, J. and Oates, J.(2011). Fifth Mission Final Report. Bumbuna Dam Environmental and Social Advisory Panel. Prepared for Project Management Unit Ministry of Energy Sierra Leone.

demand and generation, network rehabilitation and expansion and access options. The Action Plan also tackles the task of separating electricity supply and generation from generation and transmission. This has consequently led to the creation of two separate entities: The Electricity Distribution Supply Authority (EDSA) and the Electricity Generation and Transmission Company (EGTC). Both entities are regulated by the Electricity and Water Regulatory Commission (EWRC).

The Action Plan is being executed by the Ministry of Environment and regulatory authorities.

Policies

National Environmental Policy (1994)

This National Environmental Policy seeks to achieve sustainable development through the implementation of sound environmental management systems. It includes policies on the topics listed below.

- Land Tenure, Land Use and Soil Conservation.
- Water Resources Management.
- Forestry and Wildlife.
- Biodiversity and Cultural Heritage.
- Air Quality and Noise.
- Sanitation and Waste Management.
- Toxic and Hazardous Substances.
- Working Environment (Occupational Health and Safety).
- Energy Production and Use.
- Settlements, Recreational Space and Greenbelts.
- Public Participation.
- Quality of Life.
- Gender Issues and the Environment.
- Institutional and Government Arrangements.
- Legal Arrangement.

National Biodiversity Strategy and Action Plan

Following on from ratification of the 'Convention on Biodiversity in 1994 and 1996 respectively' Sierra Leone developed a National Biodiversity Strategy and Action Plan (NBSAP) in 2003 which is integrated into the overall development plan of the country. This comprises of a series of measures and mechanisms intended to conserve and promote the sustainable use of the different components of the country's biodiversity. The action plan covers Sierra Leone's key systems, namely: (i) Forests; (ii) Montane Ecosystems; (iii) Savannah; (iv) Agricultural Biodiversity; (v) Wetlands and Freshwater; (vi) Coastal and Marine.

The NBSAP aims to protect, restore or lead to the sustainable utilisation of biodiversity as well as focusing on assessments, research, and the provision of policy and an institutional framework. Although no overarching policy exists yet in Sierra Leone around biodiversity, all ministries, NGO's, institutions, community organisations and individual entities are expected to work to achieve the aims of the Biodiversity strategy, following guidelines laid out in the Action plan.

Legislation and Regulations

Environmental Protection Agency Act, 2008

The key legislation governing the EIA/ESHIA process is currently the Environment Protection Agency Act, 2008 (EPAA 2008) (as amended in 2010). This Act establishes the role of the EPA-SL and sets out its functions and management. The EPAA 2008 is the overarching legislation that deals with the protection of the environment. They are responsible for monitoring the implementation of national environmental policies relating to Sierra Leone and deal with all activities and requirements of an EIA.

4.2.2 *Energy and Water*

Institutions

Ministry of Energy

This Ministry has the mandate for the development of policies and programmes for the provision of energy (electrical or otherwise). It is responsible for overseeing the development of hydroelectric and other power projects and is a key stakeholder for Bumbuna II, with a dedicated Project Manager in place to provide effective coordination between all government agencies and departments, and Joule Africa. The National Power Authority (NPA) comes under this Ministry.

Ministry of Water Resources

This Ministry has the mandate to provide strategic leadership for the sustainable management of water resources to enhance socio-economic development for the benefit of all Sierra Leoneans. This Ministry has responsibility for the provision of and safe drinking water on a constant and sustainable basis to the entire population of Sierra Leone. It is responsible for water schemes and for the protection and management of water resources and is a key stakeholder for the Project. The Sierra Leone Water Company (SALWACO) comes under this Ministry.

World Commission on Dams (1998)

The World Commission on Dams (WCD) was set up in 1998 to review the development effectiveness of dams, and to develop standards and guidelines

for future dams. The WCD presented a new framework for decision-making based on recognising the rights and assessing the risks of all interested parties. The WCD framework puts forward seven general "strategic priorities" each based on a set of "policy principles." A set of 26 "guidelines for good practice" lay out specific actions for complying with the strategic priorities at five key stages of the project development process. The list below summarises the WCD's recommendations. After publishing its final report in November 2000, the WCD dissolved. However, the WCD framework remains to be the most important benchmark in international dam building.

Box 4.1 World Commission on Dams Recommentations for Dams

1. Development needs and objectives should be clearly formulated through an open and participatory process, before various project options are identified.

2. A balanced and comprehensive assessment of all options should be conducted, giving social and environmental aspects the same significance as technical, economic and financial factors.

3. Before a decision is taken to build a new dam, outstanding social and environmental issues from existing dams should be addressed, and the benefits from existing projects should be maximized.

4. All stakeholders should have the opportunity for informed participation in decision-making processes related to large dams through stakeholder fora. Public acceptance of all key decisions should be demonstrated. Decisions affecting indigenous peoples should be taken with their free, prior and informed consent.

5. The project should provide entitlements to affected people to improve their livelihoods and ensure that they receive the priority share of project benefits (beyond compensation for their losses). Affected people include communities living downstream of dams and those affected by dam-related infrastructure such as transmission lines and irrigation canals.

6. Affected people should be able to negotiate mutually agreed and legally enforceable agreements to ensure the implementation of mitigation, resettlement and development entitlements.

7. The project should be selected based on a basin-wide assessment of the river ecosystem and an attempt to avoid significant impacts on threatened and endangered species.

8. The project should provide for the release of environmental flows to help maintain downstream ecosystems.

9. Mechanisms to ensure compliance with regulations and negotiated agreements should be developed and budgeted for, compliance mechanisms should be established, and compliance should be subject to independent review.

10. A dam should not be constructed on a shared river if other riparian States raise an objection that is upheld by an independent panel.

Source: https://www.internationalrivers.org/resources/the-world-commission-on-dams-framework-a-brief-introduction-2654

Policies

The Energy Policy of Sierra Leone

As defined in the energy policy draft document, the main policy target for electricity is to sustainably produce adequate energy supplies to meet the development aspirations of Sierra Leone and sustainably provide environmentally friendly electricity at affordable prices throughout the country.

The main legislative arrangements for the electricity sector are contained in the National Power Authority Act of 1982 and the National Power Authority (Amendment) (NPA) Act of 2005. The 1982 NPA Act defines the responsibilities of the NPA, and the development of hydroelectric projects. The NPA forms part of the Steering Committee which supervises the Project Implementation Unit.

Legislation and Regulations

Bumbuna Watershed Management Authority and the Bumbuna Conservation Area Act, 2008

This Act established the Bumbuna Watershed Management Authority (BWMA). The BWMA manages the watershed of the Bumbuna reservoir created by the Bumbuna I. The main objective of the BWMA is to promote sustainable land use practices, water processes and environmental management in the Bumbuna Watershed and to exercise control in the Bumbuna Conservation Area (BCA) (the BCA is 3,532 ha in area and is located to the northwest of Bumbuna I) in order to protect the fauna and flora in its natural state and address environmental and social needs associated with the operation of Bumbuna I. The BWMA will be an important stakeholder for the Project, however, the board and funding is apparently not fully in place, which will pose a challenge to the implementation of the activities(1).

Local Government Act, 2004

This Act deals with the establishment and operation of local councils around the country to enable meaningful decentralisation and devolution of Government functions. It stipulates that a local council shall be the highest political authority in the locality and shall have legislative and executive powers to be exercised in accordance with this Act or any other enactment. This Project will operate within areas controlled by more than one local council and it is advisable for companies to involve local councils in their development work as well as respecting the relationship between the local council and the Chiefdom.

(1) The EIA of 2005 recommended the revival of the Seli River Development Authority (SRDA) to support the functioning of the BWMA. However, to date there has been no evidence that such organisation exists in the area.

4.2.3 *Land*

Institutions

The Ministry of Lands, Country Planning and the Environment

This Ministry develops appropriate policies and programmes for land planning and the environment, though its role is more limited since the formation of the EPA-SL.

Policies

National Lands Policy (Draft)

The Draft National Land Policy of Sierra Leone (August 2015) aims to manage the use of land and natural resources in accordance with sustainable resource management principles and by maintaining viable ecosystems. It has a focus on sustainable land use and provides guidelines on land categories and use of wetland and conservation areas.

Land Tenure and Ownership

Land administration in Sierra Leone is governed by a dual system of law, dispersed in about twenty statutes and regulations. These consist of Property Statutes where land is either State (publicly) owned or privately owned and customary law practiced in the Provinces where ownership of land is vested in the Chiefdoms and communities and land can never be owned freehold. This principle is established by the Chiefdom Councils Act 1974 as well as by Section 28 (d) of the Local Government Act 1994 (Amended 2004).

4.2.4 *Agriculture, Forestry and Fishing*

Institutions

Ministry of Agriculture, Forestry and Food Security (MAFFS)

The MAFFS is the central government agency responsible for promoting the development of appropriate policies and programmes geared towards the development of agriculture, animal husbandry and the attainment of national food security in the country. Agriculture is the backbone of Sierra Leone's economy, accounting for almost half its Gross Domestic Product (GDP) and providing a living for over two thirds of the population.

In 2014 MAFFS launched the National Parks Protected Areas Authority and the Conservation Fund to prevent housing construction, quarrying, stone breaking or gathering, logging, charcoal burning, farming, extraction and forms of forest clearance within the national park in accordance with the wildlife conservation Act 1972 and the National Protection Area Authority and the Conservation Trust Fund Act 2012..

Ministry of Fisheries and Marine Resources (MFMR)

The Ministry of Fisheries and Marine Resources (MFMR) is the sole government agency with the legal mandate to promote aquaculture activities and to develop policies regarding the fishing sector, control and monitor fisheries and other aquatic resources within the territorial waters in Sierra Leone. The Ministry's overall responsibility is the control, development and conservation of all aquatic organisms, including those in freshwater environments and inland fisheries and aquaculture such as those the Project will impact.

Policies

The National Sustainable Agriculture Development Plan (NSADP) 2010 - 2030

The overall objective of the policy is to increase agriculture sector growth from 2% to 6% per annum by 2015 and increase incomes of producers. The Programme seeks to contribute substantially to increased wealth and food security in line with the first Millennium Development Goal and World Food Summit targets. The policy may have relevance to the Project if the footprint requires acquisition or change in use of any agricultural land.

Forestry and Wildlife Sector Policy 2010

The policy covers issues such as land use planning, forest reserve management, community forest management, private forestland management, wetlands management in forest reserve protected areas, wetlands management outside forest reserve/ protected areas, timber based enterprises, ecotourism, watershed and wildlife management. This policy will have relevance to any forested areas within the Project footprint.

Legislation and Regulations

Forestry Act, 1988

The Chief Conservator of Forest is responsible for the implementation of the Act which relates to preserving the forest environment, promoting the practice of forestry, ensuring sustainability of forest products and the protection of the soil and water resources that constitute the forest environment. The Forestry Act is under review however no draft legislation has been published to date.

Wildlife Conservation Act, 1972

The Wildlife Conservation Act, 1972 and the Forestry Act, 1988 are the main legislations that deal with issues of Biodiversity Conservation in Sierra Leone. It provides for the establishment, conservation and management of National

Parks, Game Reserves and other forms of Natural Reserves. Dams or reservoirs are usually not permitted within any Parks or Reserves.

Fisheries Act, 2007

The Fisheries Act of 2007 builds on the 1988 Fisheries Act by including conservation provisions. It provides protection for both fresh and marine species as classified by IUCN. It defines where artisanal fisheries operations could exploit – Inshore Exclusive Zone (IEZ) in relation to inland water ways such as those the Project will impact.

Employers and Employed Act, consolidated to 1960

This Act regulates relations between employers and employed, and safeguards health of the employed. It sets forth provisions relating to the formation and interpretation of contracts of service, the recruitment of native labour for foreign services, restrictions on the engagement of industrial workers, employment of women, adolescents and children apprenticeship contracts. Also regulates the death, insolvency and change of residence of employer; breaches of contract and disputes between employer and employed, provisions as to agents; advances by employers.

Factories Act,1974

The Factories Act of 1974 is administerd by the Ministry of Labour and was set up to regulate occupational health and safety issues which might arise at factories. It addresses the registration of factories, inspection, health and cleanliness in establishments, keeping of records, notification of occupational accidents and diseases, and offences and penalties.

4.3 *INTERNATIONAL CONVENTIONS, POLICIES AND PROTOCOLS*

Sierra Leone is a party to many international agreements, conventions, and protocols that seek to protect the environment and ensure sustainable development. Of potential relevance to the Bumbuna II Project are as follows.

- The UN Framework Convention on Climate Change (New York, 1992) – signed in 1993, with Sierra Leone submitting a new Intended Nationally Determined Contribution (INDC) in 2015.

- The Kyoto Protocol (Kyoto, December 1997)- ratified by Sierra Leone in 2006, with signatory states commited to reducing greenhouse gas emissions.

- RAMSAR Convention for the Internationally Important Wetlands Especially as Waterfowl Habitats (1971) – signed in 1999, Sierra Leone identified and listed one wetland site located along the Sierra Leone River Estuary near Freetown.

- Stockholm Convention on Persistent Organic Pollutants (22 May 2001; came into force 17th May 2004)- ratified by Sierra Leone on 26th September 2003, with signatory states obliged to outlaw designated persistant organic pollutants.

- Convention on Biological Diversity (Rio de Janeiro, 1992)- ratified by Sierra Leone on 12th December 1994, with the objective of developing national strategies for the conservation and sustainable use of biological diversity.

- Rio Declaration on Environment and Development (UN Conference, 1992)- Signed by Sierra Leone in 1992, with all signitature states obliged to follow principles intended to guide contries in future sustainable development.

- United Nations Convention on Biological Diversity (UNCBD) (1992)- Ratified by Sierra Leone on 12 December 1994, with all signatory states obliged to develop a national biological diversity strategy plan and establish protected areas.

4.4 INTERNATIONAL LENDING INSTITUTIONS' POLICIES, STANDARDS AND GUIDELINES

In addition to complying with national policies, regulations and guidelines, the Bumbuna II Project will review best practices, international standards, and associated guidance and adopt an approach that is appropriate to the specific context of Sierra Leone and the Project's own Corporate Policy.

The World Bank Environmental, Health and Safety (EHS) Guidelines are technical reference documents with general and industry-specific examples of Good International Industry Practice (GIIP). They contain the performance levels and measures that are normally acceptable to the World Bank Group and that are generally considered to be achievable in new facilities at reasonable costs by existing technology. They are used by the World Bank, International Finance Corporation (IFC),Multilateral Investment Guarantee Agency (MIGA) and other DFIs.

4.4.1 *International Finance Corporation*

The IFC's Sustainability Framework and its supporting documents consist of the Performance Standards on Environmental and Social Sustainability (2012).

The standards applicable to the Bumbuna II Project are outlined below.

- Performance Standard 1: Assessment and Management of Environmental and Social Risks and Impacts:

- Performance Standard 1 addresses the social and environmental risks and impacts associated with the project, requiring a process of environmental and social assessment followed by an Environmental and Social Management System (ESMS) in accordance with the legislation.

- Performance Standard 2: Labour and Working Conditions:

  - Performance Standard 2 is triggered by the engagement of workers in a direct, contracted or supply chain capacity and requires the adherence to policy and guidelines protecting the work force.

- Performance Standard 3: Resource Efficiency and Pollution Prevention:

  - Performance Standard 3 requires the project to adhere to resource efficiency and pollution prevention by following international guidelines; minimising impacts on the environment from pollution, promoting sustainable use of resources and reducing project-related Greenhouse Gas (GHG)Emissions.

- Performance Standard 4: Community Health, Safety and Security:

  - Performance Standard 4 requires the Project to address potential risks and impacts to the affected communities from project activities, which may be at greater risk in conflict or post-conflict areas such as Sierra Leone.

- Performance Standard 5: Land Acquisition and Involuntary Resettlement:

  - Performance Standard 5 apples to physical and/or economic displacement, requiring that displacement caused by the project must be avoided, and where avoidance is not possible, minimised through alternative project designs; with the impacts of land acquisition or restriction compensated for.

- Performance Standard 6: Biodiversity Conservation and Sustainable Management of Living Natural Resources:

  - Performance Standard 6 requires the protection and conservation of biodiversity and the maintenance of benefits arising from ecosystem services, including the sustainable management of living natural resources, by the consideration of direct and indirect project-related impacts.

- Performance Standard 8: Cultural Heritage:

  - Performance Standard 8 requires the client to protect cultural heritage in project design and execution, and to promote the equitable sharing of benefits from the use of cultural heritage.

It is not expected that the Project will trigger Performance 7 (indigenous people) since none of the ethnic groups living in the Project area (Fula, Koranko, Mandingo and Limba, Temne, Mandingo and Krio) are recognised as indigenous by the Government of Sierra Leone.

Performance Standard 7 recognizes that Indigenous Peoples "*as social groups with identities that are distinct from mainstream groups in national societies, are often among the most marginalized and vulnerable segments of the population. In many cases, their economic, social, and legal status limits their capacity to defend their rights to, and interests in, lands and natural and cultural resources, and may restrict their ability to participate in and benefit from development*".

The only ethnic group that might have qualified indigenous according to this definition would be the Fula or Fulani who are nomadic cattle herders. However, the Fulani are not recognised as indigenous by the government and there is a lack of consistent agreement in the scientific literature as to whether they qualify as indigenous or not(1). Thus for the purposes of this ESHIA, it will be assumed that Performance Standard 7 does not apply.

4.4.2 *World Bank*

The World Bank Group EHS Guidelines will be complied with including the guidance documents listed below.

- General Environmental Health and Safety Guidelines.
- Environmental, Health, and Safety Guidelines for Electric Power Transmission and Distribution.
- Environmental, Health, and Safety Guidelines for Water and Sanitation.
- Environmental, Health, and Safety Guidelines for Construction Materials Extraction.

The relevant Operational Policies (OP) will also be applied including World Bank Operational Policy 4.01: Environmental Assessment, 1999 (Revised April 2013) Bank Procedure 4.01, Annex A: Application of EA to dam and reservoir Projects, and OP 4.37 - Safety of Dams.

4.4.3 *Equator Principles*

The Equator Principles (EP), 2013: A financial industry benchmark for determining, assessing and managing environmental and social risk in project financing. The Bumbuna II Project, as a Category A project in a non-Organisation for Economic Co-operation and Development (OECD) country will trigger the EP principles as follows:

- Principle 1: Review and Categorisation;
- Principle 2: Environmental and Social Assessment;

(1) World Bank (2011) Policy Brief Indigenous peoples still among the poorest of the poor.

- Principle 3: Applicable Social and Environmental Standards;
- Principle 4: Environmental and Social Management System and Equator Principles Action Plan;
- Principle 5: Stakeholder Engagement;
- Principle 6: Grievance Mechanism;
- Principle 7: Independent Review;
- Principle 8: Covenants;
- Principle 9: Independent Monitoring and Reporting; and
- Principle 10: Reporting and Transparency.

4.4.4 *African Development Bank*

The African Development Bank (AfDB) requires that borrowers/ clients comply with a set of operational safeguards (OS) during project preparation and implementation. OS1 sets out the Bank's overarching requirements for borrowers or clients to identify, assess, and manage the potential environmental and social risks and impacts of a project, including climate change issues and OS 2-5 support the implementation of OS1 and set out specific requirements relating to different environmental and social issues, including gender and vulnerability issues, that are triggered if the assessment process reveals that the Project may present certain risks. The five Operational Safeguards (OS) are:

- Operational Safeguard 1: Environmental and social assessment;
- Operational Safeguard 2: Involuntary resettlement land acquisition, population displacement and compensation;
- Operational Safeguard 3: Biodiversity and ecosystem;
- Operational Safeguard 4: Pollution prevention and control, hazardous materials and resource; and
- Operational Safeguard 5: Labour conditions, health and safety.

4.4.5 *European Investment Bank*

The European Investment Bank (EIB) is the European Union's bank and is owned by European Union Member States. The EIB is governed by both public and corporate governance principles. Three decision–making bodies guide the EIB:

- the Board of Governers, responsible for determining the general directives of the EIB;
- the Board of Directors, responsible for the strategic management; and
- the Management Committee, in charge of the day-to-day management of the EIB.

The Environmental and Social handbook of the European Investment Bank (EIB) sets the policy context for the protection of the environment and human well-being across two volumes. Volume 1 details the roles of external actors spanning the following 10 themes.

- Theme 1: Assessment and Management of Environmental and Social Impacts and Risks.
- Theme 2: Pollution Prevention and Abatement.
- Theme 3: EIB Standards on Biodiversity and Ecosystems.
- Theme 4: EIB Climate-Related Standards.
- Theme 5: Cultural Heritage.
- Theme 6: Involuntary Resettlement.
- Theme 7: Rights and Interests of Vulnerable Groups.
- Theme 8: Labour Standards.
- Theme 9: Occupational and Public Health, Safety and Security.
- Theme 10: Stakeholder Engagement.

Volume 2 details EIB's internal policy and services, spanning routine practices in due diligence, monitoring, reporting, advisory work and policy discussions. It provides detail on the requirements for investment and framework loans, intermediated financing, documentation and the disclosure process.

The independent EIB Compliance function identifies, assesses, monitors and reports compliance risk. The EIB adheres to the Basel Committee on Banking Supervision of compliance risk (1), comprising of the following principles.

- Principle 1: The bank's board of directors is responsible for overseeing the management of the bank's compliance risk. The board should approve the bank's compliance policy, including a formal document establishing a permanent and effective compliance function. At least once a year, the board or a committee of the board should assess the extent to which the bank is managing its compliance risk effectively.

- Principle 2: The bank's senior management is responsible for the effective management of the bank's compliance risk.

- Principle 3: The bank's senior management is responsible for establishing and communicating a compliance policy, for ensuring that it is observed, and for reporting to the board of directors on the management of the bank's compliance risk.

- Principle 4: The bank's senior management is responsible for establishing a permanent and effective compliance function within the bank as part of the bank's compliance policy.

- Principle 5: The bank's compliance function should be independent.

- Principle 6: The bank's compliance function should have the resources to carry out its responsibilities effectively.

(1) Described as risk of "legal or regulatory sanctions, material financial loss, or loss to reputation" to which an EIB Group member may be exposed, arising from a failure to comply with applicable laws, rules and regulations.

- Principle 7: The responsibilities of the bank's compliance function should be to assist senior management in managing effectively the compliance risks faced by the bank. Its specific responsibilities are set out below. If some of these responsibilities are carried out by staff in different departments, the allocation of responsibilities to each department should be clear.

- Principle 8: The scope and breadth of the activities of the compliance function should be subject to periodic review by the internal audit function.

- Principle 9: Banks should comply with applicable laws and regulations in all jurisdictions in which they conduct business, and the organisation and structure of the compliance function and its responsibilities should be consistent with local legal and regulatory requirements.

- Principle 10: Compliance should be regarded as a core risk management activity within the bank. Specific tasks of the compliance function may be outsourced, but they must remain subject to appropriate oversight by the head of compliance.

5 STAKEHOLDER ENGAGEMENT

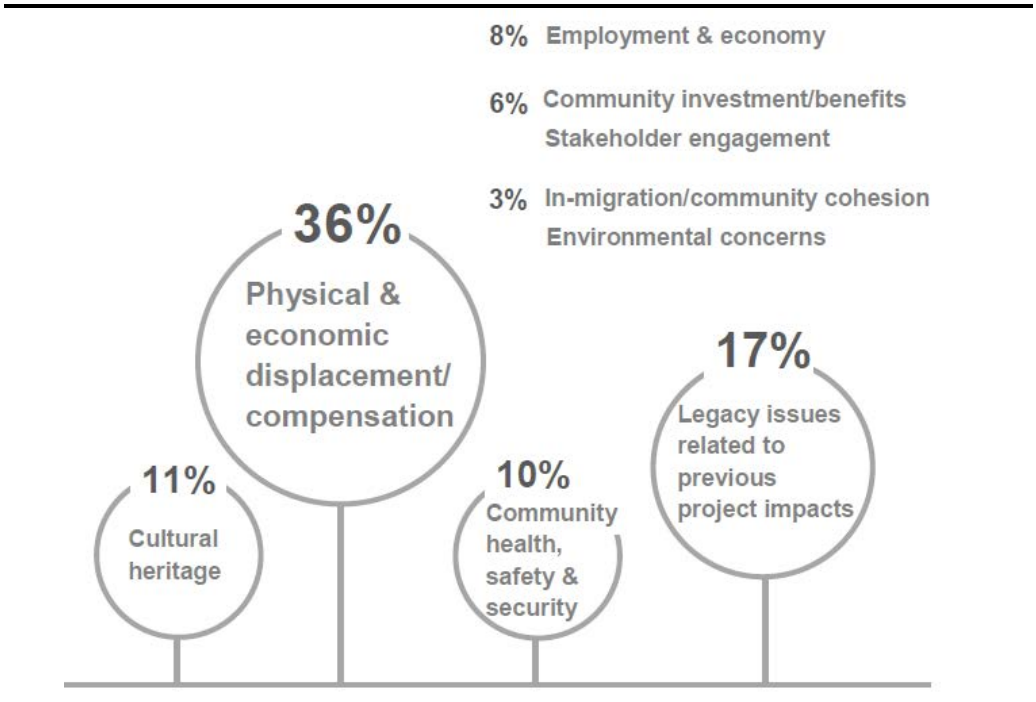
5.1 INTRODUCTION AND OVERVIEW

This chapter provides an overview on stakeholder engagement activities that have been carried out to date in support of the Project, and further steps required, to ensure that stakeholder concerns are taken into consideration following the ESHIA process.

Figure 5.1 provides an overview of the key issues raised regarding the Project to date. As the figure shows, resettlement has been of most concern, in particular economic displacement affecting land based livelihoods. Legacy issues related to the previous resettlement (under Bumbuna I) was a concern as well as community health and safety issues in relation to flooding and water borne illness and disease. Additionally communities have high expectations regarding employment benefits and community investments, such as improvements to healthcare, education and community infrastructure (for example, access to electricity and clean water).

Further detail regarding these issues and how they have been addressed in the ESHIA is provided in *Section 5.4.3* below.

Figure 5.1 Key Issues Raised as Percent of all Comments Raised during Household surveys and Stakeholder Meetings



Source: ERM

5.1.1 *Purpose of Stakeholder Engagement and Key Principles*

Stakeholder engagement is an ongoing 'two way' process of information sharing between companies and those that may influence or be affected by the Project. Engaging with stakeholders is essential for effective risk management and project delivery, and is a key component of the ESHIA process.

A stakeholder as defined by the IFC is provided in *Box 5.1*

Box 5.1 *IFC Definition of a Stakeholder* (1)

"Stakeholders are persons or groups who are directly or indirectly affected by a project, as well as those who may have interests in a project and/or the ability to influence its outcome, either positively or negatively. Stakeholders may include locally affected communities or individuals and their formal and informal representatives, national or local government authorities, politicians, religious leaders, civil society organizations and groups with special interests, the academic community, or other businesses."

The purpose of stakeholder engagement is to facilitate participation in the Project decision making process and to provide a platform for views to be expressed which inform the identification of impacts and associated mitigation measures. The process involves sharing information and knowledge, understanding the concerns of others and relationship building, thereby allowing stakeholders to understand the risks, impacts and opportunities of the Project to achieve positive outcomes.

A summary of key IFC principles regarding stakeholder engagement are summarised in *Box 5.2* below.

Box 5.2 *IFC Principles of Stakeholder Engagement*

- Provide the affected communities with opportunities to express their views on project risks, impacts and mitigation measures;
- Begin early in the process of identification of environmental and social risks and impacts and continue on an ongoing basis as risks and impacts arise;
- Stakeholder engagement shall be based on the prior disclosure and dissemination of relevant, transparent, objective, meaningful and easily accessible information which is in a culturally appropriate local language(s) and format and is understandable to affected communities;
- It shall be inclusive of all the relevant groups within the community (including the vulnerable and marginalized);
- It shall focus on those directly affected as opposed to those not directly affected and shall be free of external manipulation, interference, coercion, or intimidation; and
- Engagement shall be documented and include opinions and concerns as well as the measures taken to respond to them, ie the actions taken by the project to avoid or minimize risks to, and adverse impacts on, the affected communities.

(1) IFC (2007) Stakeholder Engagement: A Good Practice Handbook for Companies Doing Business in Emerging Markets Available at: http://www.ifc.org/wps/wcm/connect/938f1a0048855805beacfe6a6515bb18/IFC_StakeholderEngagement.pdf?MOD=AJPERES [Accessed 06.09.16]

5.2 ENGAGEMENT BACKGROUND

Since the early stages of Bumbuna II in 2011, the local Joule Africa team have undertaken extensive community consultation throughout the Project area. Some of this has been carried out in relation to the undertaking of topographical survey and ground investigation works, and also in relation to the resource centre built in Bumbuna town by Joule Africa in 2013. Strong relationships have been made with the respective Paramount Chief of each Chiefdom, and their leadership.

Specifically, in relation to ESHIA activities, meetings were held in 2011 and 2012, as part of the draft ESHIA prepared by CEMMATS for the Project, further engagement was carried out with some of the affected communities as well as with national and district level government.

In 2013, further engagement was also undertaken by Joule Africa for the establishment of the Bumbuna Resource Centre for literacy training and youth club meetings.

The Project has also established a strong partnership with the Government of Sierra Leone's (GoSL) central government. There has been ongoing and regular coordination with the GoSL during the development of the Project, and the establishment of the Energy Sector Task Force to support the Project's development.

Due to the outbreak of the Ebola Virus Disease, community engagement was suspended throughout much of 2014-2015, due to emergency government protocols regarding movement and travel within Sierra Leone.

Table 5.1 includes a summary of the engagement started for the Bumbuna Extension ESIA as conducted by CEMMATS.

Table 5.1 Meetings Held by CEMMATS in 2011/2012

Date	Meeting Held	Issues Raised
Community Level Meetings		• Lack of clarity regarding the extent and impact of physical and economic displacement including the resettlement process; • Disruption to community structures and cohesion creating conflicts among inhabitants; • Increased transmission of Sexual Transmitted Infections (STIs) from interaction with the workforce; • Impacts to water quality, in particular the reservoir area; • Increased waterborne diseases such as malaria; • Impacts on food security and natural resources (forests, vegetation etc); • Concerns regarding the stakeholder engagement and participation process including information dissemination.
2nd November, 2011	• Madina – Kassasi (Kassunko chiefdom, Koinadugu District); • Kabarri, Sawule, Kapanpahe, Kuwubanaya, Yiben (Diang chiefdom, • Koinadugu District)	
14th November, 2011	• Bumbuna (Kalansongoia chiefdom, Koinadugu District)	
9th December, 2011	• Bumbuna (Kalansongoia chiefdom, Koinadugu District)	
Other Meetings 2011-2012 (no dates are available in the CEMMATS Scoping Report)		
National Government level	• EPA-SL • Ministry of Energy • Ministry of Water Resources (MEWR)	
District Level	• District Chairpersons • Members of Parliament for the relevant Districts	
Local Traditional Authorities	• Paramount Chief's for the relevant chiefdoms • Section and town chiefs • Local religious leaders • Revered persons in the community	

Table 5.2 summarises engagement activities completed by Joule Africa in relation to Bumbuna II, supported by ERM in 2014.

Table 5.2 Engagement Activities Held by Joule Africa 2013/2014

Period	Document	Activities

09th-12th February 2013	Community development report, reporting week 5 & 6, date 31 Jan- 13th Feb 2013	Meetings were held in Kayakala, Kamankay and Kamator and Bumbuna to discuss project feasibility in the area and potential partnerships. Key observations and actions were detailed below:
		• Positive feedback regarding the Project to enhance well-being and future community development.
		• Formalisation of partnerships and the communities through establishing Village Development Councils (VDC) members and roles and responsibilities.
		• High expectations regarding the possibility of health centres, clean drinking water, electricity and employment, particularly of Community Liaison Officers.
		• Good representation of women in meetings:
		  • Kayakala: 35 female, 43 male
		  • Kamakay: 174 female, 118 male
		  • Kamator: 61 female, 66 male

Period	Document	Activities
2012 to December 2013	Matrix showing community engagement objectives, activities and results	Progress detailed in the report included: • Meetings with communities every two months. • Draft MOU with Radio Numbara Bumbuna developed to start a radio discussion and phone in programs. • Establishment of the Bumbuna resource centre. The resource centres provides literacy sessions, child youth club meetings and learning materials. • Engagement with Sustainable Nutrition and Agriculture Promotion to form a partnership in order to deliver water purification to high impact areas.
November 2013	Community development department report, reporting month, November. Date 04/12/13	Meetings held: • Kayakala - 8 VDC members. • Kamathor - 7 VDC members including the town chief. • Kamankay school support meeting with the group Secretary General, Mammy Queen (Chair Lady), PRO and youth. • Paramount chief court Barry - Met with chief and his council of elders on compensation issues. • Radio Numbara in Bumbuna town. Discussion points included: • The actual start date of Bumbuna Phase II. • Employment. • Project benefits. • VDC/ Project Area Development Committees inauguration ceremony.
February 2014	Draft MoU for the JA Hour on Radio Numbara 102.5 FM	A draft MoU was prepared for dissemination of information regarding the Bumbuna Phase II project. Covers all villages and sections in the Kalasonkoya Chiefdom, including Kayakala, Kamathor and Kamankay the Project area for the Bumbuna Extension Tunnel in Limba, Temne, and Krio. Objectives included: • Inform, educate, and encourage active public participation in debates about the Bumbuna Phase II project • Provide adequate and accurate information on project development • Encourage active discussion on the potential impacts and implications of the Project on the environment and livelihoods • Use radio as a tool to empower and enable citizens to learn about, understand, and act upon their rights to information and freedom of expression. • Ensure a conducive environment where communities express their concerns and grievances constructively, and ensure that these are properly taken into account and responded immediately • Promote inter and intra community dialogue and enhance local civic participation in issues of community development within the Project area. • Strengthen JA's credibility, openness and transparency in discussing project/community issues.

Period	Document	Activities
October 2014	Meeting Minutes from JA	A series of meeting were held with key government representatives in London to discuss the initial findings of the Project and the timeline for ESHIA delivery. Discussion points included: • Ensuring that ERM draws upon the wealth of existing data from extensive primary data gathering in the area over the last two decades. • The importance of the participation of women and vulnerable groups in stakeholder engagement. • Impacts to water quality and fishing livelihoods • Biodiversity offsetting. • Community health issues relating to landslides, malaria and sexually transmitted infections. • The importance of training local consultants and training local students to build in-country capacity. • The importance of engaging the EPA-SL and other government stakeholders throughout the ESHIA process.

Stakeholder Engagement carried out by ERM relating to this ESHIA is described in the remainder of this section.

5.3 STAKEHOLDER IDENTIFICATION AND MAPPING

The purpose of the stakeholder identification process is to establish which organisations and individuals have the potential to be directly or indirectly affected, positively or negatively, by the Project for the purpose of further assessment in the ESHIA.

The mapping process detailed in the Stakeholder Engagement Plan (SEP) and information gathered for the baseline was used to identify stakeholders for the overall project to date. However, it is an ongoing process requiring regular review and updates as the Project develops. The stakeholder groups identified to date are listed in *Table 5.3* below. A full list is provided in *Volume II, Annex J; SEP*.

Table 5.3 Stakeholder List

Stakeholder groups	Interest in the Project
National government	• Project approvals. • Compliance and legalities regarding specific subject areas. • Access to specific documents required for the Project such as the Cadastre and protected areas.
Regional/District Authorities	• Representatives of the national government. • Participate in decision making regarding project approvals. • Access to district level data.

Stakeholder groups	Interest in the Project
Traditional leaders:	• Representatives of affected communities, reporting key concerns/opinions to the government and inter-acting directly with the Project.

Potentially affected communities, including:
• settlements that will be directly and indirectly impacted - Refer to the list of settlements provided in *Volume II, Annex H; Social*.
• Landowners that may own land in the impacted area that live outside.
• Includes vulnerable groups:
  • Women / female headed-households.
  • Children / child orphans.
  • Youth.
  • Elderly.
  • Households on low income.
  • Physically/mentally disabled, including the blind.
  • Households in isolated rural settlements.
  • Non-landowning households, including the Fulani and Limba communities.
	• Communities that will be impacted by loss of land and or houses and other impacts from the inundation are and project infrastructure. In total it is anticipated that there are 5,623 inhabitants within 1,175 households and 52 settlements within the inundation area; and 9,633 inhabitants within 846 households and 39 settlements outside the inundation area.

Community based organisations in project districts/chiefdoms and affected communities, including: • Religious/traditional groups. • Farming associations. • Women's associations. • Hunting association etc.	• Representatives of vulnerable groups and community groups that will experience direct and indirect impacts.
Project employees/contractors	• Likely to experience impacts related to labour and working conditions and health and safety during all stages of the Project.
National, regional and local level labour unions	• Represent employees to be engaged on the Project.
National, district and local NGOs – social and environment	• Potential partner on community investment project as well as potential opposition to /support for the Project.
Public Services including community and government health centres and schools, police and military and users of the existing Bumbuna transmission supply:	• Some services may experience direct and indirect project induced impacts. • Management of project opposition or legal activities triggered by the Project. • May be affected by costs associated with the Project.
Media	• Have the power to disseminate information regarding the Project positively or negatively.
Businesses eg mining companies in the Project area, and artisanal miners:	• Potential partner in managing potential cumulative impacts during the construction phase of the Project. The project may also impact on the activities of these groups.
Academics and research institutes at the national, regional and local level:	• Potential partner to the Project in terms of environmental studies. Also likely to be linked to NGO organisations.
Communities affected by Bumbuna I:	• Ongoing grievances regarding Phase I.

Figure 5.2 below provides some pictures of male and female stakeholders.

Figure 5.2 Pictures of Stakeholders

Pictures: Left FGD women Badala; Right FGD Men Dian Sokurela I

5.4 STAKEHOLDER ENGAGEMENT PROCESS: SCOPING ENGAGEMENT

As described in the SEP and presented in *Table 5.4* below, stakeholder engagement during the ESHIA comprised a series of four main stages throughout the life of the Project; from scoping to decommissioning.

Table 5.4 Stages of Engagement

Stage	Purpose	Status
Stage 1: Scoping Engagement/draft ESHIA engagement	National, district and local level engagement to provide the following information. • Project updates regarding the nature, scale and purpose of the Project; • ESHIA & stakeholder engagement process; • Disclosure of scoping and preliminary ESHIA findings, including identification of impacts; • Grievance mechanism. A key purpose of the meetings is also to collect information on stakeholder opinions and concerns relating to the Project and potential impacts.	Completed - Undertaken between March and July 2016 covering dry and wet season respectively. Was undertaken in parallel with social baseline data gathering
Stage 2: ESHIA Disclosure (Note: ESHIA disclosure would normally be separate to consultation on the draft ESHIA. However, due to the remote nature of the settlements, timeframe for delivery of the ESHIA and pending requirement for a RAP	National, district and local level engagement to provide the following information. • Updates regarding the nature, scale and purpose of the Project; • ESHIA & stakeholder engagement process; • Disclosure of ESHIA findings and mitigation measures; • Grievance mechanism Meetings shall be led by the EPA-SL and JA, with support from a third party consultant to engage on the contents and findings of the ESHIA, including the impacts and mitigation measures.	ESHIA Disclosure planned for Q1 2017

Stage	Purpose	Status
these shall be carried out in parallel to ensure that communities have the opportunity to provide detailed feedback to be incorporated into the final document.)	Opportunities for comment will be advertised in the Gazette as stipulated by the EPA Act. The ESHIA should be widely available to communities and available on the company website.	
Stage 3: Construction	The project will continue to engage with stakeholders during construction to continually update them of disturbances that they may experience and associated timeframes. This will include ongoing relationship building and participation of affected communities regarding management of construction impacts and effectiveness of monitoring. This will be through meetings and other forms of information dissemination (eg background information documents) as well as through the grievance mechanism.	Consultation to be carried out during construction by Project Community Liaison Officers.
Stage 4: Operation	As with construction, the Project will continue to engage with stakeholders and a grievance mechanism will remain in place. However with time the frequency of engagement will reduce and become more routine.	Consultation to be carried out during operation by Project Community Liaison Officers.
Stage 4: Decommissioning	Prior to decommissioning, JA will prepare a Site Closure Plan for the Project. The project will consult with stakeholder groups to ensure that feedback regarding the impacts of decommissioning is considered in the Plan.	Consultation to be carried out during prior to decommissioning by Project Community Liaison Officers.

Although there was previously engagement undertaken between 2011 and 2014 as detailed in *Section 5.2* above, engagement undertaken in support of this ESHIA to date relates to scoping/draft ESHIA engagement. The main purpose of the process was to provide stakeholders with an update of project, following on from engagements undertaken for previous ESHIAs and meetings held by JA as detailed in *Section 5.2* above, as well as to capture issues and concerns for consideration in the report. A more detailed process of engagement with communities will be held once the ESHIA is complete, to consult on the findings and mitigation measures identified. This will be carried out in conjunction with the development of the Resettlement Action Plan.

5.4.1 *Meetings Held During the Scoping/Baseline Data Collection Process*

A combination of detailed technical meetings and topic based engagement was carried out at the national, regional and local level. During the meetings, participants were provided with an overview of the Project and asked about their experiences to date. All meeting participants were provided with an opportunity to ask questions and express their opinions and concerns regarding the Project.

Technical meetings were held with the government and NGOs which primarily included a presentation of the Project, potential project impacts and an overview of the ESHIA process. Stakeholder Engagement carried out in affected communities primarily involved a series of village meetings, focus group discussions, key informant interviews and village profiling during the social baseline data collection.

A summary of meetings and the approximate number of participants is provided *Table 5.5* below. A full list of meetings is provided in *Volume II, Annex J; SEP.*

Table 5.5 Summary of Meetings Held

Meeting Type	Purpose	Approximate Number of Participants		
		Male	Female	Total
Meetings				
National Level Meetings				
• Chief of Staff & Senior Ministerial Delegates • Ministry of Lands • Environmental Protection Agency • Conservation Society of Sierra Leone • UNICEF	Meetings with regulatory bodies and key stakeholders, to provide a detailed technical description of the Project and discuss the regulatory requirements and key sensitivities/project concerns.	27	6	33
Total number of meeting participants		**27**	**6**	**33**
Topic Based Consultation				
Village Profile:	Village profile questionnaire, including a basic list of key socio-economic information on demographics, livelihoods and social amenities such as, sources of water, electricity, access to health centres and schools, etc, and on project perceptions.	39	24	62
Focus Group Discussions (FGDs): • Men • Women • Hunters • Cultural Heritage • Farmers	Consultation with a representative sample of the affected population to gather gender differentiated and topic specific data, provide an overview of the Project and the ESHIA process, and understand perceptions/concerns specific to the topic area.	235	194	429
Key Informant Interviews (KII): • Paramount Chief • Health • Education • Landowner • Sustainable Nutrition and Agriculture Promotion (SNAP) • IBIS Education for Development	Consultation with specific stakeholders to gather relevant baseline data, provide an overview of the Project and the ESHIA process and understand perceptions/concerns specific to the topic area.	70	7	77

Meeting Type	Purpose	Approximate Number of Participants		
Total number of topic based consultation participants		**310**	**223**	**533**
Total number of people met and consulted		**337**	**229**	**566**

A total of 139 meetings were undertaken attended by approximately 566 participants, of which 134 were held in a sample of communities. These included all of the settlements within the Yiben reservoir area. These meetings included:

- 5 National level meetings;
- 46 Village profile meetings;
- 52 Focus group discussion meetings; and
- 36 Key informant interviews.

A full list of meetings is provided in *Volume II, Annex J; SEP.*

As shown in the table, participation of women in discussions was primarily limited to the women's FGDs. Consultation on the ESHIA will require full participation of women to ensure that their voices are represented in the decision making process regarding impacts and mitigation measures. Pictures of meetings are provided in *Figure 5.3* below.

Figure 5.3 Pictures of Meetings

Pictures: Left - Kapampahe Consultation; Right - Amadu Malonde Consultation

5.4.2 Approach to Engagement

A summary of the engagement process for national and settlement level engagement is detailed below.

Approach to National Level Engagement

Email meeting invitations were sent to government and NGO stakeholders. Meetings involved a detailed presentation of the Project and key potential impacts. Meeting minutes were captured in a template and in a stakeholder engagement log, in order to record the main issues raised.

The following national level meetings were held:

11th July 2016	• Environmental Protection Agency • Conservation Society of Sierra Leone
12th July 2016	• Chief of Staff & Senior Ministerial Delegates from a range of ministries • UNICEF • Ministry of Lands
9th December 2016 and 17th January 2017	• Environmental Protection Agency

Approach to Settlement Level/Topic Based Engagement

Due to the remote nature of the Project area, the settlements in the area had to be identified and verified through satellite imagery and ground truthing. During the visits to each settlement, to ensure all topics were covered consistently, survey teams used a series of protocols, which included a series of specific questions and other questions related to project perceptions and impacts.

Meetings were held in the local languages, which mainly includes Kuranko and Limba. Other languages comprise Fullah, Temne and Krio. In the case that language was problematic, a local community representative translated. These languages have no written form.

Given the number of settlements and distances to be covered, meetings could not be organized in all settlements. Therefore a sample number of villages were selected based on the following criteria:

- accessibility and time constraints;
- settlement size and nature (eg mining *vs.* farming);
- likelihood to be affected (eg in or out of reservoir area);
- importance of impacts (eg in reservoir *vs.* along the access road); and
- Geographical considerations (eg are nearby villages covered or not).

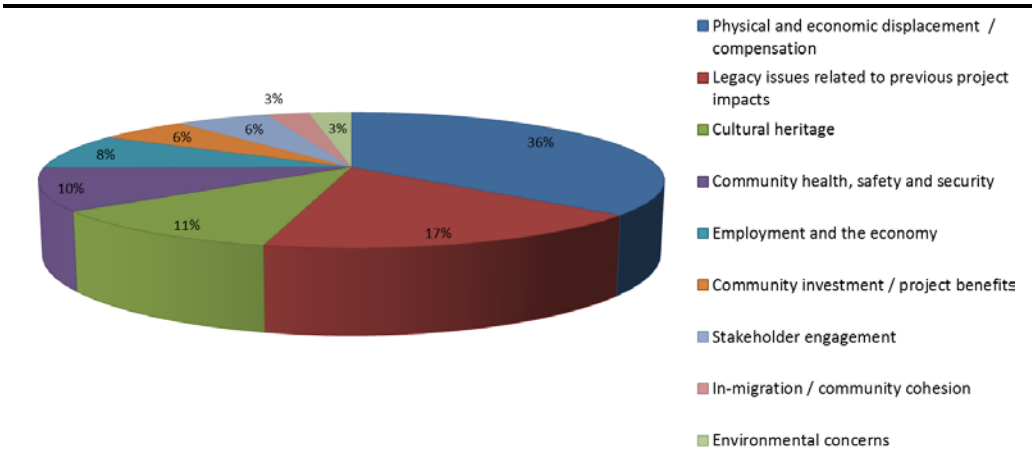
However, over the course of the dry and wet seasons, over 90% of all the affected settlements were visited. It will nevertheless be important to ensure that a further engagement process is undertaken with all affected communities to ensure that their views are considered in the final Resettlement Action Plan.

5.4.3 *Engagement Outcomes and Issues Raised During Household Surveys Stakeholder Engagement Meetings*

This section provides an overview of the key issues raised by national and village and household level stakeholders and where these issues have been addressed in the ESHIA.

As shown in *Figure 5.4*, impacts related to physical and economic displacement were of most concern (36% of all comments raised during household surveys and engagement meetings) while legacy issues in relation to previous resettlement, in particular quality of housing and compensation was also a key issue (17% of all comments raised during household surveys and engagement meetings). Due to the traditional context and religious beliefs, communities raised concern about cultural heritage, such as movement of sacred sites such as trees and bushes (11% of all comments raised during household surveys and engagement meetings). Issues raised in relation to health were in relation to increased water borne illness and disease such as malaria (10% of all comments raised during household surveys and engagement meetings). Expectations regarding employment and community investment are also high (8% and 6% respectively). Additionally, stakeholders are keen for continued engagement and participation regarding the Project (6% of all comments raised during household surveys and engagement meetings). Other issues raised were mainly in relation to changes to the institutional structure resulting from resettlement (3% of all comments raised during household surveys and engagement meetings) and environmental issues such as deforestation and impacts to endangered species (3% of all comments raised during household surveys and engagement meetings).

Figure 5.4 Percentage of Issues Raised during Household surveys and Engagement meetings



Further detail regarding these issues is provided below.

National Level Engagement Outcomes

National level issues raised were mainly related to specific regulatory and international requirements, and to biodiversity, resettlement and stakeholder engagement.

Biodiversity and resettlement are the main concerns among national level stakeholders, particularly in relation to the resettlement process and impacts to endangered species and offsetting.

Table 5.6 below provides a summary of issues raised and how they have been addressed in the ESHIA.

Table 5.6 National Level Meeting Outcomes

Topic	Issues Raised	Project Response/ESHIA Reference.
Compliance with national legislation	• Demonstrate that the legislative framework has been considered in the scoping report.	*Volume I - Chapter 4; Legal and Administrative Framework* of the ESHIA outlines the relevant legislation considered in the ESHIA.
Biodiversity	• New regulations for offsets that meet international standards regarding wildlife, including the EPA-SL act, the NPA act of 2012 and the Wildlife Conservation Act of 1972, should be considered in the ESHIA.	The ESHIA considers the need for offsets to deliver net biodiversity gain in line with international lenders' standards. This will be delivered as part of a Biodiversity Action Plan. Refer to *Volume II, Annex F; Biodiversity.*
	• Concern on how much (if any) of the Loma Mountains will be flooded.	The Loma Mountains area lies approximately 30 km west of the inundation zone, outside the AoI.
	• A thorough identification of all species in the proposed project area needs to be developed and a means of negating the impacts caused by the Project on the environment and wildlife other than off-setting, which is seen as a last option, should be considered. This includes ensuring that mitigation is in place for any IUCN Red List species identified.	Detailed surveys were undertaken in 2014 and 2016. Refer to *Volume II, Annex F; Biodiversity*. Mitigation measures have been developed in line with the mitigation hierarchy, with offsetting proposed as a last resort.
	• Ensure that ERM are working alongside the EPA-SL to develop effective mitigation against any impacts.	Engagement with the EPA-SL is ongoing and EPA-SL will review the draft ESHIA.
	• Ensure that the Conservation Society of Sierra Leone (CSSL) is consulted regarding the identification of impacts and monitoring of wildlife and the environmental impacts.	The CSSL are included in the list of stakeholders to be engaged on the draft ESHIA. Refer to *Table J3.1* in *Volume II, Annex J; SEP*
Downstream impacts	• Ensure that downstream impacts are addressed in the ESHIA.	Impacts on the watercourses downstream re included in *Volume II, Annex E; Water Resources, Annex F; Biodiversity and Annex H; Social.*
Physical and economic displacement	• Ensure all social impacts, including resettlement, are well understood and that lessons are learnt from Bumbuna I.	Refer to *Volume II, Annex H; Social* and *I; Resettlement Framework*
	• Ensure the Ministry of Lands (MOL) are informed of any potential issues regarding resettlement. The Ministry needs to have a Memorandum of Understanding (MOU) with all the relevant stakeholders of the Project.	The MOL is a key stakeholder in the resettlement project. Refer to *Volume II, Annex J; SEP* and *I: Resettlement Framework*

Topic	Issues Raised	Project Response/ESHIA Reference.
	• Ensure that impacted communities are engaged and that alternative livelihoods are in place wherever they are relocated too.	All stakeholders will be fully engaged during the resettlement process. Refer to *Volume II, Annex J; SEP* and *I Resettlement Framework.*
	• Community infrastructure such as schools and hospitals should be present at any relocation site.	This will be considered in the RAP prepared at a later stage. Refer to *Volume II , Annex I; Resettlement Framework.*
	• A resettlement engagement plan is required for this component.	A RAP is required for resettlement. Refer to *Volume II, Annex I; Resettlement Framework. This includes provisions about engagement.*
Impacts relating to vulnerable groups	• What will be the impact on children? Is there any specific mitigation in place for these impacts?	Children have been identified as a vulnerable group and are considered in the impact assessment. Refer to *Volume II, Annex H; Social*
Stakeholder engagement	• Stakeholder engagement should be ongoing throughout the ESHIA process and should not be limited to the MDAs (Ministries, Departments and Agencies). All stakeholders should be engaged to create appropriate mitigation for the environment, wildlife and the communities impacted.	All stakeholders will be fully engaged during the Project. Refer to *Volume II, Annex J; SEP*
	• Ensure that all the relevant stakeholders are listed for reference in the Scoping Report.	All stakeholders are listed in *Section 1.2* and in *Volume II, Annex J; SEP.*
Legacy issues	• Ensure that environmental issues emerging from Bumbuna I are addressed. • Ensure that we learn lessons from Bumbuna I.	GoSL will be responsible for addressing legacy issues from Bumbuna I.
Project description	• Will the dam generate 190MW of power continually?	The Bumbuna II Project involves two stages, namely the extension of Bumbuna I through the addition of 86MW (to the existing 50MW of installed capacity), and the construction of a new dam and generating facilities at Yiben to produce 54 MW. The continual ("firm") power is expected to be 80.9MW. Refer to *Volume I, Chapter 2; Project Description*
Project funding	• How will the Project be funded and what are the cost recovery measures in place?	The Project will be funded by a consortium of international lenders. Cost recovery will take place through customers paying for the electricity they are supplied under an agreement reached with the GoSL and the Electricity Distribution and Supply Authority.

Topic	Issues Raised	Project Response/ESHIA Reference.
ESHIA process	• Why are you combining the Yiben Dam project and the Bumbuna Dam extension as one ESHIA?	This Bumbuna II Scheme involves the development of both the Bumbuna Extension and Yiben components. Both will have impacts on the Seli River. Technically it is more appropriate to assess the impacts of both project components within the one ESHIA to assess impacts in combination.
	• The management plan of the Project should be implemented and updated after 5 or 10 years to see the changes that have occurred.	The management plans developed for the Project will be practical and fully integrated into Joule Africa's Environmental and Social Management System (ESMS) once developed. The management plans will be live, working documents and as such will require periodic review and updates
	• EPA-SL would like to see ecosystem services addressed in the ESHIA.	Ecosystems Services have been assessed and included as *Annex G; Ecosystem Services in Volume II* and in *Volume I*.

5.4.4 *Settlement Level/Topic Based Engagement Outcomes*

During topic based consultation, as with national level engagement, main concerns related to the resettlement process, in particular economic displacement affecting land based livelihoods. Legacy issues were also a key concern as participants suggested that housing provided during Phase I resettlement was not sufficient and is unsafe. Some participants highlighted that their houses had cracks in the walls or had partially collapsed.

Community health and safety issues raised were primarily related to flooding, including impacts to land and access roads. Water borne illness and disease resulting from inundation was also a concern.

Additionally the communities have high expectations regarding employment benefits resulting from the development and community investment including improvements to health, education and community infrastructure such as access to electricity and clean water.

Figure 5.5 shows examples of focus group discussions. *Table 5.7* provides further detail of the issues and stakeholder perceptions

Figure 5.5 Pictures of Focus Group Discussions

Pictures: Left – FGD Men Kagbema, FGD Women Yiben

Table 5.7 Outcomes and ESHIA Considerations

Number	Topic/Description of Issues Raised	Stakeholder Perceptions/Feedback	Project Response/ESHIA Reference
1	**Physical and Economic Displacement / Compensation**		
1.1	Impacts to livelihood activities, primarily farming, fishing and mining, affecting income generation.	The Seli River is a major source of livelihood due to fishing, mining and vegetable production. The community are concerned about how inundation will affect their livelihoods (FGD hunting, Kondembaia). Fear regarding the capability to engage in alternative livelihoods due to the reliance of mining activities along the Seli River (FGD women, Dian Sokurela-2).	These issues will be considered in the RAP that will be developed for the Project at a later stage. The RAP will be based on the following principles, in line with national and international requirements, in particular the IFC and AfDB standards. • The Project will avoid, and when avoidance is not possible, minimise resettlement. This principle applies to all resettlement activities including the selection and acquisition of host sites. • All assets will be compensated at full replacement value, defined as the market value of the assets plus transaction costs. • Physical relocation of households will be supported through an assistance package tailored to the existing socio-economic conditions and which is culturally appropriate. • The Project will encourage households to opt for in kind compensation for key assets such as housing. • Livelihood restoration measures will be developed taking into consideration of current livelihood activities, development benefits associated with the railway development and availability of replacement lands / resources. • The Project will establish a programme of
1.2	Types and method of compensation	Compensation should be provided in kind rather than in cash so that affected households have direct access to new houses and agricultural land to maintain their livelihoods (KII Paramount Chief, Kondembaia Chiefdom). Compensation should be provided in the form of house for house, land for land, garden for garden (FGD cultural heritage, Sandia).	
1.3	Construction and quality of new houses in settlements	For those to be relocated new houses should be constructed enabling a higher living standard (eg constructed of good quality durable materials and with access to electricity, potable water and sufficient agricultural land) and structures should have an adequate number of rooms (FGD women Badala).	
1.4	Engagement process and leadership of resettlement	Active participation and continual monitoring by the government throughout the Project construction and operational phase to ensure that adequate compensation is received by the communities impacted. Local people must own the relocation and compensation process so that they play a role in decision making. (KII SNAP, Kabala). Trust in JA to lead the resettlement process and utilise local resources (FGD farmers, Kondembaia). Resettlement sites should be selected by the community (FGD cultural heritage, Sandia). Lack of trust and concerns regarding corruption and governance issues among law enforcement in relation to the resettlement and	

Number	Topic/Description of Issues Raised	Stakeholder Perceptions/Feedback	Project Response/ESHIA Reference
		compensation process. This is due to legacy issues regarding abuse of power among the police force. JA are trusted to lead the process (FGD men, Badala).	monitoring and evaluation to provide timely information regarding the success of the resettlement activities. Refer to *Volume II, Annex I; Resettlement Framework* for more detail regarding the approach to the RAP.
1.5	Communities to be relocated within the same areas of the chiefdom that they currently reside to avoid conflict and disturbances.	Resettlement should be done within the same sections of the communities and not outside the sections. This should be done to ensure peace and stability in the chiefdom (KII Paramount Chief, Kondembaia Chiefdom). Communities have a connection to the land as it is where they were born and grew up. They do not feel that they can settle elsewhere (FGD men, Kapampahe).	In terms of broad area where host sites might be located, the Paramount Chief and Ministry of Land advised that displaced households should be relocated to a host site within their current section or district respectively (and within their Chiefdom) as this would minimise the potential for conflict. The Project will work with the Paramount and Section Chiefs to identify appropriate host sites, with involvement from the affected communities. Displaced and host communities will participate in the decision making process regarding the resettlement process to ensure that it is managed sensitively, meeting their needs as much as possible. Refer to *Volume II, Annex I; Resettlement Framework* for more detail regarding the approach to the RAP.
2	**Legacy Issues Related to Previous Project Impacts**		
2.1	Complaints regarding the resettlement process, specifically insufficient compensation, housing, and land, including poor soil quality for agriculture and reports of temporary homelessness.	Insufficient agricultural land was provided for farming; replacement land has not been allocated for plantations. Living conditions have also deteriorated and housing is poor (FGD farmers, Badala). Structures constructed for the people are in poor quality; some of them have started collapsing (FGD farmers, Kondembaia). People have been provided with sub-standards houses with little or no land to farm. This has resulted in people going back to their original communities in Bumbuna in search of enough lands to do their farming (KII SNAP, Kabala). Flooding destroyed plantations and houses and the people became homeless for a period of time (KII landowner, Sandia).	GOSL will be responsible for addressing legacy issues from Bumbuna I.

Number	Topic/Description of Issues Raised	Stakeholder Perceptions/Feedback	Project Response/ESHIA Reference
2.2	Issues relating to health, safety and security, such as increased prevalence of harmful animals, water borne disease and illness, and conflict.	Due to the increase of water levels in Bumbuna, prevalence of mosquitos and snakes has increased (KII landowner, Yiben). During Phase 1, violence was reported due to resettlement related issues (FGD men, Amadu Malonde). Sicknesses like malaria and yellow fever became rampant immediately after the dam flooded (KII landowner, Kapampahe).	Mitigation measures include: • Development and implementation of an Integrated Vector Control, Prevention and Treatment Programme. • The establishment of an effective and transparent grievance mechanism and to report on this mechanism to the authorities in the communities impacted by the Project. • Favour methods of communication that can reach the majority of the stakeholders/communities (radio broadcasting for example). • Implement measures seeking to mitigate increased pressure on land and social tension. Refer to *Annex H; Social; Chapter 8 ESHMP*.
2.3	Loss of teachers in schools who have hired by the Project.	Teachers have left schools for better salaries with the (mining) company, creating a lack of teachers (KII education, Badala).	The Project will invest in education infrastructures and services related to the implementation of the RAP eg through support to education through training of teachers and via the Community Investment Plan which will include provisions to public schools and bursaries and literacy programs for schools. Refer to *Annex H; Social; Chapter 8 ESHMP*.
2.4	Negative perceptions regarding the Project overall in relation to community investment and benefits.	In Yisasa it was suggested that the community has not experienced any positive benefits (from Bumbuna I) for the last six years. There has been no provision of electricity (KII IBIS, Kabala). People have not benefited from the electricity supply after they have lost all their farm lands (FGD men, Gbenikoro).	The Project will develop a Community Investment Plan and access to energy strategy. Refer to *Annex H; Social and Chapter 8 ESHMP*.

Number	Topic/Description of Issues Raised	Stakeholder Perceptions/Feedback	Project Response/ESHIA Reference
2.5	Positive impacts related to community investment and compensation from the resettlement process.	Positive impacts to education in Yiben due to the provision of books provided by the Project. Employment of parents at the school has also created benefits for affected communities (KII education, Yiben). The settlement of Kasoloba is a 'success story' as they have experienced positive impacts (KII IBIS, Kabala). People have benefited from improved housing and sufficient cash compensation (KII landowner, Kumgbania).	None required.
3	**Cultural Heritage**		
3.1	Conversations with Paramount Chiefs, Village Chiefs, Mammy Queens, Village Elders and Youth Leaders is essential to determine what ceremonies, sacrifices and procedures will be required prior to the area being inundated. Relocation of scared sites, shrines, idols and bushes.	Inundating communities has serious impacts as these communities would lose some of their sacred sites. Cultural preservation is held in high esteem by the people (KII IBIS, Kabala). Sacrifices to ancestors and gods must be undertaken prior to resettlement. The community will require compensation to purchase goats, palm oil, chickens, sheep, flour, rice etc for ceremonies. Elders, town chief, youths and the mammy queen should be involved in the organisation (FGD cultural heritage, Kamagbama). The community has great respect for our customs and traditions so resettlement would mean losing our cultural values. The only way to pacify the gods is to respect these customs by organizing ceremonies and rituals to appease our gods and ancestors (FGD cultural heritage, Koikoitown). Relocating with the materials used for their ritual/sacrifices and secret society are major concerns (FGD women, Koi Koi & Balop Kuma).	Currently, the sensitivity of most recorded sacred sites is unknown. In addition, stakeholder engagement should be undertaken to identify appropriate mitigation measures. Should high sensitivity sacred sites exist, each site may require a unique mitigation and so it is not possible to suggest mitigation measures at this point. Typically, mitigation measures for high sensitivity sites would involve multiple sacrifices and rituals to remove and reinstall spirits in new locations, but the exact manner of re-instalment may vary widely between different sites and communities. Refer to *Annex H; Social and Chapter 8 ESHMP.*
4	**Community Health, Safety and Security**		
4.1	Expectations that access to healthcare will be improved or maintained resulting from displacement.	It is envisaged that the project will built well equipped health centre for the people in the community (KII health, Badala). The project will be required to work with the government and NGOs support the health sector in affected communities to help manage health risks resulting from the Project (KII health, Yarah).	The Project will develop a Community Investment Plan. Additionally, following further consultation and agreement, it is likely support will be provided to improve some existing services Refer to *Annex H; Social and Chapter 8 ESHMP*

Number	Topic/Description of Issues Raised	Stakeholder Perceptions/Feedback	Project Response/ESHIA Reference
4.2	Fear regarding flooding of land and houses in relation to inundation from the dam.	There will be shortage of food and good drinking water (KII health, Yarah). The community is situated between two rivers, so the possibility for flooding to happen in their village high (KII education, Dian Sokurela-1). Flooding may move dangerous animals to locations close to settlements (KII landowner, Makoniyifeh). We are afraid of dangerous animals entering the village when the water level increases (FGD hunters, Badala).	Resettlement will be required for communities displaced as a result of inundation, including livelihood restoration to mitigate impacts to food security. The Project will also implement a Water, Sanitation and Hygiene (WASH) programme to offset impacts to associated facilities. Human-wildlife conflict will be considered and mitigated during construction. For example the Project Vegetation Clearance Plan will be designed in such a way that it directs animals away from communities and populations centres. Refer to *Volume II, Annex F; Biodiversity* and *Chapter 8 ESHMP*. Settlements located in the inundation area will be resettled in line with *Volume II, Annex I; Resettlement Framework* and the full RAP.
4.3	Concerns regarding impacts to roads and access constraints due to flooding resulting from inundation.	Flooding will prevent the community from using the road especially in the raining season (FGD men, Dain Sokurela-1). Feeder roads should also be constructed to allow access to markets by the remotest village (KII Paramount Chief, Kondembaia). One of them raise a concern that if the dam is raised, there is going to be a major cut off for them and how would they get access to go to other places (FGD men, Gbenikoro).	Increased isolation and some decreased mobility will occur in some areas resulting from inundation creating a natural barrier and resulting in the flooding of the main north-south road and bridge over Seli River. A bypass road and bridge (upstream of Badala) will be constructed to mitigate impacts. Refer to *Volume II, Annex H; Social*

Number	Topic/Description of Issues Raised	Stakeholder Perceptions/Feedback	Project Response/ESHIA Reference
4.4	Consideration for vulnerable groups in relation to adverse project impacts, including displacement and disruption to access routes resulting from inundation	The project needs to consider the elderly, disabled and blind, who are unable to earn a living to ensure that they are not worse off (KII health, Badala). Consideration for pregnant women who already have to walk 4 to 8 miles, depending on their location, to access ante natal facilities (KII health, Kondembaia).	Communities that may be affected by severe flooding resulting from inundation, including vulnerable groups, will be resettled in line with *Volume II, Annex I; Resettlement Framework* and the full RAP. Vulnerable groups have been identified in *Section 5.3*, in *Volume II, Annex J; SEP* and *Annex H; Social.* However, the RAP census will identify vulnerable groups and individuals requiring assistance.
4.5	Increased traffic flow during the construction period causing health and safety risks.	Roads leading to the community will be constructed hence the flow of vehicles in the community will increase (FGD women, Kondembaia).	During construction, there will be vehicle movements from the transport of construction materials and to a lesser extent, from local traffic movements associated with workers. This will reduce during the operational phase. Traffic related impacts and mitigation measures are described in *Volume , Annex H; Social.*
4.6	Increased prevalence of water related illness and disease due to inundation.	Flooding and high water levels may increase the prevalence of colds, pneumonia, malaria, diarrhoea and vomiting (KII health, Kondembaia). People may be affected by diseases related to high water levels along the river (KII health, Yarah).	The project will develop and implement an Integrated Vector Control, Prevention and Treatment Programme. Refer to *Volume II, Annex H; Social* for detailed mitigation regarding water borne illness.
4.7	Impacts to wellbeing and mental health resulting from adverse impacts, in particular loss of livelihoods.	The project will affect people emotionally because most will their livelihood in the river through their mining activities (KII health, Yarah).	Resettlement Assistance will be provided, in particular to vulnerable groups that will be identified through the RAP census. The Project will also develop a Livelihood Restoration Plan to support economically displaced persons. Refer to *Volume II, Annex I; Resettlement Framework.*
5	**Employment and the Economy**		

Number	Topic/Description of Issues Raised	Stakeholder Perceptions/Feedback	Project Response/ESHIA Reference
5.1	Expectations regarding employment opportunities, particularly for the youth	Provide employment for their children who have basic education, technical skills and higher education (KII landowner, Kabrutown). Benefits should be felt by the local community through employment as well as support loss of livelihoods resulting from economic displacement (KII landowner, Koi Koi & Balop Kuma). Women fear that when the dam starts their children will not be employed (FGD women, Kondembaia).	Employment opportunities will mostly be available during the construction period with a smaller number available during operations. The project will develop a develop and implement a Local Preferential Hiring procedure prioritizing employment by JA and the contractors to Project Affected People and host communities members. Refer to *Volume II, Annex H; Social.*
5.2	Increase in living standards arising from potential employment and indirect economic benefits through increased trading.	Trading will increase; there will be flow of money due to workers associated with the dam project in the community (FGD men, Malonde – Fulani community). The project may employ the youth and raise the standard of living in the town (FGD men, Yisaia).	Community development initiatives and some influx from jobseekers may increase trading. Employment during construction may also facilitate a rise in economic development and standards of living. Refer to *Volume II, Annex H; Social.*
6	**Expectations and Suggestions regarding Community Investment/Project Benefits**		
6.1	Support local communities with agricultural development	We would also like Joule Africa to provide money for us to buy livestock to rear in the village (FGD hunters, Badala). Assist the women with micro- finance, support them with seedlings and farming tools (FGD women, Kasokira). I think micro-finance should be the most important thing for the people in their new settlements. Providing loans for agricultural purposes will enable the farmers have income and improved productivity (KII Paramount Chief, Kondembaia).	The Project will develop a Community Investment Plan. Refer to *Chapter 7; Analysis of Impacts* and *Section 8.4, Chapter 8; ESHMP.*
6.2	Electrification in the new communities.	If the village has to move will the new settlement benefiting from the light? (FGD hunters, Badala). Provide light at the health centre to enable a doctor to manage emergency cases / operations (KII health, Yarah). Provision of electricity (FGD men, Yarah). Electricity in the community (FGD men, Dain Sokurela-1).	The project is planning to develop a programme to improve local access to energy However settlements that will benefit from the programme have not yet been identified. Refer to *Volume II, Annex H; Social.*

Number	Topic/Description of Issues Raised	Stakeholder Perceptions/Feedback	Project Response/ESHIA Reference
6.3	Support to increasing access to public infrastructure eg schools and healthcare facilities.	The community require a good school, hospital and good drinking water (FGD hunters, Kondembaia). Support to the health sector in terms of provision of drugs supply and improved the water facility in health centre (KII health, Kondembaia). Vocational centres for skills development and educational facilities/good schools (FGD men, Sawule 1&2)	The Project will develop a Community Investment Plan. Refer to *Volume II, Annex H; Social.*
6.4	Entrepreneur/business/vocational training and provision of scholarships for children.	Entrepreneurial training would also be a great benefit for the community since most are engage in petty trading and they require improved business and financial skills (KII Paramount Chief, Kondembaia). Provide scholarships for their children (FGD men, Yarah). Most of the youth should be employed as apprentices in order for them to have the opportunity to learn skills which will help them in the future (FGD men, Gbenikoro).	As above.
6.5	Sanitary drinking water for the new communities.	Provision of a protected well and good drinking water for the community (KII health, Yarah).	
6.6	Improved access to sanitation and waste disposal facilities.	Provision of safe disposal facility for better hygiene (FGD men, Badala).	
6.7	Provision of a road network to communities.	Access to a good road network as a result of the Project (FGD men, Yisaia).	
7	**Stakeholder Engagement**		

Number	Topic/Description of Issues Raised	Stakeholder Perceptions/Feedback	Project Response/ESHIA Reference
7.1	Effective stakeholder engagement is required throughout the duration of the Project to ensure that the affected communities are fully informed, in order to identify impacts and mitigation measures.	Effective stakeholder engagement in the potentially affected communities should be organized to discuss issues of relocation; this would reduce or mitigate the negative impacts of relocation or inundation. The people would decide their fate when it comes to relocating them and for other issues that are associated the Project (KII IBIS, Kabala). The only effective mitigation strategy to avoid these potential negative impacts is to have an effective consultation with the people that would be affected to hear their views regarding the relocation process (KII SNAP, Kabala). Joule Africa and the government of Sierra Leone should have dialogue with all stakeholders in the land to come to an agreement before starting the activities (KII landowner, Yarah). The community did not know about the Project (FGD women, Kasokira).	A Stakeholder Engagement Plan (SEP) has been prepared to manage the engagement process in line with national and international requirements, as detailed in the above sections of this chapter and in *Volume II, Annex J; SEP.*
7.2	Provision of clear information so that the Project can be fully understood by stakeholders.	Information about the reason for the Project is not enough and is not clear (FGD cultural heritage, Koikoitown). Lack of information regarding the Project and potential resettlement (FGD women, Kamagbama).	
7.3	Relationship and trust building is required to manage social risks and to ensure that the community 'buy in' to the Project, avoiding adverse impacts.	The project should always inform the community about any steps they want to take with regards the settlement and the proposed phase two project (KII education, Yisasa). Lack of trust among the community regarding the Project, highlighting that they will be abandoned (FGD men, Yarah).	
8	**In-Migration / Community Cohesion**		
8.1	Disruption to community structures and cohesion creating conflicts among inhabitants regarding land.	If the community are relocated to another land, people fear conflict with neighbouring communities (FGD men, Sandia). Concerns regarding if the communities will live together (in 'unity') as they do now (KII Landowner, Badala).	The RAP development will include involving local authorities in the decision and organization process of the displacements (eg selection of areas, organization of displacements, restoration programs, etc). Additionally, Paramount and Section Chiefs, in
8.2	Separation of school children resulting from resettlement	Concerns that school children will be separated if they relocate (KII education, Badala).	

Number	Topic/Description of Issues Raised	Stakeholder Perceptions/Feedback	Project Response/ESHIA Reference
8.3	Loss of access routes to settlements due to inundation	Due to inundation there are communities that will not be able to maintain access to other communities (FGD men, Musaia).	consultation with affected communities will be involved in site selection. Refer to *Volume II, Annex I; Resettlement Framework.* Related impacts and mitigation are also addressed in *Volume II, Annex H; Social.*
9	**Environmental Concerns**		
9.1	Deforestation resulting from project infrastructure and inundation.	Destruction of the lands and forest in the communities (FGD hunters, Badala).	Parts of the Project AoI will be deforested prior to development and there will be a loss of forest habitat in the inundation area. The Project will demarcate forest areas that should be protected during construction. Refer to *Volume II, Annex F; Biodiversity.*
9.2	The extinction of critically endangered species.	There is the possibility of the extinction of endangered species as a result of the activities of the Project (KII IBIS, Kabala).	Further survey work is required upstream of the inundation area along the Seli River and along the Mawoloko River to search for other locations of IUCN Endangered and Critically Endangered species *Ledermanniella aloides* and *Ledermanniella sp nov*, *Stylochaeaton pilosus* and *Vepris felicis*. 'No-go' sensitive areas will be demarcated. Project impacts on Critically Endangered and Endangered species, as well as all other IUCN Red List Threatened species are assessed in *Volume II, Annex F; Biodiversity,* including offsetting.
9.3	Pollution of the Seli and Rokel River resulting in an impact of marine resources.	The river will be polluted affecting marine resources (KII SNAP, Kabala). The water/river is going to be polluted and exposing communities to danger (KII FGD, Kamagbama).	Water management measures to intercept and treat sediments and potential pollutants, as outlined in *Annex E; Water Resources.*

5.5 GRIEVANCE MECHANISM

The grievance mechanism is a company process that enables any stakeholder to make a complaint or a suggestion about the way a project is being implemented. This may take the form of specific complaints for damages/injury, concerns about routine project activities, or perceived incidents or impacts. Identifying and responding to grievances supports the development of positive relationships between the Project and the communities and other stakeholders they may affect.

Grievances can be an indication of growing stakeholder concerns (real and perceived) and can escalate if not identified and resolved. The management of grievances is therefore a vital element of stakeholder management and an important aspect of risk management for the Project.

A summary of the grievance mechanism is provided below. A detailed description is provided in the *Annex J; SEP.*

The process involves the following steps:

- record the grievance;
- acknowledge the grievance;
- investigate the grievance;
- develop a response;
- communicate the response and establish agreement on next steps; and
- close-out process.

The following feedback channels have been available to stakeholders throughout the ESHIA process:

- public meetings;
- focus group discussions and key informant interviews;
- verbally via Joule Africa's in country team;
- in writing; and
- e-mail.

5.6 NEXT STEPS

A comprehensive engagement process will be undertaken to enable stakeholders to provide feedback on the defined project description and associated impacts and mitigation measures that have been identified. Detail regarding this process will be included in the updated SEP.

6 ENVIRONMENTAL, SOCIAL AND HEALTH IMPACT ASSESSMENT METHODOLOGY

6.1 INTRODUCTION

This Chapter describes the methodology that has been followed throughout this ESHIA. The key objectives of the ESHIA are to assess the potential environmental and social impacts associated with the construction and operation of Bumbuna II, and to identify measures that can be adopted to avoid, minimise or offset adverse impacts and enhance beneficial impacts.

6.2 OVERVIEW OF THE ESHIA PROCESS

6.2.1 *Categorisation*

Under IFC's environmental and social review process (1), projects are categorised in terms of the IFC Sustainability Framework Policy (2012) as either Category A, B, or C according to the following criteria.

- Category A: Projects expected to have significant adverse social and/or environmental impacts that are diverse, irreversible, or unprecedented.
- Category B: Projects expected to have limited adverse social and/or environmental impacts that can be readily addressed through mitigation.
- Category C: Projects expected to have minimal or no adverse impacts, including certain financial intermediary projects.

This categorisation framework was used in the assessment to categorise the Project.

According to these criteria, the Bumbuna II Project would be considered to be Category A ie:

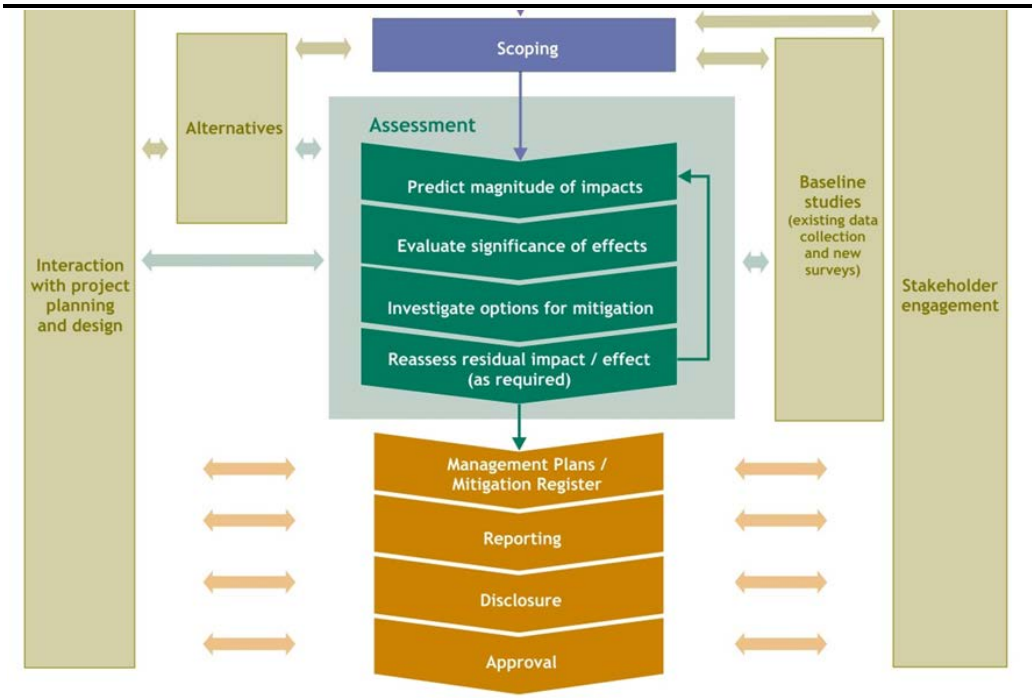
'*Projects with potential significant adverse social or environmental impacts which are diverse, irreversible or unprecedented*' (2).

International lenders require that applications for funding of Category A projects or operations are supported by an environmental analysis. To comply with this requirement, a full Environmental and Social Impact Assessment (ESHIA) has been undertaken to present the risks and impacts associated with Bumbuna II. This approach has been accepted by the principal lenders.

(1) The project has been completed in accordance with the IFC environmental and social Performance Standards since this is the standard referred to by the majority of international lenders (e.g. CDC, AIIM, etc). The AfDB and EIB also have sets of standards that are similar to the IFCs but with some differences in aspects. Where these differences are relevant, this is indicated within the ESHIA.
(2) http://www.equator-principles.com/resources/equator_principles_III.pdf

The key stages for this ESHIA process are highlighted in *Figure 6.1*.

Figure 6.1 Overview of the ESHIA Process



6.2.2 Scoping

Prior to the commencement of the ESHIA ERM completed a review and gap analysis of all environmental and social studies undertaken as part of Bumbuna I and the Draft 2012 ESIA for Bumbuna II prepared by CEMMATS Group Ltd and Lahmeyer International. This work involved a detailed review of all the physical and biological studies undertaken as part of the previous work (*Table 6.1*).

Where relevant these studies have been discussed or referenced within the specific Technical Annexes of *Volume II* of this ESHIA namely; *Annex D; Geology and Soils*, *Annex E; Water Resources and Geological Flows*, *Annex F; Biodiversity*, *Annex H; Social*, *Annex K; Traffic*.

Following the gap analysis ERM carried out limited biodiversity and social field surveys in May/June 2014, which were discontinued due to the outbreak of the Ebola Virus Disease (EVD).

Based on the review of earlier studies and 2014 field work a Scoping Report for Bumbuna II was undertaken in August 2016 with the aim of identifying the effects that have the potential to be significant and to exclude (scope out) from the assessment those effects that are unlikely to be significant.
During the scoping phase, a summary of high level baseline information was provided, key potential environmental, social and health impacts and sensitive receptors and resources were identified, the impact assessment

methodology was defined and the Terms of Reference (ToR) for the ESHIA were developed. Issues that were raised by stakeholders during the scoping phase were taken into account in the ESHIA ToR.

6.2.3 *Terms of Reference*

The ESHIA Terms of Reference (ToR) was developed in February 2016 in support of the ESHIA for the Bumbuna II Project. It also provided an account of the key findings of the social and biodiversity surveys undertaken in May/June 2014. The ToR looks at the analysis of alternatives, the key findings from the surveys and information gaps identified.

The ToR provided an overview of the ESHIA process, it outlined the impact assessment methodology and identified and discussed potential impacts from the Project.

The ToR also presents the proposed ESHIA project team.

6.3 *BASELINE STUDIES*

The baseline describes the existing environmental, social and health conditions of Bumbuna II. It is this baseline against which the effects of Bumbuna II can be assessed. Primary and secondary, social and health data were collected in order to enhance the understanding of the receiving environment. The baseline forms the background against which impacts were identified and evaluated. The baselines for each assessment topic is contained in the specialist Annexes in *Volume II* of this report.

Table 6.1 Topics previously covered in support of Bumbuna II Project

Topic	Details of study	Timing
Scoping report	Conducted by CEMMATS to local requirements	2011/2012
ESIA	Conducted by CEMMATS to local requirements. ESIA was submitted to GoSL but no formal approval was sought	2011/2012
Gap analysis of ESIA	Undertaken by ERM to bring ESIA to up to meet both national and international standards	2013
Bumbuna Extension ESIA update	Originally a separate ESIA was prepared for Bumbuna Extension. ERM were requested to upgrade the original ESIA for the Bumbuna Extension to meet both national and international standards	April 2014
Baseline surveys	Biodiversity and social baseline surveys undertaken to fill the gaps identified during the gap analysis	May/June 2014

Topic	Details of study	Timing
ESHIA Baseline – physical	Includes desk based study on climate and meteorology, air quality, GHG, noise and vibration, topography, terrestrial geology and soils, surface water and hydrogeology	2016 ESHIA scoping report and ESIA
ESHIA Baseline – social and stakeholder engagement	Includes desk based and field studies of communities located within the Project area. This work also included stakeholder engagement with project affected communities.	Field surveys undertaken throughout the Project area between 22nd March and 12th April 2016 and between 26th June and 10th July 2016
ESHIA Biodiversity baseline	Includes desk based and field studies of habitats and flora, primates and large and small mammals, amphibians, reptiles, bats, fish, birds, specific surveys for pygmy hippo, slender-snouted crocodile.	Field surveys undertaken throughout the Project area between 18th May and 20th June 2014, between 22nd March and 12th April 2016 and between 26th June and 10th July 2016
2016 ESHIA	ERM completed and ESIA based on the information compiled from the previous studies outlined above.	ESHIA completed between August 2016 and January 2017.

6.4 SCOPE OF THE ESHIA

6.4.1 General Considerations

During the impact assessment phase, the ways in which Bumbuna II will interact with the environmental and social environment to produce impacts to receptor have been assessed. This has involved a number of stages as set out below.

6.4.2 Technical Scope

This assessment has been developed to identify impacts and effects of Bumbuna II on the biodiversity and social baselines whilst meeting lender requirements and relevant Sierra Leonean and international directives and conventions, as described in *Volume I, Chapter 4; Legal and Administrative Framework*. In the context of Bumbuna II, this has required an assessment of the following:

- Air quality;
- Greenhouse gases and climate change;
- Noise;
- Soils;
- Water Resources and Geological Flows;
- Biodiversity (aquatic and terrestrial);
- Ecosystem Services;

- Social;
- Resettlement (and development of a Resettlement Framework);
- Stakeholder Engagement Plan development; and
- Traffic.

6.4.3 *Spatial Scope/Area of Influence*

The Area of Influence or Study Area takes into account;

- the physical extent of the Bumbuna II Project activities; and

- the nature of the affected resource, the source of impact and the manner in which the resultant impact is likely to be propagated beyond the physical extent of the Bumbuna II Project activities.

6.4.4 *Temporal Scope*

The assessment considers the construction and operation of the Bumbuna II Project including operation by Joule Africa for 25 years before transfer to the Government of Sierra Leone. The construction of the Bumbuna Extension and Yiben are planned to start in the last quarter of 2017 and will last for approximately three and four years respectively.

Due to the length of time of proposed operation of Bumbuna II, decommissioning has not been considered within the scope of this assessment.

6.5 *STAKEHOLDER ENGAGEMENT*

Periodic engagement has been undertaken with stakeholders throughout the ESHIA process and stakeholders' views were incorporated into the assessment process. The engagement process conformed to the IFC's Performance Standards and is described in more detail in *Chapter 4; Legal and Administrative Framework*. The stakeholder engagement plan developed for the Bumbuna II Project provides a list of stakeholders that were consulted throughout the ESHIA process.

6.6 *ASSESSMENT OF IMPACTS*

6.6.1 *Introduction*

The aim of the scoping process is described in *Section 6.2.2*. This process takes into account the mitigation measures that are an integral part of the Bumbuna II Project (eg good construction working practice). Where there is uncertainty or expressed stakeholder concern about the likely significance of effects, these have been carried forward from scoping and included in the ESHIA.
The assessment methodology is set out in *Figure 6.2*.

Further to the methodology presented in *Figure 6.2,* more detailed methodology and significance criteria are set out in the assessment technical Annexes in *Volume II*.

An activity or impact may result in a variety of effects. In identifying these, the ESHIA takes into account their nature, duration and other factors, as defined in *Table 6.2*. These are the definitions used within the assessment of environmental and social and health effects.

Figure 6.2 Impact Significance Matrix

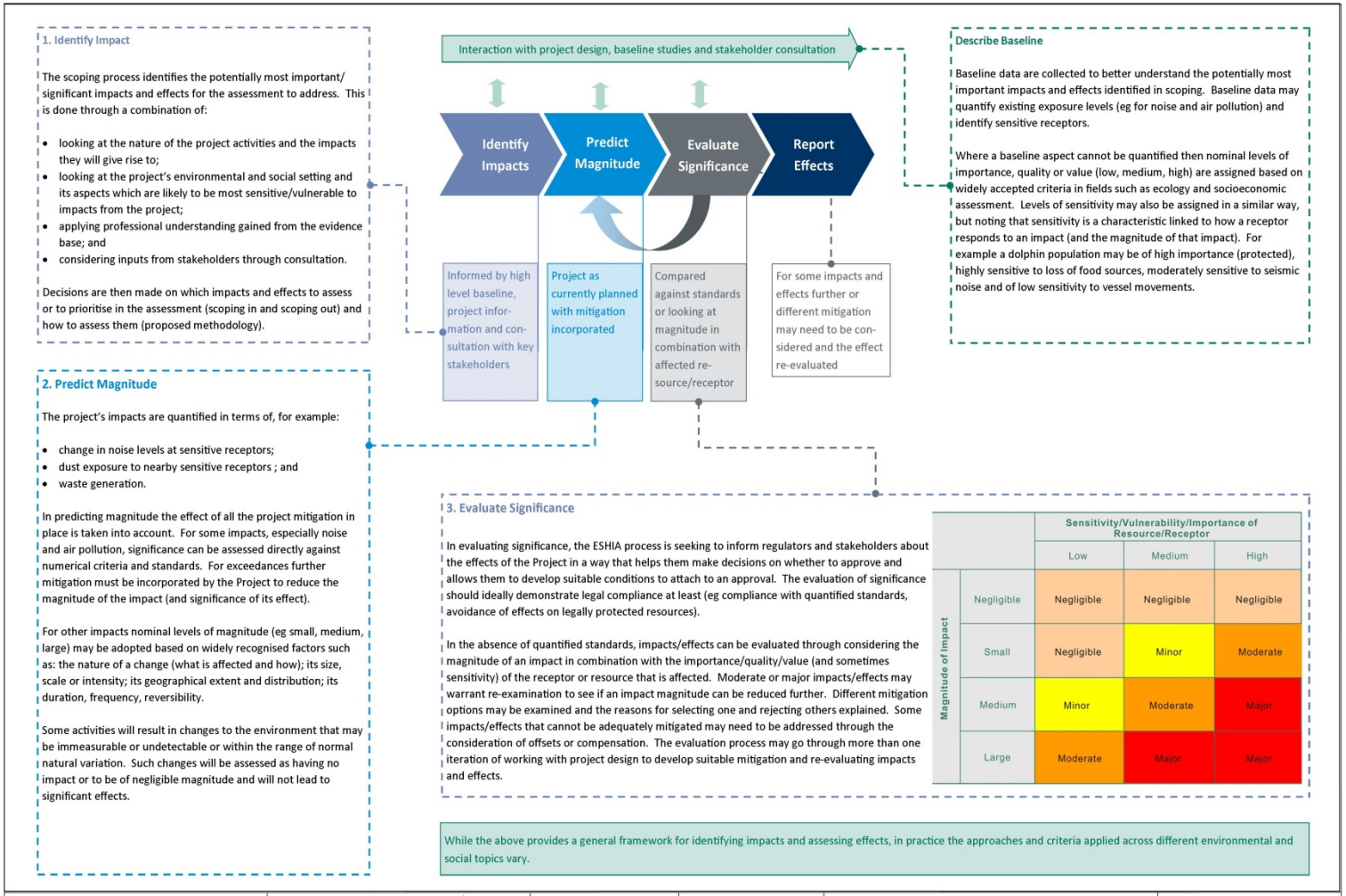


Table 6.2 Nature and Duration of Effects

Positive or beneficial effects: are considered to present an improvement to the existing conditions or to introduce a new desirable factor versus negative or adverse effects.	
Negative or adverse effects: are considered to result in deterioration in existing conditions or to introduce a new undesirable factor.	
Site-specific effects: result from a geographically localised impact and are considered significant primarily at a neighbourhood or local level.	**Wider effects:** are individually significant at a regional level, but may not be significant locally.
Temporary effects: effects which are time limited, eg due to particular construction activities (land use for construction camps) and are reversible (camps cleared post-construction and land returned to natural state).	**Permanent effects**: occur as a result of an irreversible change to the baseline environment (eg loss/gain of habitat).
Shorter-term effects: are predicted to last only for the duration of the activity giving rise to the impact (eg earthworks causing dust to be mobilised, noise and vibration from construction).	**Longer-term effects:** are predicted to continue through operation or beyond the cessation of the activity, giving rise to the impacts concerned but ceasing over time.
Continuous effects: occur continuously or frequently.	**Intermittent effects:** are occasional or occur only under specific planned circumstances (eg during commissioning or annual maintenance).
Direct effects: arise from the impact of activities that form an integral part of the Bumbuna II Project (eg new infrastructure).	**Indirect or induced effects**: arise from the impact of activities not explicitly forming part of the Bumbuna II Project.
Cumulative effects: effects that result from incremental changes caused by other past, present or reasonably foreseeable development together with those from the Bumbuna II Project.	
Routine effects: resulting from planned activities during the construction and operation of the Bumbuna II Project.	**Unplanned effects:** resulting from unplanned activities during the construction and operation of the Bumbuna II Project.

6.6.2 Prediction of Magnitude

The magnitude of each impact falls into one of the following designations: *negligible, small, medium* or *large*. The magnitude encompasses various possible dimensions of the predicted impact, such as:

- extent (ie local, regional or international);
- duration (ie temporary, short-term, long-term or permanent);
- scale or size (no fixed designations);
- frequency (no fixed designations); and
- likelihood, for unplanned events only (ie unlikely, possible, likely).

Each ESHIA topic area (eg noise, air, social, etc) adopts a different methodology for defining the magnitude of the impact however, the designations used are consistent. For example, for readily quantifiable

impacts, such as noise, numerical values are used to define its size, whilst for other topics, eg social impacts, a more qualitative classification is necessary.

In the case of positive impacts, no magnitude is assigned.

6.6.3 *Sensitivity of Resources and Receptors*

The sensitivity (or vulnerability / importance) of the impacted resource or receptor is also defined using one of the followings designations: *low, medium* or *high*. As per the magnitude rating, the definition for each designation varies on a resource/receptor basis. Where the resource is physical (for example, a water body) its quality, sensitivity to change, and importance (on a local, national and international scale) are considered.

Where the resource/receptor is biological or cultural, its importance (local, regional, national or international) and its sensitivity to the specific type of impact are considered. Where the receptor is human, the vulnerability of the individual, community or wider societal group is considered. The sensitivity definition for each resource / receptor is defined in more detail in the individual topic assessment chapters.

6.6.4 *Evaluation of Significance*

Once the magnitude of the impact and sensitivity of the resource/receptor has been characterised, the impact significance is assigned using the significance matrix presented in *Figure 6.2*.

Table 6.3 provides context for what the various impact significance ratings signify.

Table 6.3 Context of Impact Significance

Significance Designation	Significance Context
Negligible	A resource/receptor (including people) will essentially not be affected in any way by a particular activity or the predicted effect is deemed to be 'imperceptible' or is indistinguishable from natural background variations.
Minor	A resource/receptor will experience a noticeable effect, but the impact magnitude is sufficiently small (with or without mitigation) and/or the resource/receptor is of low sensitivity/ vulnerability/ importance. In either case, the magnitude should be well within applicable standards.
Moderate	Has an impact magnitude that is within applicable standards, but falls somewhere in the range from a threshold below which the impact is minor, up to a level that might be just short of breaching a legal limit.
Major	An accepted limit or standard may be exceeded, or large magnitude impacts occur to highly valued/sensitive resource/receptors.
Positive	There will be a beneficial impact to a resource/receptor (note: no magnitude is assigned for positive impacts).

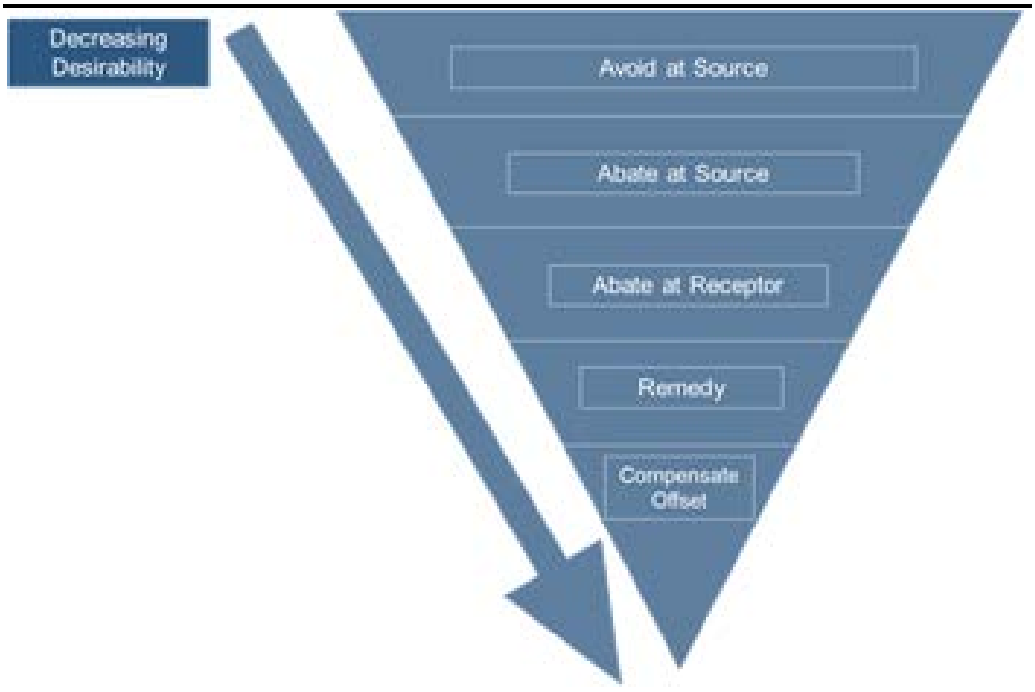
6.6.5 *Identification of Mitigation Measures*

Where significant impacts are identified (ie those with a minor, moderate or major rating), mitigation measures are developed to find practical ways of addressing negative impacts and enhancing positive impacts. The key objective is to mitigate impacts to a level that is "As Low As Reasonably Possible" (ALARP).

A hierarchy of mitigation options is then considered, with avoidance at the source of the impact a priority and compensatory measures or offsets to reduce the impact significance as a last resort. The mitigation hierarchy is presented in *Figure 6.3*.

In keeping with the mitigation hierarchy, the priority for the mitigation prescribed, is to first apply measures to the source of the impact (ie, to avoid or reduce the magnitude of the impacts from the associated Bumbuna II Project activity), and then to address the resultant effect to the resource/receptor via abatement or compensatory measures or offsets (ie to reduce the significance of the effect once all reasonably practicable mitigations have been applied to reduce the impact magnitude).

Figure 6.3 *Mitigation Hierarchy*



It should be noted that embedded controls and mitigations (ie physical or procedural controls that are planned as part of the Bumbuna II design and are not added in response to an impact significance assignment), are considered as part of Bumbuna II (ie prior to the impact assessment stage of the ESHIA Process). Accordingly, they are not described as mitigation measures in the individual topic assessment annexes, but are described and incorporated into the impact assessment.

6.6.6 *Assessment of Residual Impact*

Following the identification of mitigation measures, impacts are re-assessed to determine their residual impact. This is essentially a repeat of the impact assessment steps discussed above, albeit with a consideration of the assumed implementation of the mitigation measures.

6.7 ALTERNATIVES

Chapter 3; Alternatives of *Volume I* of the ESHIA summarises the process by which the energy potential of the Bumbuna-Yiben hydropower complex (ie Bumbuna I and the proposed Bumbuna II Project) was identified and initially assessed, the policy and strategic framework within which potential development of both Bumbuna I and particularly Bumbuna II has been progressed, and alternatives that have been considered during the design and development process. *Chapter 3; Alternatives* includes an overview of a number of alternative options which were considered for the location of the main project components ie the Bumbuna Extension and Yiben dam and its inundation area as well as alternative design options. Additionally *Chapter 3* provides a review of the 'No Project' option.

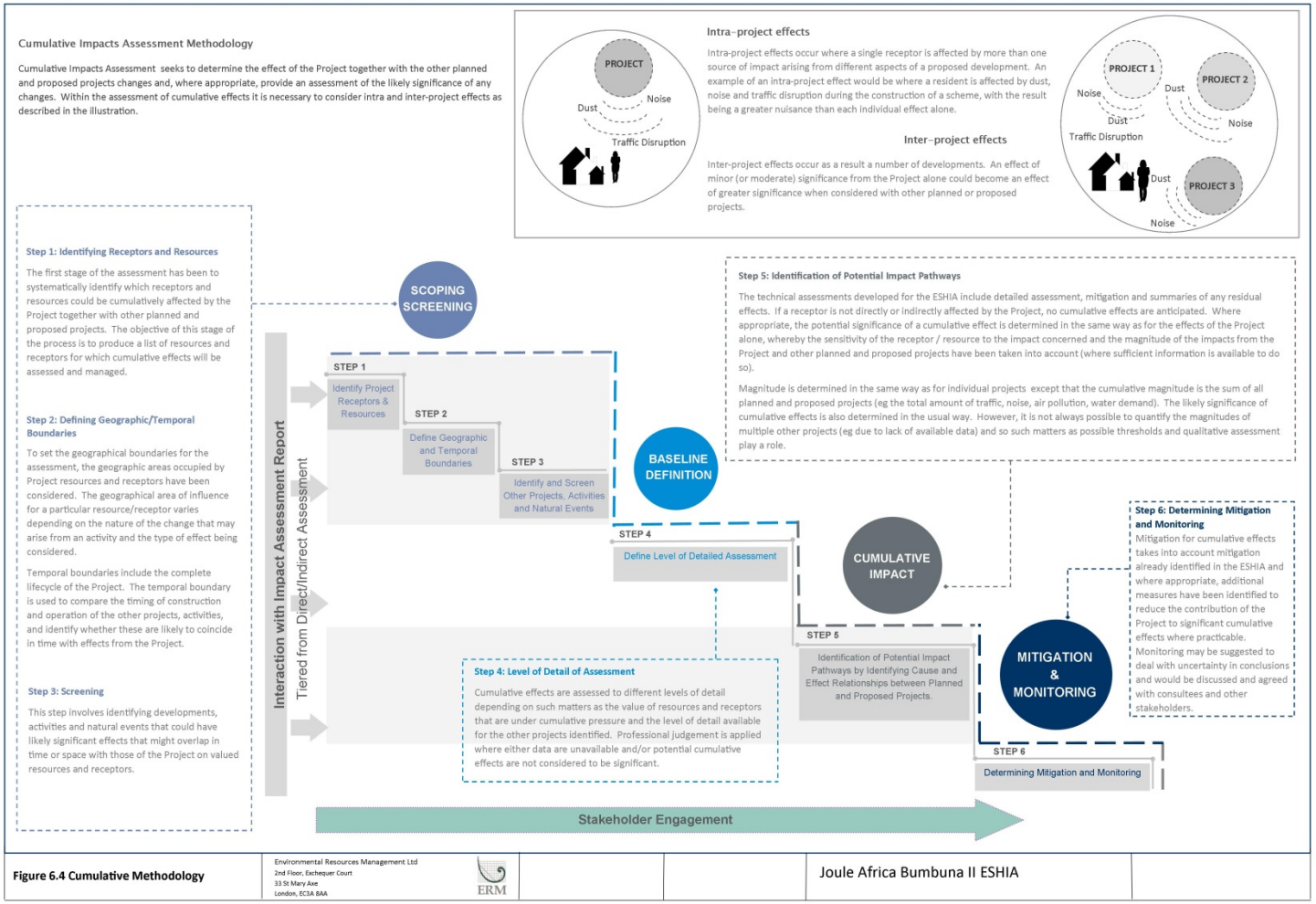
6.8 ASSESSMENT OF CUMULATIVE IMPACTS

The assessment of cumulative effects is an integral part of the ESHIA process and ensures that all aspects of potential effects from Bumbuna II have been, or will be, addressed. Cumulative effects result from incremental changes caused by other past, present or reasonably foreseeable developments together with those from the construction and operation of Bumbuna II.

In most instances, past and present developments will have been captured in the baseline for Bumbuna II (for example, through noise measurements, traffic counts) and the normal practice of 'adding' impacts from Bumbuna II to the baseline will assess the cumulative effect. ERM's Cumulative Impact Assessment methodology is presented in *Figure 6.4*.

The cumulative assessment approach is based on a consideration of the approval status or existence of the 'other' activity and the nature of information available to aid in predicting the magnitude of impact from the other activity.

Figure 6.4 Cumulative Assessment Methodology



6.9 MANAGEMENT PLANS

Following the assessment of impacts, management plans will be developed for each topic area eg air quality management plan, noise management plan, social management plan, etc. These set out how the mitigation measures will be put into practice, monitored and upheld. This includes defining the responsibility, timing and reporting requirements associated with each measure.

6.10 DISCLOSURE

Disclosure in-country

As part of the formal regulatory process, in this stage EPA-SL will make a public notice of the opportunity for information and comment on the draft ESHIA report for Bumbuna II. This notification is typically done through advertising in two consecutive issues of the local newspaper and two issues in a national newspaper (except that in the case of a newspaper there shall be an interval of at least seven days between the first and second publications).

The ESHIA disclosure notification will provide:

- a brief description of the Project;
- a list of venues where the EIA report is on display and available for viewing;
- duration of the display period; and
- contact information for comments.

Comments shall be submitted within fourteen days of the last publication in the local or national newspaper to the Executive Director (EPA-SL). Display venues will be decided by EPA-SL (the Act does not state recommended venues) but would be expected to include:

- EPA-SL, Freetown office;
- Capital of the Northern Province (Makeni);
- Capital of Koinadugu District (Kabala), and
- A selection of key towns in the Project area (eg Kondembaia).

In addition, EPA-SL will expect the consultant and the proponent to conduct disclosure meetings at a selection of venues (usually the same as the places where the ESHIA is displayed) to which a range of stakeholders will be invited. In addition to the Non-Technical Summary, an overview of the ESHIA will be presented and comments will be solicited from stakeholders.

An ESHIA which is referred back to the applicant for additional information shall be resubmitted within twenty-one days of the date of receiving consolidated comments from EPA-SL.

Lender Disclosure (World Bank and African Development Bank)

The ESHIA may also be made publicly available through the website(s) of lenders to the Project as required by the policies of the individual lenders.

6.11 ASSUMPTIONS

Every effort has been made to obtain data concerning the existing environment and to accurately predict the effects of Bumbuna II. Bumbuna II-specific aspects of this ESHIA have drawn upon existing literature, Bumbuna I information, Bumbuna II-specific documentation, personal communication with consultees, Joule Africa, local communities, stakeholders and local experts.

Assumptions adopted in the evaluation of effects are reported in the relevant technical annexes. However, interpretations of these assumptions often rely on expert judgement. Where technical deficiencies are known, or it has been necessary to make assumptions, these are documented where relevant in the specific *Technical Annexes* of *Volume II* of the ESHIA.

The ESHIA has been undertaken based on the latest project design details for Bumbuna II. However, as the EPC contractor has yet to be selected there are some technical aspects of Bumbuna II which have yet to be determined.

Additionally should there be any significant changes in the assessed design of Bumbuna II with potential effects to the environment or society, or the footprint of the project, relevant stakeholders will be consulted and amendment(s) to the ESHIA prepared as deemed appropriate.

7 ANALYSIS OF IMPACTS

7.1 SUMMARY

7.1.1 Overview of impact assessment and Key Impacts

This chapter provides a summary of the impacts identified during the ESHIA study for the construction and operation of the Project. The methodology used to identify and assess impacts is described in detail in *Volume I*, *Chapter 6* of the ESHIA. Additional detail is provided on each topic in *Volume II*.

Volume I, Chapter 8 Environmental, Social and Health Management Plan incorporates all of the mitigation measures associated with all identified impacts including Major, Moderate, Minor and negligible impacts.

Following the application of mitigation measures to each environmental, social and health impact, a rating was applied to the residual impacts. *Box 7.1* below presents the residual ratings for impacts related to the environmental, social and health issues assessed within the ESHIA.

In *Box 7.1* the residual environmental impacts were numbered from 1 to 11 while the residual social impacts were numbered from 12 to 22 to allow them to be plotted on a graph against the sensitivity of the receptors (*Figure 7.1*)

It can be seen from the graph below that there are three impacts with major residual ratings. These are as follows.

- Impacts on water resources.
- Impacts on biodiversity.
- Physical and economic displacement impacts.

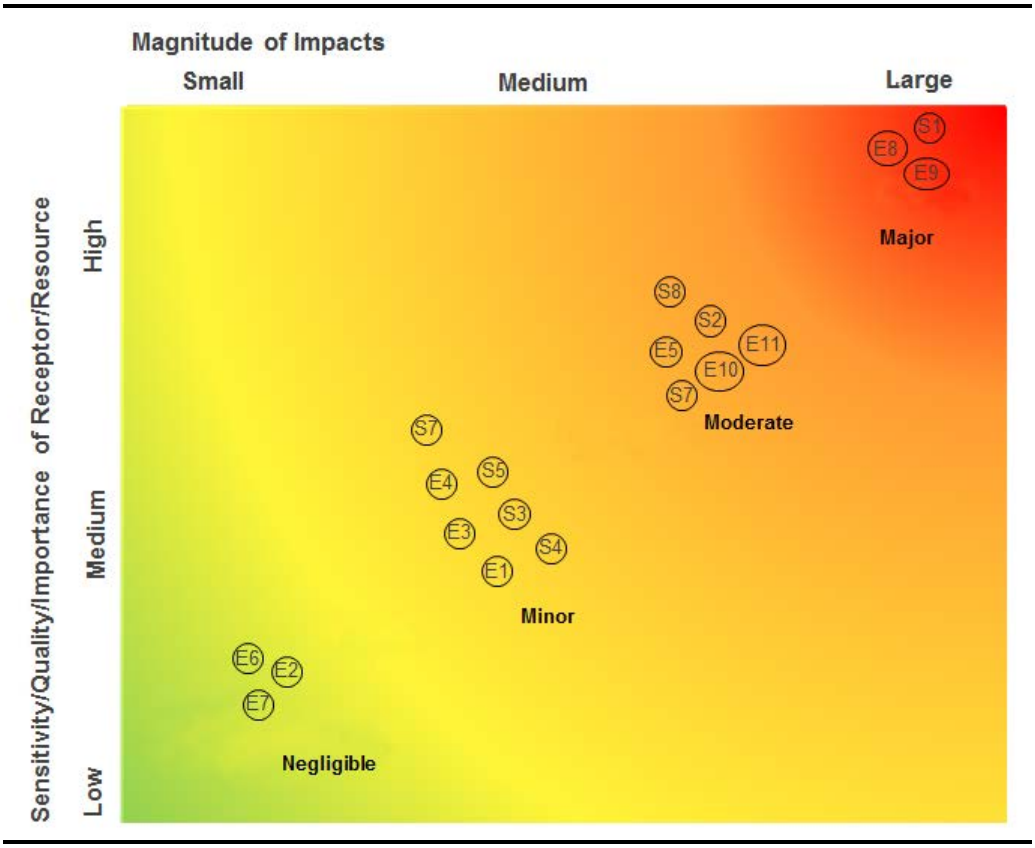
An overview of each of these is discussed below in *Sections 7.1.2-7.1.4* and in more detail in the Sections 7.7, 7.8 and 7.10 respectively. Information on the baseline for the three topics is summarised in these sections also. However, for all other topics baseline information is included within the individual Annexes for each topic ie *Annexes A –K*).

Box 7.1 Key Environmental, Social and Health Impacts

Key Environmental Impacts	
Construction dust	E1
Minor	
Green House Gas from construction activities	E2
Negligible	
Green House Gas emissions from reservoir	E3
Minor	
Climate change	E4
Minor	
Noise	E5
Moderate	
Vibration	E6
Negligible	
Soils	E7
Negligible	
Water resources	E8
Major	
Biodiversity (Plants and Animals)	E9
Major	
Ecosystem services	E10
Moderate	
Traffic and transport	E11
Moderate	

Key Social Impacts	
Local people's homes and livelihoods	S1
Major	
Poor financial management of compensation received	S2
Moderate	
Weakening of traditional governance	S3
Minor	
Social tension related to resettlement and local employment	S4
Minor	
Increased pressure on land and competition for it	S5
Minor	
Increase in land for farming downstream of Bumbuna	S6
Positive	
Loss of burial grounds	S7
Moderate	
Loss of sacred sites	S8
Moderate	
Access to electricity	S9
Positive	
Increase in local incomes	S10
Positive	
Increase in local development initiatives	S11
Positive	

Figure 7.1 Impact Rating



7.1.2 *Impacts on Water Resources*

The Rokel River (also known as the Seli River upstream of Bumbuna), and its basin, is the third largest in Sierra Leone. Since the operation of Bumbuna dam commenced in 1999, flows in the Seli River have been controlled through the operation of Bumbuna I. Nevertheless, the river's flows are still strongly seasonal with its flow more than doubling during the wet season.

There has been a requirement from the Government of Sierra Leone for Bumbuna I to maintain the lowest volume of water needed to protect the habitat and community livelihoods downstream; however, it seems that there are times when this minimum flow has not always been possible.

Once Bumbuna II has been constructed, and commissioned, this is expected to change the water flow rates and patterns of water flow down the river overall. Upstream of Yiben, the formerly fast flowing river will become a wide shallow slow moving water body. This will favour different species of fish from those currently found in the river. There could also be a change in water quality due to rotting vegetation in the slow moving water. Nevertheless there will be an increase in opportunities for fishing.

The change in the water quality in the Yiben reservoir could affect the quality of the water further downstream although how much it will be affected is currently unknown. It is recommended that additional studies be carried out to determine this. More information on this is provided in *Annex E6; Water Resources.*

Studies of the river have shown that increasing the flow of water into the river downstream from Bumbuna could negatively affect river species that are used to living in shallow water. There are a number of options to reduce the flow in the Rokel river to manage this, but these would greatly reduce the amount of electricity that could be generated by the Project and significantly increase the costs. To reduce the amount of electricity generated through Bumbuna II would be opposed to the Ministry of Energy's Energy Sector Strategy and Action Plan, 2014 -2017 which has a stated objective of achieving 1,000 MW of generating capacity (more information on this can be found in *Chapter 3; Analysis of Alternatives*).

In the Bumbuna reservoir in between the Bumbuna Extension and Yiben, the flow of water will become more even between the dry and wet seasons. Downstream from the Bumbuna dam, diversion of water into the tunnel will reduce the flow of water into the 4 km stretch of the Rokel River before the water from the tunnel re-joins the river. This will affect the habitats and farming within in this short stretch of the river. However, it will also provide a river with slower flowing water which will support a greater range of habitats thus a greater diversity of fish species than is currently present which should be of benefit to the fishery. The flow of water downstream into the Rokel River will be evened out. Less sand, leaf particles and other matter could reach downstream river habitats, reducing the fertility of the river and

therefore affect farming on the river banks as well. However it will provide safer access to the river banks.

7.1.3 *Impacts on Biodiversity*

The ESHIA studied the natural environment in the Project area. Preliminary Studies were also carried out in the Loma Mountains National Park and the Lake Sonfon proposed National Park to see if they have sufficient forests and grassland and populations of endangered plants and animals to replace what will be lost once the land under the Yiben reservoir becomes flooded. The landscape in the Project area consists of woodland, degraded forest and grassland with farming in lowland areas and swamps. There are also narrow strips of rainforest along river banks in the area and a variety of different plants living in the different streams and rivers. The studies found a number of important rare species which have currently been assessed as follows:

- Forty-one plant species of conservation concern including one new to science species assessed as Critically Endangered river weed (*Ledermanniella sp nov*) and five species assessed as Endangered;
- Eight bat species of conservation concern including one species potentially new to science (*Neoromicia aff. Nana*) and one species, Ziama Horseshoe Bat (*Rhinolophus ziama*) assessed as Endangered;
- Eight terrestrial mammal species of conservation concern including the Endangered West African Chimpanzee (*Pan troglodytes ssp. verus*) and Pygmy Hippopotamus (*Choeropsis liberiensis*);
- Seven bird species of conservation concern including the Critically Endangered Hooded Vulture (*Necrosyrtes monachus*);
- Thirteen amphibian species of conservation concern including the Endangered Freetown Long Fingered Frog (*Arthroleptis aureoli/ Cardioglossa aureole*);
- Four reptile species of conservation concern including the Critically Endangered Slender Snouted Crocodile (*Mecistops cataphractus*);
- Eight butterfly species of conservation concern; and
- Twenty-six freshwater fish species of conservation concern including two endangered species (*Entermius liberiensis* and *Marcusenius meronai*) and four likely restricted range species.

The Project is developing a range of measures to avoid, reduce and restore biodiversity impacts (for example management of construction activities to reduce potential habitat destruction and restore habitat after construction has been completed and redesign of some project infrastructure eg roads and transmission lines to avoid sensitive places). However in some places within

the Project area, there will be a total loss of all existing habitats and plant species, as well as the likely loss of slow moving animals.

Despite the measures to minimize impacts on plants and animals, it must be acknowledged that the Project will have an inevitable impact on them. To achieve an overall positive impact on biodiversity, the Project will develop and implement a Biodiversity Action Plan (BAP) that will include an Offset Strategy. The BAP will set out the approach to developing government/NGO partnerships, developing joint plans with these organisations to demarcate and protect offset areas and develop long term sustainable financing for the offset areas. The initial work to develop an offset strategy has identified three potential offset areas:

- an expansion of the existing Loma Mountains National Park;
- an expansion of the existing Lake Sonfon proposed National Park; and
- creation of a new riverine habitat protected area in the Seli River catchment upstream of Yiben reservoir.

In order to further confirm the suitability of each of these three areas as suitable offsets, a programme of additional surveys is proposed (See *Table F7.1* in *Annex F; Biodiversity*).

7.1.4 Physical and Economic Displacement

During construction the Project will aim to avoid displacing people's houses or affecting the ways in which they make a living as far as possible. Where this is not possible, alternative project designs will be considered to reduce this displacement. Nevertheless the most important impact on people will be the physical resettlement of 1,200 households and 52 settlements within the Project area which will be affected by the construction of access roads and other supporting Project facilities.

The Project has already developed a Resettlement Framework that has identified all the affected villages and sets out an approach to compensating the affected households. Initial discussions with the Paramount Chief of Diang also indicate that there is adequate available land for relocated of the affected households. The Project is developing a detailed Resettlement Action Plan that identifies all the affected people and their assets, and will identify host sites for them to move to and the process by which they will be moved and compensated for their losses. Efforts will also be made to relocate sacred sites and graveyards if possible.

Despite the implementation of the RAP, it must be acknowledged that the changes to the lives of those affected by resettlement will be significant and permanent. The resettlement programme will therefore aim to provide the affected communities with new villages and ways of making a living that are an improvement on what they currently have. Support will also be given to people to enable them to re-establish themselves after they have moved to their new locations. This will include new economic opportunities that might

come from increased access to energy and increased fishing in the new Yiben reservoir for example.

During construction, the Project will require over 2,300 workers many of whom will come from the local area. This will improve the local economy and will provide people with new skills. The Project will also deliver reliable year round electricity into the Sierra Leone power grid which will benefit many households and businesses and contribute to the economic development of the country.

7.2 ISSUES FROM SCOPING REPORT TOR

A Scoping Report was issued in August 2016, setting out the terms of reference for the ESHIA study, which was previously submitted to and approved by EPA-SL in February 2016. The terms of reference specified that the following issues would be included in the scope of the study:

- Greenhouse Gasses, Climate Change and Air Quality;
- Ambient Noise and Vibration;
- Geology and Soils;
- Water Resources;
- Biodiversity;
- Ecosystem Services;
- Community Health and Safety and Security;
- Worker Health and Safety;
- Local Community Demographics;
- Leadership Structures;
- Physical Loss of Homes, Land Use and Livelihoods;
- Local and Macro Economy;
- Infrastructure and Services;
- Traffic and Transportation; and
- Cultural / Heritage Resources.

All of these issues are described in this chapter.

A presentation and response to queries from EPA-SL on the ESHIA scoping report made in Q4 2016 was provided by Joule Africa in December 2016.

7.3 AIR QUALITY

7.3.1 Introduction

The full Air Quality Impact Assessment (AQIA) is presented in *Volume II, Annex A* of this ESHIA Report. The AQIA presents a detailed description of the air quality environment, significant impacts, mitigation measures and alternative designs. The sections below summarise the findings of the AQIA.

7.3.2 *Summary of Significant Construction Impacts*

Dust and Particulate Matter Emissions

Emissions of dust will arise from the Project during construction, primarily as a result of demolition/blasting, earth moving activities, vegetation clearance, exposure of bare ground, stockpiling of material, the passage of vehicles over unpaved roads and the on-site concrete batching plant.

The unpaved road network used across the Project site prior to works completion, is likely to be constructed from a mixture of rocks, stone, gravel, sand and silt, and can be particularly dusty when disturbed by vehicle movements. Whilst less of an issue during the rainy season, any moisture in the material or applied by water sprays, rapidly evaporates during periods of high temperatures and low moisture content in the air. When the surface is disturbed little or no moisture is therefore available to fix fine particulates and reduce the generation of dust. The elevated wind speeds occurring in the region together with the absence of natural barriers at the Project site further increase the high potential for dust generation and its ability to travel considerable distances.

The duration of the impact will continue for the duration of the construction phase, lasting approximately three years. The climatic conditions within the Project area are also considered to promote dust-generation for a large proportion of the year. Therefore, exposure to dust generating activities and associated dust emissions are likely to occur intermittently over the duration of the Project construction.

Taking into consideration the dust emission magnitude and the sensitivity of the area, the site has been classified as High Risk. On balance, dust emissions have the potential to result in impacts of a **Major** significance for the sensitive receptors found within 200 m of the source, without the application of mitigation. All other receptors are considered to be at distances between 200 m and 500 m and greater away from the source and therefore have the potential to experience impacts of **Minor** significance, again without the application of mitigation.

The airshed is considered to be *degraded* with regards to PM_{10}, $PM_{2.5}$ and dust deposition. It is therefore expected that mitigation measures will be embedded into the Project design and employed at the site during construction reducing the impact during construction to **Minor** significance at worst.

Construction Road Traffic Emissions

At the time of preparing this AQIA no precise construction traffic information was available. Construction traffic will have two types of emissions: the raising of dust (and PM_{10} and $PM_{2.5}$) especially from unpaved roads; and emissions from the combustion of fuel.

Impacts due to dust being raised by HGV traffic on roads are a function of the number of journeys, the emission standard of the engines and the distance to the road side. The potential impacts to sensitive receptors can be assessed, based upon the method and formulae presented in the UK Highways Agency Design Manual for Roads and Bridges (DMRB). These formulae are based upon modelling of a generic road and represent decreasing impacts with increasing distance from the roadside. In terms of NO_2 and PM_{10}, impacts are assumed in the method to be negligible at distances >200 m.

The results show that impact magnitudes associated with vehicle movements are most critical for PM_{10} and $PM_{2.5}$, and less critical for NO_2. Where there are receptors close to the roadside (ie <5m), impacts associated with vehicle movements on paved and unpaved road with no mitigation are as follows:

- Paved roads:
  - minor effects are avoided where there are less than 160 HGV movements a day on paved roads; and
  - moderate effects are avoided where there are less than 470 HGV movements a day on paved roads;
- Unpaved roads:
  - minor effects occur close to the roadside with any movements, without mitigation; and
  - moderate effects are avoided where there are less than 3 HGV movements a day on unpaved roads

In several locations alongside roads used to access the Project, there are sensitive receptors close to the roadside, including in the settlements set out above. The impacts are associated with emissions of PM_{10} and $PM_{2.5}$ principally raised from the road surface and it is clear that there is the potential for significant impacts at sensitive receptors if these impacts are unmitigated.

Combustion Sources on Site during Construction

Mobile equipment (excavators, dump trucks etc) on a construction site using fossil fuel will create combustion emissions of the same nature as the traffic emissions discussed earlier, and will be of negligible magnitude when this fleet stays below 120 HGV units.

Some diesel generators will also be on site during construction. However, the need for these is expected to be limited to localised use, as there is mains electricity available at the site. Details about the capacity and emission characteristics of these generators are still unknown, but the impacts of these are expected to be of negligible magnitude due to the expected size of the units required and when mitigating measures are applied.

7.3.3 *Summary of Significant Operational Impacts*

In the operational phase there are anticipated to be no significant impacts on air quality; the only foreseeable emissions may arise from road traffic.

However, the numbers of vehicles during operational phase are considered to be significantly lower compared to the construction phase and negligible in terms of impacts on air quality. On this basis, operational impacts have been scoped out of the assessment.

7.3.4 *Summary of Significant Decommissioning Impacts*

Decommissioning will entail the removal of any non-permanent features (ie temporary office and accommodation structures, generators and electrical sub-station). The proposed intake and tunnel will be closed and the tailrace channel backfilled. Impacts during decommissioning will therefore be of the same nature as for construction (ie mainly related to dust raising activities and traffic (primarily HGVs)).

A detailed assessment will be undertaken before decommissioning is started.

7.3.5 *Mitigation Measures during Construction*

Details on the embedded mitigation and additional mitigation measures are provided in *Chapter 8 (Environmental, Social and Health Management Plans* and in *Volume II, Annex A Air Quality*.

7.3.6 *Residual Impacts*

As complete control of dust emissions is difficult, the impact of construction will be reduced to **Minor** significance at worst, with the full application of embedded mitigation and the additional mitigation set out above.

Operational impacts have been scoped out of the assessment and are not significant.

7.4 *GREENHOUSE GASSES AND CLIMATE CHANGE*

7.4.1 *Introduction*

The full greenhouse gas (GHG) and climate change assessments are presented in *Volume II*, *Annex B* of this ESHIA Report. The sections below summarise the findings of the assessments.

The GHG assessment estimates the emissions contributing to climate change from Bumbuna II during its construction and operation phases. Conversely, the climate change assessment looks at the potential impacts of future climate change upon Bumbuna II during its construction and operation phases.

The GHG and climate change assessments look at the emissions associated with Bumbuna II during its construction and operation phases.

7.4.2 Summary of Significant Construction Impacts

Greenhouse Gasses

Transport of Materials Emissions

Emissions are associated with transport required to deliver materials, predominantly aggregates, cement and steel around both Bumbuna Extension and Yiben Project areas. The base data provided for making calculations is shown in *Table 7.1*. In the absence of further information regarding the 'generation equipment' and 'other' materials required for Yiben dam, figures required for the Bumbuna Extension have been assumed in their place.

Table 7.1 Materials Requiring Transportation

Site	Item	Value	Unit
Bumbuna Extension	Shotcrete for Bumbuna Extension	104,000	m^3
	Generation Equipment	500	tonnes
	Other	250	tonnes
Yiben	Concrete for Yiben	1,493,000	m^3
	Generation equipment	500	tonnes
	Other	250	tonnes

Based upon the density of the materials transported and a range of assumptions about the vehicles required for transportation, distance, speed, hours of operation and efficiency of the vehicles, the total fuel (in litres of diesel) was calculated and is shown in *Table 7.2*.

Table 7.2 Estimated Litres of Fuel Required for Transportation of Materials at Sites

Site	Item	Value	Unit
Bumbuna Extension	Concrete mixer	99,626	litres
	Caterpillar	761,516	litres
Yiben	Concrete mixer	2,383,674	litres
	Caterpillar	11,004,812	litres
	2.699 kg CO_2e/litre	**38,032**	**tCO_2e**

Construction emissions associated with the transport of materials are considered to be **Moderate**.

Excavation Transport Emissions

Excavation emissions are again associated with vehicles required for transportation. These include excavation of material related to:

- Excavation for intake;
- Balance of tunnel and shaft;
- Excavation for aggregate; and
- Powerhouse, penstock and manifold.

The density of excavated material for each of these aspects of the Bumbuna Extension has been provided and is shown in *Table 7.3*, alongside figures for the Yiben dam which, in the absence of data, have been assumed as the same totals.

Table 7.3 Density of Material to be Excavated

Site	Item	Value	Conversion	Total
Bumbuna Extension	Excavated material	3,284,000 m^3	2.699 kg CO_2e/litre	3,768 tCO_2e
Yiben dam	Excavated material (assumed totals)	3,284,000 m^3		3,768 tCO_2e

Based upon a further range of assumptions regarding the vehicles used for excavation and transportation of the material, a total of 3,768 tCO_2e has been calculated as the total emissions associated with the excavation of materials at each site.

Construction emissions associated with the excavation transport are considered to be **Minor**.

Construction Activity Emissions

There will be demand for fuel for construction machinery and on-site power generation at both the Bumbuna Extension and Yiben dam sites. *Table 7.4* shows the demands associated with the Project. For both sites the demand for fuel related to construction machinery are estimates. For on-site power generation, data has been provided for the Bumbuna Extension and in the absence of data this is again replicated for the Yiben dam project.

Table 7.4 On-Site Fuel Use for Construction Activities

Site	Item	Value	Conversion	Total
Bumbuna Extension	Fuel use for construction machinery & power generation	694,949 litres	2.699 kg CO_2e/litre	1,855 tCO_2e
Yiben	Fuel use for construction machinery & power generation (assumed totals)	694,949 litres		1,855 tCO_2e

Construction emissions associated with construction activities are considered to be **Minor**.

Land Use Change Emissions

Greenhouse gas emissions will result from land clearance in the areas required for construction of the Bumbuna Extension and to be inundated following construction of the Yiben dam. GHGs resulting from clearance will be determined by the current use of the land, and how much carbon is estimated to be stored within it. The different land uses and their associated areas for both the Bumbuna Extension and Yiben dam are shown in *Table 7.5*.

The area totals for each of the land use types has been provided for the Bumbuna Extension. However, for Yiben, the Project team has used the total expected reservoir area of 11,517 ha and divided this in to the same proportions as the Bumbuna Extension development because the land use types were not available at the time of the assessment. It is assumed that the Yiben reservoir area will not be cleared of vegetation extensively (eg burned) before inundation, which could have significant effects upon the local biodiversity.

Table 7.5 Land Use Types and Total Areas for the Bumbuna Extension and Yiben

Current land use	Bumbuna	Yiben	Units	Conversion	Units
Agriculture Land	51.8	96.9	ha	49.5	tCO_2e/ha
Built environment	17.7	33.1	ha	0	tCO_2e/ha
Hillslope Forest	20.1	37.6	ha	264	tCO_2e/ha
Riparian Forest	2.6	4.9	ha	612	tCO_2e/ha
Secondary habitat	8.5	15.9	ha	264	tCO_2e/ha
Water environment	5.9	11.0	ha	165	tCO_2e/ha
Wooded Grassland	8.3	15.5	ha	165	tCO_2e/ha
Total land area changed	115	214.9	ha		
Converted totals	**14,049**	**26,276**	**tCO_2e**		

The total expected GHG emissions for the Bumbuna Extension and Yiben are shown in *Table 7.6* below.

Table 7.6 Total Expected Construction GHG Emissions

Item	Bumbuna Extension	Yiben	Total
Transport of materials	2,298	35,734	38,032
Excavation transport	3,768	3,768	7,536
Construction activity	1,855	1,855	3,710
Land use change	14,049	**26,276**	40,325
	21,970 tCO_2e	**67,633 tCO_2e**	**89,603 tCO_2e**

Construction emissions associated are considered to be **Major**.

7.4.3 Summary of Significant Operation Impacts

Greenhouse Gasses

Best available research suggests that decay of biomass material in inundated reservoirs leads to emissions of both CO_2 and CH_4 with the main impact occurring during the first 10 years of relevant projects (1). The IPCC has suggested an approach to calculating these emissions which takes the total area to be inundated, climate it is situated in and multiplies it by estimated daily GHG emissions produced. The IPCC approach used because of the data constraints from a proposed development allows for a high-level 'Tier-1' estimation of GHG emissions.

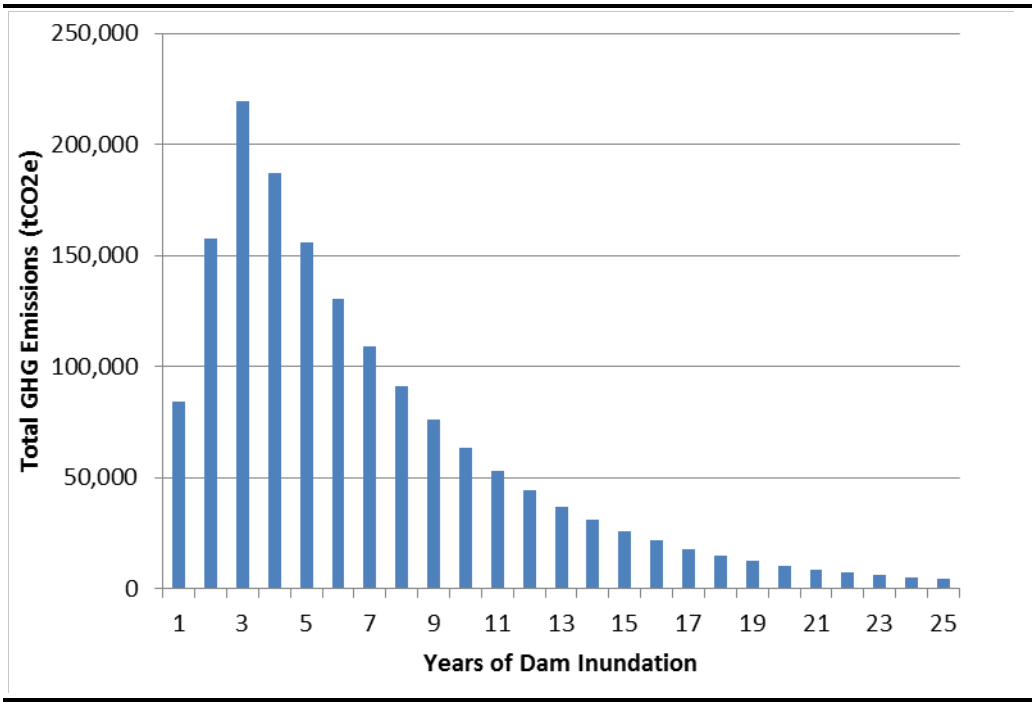
This only accounts for the diffusive flux emissions across the air-water interface as shown. UNESCO/ IHA are developing a publically available tool to estimate net GHG emissions from planned and existing reservoirs, without the need for large-scale field campaigns and multi-year studies. This would increase the accuracy of GHG emission calculations related to hydropower schemes and it is recommended that this is used, when available, to reassess the impacts.

Yiben is expected to create an inundated area with a surface area of 11,517 ha. Emissions will not reach 100% of their potential immediately. For the purpose of this study, it has been assumed, in the absence of any data, that full inundation of the reservoir area will be complete within a three year period, assuming 33.3% total area inundation each year, leading to 100% inundation by the end of year three. Emissions are seen to rise from Years 1 to 3 because of the increasing area of inundation over the first 3 years (the reservoir is assumed to be fully inundated after 3 years), as reflected in *Figure 7.2.*

The graph also shows the estimated emissions throughout the whole 25 year concession period. Over 25 years, it is estimated that the total GHG emissions from the decay of biomass is 1,574,862 tCO_2e, of which 1,274,580 tCO_2e (80%) occurs during the first 10 years. This is primarily from CO_2 emissions, which account for approximately 75% of the total and 26% is from CH_4.

(1) IPCC research indicates that emissions are associated with decay of organic matter in the first 10 years following inundation of a previously vegetated area. The best available research indicates that these emissions do not remain beyond this initial period. Source: http://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/4_Volume4/V4_p_Ap2_WetlandsCO2.pdf

Figure 7.2 GHG Emissions from Decay of Biomass Material in the Yiben Reservoir



Emissions are seen to rise from Years 1 to 3 because of the increasing area of inundation over the first three years. The reservoir is assumed to be fully inundated after three years. Research by the International Hydropower Association [1]suggests that emissions will decrease in the years following full inundation, falling to over 50% of peak emissions by Year 8 following inundation; and less than 25% of peak emissions by Year 10 following inundation.

The average operational emissions are equivalent to 62,994 tCO_2e per annum over a 25 year period. After 25 years annual operational emissions associated with decaying vegetation are approximately 2% of peak emissions and would continue to decline thereafter

Operational emissions additional to the decay of the biomass material are not expected to be significant and are briefly outlined in *Table 7.7.*

Table 7.7 Annual Expected Emissions from Site Operations

Item	Year 1 (tCO_2e)	Year 2 (tCO_2e)	Year 3 (tCO_2e)
Decay of reservoir biomass material	84,136	157,926	219,572
O&M vehicles	0.28	0.28	0.28
Operations activity, including machinery fuel use, on-site power generation and grid electricity	0.52	0.52	0.52
Total	**84,137**	**157,927**	**219,573**

Note: Numbers may not add up due to rounding

(1) International Hydropower Association, 2010. 'GHG Measurement Guidelines for Freshwater Reservoirs'. Calculation Manual, pp121

For the underlying assumptions of the operational emission impacts please refer to *Annex A; Air Quality, Section A4.2* and *Annex B; Greenhouse Gas and Climate Change, Section B4.2*.

O&M (Operations and Maintenance) vehicles emissions are estimated based on an assumed number and length of journeys as well as GHG conversion factors for vehicle emissions per km, based on an average passenger car using an unknown fuel type from Defra 2014 GHG reporting guidelines. 75 return journeys, each covering a distance of 10km per year, (a total of 1,500 km per year) is assumed for the O&M vehicle emissions.

Sierra Leone's National GHG Inventory

Sierra Leone submitted its latest National GHG Inventory alongside its Second National Communication Update Report to the UN Framework Convention on Climate Change in 2012 (1). This updates the emissions inventory included in the First National Communication submitted in 2007. However, this inventory only includes emissions data up to 2000. Consequently, World Resources Institute (WRI) data have been used instead, which have estimations up to 2012 (2).

Table 7.8 summarises Sierra Leone's emissions from 1990 to 2012, compared with total global emissions. Sierra Leone emitted an estimated 13.02 million tCO_2e in 2012, including the emissions from land use, land use change and forestry. Sierra Leone was responsible for 0.03% of global emissions in 2012. The country is considered a low emitter with one of the very lowest emissions per capita. However, national emissions grew by 74% between 1990 and 2012.

The data available is not sufficiently detailed to show the sector emissions specifically associated with energy for Sierra Leone.

Table 7.8 World and Sierra Leone GHG Emissions

		1990	2000	2010	2011	2012
World	Total Mt CO_2e, including LULUCF	33,937.2	36,679.7	45,747.7	46,905.7	47,598.6
	Total Mt CO_2e, excluding LULUCF	30,423.8	33,886.6	42,968.1	44,190.7	44,815.5
Sierra Leone	Total Mt CO_2e, including LULUCF	9.62	9.18	11.11	11.60	13.02
	Relative to 1990 base		-4%	15%	20%	35%
	Total Mt CO_2e, excluding LULUCF	3.74	3.34	5.38	5.86	6.50
	Relative to 1990 base		-11%	44%	57%	74%

Source: http://cait.wri.org/profile/Sierra%20Leone

(1) Source: http://unfccc.int/essential_background/library/items/3599.php?rec=j&priref=7677#beg
(2) Source: http://cait.wri.org/profile/Sierra%20Leone

During each of the three construction years, it is estimated that Bumbuna II will increase the national inventory by 11.52% per year, based on 2012 emissions levels. It will subsequently increase the national inventory by 0.64% in the first year of operation, rising to 1.96% in the third year to the tenth year and then down to 0.0000012% from the eleventh year onwards.

As the relevant data is not available, it is not possible to say the extent to which the Project will increase the emissions in the energy sector.

Significance of Potential Impact

Excluding the emissions from the decay of biomass in the reservoir, the Project's forecast project-wide estimated annual GHG emissions over a 25 year period can be categorised as small on the emissions magnitude scale (5000-20,000 tCO_2e per annum) shown in *Table 7.9*. However, if the emissions from the decay of biomass are included, it is raised to a medium magnitude (25,000-100,000 tCO_2e per annum). A summary of the average annual emissions over 25 years is shown in *Table 7.10*.

Table 7.10 combines the magnitude and likelihood ratings to assess the significance of the emissions from Bumbuna II in relation to the Republic of Sierra Leone's national emissions which contribute to global GHG concentrations. The annual emissions from the first year of operation onwards are compared against Sierra Leonean national emissions twice: once including the decay from biomass against the national emissions including Land use, land-use change and forestry (LULUCF) and a second time excluding the decay, which would have reduced to less than 2% of its peak after 25 years, when it is compared against the national emissions excluding LULUCF.

Table 7.9 Summary of Bumbuna II and Sierra Leone annual GHG emissions

Annual GHG emissions	tCO_2e	Bumbuna II relative % contribution to the Sierra Leone GHG inventory
Sierra Leone, including LULUCF (2012)	13,020,000	
Sierra Leone, excluding LULUCF (2012)	6,500,000	
Bumbuna II construction (annual average over 25 years)	3,584	0.28 % (of SL total including LULUCF)
Bumbuna II annual operations year 1 to year 25, (ie including decay)	62,994	12.10% (of SL total including LULUCF)
Bumbuna II annual operations year 25 onwards, (ie minimal decay)	4,268	0.066% (of SL total excluding LULUCF)

Table 7.10 Assessment of Significance

Item	Criteria
Extent	The extent of the potential impact is **national** as it is Sierra Leone's GHG emissions that would be directly increased due to the potential impact of Bumbuna II. Although the greenhouse effect is **transboundary** and global emissions are directly affected, this section assesses the potential impact of the Project on Sierra Leone's emissions.
Duration	The duration of the potential impact is regarded as **permanent** as science has indicated that the persistence of carbon dioxide in the atmosphere is said to range between 100 and 300 years and therefore continues beyond the life of the Project.
Intensity	The 0.69% increase in Sierra Leone's national GHG emissions during construction stages and either 12.10% or 0.066% during the operational stages and the long residence time in the atmosphere would indicate that the potential impact would have the potential to have a **high** intensity during both the construction phase and a **high** intensity during the first 7 years of the operational phase, and would lower to a **negligible** level of intensity after 25 years.
Magnitude	Magnitude is a function of extent, duration and intensity. Given the far reaching and permanent nature of the potential impacts as well as the high intensity of the potential impact on Sierra Leone's national emissions, the magnitude of the potential negative impacts is considered to be **medium** during the construction phase and **high** during the first 7 years of the operational phase, which would then lower to **negligible** after 25 years of the Project.
Likelihood	The probability of the potential impact of increased levels of GHG emissions with the proposed power plant is regarded as **likely**.

Operation emissions are considered to be **Major** for the first 25 years and would then be **negligible** thereafter.

Climate Change

Three key risks associated with the operation of the Project have been identified, and are presented in *Table 7.11*. The significance of these impacts on the activities of Bumbuna II has been assessed against the baseline conditions and future climate change scenario and full findings are presented in *Volume II, Annex B2 Climate Risk Assessment.*

Table 7.11 Key Climate Change-Related Risks to Bumbuna II

Type	Title	Potential Current and Future Risks to the Project	Risk Significance using current baseline	Risk Significance using future climate scenario
Extreme temperatures	Occupational health and safety	More sustained and more frequent extreme temperatures are at risk of affecting the health and safety of staff active at the site. This is an existing risk, as high temperatures are already experienced throughout the year. However climate change is projected to increase the severity of this issue, requiring changes to working practices.	Negligible	Minor

Type	Title	Potential Current and Future Risks to the Project	Risk Significance using current baseline	Risk Significance using future climate scenario
Flooding	Site flooding	Flooding is possible at the site's manned operating areas as a result of heavy rainfall, which is projected to become more severe and frequent in future.	Negligible	Moderate
Low water availability	Reduction in generating capacity	Changes in rainfall patterns across the catchment region could result in periods where the reservoir-supplying river is below its peak. However, future climate projections are showing a general increase in precipitation that could reduce the impact from the changes in rainfall patterns. If the water level in the reservoirs for both dams is reduced, there could be a direct implication of reduced power generating capacity.	Minor	Minor

7.4.4 *Mitigation Measures*

Details on the embedded mitigation and additional mitigation measures are provided in *Chapter 8 (Environmental, Social and Health Management Plans)* and in *Volume II, Annex B1 Greenhouse Gas Emissions Assessment*.

7.4.5 *Residual Impacts*

Greenhouse Gasses

The residual risk significance following on from the mitigation measures are presented in *Table 7.12.*

Climate Change

The residual risk significance following on from the mitigation measures are presented in *Table 7.13.*

Table 7.12 Risk Assessment after Implementation of Mitigation Measures

Impact	Magnitude Rating	Timing	Significance
Emissions associated with transport of raw materials	Medium	During construction	Major
Emissions associated with excavation	Small	During construction	Minor

Impact	Magnitude Rating	Timing	Significance
Emissions associated with construction activity	Negligible	During construction	Negligible
Emissions associated with land use changes	Medium	During construction	Major
Emissions associated with onsite fuel or energy use	Negligible	During operation	Negligible
Emissions associated with the decay of reservoir biomass material within the inundated area	Large	During first 10 years of operation	Major

Table 7.13 Risk Assessment Using Future Climate Scenario after Implementation of Mitigation Measures

Risk	Magnitude Rating	Timing	Risk Significance
Occupational health and safety	Small	Occurs once in 5 to 10 years	Minor
Site flooding	Small	Occurs once in 5 to 10 years	Negligible
Reduction in generating capacity	Medium	Occurs once in > 10 years	Minor

7.5 NOISE AND VIBRATION

7.5.1 Introduction

The full Noise and Vibration Impact Assessment (NVIA) is presented in *Volume II*, *Annex C* of this ESHIA Report. The NVIA presents a detailed description of the existing acoustic environment, significant impacts and mitigation measures. The sections below summarise the findings of the NVIA.

7.5.2 Summary of Significant Construction Impacts

During construction activities with potentially significant noise sources include earthworks, excavation (which may include drilling and blasting), concreting, foundation works, construction traffic, rock disposal and aggregate crushing. A quarry will also be located approximately 4 km away from the Yiben dam, to provide aggregate for the construction of the Project. It will be operational only during the construction phase of the Project. New access roads will be constricted and some existing access roads upgraded, which will create some noise from roadworks.

When assessing noise from construction, except where it is specifically mentioned, none of the influencing factors which would reduce the significance of the impact (as set out in *Table 7.14*) have been included, which is conservative.

Table 7.14 Noise and Vibration Impact Significance

Impact Magnitude Classification	Influencing Factors	Impact Significance Rating
Negligible	Consider other factors that have the ability to affect the significance of the impact such as duration, receptor detail / design or the receiver perception of noise	Negligible
Small		Minor
Medium		Moderate
Large		Major

Forebay and Power Intake

Only one settlement is situated within buffer distances representing the thresholds of a Small, Medium and Large impact at night; Kadala, which is predicted to experience a noise level of 53 dB, resulting in a **Moderate** impact during the night and a **Negligible** impact during the day.

Headrace Tunnel, Surge Shaft, Penstock and Manifold, Powerhouse, Tailrace Canal and Batching Plant

Approximately 40 properties in Bumbuna Village, Kamange, Kamathor, Kamator 2 and all properties in Kamator 1 are predicted to experience **Minor** impacts during the day, whilst approximately 20 properties are predicted to

experience **Moderate** impacts. Approximately 10 properties are predicted to experience **Large** impacts during the day. Further mitigation to reduce the significance of these **Large** magnitude impacts is discussed below.

Large numbers of properties in Bumbuna Village and Kamange are predicted to experience **Minor** impacts at night. Approximately 100 properties in Bumbuna Village, Kamange and Kamator 2 and approximately 40 properties in NSR A are predicted to experience **Moderate** impacts at night. Approximately 70 properties in Bumbuna Village, Kamange and Kamathor and all properties in Kamator 1 are predicted to experience **Large** magnitude impacts. Further mitigation to reduce the significance of these **Large** magnitude impacts is discussed below.

Significant intra-project cumulative noise levels are expected to affect the O&M camp from works to construct the headrace tunnel and surge shaft as well as, to a lesser extent, works to construct the penstock and manifold, powerhouse and tailrace canal. This is predicted to result in a **minor** impact during the day and a **Large** magnitude impact at night. Further mitigation to reduce the significance of these **Large** magnitude impacts is discussed below.

Significant intra-project cumulative noise levels are expected to affect Kamator 1 from works to construct the headrace tunnel, surge shaft, penstock and manifold, powerhouse, tailrace canal and batching plant. This is predicted to result in a **moderate** impact during the day and a **Large** magnitude impact at night. Further mitigation to reduce the significance of these **Large** magnitude impacts is discussed below.

Significant intra-project cumulative noise levels are expected to affect the nearest NSRs at the northern end of Kamator 2 from works to construct the penstock and manifold, powerhouse, tailrace canal and batching plant as well as, to a lesser extent, works to construct the headrace tunnel and surge shaft. This is predicted to increase the number of properties experiencing a **Large** magnitude impact by approximately 10. Further mitigation to reduce the significance of these **Large** magnitude impacts is discussed below.

Noise trigger levels are set out in *Annex C; Ambient Noise and Vibration* and indicate those which equate to a **Large** magnitude impact. In instances where these levels are predicted to be exceeded ie:

- where the duration of the impact meets the requirements for further mitigation, these impacts will be mitigated. Details are presented in *Annex C; Ambient Noise and Vibration*.

- where these impacts are expected to last for a shorter period of time, the significance of the impact is considered to be **Moderate** as a result of the shorter duration of the impact.

The highest noise levels expected as a result of these activities is predicted to result in a **Minor** impact during the day and a **Moderate** impact at night.

Switchyard

The switchyard is located close to the powerhouse and the tailrace channel, however, construction of the switchyard will begin after construction of the powerhouse and tailrace channel has finished and therefore noisy works from these activities will not overlap with construction of the switchyard.

Work is expected to continue at night. Duration is expected to be approximately four months. The noisiest works during construction are expected to be earthworks and site levelling.

The closest properties in Kamator 2 and Kamathor are situated approximately 30 m from the proposed switchyard. Noise levels are predicted to result in a **Large** magnitude impact during the day. Further mitigation to reduce the significance of these **Large** magnitude impacts is discussed below.

Approximately 25 properties in Kamange and all properties in Kamator 1 are predicted to experience **Minor** impacts at night. Approximately eight properties in Kamange are predicted to experience **Moderate** impacts at night, whilst all properties in Kamator 2 and Kamathor are predicted to experience **Large** magnitude impacts. Further mitigation to reduce the significance of these **Large** magnitude impacts is discussed below.

A batching plant will be located to the north of the powerhouse, at a distance of at least 450 m from the nearest NSRs in Kamator 1 and Kamator 2. Noise levels at this distance are predicted to **Minor**. Cumulative impacts from this plant are not expected.

Noise trigger levels are set out in *Annex C; Ambient Noise and Vibration* and indicate those which equate to a **Large** magnitude impact. In instances where these levels are predicted to be exceeded ie:

- where the duration of the impact meets the requirements for further mitigation, these impacts will be mitigated. Details are presented in *Annex C; Ambient Noise and Vibration*; and

- where these impacts are expected to last for a shorter period of time, the significance of the impact is considered to be **Moderate** as a result of the shorter duration of the impact.

Site Installation Areas

Construction of the site installation areas will take place during the daytime only. Duration is expected to be approximately six months. Approximately 20 properties in Kamange are predicted to experience **Minor** impacts. Approximately 10 properties are predicted to experience **Moderate** impacts. Approximately 40 properties in Kamangee and all properties in Kamator 2 and Kamathor are predicted to experience **Large** magnitude impacts.

Noise trigger levels are set out in *Annex C; Ambient Noise and Vibration* and indicate those which equate to a **Large** magnitude impact. In instances where these levels are predicted to be exceeded ie:

- where the duration of the impact meets the requirements for further mitigation, these impacts will be mitigated. Details are presented in *Annex C; Ambient Noise and Vibration*; and

- where these impacts are expected to last for a shorter period of time, the significance of the impact is considered to be **Moderate** as a result of the shorter duration of the impact.

RCC Dam, Powerhouse, Switchyard, River Diversion and Tailrace Channel

The following construction activities will take place concurrently at times, resulting in elevated noise levels:

- river diversion works and dam works;
- dam, powerhouse and tailrace construction works (river diversion works will have ceased); and
- dam works and switchyard construction

The only settlements near enough to be significantly affected by noise from these works are Sawule 1, Sawule 2 and Yiben.

Noise levels at Yiben are predicted to be **Negligible** during the day and night whilst river diversion and dam works take place concurrently. Whilst dam works occur at the same time as powerhouse and tailrace works and at the same time as switchyard works, **Minor** impacts are predicted. At Sawule 1, noise levels are predicted to be **Negligible** during the day and **Minor** at night, except when dam works and switchyard works occur together, when a **Moderate** impact at night is predicted. Sawule 2 is situated slightly closer to works than Sawule 1 to most works, and consequently, noise levels are predicted to be **Negligible** during the day and **Moderate** at night.

Quarry

Kamawewe is the only settlement located close to the proposed quarry. This settlement is located approximately 100 m from the quarry boundary. The quarry will operate during the daytime only. The impacts on NSRs from noise levels at this settlement are predicted to range between **Minor** and **Major**. Impacts are expected to be above **Moderate** for the Majority of the life of the quarry.

Site Installation Areas

Construction of the site installation areas will take place during the daytime only and is not expected to result in significant impacts at any NSRs.

A batching plant will be located close to the quarry and will operate throughout the day and night. Kamawewe is the only settlement located nearby (at a distance of approximately 490 m). Noise is not significant during the day and at night results in a **Minor** impact at night.

Transmission line

Installation work will be carried out during the day only. NSRs located close to the proposed transmission line between the Yiben and the Bumbuna Extension switchyard are located well away from other project construction works and won't be affected by noise from them. No impacts above **Negligible** are expected.

For the transmission line between Bumbuna Extension switchyard and the proposed WAPP substation, most NSRs are located in or close to Bumbuna and may experience construction noise for a prolonged period. Although a number of properties lie close to the route the construction of each tower will be relatively brief, up to two weeks, and the significance of this impact is considered **Moderate**.

Access Roads and Road Upgrades

Road works will take place during the daytime only. Noise impacts of a medium magnitude as a result of these works are predicted at NSRs within 216 m. NSRs within 129 m of works are predicted to experience medium magnitude impacts. Impacts at this level could last for up to approximately two weeks. Beyond 360 m, impacts are predicted to be of negligible magnitude.

At the Yiben, access roads close to the dam will be required. However, these are expected to be further than 360 m from the nearest NSRs and impacts are therefore predicted to be **Negligible**.

Although NSRs in Kamator 2 will be situated up to 200 m from road works, works will be relatively brief at individual NSRs and the significance of this impact is considered **Minor**.

An access road from the Bumbuna I access road to the surge shaft will also be required. Although NSRs in Kamator 1 will be situated up to 100 m from road works as works will be relatively brief at individual NSRs the significance of this impact is considered **Moderate**.

Waste Management Facility

The waste management facility will operate during the daytime only. Significant impacts (of small magnitude or above) are predicted to occur at NSRs situated within 252 m, however, no NSRs are located within this distance, so no significant impacts are predicted.

Traffic

Construction traffic is expected to result in substantial flow increases on smaller roads close to and within the Project site. Deliveries of materials and equipment from Freetown (during the daytime only) are expected to be relatively infrequent and are not expected to give rise to impacts above **Moderate** at nearby NSRs. Within the Project site, construction traffic may result in significant noise levels. Impacts at NSRs nearby are expected to be **Medium** to **Large**.

Noise trigger levels are set out in *Annex C; Ambient Noise and Vibration* and indicate those which equate to a **Large** magnitude impact. In instances where these levels are predicted to be exceeded ie:

- where the duration of the impact meets the requirements for further mitigation, these impacts will be mitigated. Details are presented in *Annex C; Ambient Noise and Vibration;* and

- where these impacts are expected to last for a shorter period of time, the significance of the impact is considered to be **Moderate** as a result of the shorter duration of the impact.

Vibration

As the nearest NSRs to the RCC dam are further than 100 m, vibration impacts from the use of vibratory rollers will be N**egligible**.

Driven piling may be required to construct the cofferdam at the power intake for the Bumbuna Extension and the river diversion at the Yiben dam. The nearest NSRs lie more than 100 m from these activities and consequently vibration impacts will be **Negligible**.

At the Yiben dam, NSRs are further than 131 m from the switchyard and installation areas and significant impacts are therefore not expected.

At the Bumbuna Extension, the closest properties to the switchyard and installation areas may experience significant vibration impacts during the day and night whilst earthworks and site levelling is taking place. However, the few properties that would be close enough to experience impacts above Moderate will exceed the Noise Trigger Level for temporary re-housing as a result of noise effects from these works and will therefore be mitigated.

Blasting

Blasting will be designed so that air overpressure and vibration levels will not exceed the criteria for a Moderate impact at any NSR.

This will be achieved by regulating the maximum instantaneous charge (MIC). Reducing the MIC will result in a reduction in the vibration level. More charges are fired in rapid succession to achieve a similar effect in terms of rock

removal with a smaller MIC. Test blasts will be carried out prior to the start of construction blasting, the results of which will be used to produce a scaled distance graph suitable for estimating the magnitude of allowable MIC charges.

Therefore impacts from blasting will be **Minor** or below at all NSRs.

7.5.3 *Summary of Significant Operation Impacts*

Disturbance Criteria

During the day, the minimum one hour average noise level, $L_{Aeq,1h}$, measured during the baseline noise surveys, was below 55 dB at all monitoring locations.

During the night, the minimum one hour average noise level, $L_{Aeq,1h}$, was higher than 45 dB at Kamandi due to periods of intense rain throughout the night and at Kamator 3 due to high levels of cricket noise. As these factors are expected only for certain periods of the year, the dry season baseline measurement has been adopted as a conservative interpretation of night-time baseline noise levels that may be experienced throughout the Study Area.

Therefore the disturbance threshold criteria of 55 dB and 45 dB for the daytime and night-time respectively have not been relaxed as a result of elevated existing ambient noise levels.

Amenity Criteria

During the day, representative background noise levels, $L_{A90,15min}$, of 55 dB, 42 dB and 38 dB were measured at Sawule 2, Kamandi and Kamator 3 respectively. This would result in medium magnitude amenity impacts from the operation of the Project of 65 dB, 52 dB and 48 dB respectively.

At night, representative background noise levels, $L_{A90,15min}$, of 32 dB, 49 dB and 47 dB were measured at Sawule 2, Kamandi and Kamator 3 respectively. Following the same approach as for the disturbance criteria, the noise level at Sawule has been adopted, as the measurements at the other two locations were significantly affected by either rain or crickets and the lower levels measured at Sawule are expected to be representative outside of the wet season. This results in a medium magnitude amenity impact from the operation of the HEP turbines of 42 dB, $L_{Aeq,1h}$.

Summary of Adopted Criteria and Derivation of Design Noise Limit

The Project will commit to ensure that noise impacts from the operation of the HEP turbines are **Minor** or below at all NSRs.

As noise emissions from the turbines are expected to be relatively constant throughout the day and night, the more stringent of either the daytime or

night-time criteria will determine the level to which the plant must be designed.

A noise level, $L_{Aeq,1h}$, of 45 dB must be met at the nearest NSRs to ensure disturbance effects are **Minor** or below.
A noise level, $L_{Aeq,1h}$, of 42 dB must be met at the nearest NSRs to ensure amenity effects are **Minor** or below.

The HEP turbines will be designed to meet a free-field noise level, $L_{Aeq,1h}$, of 42 dB at the nearest NSRs to ensure that noise effects from their operation are **Minor** or below at all NSRs.

7.5.4 *Mitigation Measures*

Details on the embedded mitigation and additional mitigation measures are provided in *Chapter 8 (Environmental, Social and Health Management Plans)* and in *Volume II, Annex C; Ambient Noise and Vibration*.

7.5.5 *Residual Impacts*

Construction

This section summarises the predicted residual construction noise impacts. *Table 7.15* summarises residual construction noise impacts predicted at the Bumbuna Extension worksite, whilst *Table 7.16* summarises residual construction noise impacts predicted at the Yiben worksite. Predicted residual impacts from works to construct the transmission line, the off-site waste management facility, road works and construction traffic as well as predicted vibration and blasting impacts are summarised below these tables.

Table 7.15 Summary of Residual Impacts at the Bumbuna Extension Worksite

Construction activity	NSRs Potentially Affected	Predicted Residual Impact	
		Day	Night
Power intake and forebay	Kadala	Negligible	Moderate
Headrace tunnel, surge shaft, penstock and manifold, powerhouse, tailrace canal or batching plant works	Approximately 40 properties in Bumbuna Village, Kamange, Kamathor, Kamator 2 and all properties in Kamator 1	Minor	-
	Approximately 20 properties in Kamange and Kamathor	Moderate	-
	Approximately 10 properties, situated close to worksites in Kamange and Kamathor	Large magnitude (2)	-
	Large numbers of properties in Bumbuna Village and Kamange.	-	Minor
	Approximately 100 properties in Bumbuna Village, Kamange and Kamator 2 and approximately 40 properties in the O&M camp	-	Moderate

Construction activity	NSRs Potentially Affected	Predicted Residual Impact	
		Day	Night
	Approximately 70 properties in Bumbuna Village, Kamange, Kamathor, Kamator 2 and all properties in Kamator 1.	-	Large magnitude (2)
Noise from the combination of works to construct the headrace tunnel and surge shaft as well as, to a lesser extent, works to construct the penstock and manifold, powerhouse and tailrace canal.	O&M camp	Minor	Large magnitude (2)
Noise from the combination of works to construct the headrace tunnel, surge shaft, penstock and manifold, powerhouse, tailrace canal and batching plant.	Kamator 1	Moderate	Large magnitude (2)
Noise from the combination of works to construct the penstock and manifold, powerhouse, tailrace canal and batching plant as well as, to a lesser extent, works to construct the headrace tunnel and surge shaft.	The nearest NSRs at the northern end of Kamator 2	Predicted to increase the number of properties experiencing a Minor impact set out above by approximately 10.	Predicted to increase the number of properties experiencing a large magnitude impact set out above by approximately 10. (2)
Switchyard	The closest properties in Kamator 2 and Kamathor, situated approximately 30 m from the proposed switchyard.	Large magnitude (2)	-
	Approximately 25 properties in Kamange and all properties in Kamator 1	-	Minor
	Approximately 8 properties in Kamange	-	Moderate
	All properties in Kamator 2 and Kamathor	-	Large magnitude (2)
Site installation areas	Approximately 20 properties in Kamange	Minor	1
	Approximately 10 properties in Kamange	Moderate	1
	Approximately 40 properties in Kamange and all properties in Kamator 2 and Kamathor	Large magnitude (2)	1

1) Construction works will take place during the daytime only.
2) Further mitigation to reduce the significance of these large magnitude impacts is described below *Table 7.10*.

Table 7.16 Summary of Residual Impacts at the Yiben Worksite

Construction activity	NSRs Potentially Affected	Predicted Residual Impact	
		Day	Night
Whilst dam works occur at the same time as powerhouse and tailrace works and whilst dam works occur at the same time as switchyard works	Yiben	Negligible	Minor
	Sawule 1 and Sawule 2	Negligible	Moderate
Quarry operation	Kamawewe	Between small and large (expected to be above medium for the majority of the life of the quarry). (2)	1
Batching plant located close to the quarry	Kamawewe	Not significant	Minor

1) Construction works will take place during the daytime only.
2) Further mitigation to reduce the significance of these large magnitude impacts is described below this table.

Some Large magnitude impacts are reported in *Table 7.15* and *Table 7.16*. Noise trigger levels for noise insulation or temporary re-housing are set out in *Annex C* which align with the level for a large magnitude impact (ie above 65 dB(A) during the day and 55 dB(A) at night). Where they are predicted to be exceeded:

- where the duration of the impact meets the requirements for further mitigation, these impacts will be mitigated. Details are presented in *Annex C;* and

- where these impacts are expected to last for a shorter period of time, the significance of the impact is considered to be moderate as a result of the shorter duration of the impact.

No impacts above **Negligible** are expected from works to construct the transmission line between the Yiben and the Bumbuna Extension switchyard.

A number of properties lie close to the transmission line between Bumbuna Extension switchyard and the proposed WAPP substation. Should towers be located close to these settlements, impacts up to large may be experienced during the daytime only. However, as the construction of each tower will be relatively brief, up to two weeks, the trigger for further mitigation (which includes threshold relating to duration) is unlikely to be exceeded. The significance of this impact is considered **Moderate** because of the short duration.

Road works will take place during the daytime only. At Yiben impacts are predicted to be **Negligible**.

NSRs in Kamator 2 will be situated up to 200 m from works to relocate the Bumbuna hydro dam access road, resulting in a medium daytime impact. However, as works will be relatively brief at individual NSRs, up to two weeks, the significance of this impact is considered **Minor**.

NSRs in Kamator 1 will be situated up to 100 m from works to construct an access road from the Bumbuna hydro dam access road to the surge shaft, resulting in a large impact. However, as works will be relatively brief at individual NSRs, up to two weeks, the significance of this impact is considered **Moderate**.

No significant impacts are predicted from the operation of the waste management facility, which will operate during the daytime only.

Noise impacts on smaller roads close to the Project site from deliveries of materials and equipment from Freetown (which will approach the Project site during the daytime only) are expected to be relatively infrequent and are not expected to give rise to impacts above **Moderate** at nearby NSRs.

Within the Project site, construction traffic may result in significant noise levels. Without further mitigation, impacts at NSRs nearby are expected to be **Medium** to **Large** and may be sufficient to increase overall construction noise levels at NSRs close to the traffic routes.

Noise trigger levels for noise insulation or temporary re-housing set out in *Annex C*, which align with the level for a large magnitude impact (ie above 65 dB(A) during the day and 55 dB(A) at night), are predicted to be exceeded:

- where the duration of the impact meets the requirements for further mitigation, these impacts will be mitigated. Details are presented in *Annex C*; and

- where these impacts are expected to last for a shorter period of time, the significance of the impact is considered to be moderate as a result of the shorter duration of the impact.

Vibration impacts from the use of vibratory rollers to construct the RCC dam are predicted to be **Negligible**.

Vibration impacts from driven piling to construct the cofferdam at the power intake for the Bumbuna Extension and the river diversion at the Yiben dam are predicted to be **Negligible**.

Vibration impacts from the use of a hydraulic vibratory compactor during earthworks and site levelling at the switchyard and installation areas at the Yiben dam are predicted to be **Negligible**. At the Bumbuna Extension, the closest properties to the switchyard and installation areas may experience significant vibration impacts during the day and night. However, properties that would be close enough to experience impacts above moderate are likely to be re-housed as a result of noise effects from these works.

Impacts from blasting will be **Minor** or below at all NSRs.

Operation

The HEP turbines, which will be located in the Bumbuna Extension and Yiben dam power houses and at the Bumbuna I Environmental Flow outlet will be enclosed within the building structure. They will be designed to meet a free-field noise level, $L_{Aeq,1h}$, of 42 dB at the nearest NSRs to ensure that noise effects from their operation are **Minor** or below at all NSRs.

7.6 GEOLOGY AND SOILS

7.6.1 Introduction

The full Geology and Soils impact assessment is presented in *Volume II*, *Annex D* of this ESHIA Report. The Geology and Soils impact assessment presents a detailed description of the socio-economic environment, significant impacts and mitigation measures. The sections below summarise the findings of the Geology and Soils impact assessment.

7.6.2 Summary of Significant Construction Impacts

Most of the effects on soils for the entire Bumbuna II occur during the construction of the dam and supporting infrastructure, and in the flooding and commissioning of the Yiben reservoir and water channels.

The following effects are likely or certain to lead to negative impacts during the construction phase of the Project.

Soil lost under water

Soil lost under water by the land-take of approximately 115 km² under the Yiben reservoir, considered to be large magnitude. The effects of this are considered permanent or long-term. Prior to inundation, the Yiben reservoir will be subject to the construction of temporary roads, construction traffic and movement of plant, for timber clearance and to assist in the resettlement program. The nature and extent of timber clearance and temporary road construction in the Yiben reservoir is not yet specified, but the impacts to the soils caused will be short term before the whole area is flooded and are not considered as a separate soil impact.

However, the extent to which timber clearance and temporary road construction lead to freshly disturbed soils forming the floor of the Yiben reservoir will have direct consequences on the dissolved chemical and suspended solid load in the newly forming reservoir, with potential knock-on effects on dissolved oxygen and carbon levels and other key water quality indicators. The impact significance prior to mitigation is assessed as **Major**.

Saturation of the shallow soils

Saturation of the shallow soils on the periphery of Yiben reservoir would occur as the reservoir water body forms over the first two rainy seasons after construction is complete and the Yiben dam is commissioned into service. Previous elevated land just above the planned operating elevation (*POL*) of +320 mASL will become saturated resulting in a complete alteration to character of the soils. Although this may promote the formation of new wetland areas, to positive effect; they would replace the existing wetland/shallow groundwater areas formed mainly on alluvial soils (silts, sands, peats) with areas of residual ferrallic sandy loam soils with a totally different physical, chemical and biological character.

Fluctuations between the planned operating elevation and the minimum operating level (*MOL*; at +300 mASL) would cause further disruption to the character of the adjacent soils and lake bed sediments. Effects are considered permanent or long-term and the total areas affected likely to be large (approximately 115 km^2), but overall considered to be medium magnitude as soils would be able to re-establish over time. The impact significance prior to mitigation is assessed as **Moderate**.

Changes of land use

Changes of land use in the new areas of resettlement and agriculture as communities are relocated from the Yiben reservoir to peripheral areas. Soils are likely to be disturbed and exposed in new residential areas, roads, agricultural fields and other infrastructure. Whilst disturbance is certain to happen, impacts may not be entirely negative as agricultural processes may improve quality and overall value. The total number of new communities to be developed is unknown at present but it is likely to amount to some degree of soil disturbance. Overall magnitude is considered to be small as there are likely to be some positive impacts as well as negative, and those negatively impacted soils would be able to re-establish over time. The impact significance prior to mitigation is assessed as **Minor**.

Excavation, site clearing and levelling

Excavation, site clearing and levelling works for construction of Yiben, including the dam structure and footings itself, the offices, tunnel, construction camp, workshop and stores, construction areas, quarry and batch plant sites. Similar works at the Bumbuna Extension (excluding the dam structure, but including a tailrace canal) are over a smaller area, but much of this is in areas already disturbed by the Bumbuna dam and its access roads. Although the site area envelopes for the Yiben dam and Bumbuna Extension project components are large (146 ha and 114 ha respectively), new areas requiring clearance and excavation are a fraction of this total (10s ha), but because these impacts are considered to be permanent or long-term they are considered collectively as being of large magnitude. The impact significance prior to mitigation is assessed as **Major**.

Dumping/stockpiling of soils, weathering zone material and bedrock

The bedrock excavated comprises granite and granodiorite, and although sulphides may be present, these are minor constituents and given the relatively small volumes of bedrock exposed, issues from acid rock drainage (*ARD*) are not considered likely to be significant. Weathered rock, saprolite and soils are already leached and oxidized to varying extent, and so present even less ARD risk. Weathering and run-off erosion of the waste rock stockpiles and dumps may present an impact to surface water quality and is discussed in further in *Volume II Technical Annex E; Water Resources and Ecological Flow.* If no topsoil recovery or management is proposed then these would be buried under waste material stockpiles. Effects are considered permanent or long-term but the total areas affected are small (<10 ha); considered collectively as being of small magnitude. The impact significance prior to mitigation is assessed as **Minor**.

Construction of permanent roads

Effects are considered permanent or long-term but the total areas affected are small (<10 ha); considered as being of small magnitude. The impact significance prior to mitigation is assessed as **Minor**.

Construction of temporary roads

Construction of temporary roads, construction traffic, movement of plant around Yiben dam and construction camp areas. Effects are considered temporary and the total areas affected are small (<10 ha); considered collectively as being of small magnitude. The impact significance prior to mitigation is assessed as **Minor**.

The following effects are consider as potentially likely to occur and lead to negative impacts during the construction phase of the Project.

Accidental spillages

Accidental spillages from the refuelling of vehicles and use of oils during vehicle maintenance and the construction and installation of power station plant and equipment could occur in the camp and workshops area, as well as the power plant fabrication yards and installation areas, but could also occur anywhere vehicles and plant are operating. Individual spill events are likely to negligibly small, however, cumulative events may result in an impact over a small area (<10 ha) that if left unrecognised or unresolved would result in a long-term effect; in this case considered as being of medium magnitude. The impact significance prior to mitigation is assessed as **Moderate**.

Accidental leakage

Accidental leakage from the storage of fuels, oils and other hazardous materials could occur in the camp and workshop and storage areas, but could also occur anywhere vehicles and plant are operating or hazardous material

are being stored, handled or used. Individual leaks and spills event are likely to negligibly small, however, cumulative events may result in an impact over a small area (<10 ha) that if left unrecognised or unresolved would result in a long-term effect; in this case considered as being of medium magnitude. The impact significance prior to mitigation is assessed as **Moderate**.

7.6.3 Summary of Significant Operational Impacts

Most of the effects on soils during the operation of Bumbuna II occur in peripheral areas to the Yiben reservoir, or are related to potential effects from accidental spills and leaks.

The following effects are likely or certain to lead to negative impacts during the operation phase of the Project.

Saturation of the shallow soils

Saturation of the shallow soils on the periphery of Yiben reservoir will continue to impact the soils in that area throughout operations, as described above in the construction phase impacts. In addition, fluctuations during operations on a seasonal scale between the planned operating elevation and the minimum operating level would cause further disruption to the physical, chemical and biological character of the adjacent soils and lake bed sediments.

Cycles of saturation and drying, oxidation and reduction are anticipated to negatively impact soil quality, structure and its ability to host flora and fauna. Although these effects are temporary, they are likely to be repeated over the long term. The area of peripheral effect is likely to be hundreds of hectares, although fluctuation over minimum and maximum operating level (20 m elevation difference between POL and MOL) amounts to exposure of almost exactly half the 115 km^2 of the Yiben reservoir. Overall, these effects considered to be medium magnitude as soils would be able to re-establish over time. The impact significance prior to mitigation is assessed as **Moderate**.

Reduction in sediment transport downstream

Reduction in sediment transport downstream from the Yiben dam, reducing the opportunity for soil fertilization in the lower Seli valley and estuary is nullified by the immediate presence downstream of Bumbuna I which already has this effect and the addition of Yiben dam is not considered to be cumulative beyond the impact already caused by Bumbuna I. Because of this, this effect is not further assessed.

The following effects are considered as potentially likely to occur and lead to negative impacts during the operational phase of the Project:

Altered erosion / deposition of soils

Soils may be eroded in new areas and deposited in others (especially along the POL shoreline) due to the presence of standing water, changes to physical properties of soils or rejuvenation effects when the reservoir level falls. The duration and area of these effects are likely temporary and small, but they are likely to be repeated over the long term and so cumulatively may affect large areas (100s ha) and overall are considered to be medium magnitude as soils would be able to re-establish over time. The impact significance prior to mitigation is assessed as **Moderate**.

Accidental spillages

Accidental spillages from the refuelling of vehicles and use of oils during maintenance of vehicles and power station plant and equipment could occur in the office and power station areas, but could also occur anywhere vehicles and plant are operating. Individual spill events are likely to negligibly small, however, cumulative events may result in an impact over a small area (<10 ha) that if left unrecognised or unresolved would result in a long-term effect; in this case considered as being of medium magnitude. The impact significance prior to mitigation is assessed as **Moderate**.

Accidental leakage

Accidental leakage from the storage of fuels, oils and other hazardous materials could occur in the office, power station and storage areas, but could also occur anywhere fuel or hazardous material are being stored, handled or used. Individual leaks and spills event are likely to negligibly small, however, cumulative events may result in an impact over a small area (<10 ha) that if left unrecognised or unresolved would result in a long-term effect; in this case considered as being of medium magnitude. The impact significance prior to mitigation is assessed as **Moderate**.

7.6.4 Mitigation Measures

Details on the embedded mitigation and additional mitigation measures are provided in *Chapter 8 (Environmental, Social and Health Management Plans)* and in *Volume II, Annex D*.

7.6.5 Residual Impacts

With the implementation of mitigation measures in the ESHMP and Soil Management Plan, many of the impacts to soil expected during construction or operation can be reduced **Negligible** residual impact.

However, during the operational phase the residual impact significance for the four most significant effects remain until the decommissioning phase is complete. These are the temporary moderate and major residual impacts to soil due to the footprint of the Yiben reservoir and the low-lying land around the area. Land-take is an inevitable consequence of the development of new

reservoirs for hydro-power, exacerbated in this case by the low topographic gradients that result in large areas being flooded, and in large areas being cyclically exposed as the reservoir level fluctuates. The impacts to soils due to excavation, site clearing and levelling at both sites accumulates into impacts that even after mitigation are of moderate residual significance, until the land restoration programme is implemented in the future decommissioning phase (not considered in detail in this assessment).

Residual Soil Impact Significance following the Decommissioning Phase

Following the anticipated land rehabilitation and restoration as the dam and infrastructure is removed and the reservoir drained in the decommissioning phase, the long term impacts to inundated soils are expected to be **negligible** as the forest cover re-establishes over the period of decades.

7.7 WATER RESOURCES AND ECOLOGICAL FLOWS

7.7.1 Introduction

The full Water Resources impact assessment is presented in *Volume II, Annex E; Water Resources and Ecological Flow* of this ESHIA Report. The Water Resources impact assessment presents a detailed description of the hydrological environment, significant impacts and mitigation measures. The sections below summarise the findings of the Water Resources impact assessment.

7.7.2 Summary of Baseline Findings

Climate

Rainfall within the Study Area is typical of Sierra Leone's Tropical Rainforest. Distinct wet and dry seasons result from oscillation of the Inter-tropical Convergence Zone that is the interaction of warm dry air from the Sahara with more humid air moving inland from the coast. The wet season is typically from May to October and the dry season typically from November to April. Thunderstorms occur in the transition periods between the two seasons, accompanied by short periods of strong winds and heavy rain. Over the Seli River Basin, mean annual rainfall has been reported to vary from 2,634 mm at Bumbuna to 1,862 mm at Gberia Timbako, near the border with Guinea.

During the dry season, temperatures are high and humidity relatively low, driving evapotranspiration rates upwards. Relative humidity ranges from 40 to 70%. During the wet season relative humidity increases (70-80%) and the air temperatures are generally below the annual average of 25 °C, reducing the average rate of evapotranspiration.

March is usually the hottest month when temperatures reach an average maximum of 35 °C. As a result, the maximum monthly evaporation rate from the Bumbuna reservoir of around 170 mm usually also occurs in March. A

minimum of around 60 mm usually occurs in August, with a recorded annual total evaporation from the reservoir of 1,356 mm (1). Evaporation losses from the reservoir exceed rainfall input for about half of the year, although the annual net contribution from rain falling within the reservoir footprint, after accounting for evaporation, is still positive.

A summary of the meteorological conditions at Bumbuna, derived from regional meteorological stations at Kabala and Makeni, is presented in *Table 7.17*.

Table 7.17 Summary of Derived Mean Meteorological Data

Parameter	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Φ/Σ
Temperature (°C)	26.8	28.7	28.9	28.5	26.8	25.2	24.3	24.2	24.6	25.6	25.9	25.9	26.3
Rainfall (mm)	6	8	29	94	202	326	396	487	464	356	119	16	2503
Lake evaporation (mm)	135	141	174	145	123	108	79	66	74	89	103	118	1355

Hydrology

The Rokel River, also known as the Seli River upstream of Bumbuna, and its basin are the dominant hydrological feature within the Study Area and the third largest in Sierra Leone, covering a total drainage area of 10,622 km^2 with an annual average run-off of around 1,110 mm (2). The Rokel/ Seli River is approximately 380 km long, beginning at a height of around 900 m ASL within the interior plateau and hill ranges in the northeast of the country, near the border with Guinea. The river then flows southwest for approximately 100 km across the interior plateau, before cascading over the Bumbuna falls at the edge of the Sula Mountains and continuing southwest across the interior plains towards Freetown where it finally discharges into the Atlantic Ocean.

For around 30 km upstream of the Bumbuna I, the Seli River is contained within a major north-south tectonic fault-line that cuts to a base level of 160 m ASL and marks the boundary of the Gbengbe and Kabala granitoid hills to the west and the Sula Mountains to the east. It is this marked topography that the Seli River has exploited and which now forms the 'run of river' Bumbuna reservoir.

Upstream of Bumbuna dam, the rivers Wankatana and Mawoloko are major tributaries of the Seli. Their orientation is also tectonically controlled. Downstream of Bumbuna Falls, the Seli River leaves the Sula Mountains and is more commonly known as the Rokel River. Prior to the construction of Bumbuna dam, discharge in the Seli River was characterised as shown in *Table 7.18*.

(1) IFC 2012. Performance Standards on Environmental and Social Sustainability, published January 2012. Available in English at: http://www.ifc.org/wps/wcm/connect/115482804a0255db96fbffd1a5d13d27/PS_English_2012_Full Document.pdf?MOD=AJPERES.
(2) IFC 2012. Performance Standards on Environmental and Social Sustainability, published January 2012. Available in English at: http://www.ifc.org/wps/wcm/connect/115482804a0255db96fbffd1a5d13d27/PS_English_2012_Full Document.pdf?MOD=AJPERES.

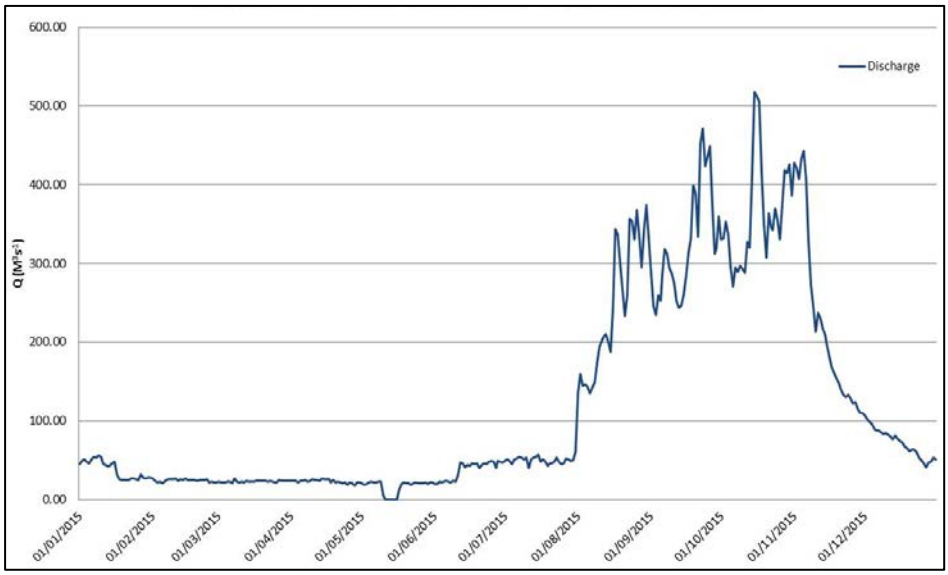
Table 7.18 Published discharge data for the Seli River (1997)

Basin	Area (km^2)	Gauge location	Area above gauge (km^2)	Flow (m^3s^{-1})		Average annual discharge (mm)	No. of years of data
				Min	Max		
Seli	10 622	Badala	2 525	1.2	503	546	5
		Bumbuna	3 990	0.4	1 052	888	9
		Magbass	4 700	2.0	1 905	-	-
Source: Akiwumi F.A. (1997) Conjunctive Water Use in An African River Basin: A Case Study in Poor Planning, in Sustainability of Water Resources Under Increasing Uncertainty, Proceedings of the Rabat Symposium, April 1997. IAHS Publ. No. 240, 1997.							

Since operation of Bumbuna dam commenced in 1999, flows in the Seli River have been subject to control through the operation of the Bumbuna I. Discharge data from the outlet of Bumbuna I (the Seli River) provided by the HEP Operators for 2015 are given in *Figure 7.3*.

Figure 7.3 illustrates the current attenuating effect of flows within the Seli River. During the dry season, flows are maintained at approximately 25 m^3s^{-1}. As water levels in the Bumbuna reservoir rise, power generation within the HEP is doubled, resulting in an increase in flow to approximately 50 m^3s^{-1}. This flow is maintained until the water level in the Bumbuna reservoir exceeds the maximum operational level, at which point any excess flows (above 50 m^3s^{-1}) bypass the HEP.

Figure 7.3 Flow within the Seli River downstream of Bumbuna HEP: 2015



River flow measurements made at Bumbuna Ferry Bridge during 1970-79, 3 km downstream of Bumbuna dam, indicate that the pre-impoundment average annual flow rate at Bumbuna was 3,482 Mm^3/a (110 m^3/s).

Up to this point in the operation of Bumbuna I, there has been a requirement for the Bumbuna I, to permanently and constantly pass a minimum flow to protect downstream ecological and community interests. This flow, referred

to as the Environmental Flow has been set at 6 m^3/s. This is currently achieved through the operation of Bumbuna dam environmental flow bypass, when water levels within the reservoir fall below operational levels for the HEP.

The Bumbuna dam environmental flow bypass is a manually operated function, and there is anecdotal evidence that the order to open the bypass is not always given. As such, there have been occasions since operation of the Bumbuna HEP commenced that the minimum environmental flow has not always been achieved (1).

Operation of the Bumbuna HEP since 2009 indicates that the average annual flow rate below Bumbuna dam is now 2,089 Mm^3/a (66 m^3/s) (2). The reduction in average annual flow since construction of the dam at Bumbuna is interpreted to be on account of evaporation and seepage losses from the impounded water body.

Surface Water Quality

Water quality within the Bumbuna reservoir has been regularly monitored by the Bumbuna Watershed Management Authority (BWMA) and has been reported within Quarterly Water Quality and Fisheries Monitoring Reports.

A review of the BWMA November 2012 to March 2013 report suggests that the surface water quality is healthy, with dissolved oxygen (DO) concentrations within WHO recommended limits. The Bumbuna dam Environmental and Social Advisory Panel Sixth Mission Draft Report (2013) provides evidence, however, that suggests this water quality may be limited to the upper few metres alone, suggesting that the water column within the reservoir is subject to eutrophication and stratification.

Independent measurements of surface water quality have been taken by ERM over two field surveys during 2016 (dry season and wet season). ERM's water quality survey indicates that water quality from upstream of the inundation area to downstream of Bumbuna dam is relatively uniform and of a good standard. Water samples reflect well oxygenated waters with well-balanced pH and only modest levels of available nutrients, such as compounds of nitrogen and phosphorous. It should be noted, however, that samples were collected from adjacent to the water's edge and from shallow water, therefore do not reflect deeper conditions within the main river or existing Bumbuna reservoir.

(1) IFC 2012. Performance Standards on Environmental and Social Sustainability, published January 2012. Available in English at: http://www.ifc.org/wps/wcm/connect/115482804a0255db96fbffd1a5d13d27/PS_English_2012_Full Document.pdf?MOD=AJPERES.
(2) IFC 2012. Performance Standards on Environmental and Social Sustainability, published January 2012. Available in English at: http://www.ifc.org/wps/wcm/connect/115482804a0255db96fbffd1a5d13d27/PS_English_2012_Full Document.pdf?MOD=AJPERES.

Hydrogeology

Bumbuna basin lies upon supracrustal crystalline rocks that form the hills and mountains of the region. These crystalline rocks typically possess low permeability and porosity due to the high temperatures and pressures under which they were originally formed. Even so, localised fractures and fissures are not uncommon and, where these occur, localised springs and limited groundwater supplies may be found. The movement of water through the sub-surface tends to reduce suspended solids and increase dissolved constituents. This generally improves water quality relative to surface water, which is more vulnerable to potential sources of pollution.

The regional geology of the area surrounding Bumbuna therefore favours surface runoff rather than infiltration, due to the relatively low permeability and porosity of the country rocks. This in turn creates a landscape that is drained by a dense network of streams and channels, often interspersed with poorly drained marshy areas in between these drainage features.

Groundwater resources in the Project area are of importance locally around Bumbuna and Fadugu; however, around 80% of total domestic needs are met by surface water. Where groundwater is present, shallow hand-dug wells tap into the unconfined (phreatic) crystalline aquifer to supplement the more abundant surface water supplies.

Phreatic aquifers are formed by weathered granitic and amphibolitic layers, over the fractured bedrock. The weathered layer is relatively permeable and extends to 10 m or more in flat low-lying areas such as Bumbuna and Fadugu, but can be less than a metre below ground on hill slopes.

Groundwater levels depend on effective infiltration (water reaching the aquifer after soil moisture deficit has been satisfied), and thus vary seasonally with changes in duration/intensity of rainfall. The water table rises in June to October and falls in the dry season, with wells in Bumbuna falling by around 5 m in March(1) . The Sula Mountains crystalline bedrock forms the basement of the area, and fracturing in the upper strata reduces to zero within 30 to 40 m of the surface, so bedrock at this depth can be considered impermeable with no deeper groundwater flow. The water table slopes steeply towards the river on both banks, so that rainfall, after saturating the overlying weathered surface, runs-off rapidly as surface water and shallow sub-surface flow.

7.7.3 *Summary of Significant Construction Impacts*

Table 7.19, Table 7.20, and *Table 7.21* summarise the identified impacts arising for the construction of the proposed project elements. The magnitude of change to direct receptors (surface water and groundwater) are assessed and the significance of effect this will have on the indirect receptors, which are vulnerable to potential impacts arising from development, is presented.

(1) IFC 2012. Performance Standards on Environmental and Social Sustainability, published January 2012. Available in English at: http://www.ifc.org/wps/wcm/connect/115482804a0255db96fbffd1a5d13d27/PS_English_2012_Full Document.pdf?MOD=AJPERES.

Table 7.19 Summary of Potential Impacts during construction of the Yiben dam and HEP

	Receptor	Impact During Construction Phase
Direct	Surface Water Quantity	Enhanced runoff from construction footprint / hardstanding area. Diversion of runoff from adjacent land. Short term prevention of flow downstream of Yiben dam
	Surface Water Quality	Downstream pollution caused by sediment erosion (and dust suppression) on site and/or accidental spillage of hazardous materials such as fuel, oil and foul wastes.
	Groundwater Quantity	Drainage and/or dewatering of foundation and tunnel operations locally intercept groundwater flow paths, re-shape the ambient groundwater table, and locally reduce existing spring flows.
	Groundwater Quality	Hazardous materials used during construction, such as fuels and oils, may be accidentally spilled. Also, tunnelling may mobilise naturally occurring constituents of concern that have the potential to cause pollution to groundwater.
Indirect	Aquatic ecology	Pollution risk arising from potential surface and groundwater quality impacts. Temporary reduction of flow in Seli River to facilitate construction
	Fish stocks	Pollution risk arising from potential surface and groundwater quality impacts.
	Communities / settlements within and around the inundation area	Pollution of and loss of water supply (drinking / washing). Loss of fishing opportunities within Seli River. Pollution / loss of water used for irrigation.

Table 7.20 Summary of Potential Impacts of Bumbuna II

	Receptor	Impact During Construction Phase
Direct	Surface Water Quantity	Enhanced runoff from construction footprint. Diversion of runoff from adjacent land.
	Surface Water Quality	Downstream pollution caused by sediment erosion (and dust suppression) on site and/or accidental spillage of hazardous materials such as fuel, oil and foul wastes.
	Groundwater Quantity	Drainage and/or dewatering of tunnelling operations locally intercept groundwater flow paths, re-shape the ambient groundwater table, and locally reduce existing spring flows.
	Groundwater Quality	Hazardous materials used during tunnelling, such as fuels and oils, may be accidentally spilled. Also, tunnelling may mobilise potentially contaminated land.
Indirect	Aquatic ecology	Pollution risk arising from potential surface and groundwater quality impacts.
	Fish stocks	Pollution risk arising from potential surface and groundwater quality impacts.
	Downstream communities / settlements	Pollution of water supply (drinking / washing) Loss of fishing opportunities within Seli River. Pollution of water used for irrigation.

Table 7.21 Summary of Potential Impacts of the Transmission Lines

	Receptor	Impact During Construction Phase
Direct	Surface Water Quantity	Diversion of runoff by new road.
	Surface Water Quality	High intensity rainfall runoff causing erosion of new road construction corridors and spoil heaps and/or accidental spillage of hazardous materials such as fuel, oil and foul wastes.
	Groundwater Quantity	Diversion of drainage and groundwater recharge pathways to water wells.
	Groundwater Quality	Hazardous materials used for new road and tower construction, such as fuel and oils, may be spilled during an accident and infiltrate groundwater.
Indirect	Aquatic ecology	Pollution risk arising from potential surface and groundwater quality impacts.
	Fish stocks	Pollution risk arising from potential surface and groundwater quality impacts.
	Downstream communities / settlements	Pollution of water supply (drinking / washing) Loss of fishing opportunities within Seli River. Pollution of water used for irrigation.

7.7.4 Summary of Significant Operation Impacts

Table 7.22, Table 7.23 and *Table 7.24* summarise the identified impacts arising from the operation of the proposed project elements. The operation of the Transmission Lines is a passive activity. Once constructed, the impacts on the water environment are negligible or the same as those identified for the construction phase (such as local changes in groundwater flow).

Table 7.22 Summary of Potential Impacts of Yiben

	Receptor	Impact During Operational Phase
Direct	Surface Water Quantity	Long term regulation of flows downstream of Yiben dam (higher flows in dry season, lower flows in wet season).
	Surface Water Quality	Reduction of surface water quality in Yiben reservoir (compared to Seli River quality) due to eutrophication within the reservoir due to changes in chemical composition following the saturation of shallow soils in the inundation area.
	Groundwater Quantity	Dam foundations and tunnel(s) intercept groundwater flow paths, re-shape the ambient groundwater table, impact spring flows.
	Groundwater Quality	Inundation of the large area of land may mobilise potentially contaminated land. Inundation of the large area of land may re-shape the ambient groundwater table, and locally impact existing spring flows.
Indirect	Aquatic ecology	Total loss of riparian habitat due to inundation of the river and banks. Discharge of deoxygenated (eutrophication) waters from Yiben reservoir into Bumbuna reservoir.
	Fish stocks	Pollution risk arising from potential surface and groundwater quality impacts.

	Receptor	Impact During Operational Phase
	Communities / settlements within and around the inundation area	Loss of income from artisanal mining. Loss of access and income from timber and non-timber forest products. Isolation of settlements around the reservoir area. Transmission of disease and ill-health related to water, hygiene and sanitation. Risk of drowning

Table 7.23 Summary of Potential Impacts of Bumbuna II

	Receptor	Impact During Operational Phase
Direct	Surface Water Quantity	Enhanced runoff from operational footprint. Diversion of runoff from adjacent land. Change in operational flow regime, increase in Seli River flows during dry season and reduction during wet season.
	Surface Water Quality	Downstream pollution caused by accidental spillage of hazardous materials, such as fuel, oil and foul wastes. Also, acid leaching from rock storage facilities.
	Groundwater Quantity	Tunnel(s) intercept groundwater flow paths, re-shape the ambient groundwater table, and locally reduce existing spring flows.
	Groundwater Quality	Change in groundwater flow paths caused by tunnelling may mobilise potentially contaminated land. Also, acid leaching from rock storage facilities.
Indirect	Aquatic ecology	Regulation of river flow downstream of Bumbuna dam. Reduction of water quality and habitat diversity from environmental flow discharge.
	Fish stocks	
	Downstream communities / settlements	

Table 7.24 Summary of Potential Impacts of the Transmission Lines

	Receptor	Impact During Operational Phase
Direct	Surface Water Quantity	Diversion of runoff by new road.
	Surface Water Quality	High intensity rainfall runoff causing erosion of road surface and/or road margins.
	Groundwater Quantity	Diversion of drainage and groundwater recharge pathways to water wells.
	Groundwater Quality	Hazardous materials transported along new access roads may spill during an accident and infiltrate groundwater.
Indirect	Aquatic ecology	As per construction phase
	Fish stocks	As per construction phase
	Downstream communities / settlements	As per construction phase

7.7.5 Mitigation Measures

In addition to the embedded mitigation which will be developed as part of the Water Resources, Drainage and Erosion Management Plan and Code of Construction Practice, the assessment has identified a number of potentially significant residual impacts related to water resources and environmental

flows that will require further consideration during the construction and operation of the Project. Details on the embedded mitigation and additional mitigation measures are provided in *Chapter 8 (Environmental, Social and Health Management Plans)* and in *Volume II, Annex D Geology and Soils*.

- The *temporary* reduction in flow in the Seli River during the construction of the Yiben dam will reduce flows to zero for a short period and result in significant (**Major** adverse) impacts on aquatic ecology, fish stocks and local communities.

- The *operation* of Yiben, and the flooding of the inundation area will result in the creation of the Yiben reservoir. Water quality modelling predicts that this waterbody will become eutrophic, and may result in a reduction in water quality both upstream and downstream of the dam. This is assessed as having a **Major** adverse impact on aquatic ecology, fish stocks and communities.

- The EFA studies have indicated that increasing the mean dry season flows will result in a degradation of sensitive shallow habitat conditions downstream of the tailrace.

The following management measures are proposed to mitigate these significant impacts where possible and bring the Project to a standard that can be acceptable to international financial organisations as far as is reasonably practicable.

Temporary reduction in flow in the Seli River during the construction of the Yiben Dam

This significant impact will be mitigated with the temporary use of water pumps, capable of maintaining an environmental flow of between 4 and 15 m^3s^{-1} which will be used to over-pump water from the Yiben reservoir into the Seli River to maintain the dry season flow requirements for the duration that the natural flows in the Seli River are prevented.

Reduced water quality within the Yiben Reservoir Inundation Area

At present, the degree of eutrophication and stratification likely to occur within the Yiben reservoir is not known. It is recommended that further studies are conducted to quantify the risk of eutrophication. The modelling work undertaken to date uses average spatial and temporal conditions within a single (lumped parameter) cell. Further studies would extend this to provide detail on the spatial and temporal distribution of any likely eutrophication at different depths and times of the year.

From this, it will be possible to quantify the level of mitigation required which may range from; reaeration using engineered turbulence inducing structures downstream of the dam and powerhouses; injection of oxygen at depth in the forebay; and or use of multi-level selective withdrawal structures that can

blend surface and bottom waters to maintain an acceptable level of oxygen in the release (ie, concentrations > 5.0 mg/l).

Increased water quantity downstream of the tailrace

The existing EFR for downstream of the Bumbuna reservoir has been re-assessed by Ecotone Freshwater Consultants CC (see *Appendix E1* to *Annex E Water Resources and Ecological Flow*) in light of latest and current ecological methods taking into account the needs of downstream aquatic habitats. In light of this, the existing (baseline) environmental flow has been found to be damaging to sensitive shallow aquatic habitats during the dry season and it has been found that the operation of the Bumbuna II will further affect these aquatic habitats by increasing flows above maximum limits during the dry season.

A number of alternative engineering options have been considered that could reduce the flow within the Seli River to achieve the EFR. However, all these options would have significant financial implications for the Project and would likely render the Project uneconomic. Consequently, it is not considered possible to mitigate these effects significant environmental effects downstream of the tailrace.

7.7.6 Residual Impacts

With the implementation of the mitigation measures outlined above, residual effects are generally reduced during construction or operation. The significance of effects after mitigation is presented in *Table 7.25* to *Table 7.27.*

Note that pre-mitigation impacts relating to the Yiben dam and HEP can be reduced to negligible levels through detailed design and construction management. However, the change in flow regime downstream of the Bumbuna dam will arise from the combined effect of the storage provided by the Yiben dam and the additional flows passing the newly constructed Bumbuna II. As such the change in flow regime (increased flows during the dry season and lower flows during the wet season) are an inherent feature of any HEP scheme and cannot be mitigated without excessive cost.

Table 7.25 Significance of Effect of Impacts of Yiben

Phase	Construction	Operation
SURFACE WATER EFFECTS		
Indirect –aquatic ecology		
Pre-Mitigation Impact Significance	**Major**	**Major**
Mitigation Measures	Over-pumping during construction	Modelling of reservoir. Reaeration Injection of oxygen Multi-level selective withdrawal structures
Post-Mitigation Impact Significance	**Negligible**	**Negligible**
Indirect – fish stocks		
Pre-Mitigation Impact Significance	**Major**	**Major**

Phase	Construction	Operation
Mitigation Measures	Over-pumping during construction	Modelling of reservoir. Reaeration Injection of oxygen Multi-level selective withdrawal structures
Post-Mitigation Impact Significance	**Negligible**	**Negligible**
Indirect – Communities / settlements within and around the inundation area		
Pre-Mitigation Impact Significance	**Major**	**Major**
Mitigation Measures	Over-pumping during construction	Modelling of reservoir. Reaeration Injection of oxygen Multi-level selective withdrawal structures
Post-Mitigation Impact Significance	**Negligible**	**Negligible**
GROUNDWATER EFFECTS		
Indirect –aquatic ecology		
Pre-Mitigation Impact Significance	**Negligible**	**Negligible**
Mitigation Measures	N/A	N/A
Post-Mitigation Impact Significance	N/A	N/A
Indirect – fish stocks		
Pre-Mitigation Impact Significance	**Negligible**	**Negligible**
Mitigation Measures	N/A	N/A
Post-Mitigation Impact Significance	N/A	N/A
Indirect –communities / settlements		
Pre-Mitigation Impact Significance	**Negligible**	**Negligible**
Mitigation Measures	N/A	N/A
Post-Mitigation Impact Significance	N/A	N/A

Table 7.26 Significance of Effect of Impacts of the Bumbuna II

Phase	Construction	Operation
SURFACEWATER EFFECTS		
Indirect – aquatic ecology		
Pre-Mitigation Impact Significance	**Negligible**	**Major**
Mitigation Measures	N/A	None
Post-Mitigation Impact Significance	N/A	**Major**
Indirect – fish stocks		
Pre-Mitigation Impact Significance	**Negligible**	**Major**
Mitigation Measures	N/A	None
Post-Mitigation Impact Significance	N/A	**Major**
Indirect - Downstream communities / settlements		
Pre-Mitigation Impact Significance	**Negligible**	**Major**
Mitigation Measures	N/A	None
Post-Mitigation Impact Significance	N/A	**Major**
GROUNDWATER EFFECTS		
Indirect – aquatic ecology		
Pre-Mitigation Impact Significance	**Negligible**	**Negligible**
Mitigation Measures	N/A	N/A

Post-Mitigation Impact Significance	N/A	N/A
Indirect – fish stocks		
Pre-Mitigation Impact Significance	**Negligible**	**Negligible**
Mitigation Measures	N/A	N/A
Post-Mitigation Impact Significance	N/A	N/A
Indirect - Downstream communities / settlements		
Pre-Mitigation Impact Significance	**Negligible**	**Negligible**
Mitigation Measures	N/A	N/A
Post-Mitigation Impact Significance	N/A	N/A

Table 7.27 Significance of effect of impacts of the Transmission Lines

Phase	**Construction**	**Operation**
SURFACE WATER EFFECTS		
Indirect - aquatic ecology		
Pre-Mitigation Impact Significance	**Negligible**	**Negligible**
Mitigation Measures	N/A	N/A
Post-Mitigation Impact Significance	N/A	N/A
Indirect - aquatic ecology		
Pre-Mitigation Impact Significance	**Negligible**	**Negligible**
Mitigation Measures	N/A	N/A
Post-Mitigation Impact Significance	N/A	N/A
Indirect - aquatic ecology		
Pre-Mitigation Impact Significance	**Negligible**	**Negligible**
Mitigation Measures	N/A	N/A
Post-Mitigation Impact Significance	N/A	N/A
GROUNDWATER EFFECTS		
Indirect - aquatic ecology		
Pre-Mitigation Impact Significance	**Negligible**	**Negligible**
Mitigation Measures	N/A	N/A
Post-Mitigation Impact Significance	N/A	N/A
Indirect - aquatic ecology		
Pre-Mitigation Impact Significance	**Negligible**	**Negligible**
Mitigation Measures	N/A	N/A
Post-Mitigation Impact Significance	N/A	N/A
Indirect - aquatic ecology		
Pre-Mitigation Impact Significance	**Negligible**	**Negligible**
Mitigation Measures	N/A	N/A
Post-Mitigation Impact Significance	N/A	N/A

7.8 BIODIVERSITY

7.8.1 Introduction

The full Biodiversity Impact Assessment is presented in *Volume II*, *Annex F; Biodiversity* of this ESHIA Report and details the species of conservation concern which may be affected by the Project. The Biodiversity Impact Assessment provides a description of the current baseline biodiversity conditions in the Project Area of Influence (AoI) and assesses the potential Project impacts, both during construction and as a result of operation, on that baseline.

The baseline characterisation includes an assessment of the presence of modified, natural and critical habitat as defined by International Finance Corporation (IFC) Performance Standard 6 (PS6) (1). The assessment of adverse impacts on biodiversity was undertaken with reference to the mitigation hierarchy as defined by IFC PS1 and PS6 (2) to ensure that appropriate avoidance, minimization and restoration measures have been applied sequentially to protect biodiversity and strive to achieve "not net loss and preferably a net gain of biodiversity", before options to design and implement biodiversity offsets are considered. Full details are presented in *Volume II, Annex F, Biodiversity*.

7.8.2 Baseline Data Collection

Based on the identified AoI and the assessment methodology set out in *Annex F*, ecological baseline data was compiled for the Project AoI by ERM; Royal Botanic Gardens, Kew; Tacugama Chimpanzee Sanctuary; Combined Ecology (the international consultancy division of BTO Services Ltd) and Ecotone Freshwater Consultants. Data collation included desk study of existing information and targeted field surveys.

Surveys were aimed at gathering baseline data on the key biodiversity groups known to be present, based on the initial desk based study, and to gather information on seasonal changes (including both wet and dry seasons) in species use of the Project AoI. Surveys were also undertaken at potential offset sites at Loma Mountains. Seasons, groups and areas covered during the field survey campaigns are outlined in *Table 7.28* and are presented in further detail in *Annex F; Biodiversity*.

(1) IFC 2012. Performance Standards on Environmental and Social Sustainability, published January 2012. Available in English at: http://www.ifc.org/wps/wcm/connect/115482804a0255db96fbffd1a5d13d27/PS_English_2012_Full Document.pdf?MOD=AJPERES.
(2) IFC 2012. Performance Standards on Environmental and Social Sustainability, published January 2012. Available in English at: http://www.ifc.org/wps/wcm/connect/115482804a0255db96fbffd1a5d13d27/PS_English_2012_Full Document.pdf?MOD=AJPERES.

Table 7.28 Surveys campaigns conducted on behalf of the Project

Date	Team	Coverage	Study scope
Dry season 2014 (May-June 2014)	Royal Botanic Gardens, Kew	Western portion of the Yiben inundation zone, transmission line and Bumbuna Extension area	Habitats and flora
	Tacugama Chimpanzee Sanctuary	Western portion of the Yiben inundation zone	Large and small mammals
	Combined Ecology		Bats, birds, fish
Dry season 2016 (March- April)	Royal Botanic Gardens, Kew	Central and eastern portions of the Yiben inundation zone	Habitats and flora
	Tacugama Chimpanzee Sanctuary		Primates and other large mammals
	Combined Ecology		Bats, amphibians, reptiles, birds, fish
Wet season 2016 (June-July)	Local botanist Joseph Momoh	Yiben inundation zone and Bumbuna Extension area, including Transmission Line	Flora, with a focus on species of conservation concern expected to flower in this period
	Tacugama Chimpanzee Sanctuary		Primates and other large mammals, with a focus on chimpanzees
	Combined Ecology		Pygmy hippo, Slender-snouted crocodile, vulture species
	Ecotone	Seli River downstream of Yiben dam location, downstream of Bumbuna dam and tributary within tailrace footprint	Fish, aquatic macroinvertebrates, diatoms

7.8.3 Summary of Baseline Findings

Legally Protected and Internationally Recognised Areas of Conservation Interest

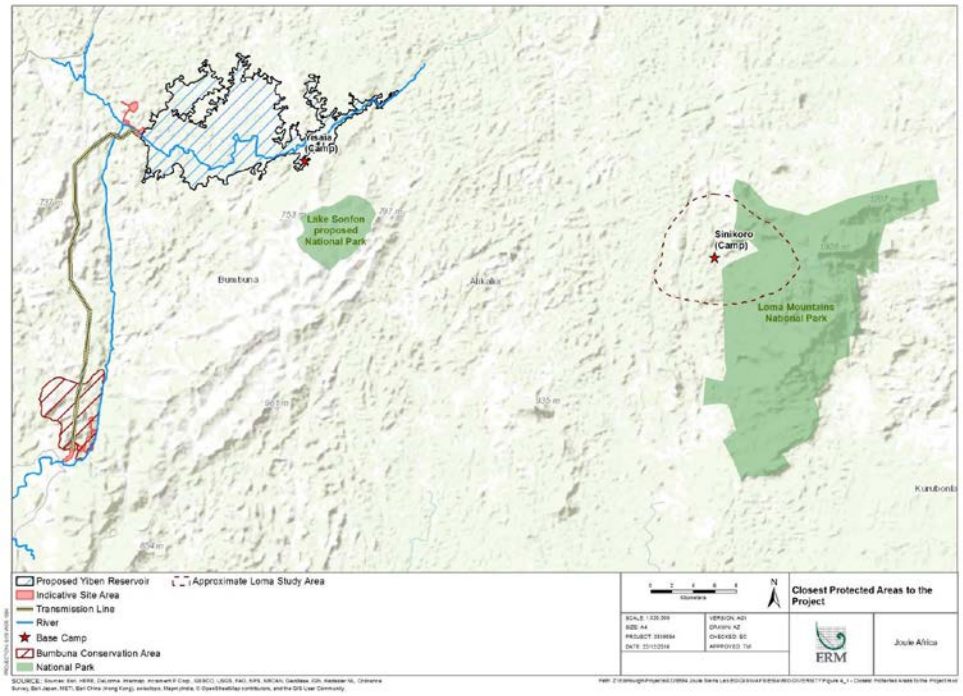
As described in *Section F4.2 Annex F; Biodiversity* no internationally recognised areas of conservation importance, or nationally recognised areas of high biodiversity value that meet IUCN Protected Area Management Categories Ib or II, are located within the Project footprint. The closest nationally recognised IUCN Category Ib or II areas are Lake Sonfon proposed National Park (also an Important Bird and Biodiversity Area, IBA) and the aforementioned Loma Mountains National Park; which are located approximately 4 km south of the Yiben inundation area (26 km northeast of the Bumbuna Extension area) and 30 km southeast of the Yiben inundation area (60 km northeast of the Bumbuna Extension area) respectively

The Bumbuna Conservation Area (BCA) is a legally protected area approximately 30 km in size located at the southern end of the current Bumbuna reservoir. The BCA was created through the *Bumbuna Watershed Management Authority (BWMA) and the Bumbuna Conservation Area Act* in 2008 to act as an area of biodiversity conservation. The primary aim of the BCA

was to establish a protected area to safeguard West African Chimpanzees (*Pan troglodytes ssp. verus*) present in the area

A small area (approximately 0.5 km²) of the BCA is located within the Project footprint as currently shown on the map. It has however been agreed that the transmission line will be rerouted around the BCA to avoid it in the final design, so there will be no direct impacts on the BCA. Lake Sonfon and the Bumbuna Conservation Area (BCA) both lie within the Project AoI. These areas are shown in *Figure 7.4*.

Figure 7.4 Closest actual and proposed Protected Areas to the Project, showing the Study Area at Loma



Habitat Types and Plants of Global Conservation Concern

As described in *Section F4.3 of Annex F Biodiversity*, surveys indicate that the Project AoI area supports a mosaic of modified and natural habitat, consisting of agricultural land, grassland, woodland, forest and small areas of swamp. Parts of the AoI have been cleared for agriculture using traditional slash and burn methods.

Small areas of grassland are predominantly found on the top of hill ridges, with woodland and degraded forest interspersed with grassland on the hill slopes. These hill slope forests support a number of species of conservation concern. Farms and farmbush/ forest re-growth are found on the lower slopes of hills, and inland valley swamps are present around streams along the valley floors, some of which have been cultivated for rice.
Some woodland species remaining after clearance of the land for agriculture and the cleared land is gradually colonised and evolves through succession to

wooded grassland and woodland again. This dynamic mosaic of modified and natural habitats contains various degrees of biodiversity value of importance to conservation.

Narrow, often degraded strips of riparian forest, are present along the banks of the River Seli and adjoining tributaries in the Yiben area. Whilst much of the riparian forest throughout the Project AoI has experienced some degree of degradation (primarily through farming, plank production and pole cutting), some wider, more intact patches remain, particularly at confluence points of tributaries with the Seli River in the Yiben AoI.

The riparian forest contains a number of species of conservation concern and is a remnant of species-rich primary rainforest. The Seli River channel supports a vegetation community which includes plant species adapted to the habitats found on seasonally inundated rapids and the river banks. These habitats support a number of species of conservation concern, either as assessed by IUCN; or through an updated assessment by recognised species experts at Royal Botanical Gardens Kew (RBGK). These species include one species assessed as globally critically endangered (CR), three assessed as globally endangered (EN) and a further six restricted range (RR) species. The key plant species, for both terrestrial and riparian habitats, are listed outlined in *Box 7.2* below.

Box 7.2 Key Baseline Plant Receptors

- **CR** - *Ledermanniella sp* nov. - a new to science species of river weed, recorded for the first time in 2016 from a rapid on the Seli River within the inundation area and known globally from this single location. Assessed by species experts at RBGK as CR since it is only known from this single location. .
- **EN** - *Ledermanniella aloides*, a river weed species recorded in the vicinity of the proposed Yiben dam in 2016 and upstream in the Seli catchment. *Vepris felicis*, a shrub restricted to the Upper Guinean Forest, known from only seven-eight localities and recorded from riparian forest in the Project AoI. *Stylochaeton pilosus*, a restricted range species only recorded from the Upper Guinean Forest and only known from five localities recorded from riparian forest in the Project AoI.
- **RR** – six tree, shrub and liana species with a known restricted range in Sierra Leone, Liberia or Guinea, and recorded within the Project AoI.

Invasive Alien Plant Species

A range of invasive alien plant species have been recorded within habitat types that are present within the Project AoI. These occur predominantly in secondary modified habitats.

A community of both alien and native weedy herbaceous species occur just downstream of the Yiben dam location, at the upper limit of Bumbuna reservoir. As the water level in Bumbuna reservoir is usually lower than maximum the sandy and muddy lake edges exposed at low water levels allow such a community to develop, which could be detrimental should invasive alien species become predominant. The key invasive species recorded from

the Project AoI are *Chromolaena odorata*, *Gmelina arborea*, *Mimosa pudica*, and *Albizia saman*

Bats

A total of 22 bat species including fruit bats and insectivorous species have been recorded in the Project AoI to date. Eight bat species of international conservation concern according to IUCN Red List criteria have been recorded. This includes one species assessed by IUCN as globally EN and two assessed as RR, as set out in *Box 7.3* below.

Box 7.3 Key Bat Species

- **EN** - Ziama Horseshoe Bat (*Rhinolophus ziama)* endemic restricted range species of Upper Guinean Forest recorded from as few as five locations. Recorded from riparian habitat north of Bumbuna dam.
- **RR** – Aellen's Roundleaf Bat *(Hipposideros marisae)* globally vulnerable species recorded from Guinea, Liberia, Cote d'Ivoire and Sierra Leone recorded from around the Yiben area. *Neoromicia* aff. *Nana (or Pipistrelle aff. nanus)* possible new to science bat species recorded within an area behind the Bumbuna dam.

Primates and other Medium/Large Mammals

A range of mammal species have been recorded from within the Project AoI. Surveys to date indicate a total of 42 mammal species, including seven primate species.

Eight terrestrial mammal species of conservation concern (1) have the potential to be affected by the Project. This includes two species assessed by IUCN as globally EN as set out in *Box 7.4* below.

Box 7.4 Key Primates and other Medium/Large Mammal Species

- **EN** - West African Chimpanzee (*Pan troglodytes ssp. verus*) restricted to West Africa and facing a range of population pressures. A chimpanzee community (the 'Dynamite community') of 6 to 15 individuals has been recorded over numerous years between 2006 and 2013 from within the Bumbuna Extension AoI. Chimpanzee evidence was recorded in the eastern buffer zone of the Yiben inundation area in 2014, and in 2016 chimpanzees were recorded in at least five different locations in the Yiben region. Pygmy hippopotamus (*Choeropsis liberiensis*) is endemic to the Upper Guinnean Forest in Sierra Leone, Guinea, Cote d'Ivoire and Liberia. Recorded in 2006 and 2013 from tributary streams of the Seli River near the village of Yiben (32 km north of Bumbuna dam). Not recorded during surveys in 2016.

Birds

Surveys to date indicate the presence of a total of 277 bird species in the Project AoI. The diversity of species within the Bumbuna dam watershed, in

(1) IUCN asses a taxon as Data Deficient when there is inadequate information to make a direct, or indirect, assessment of its risk of extinction based on its distribution and/or population status

addition to the presence of IUCN Threatened species, could potentially qualify the area as an IBA as defined by Bird Life International criteria [1].
Seven bird species of conservation concern [2] have the potential to be affected by the Project. This includes one species assessed by IUCN as CR, as set out in *Box 7.5* below.

Box 7.5 Key Bird Species

- **CR** - Hooded Vulture (*Necrosyrtes monachus)* is a widespread species, but one which has suffered very rapid population decline over recent years leading to its assessment as CR. Recorded flying over the inundation area during 2014 and 2016.

Reptiles and Amphibians

A wide range of reptile and amphibian species have been recorded from within the Project AoI. A review of past surveys indicates that a total of 41 reptile species and 42 amphibian species have been recorded.

Thirteen amphibian species and four reptile species of conservation concern [3] have the potential to be affected by the Project. This includes one CR species, one EN species and one Data Deficient (DD) species as set out in *Box 7.6* below.

Box 7.6 Key Reptile and Amphibian Species

- **CR** - Slender-snouted Crocodile (*Mecistops cataphractus*) has undergone rapid population decline and listed as CR in 2013. Has highly fragmented population, with as few as 50 individuals left in West Africa. Recorded on a tributary of the Seli River in 2006, and reported by local during dry season survey in 2016. No reports during targeted questioning during wet season survey and no records from camera trapping surveys.
- **EN** – Freetown Long-fingered Frog *(Arthroleptis aureoli/ Cardioglossa aureoli)* previously only **recorded** from the Freetown peninsula in Sierra Leone. Recorded from forest patches near the Bumbuna dam in 2013 and the Yiben inundation area in 2016.
- Data Deficient (DD) [4] and possibly RR Cameroon Grassland Frog *(Ptychadena retropunctata/ Ptychadena* (cf) *retropunctata)* species distribution, population size, ecological requirements and threats are unknown. It was previously only known globally from two locations. Recorded in 2013 from near the Salcost camp and also an area north of the Bumbuna dam. Recorded in 2016 from the Yiben inundation area.

Invertebrates

A diverse range of butterfly species have been recorded from within the Project AoI and wider Bumbuna and Yiben area during previous surveys of these areas conducted in 2006 and 2013. The 2013 survey recorded 187 species

(1) IUCN asses a taxon as Data Deficient when there is inadequate information to make a direct, or indirect, assessment of its risk of extinction based on its distribution and/or population status
(2) IUCN asses a taxon as Data Deficient when there is inadequate information to make a direct, or indirect, assessment of its risk of extinction based on its distribution and/or population status
(3) IUCN asses a taxon as Data Deficient when there is inadequate information to make a direct, or indirect, assessment of its risk of extinction based on its distribution and/or population status
(4) IUCN asses a taxon as Data Deficient when there is inadequate information to make a direct, or indirect, assessment of its risk of extinction based on its distribution and/or population status

of butterfly from the wider area. Although not evaluated by the IUCN, based on the results of both the 2006 and 2013 surveys, eight endemic or restricted range butterfly species (1) have the potential to be affected by the Project. The four species recorded from the AoI, have all been recorded from the wider area. The eight species are listed in *Annex F Biodiversity.*

Aquatic Habitat in the Bumbuna Extension AoI

Habitat within the main stem of the Seli River, in the reach immediately downstream of Bumbuna reservoir, is considered to have been modified by the construction of the Bumbuna dam. The river channel here has been heavily modified and the river has not consistently received the recommended environmental flow. The water it does receive is likely to be of lower quality (more anoxic and acidic), due to reservoir stratification (2).

During the dry season, flows have been observed to cease between the dam and the confluence with downstream tributaries

Within Bumbuna reservoir itself the habitat has dramatically changed since dam construction, with fast flowing river and tributary habitat having been replaced with deep lacustrine habitat. Surveys have found no emergent or floating vegetation in the reservoir to date. This limits habitat heterogeneity, however decaying trees underwater will provide some structural complexity and nutrient input. No evidence of organic pollution was found (3).

The Seli tributary upstream of Bumbuna Falls, which is situated between the proposed intake and tail race areas, is more steeply inclined and retains many of its fringing trees, though some sections have been cleared for agriculture.

Aquatic Habitat in the Transmission Line AoI

Aquatic habitat within the Transmission Line AoI comprises a number of perennial and seasonal tributaries which drain into the reservoir on a steep gradient. The habitat in the upstream stretches crossed by the transmission line are in a relatively pristine state, with clear water and fringing gallery forest along the larger tributaries and very little aquatic vegetation.

The upper transmission line crosses the Seli River itself close to the village of Yiben, downstream of the Mawoloko confluence. This section of the river becomes backed up during the wet season and is marked by the presence of numerous dead (drowned) trees which become exposed at lower water levels.

Aquatic Habitat in the Yiben AoI

Aquatic habitats within the Yiben inundation zone include the Seli River main stem and tributaries of varying sizes, with varying levels of fringing gallery forest cover and some areas of inland valley swamp. Some of the smaller

(1) The IUCN Red List of Threatened Species. Version 2014.2. <www.iucnredlist.org>. Downloaded on 16 October 2014
(2) The IUCN Red List of Threatened Species. Version 2014.2. <www.iucnredlist.org>. Downloaded on 16 October 2014
(3) The IUCN Red List of Threatened Species. Version 2014.2. <www.iucnredlist.org>. Downloaded on 16 October 2014

tributaries within the inundation zone cease flowing during peak dry season, either drying up completely or leaving a series of remnant pools along their length.

The main stem of the Seli River within the Yiben inundation zone is meandering with frequent rocky outcrops/rapids and mid-channel islands with intact gallery forest and patchy marginal/rock outcrop vegetation. The Seli in this area has been exploited by both artisanal and commercial gold miners in places; notably in the central inundation zone.

Aquatic Macro-Invertebrates

The majority of aquatic macro-invertebrate taxa in the Seli River system are insects. Other aquatic macro-invertebrates present include burrowing worms, molluscs and crustaceans (freshwater crabs and *Macrobrachium* shrimps) (1).

Some aquatic invertebrates known to occur in the Project AoI are responsible for the threats to human health listed below.

- **Malaria:** spread by *Anopheles* sp. mosquitoes, which lay their eggs in swamps and other areas of calm water.

- **River blindness:** members of the black-fly *Simulium damnosum* complex carry the nematode *Onchocerca volvulus* which causes river blindness. The black-fly lays eggs on rocks and vegetation in fast flowing water.

- **Bilharzia: spread** by the intermediate host snails *Bulinis* sp. and *Biomphalaria pfeifferi* (Gastropoda: Planorbidae), which are widespread in Sierra Leone, although distribution and abundance vary widely (2).

Fish

The combined results of studies of the Seli catchment undertaken since indicate the presence of at least 94 freshwater fish species, the majority of which have a conservation status of Least Concern (3). A full list of the surveys undertaken and species recorded is presented in *Annex F Biodiversity*. Additional marine/brackish water species may also occur in the middle to lower reaches of the river; however these species are considered to be outside the AoI of the Project. 26 freshwater fish species of conservation concern have the potential to be affected by the Project. *Box 7.7* below shows Key Fish Species.

The construction and operation of Bumbuna reservoir itself appears to have altered fish species distributions. It is likely that the stretch of the Seli River immediately downstream of the dam has become degraded and is unlikely to support the same fish fauna as before dam construction.

(1) The IUCN Red List of Threatened Species. Version 2014.2. <www.iucnredlist.org>. Downloaded on 16 October 2014
(2) The IUCN Red List of Threatened Species. Version 2014.2. <www.iucnredlist.org>. Downloaded on 16 October 2014
(3) The IUCN Red List of Threatened Species. Version 2014.2. <www.iucnredlist.org>. Downloaded on 16 October 2014.

Many of the fish species present within the Project AoI exhibit spawning migrations. Such migrations include movement into inundated floodplain areas to spawn, or upstream, including migration into tributary habitat.

Limited dissolved oxygen profile data collected in 2012 and 2013 suggest stratification in Bumbuna reservoir. Fish are therefore likely to be restricted to this upper layer, limiting productivity and favouring pelagic rather than demersal species

Box 7.7 Key Fish Species (Note: Aquatic Plants are covered in Box 7.2)

- **EN** *Marcusenius meronai*, restricted range mormyrid, endemic to Sierra Leone and according to IUCN known only from the Bagbe and Seli Rivers (2 locations). Extent of Occurrence and Area of Occupancy less than 5,000 km² and 500 km² respectively.
- *Enteromius liberiensis*, West African endemic cyprinid, living in streams and lakes. Estimated Area of Occupancy less than 500 km². Secondary records in the Yiben area occur mainly in the Mawoloko catchment. It is not possible to verify all secondary data records; however it is highly likely that records of *Enteromius liberiensis* in the Project AoI are misidentifications of the potentially new to science species *Enteromius* cf *trispilos*.
- **RR** -A further nine fish species with a known restricted range, endemic to Sierra Leone or West Africa. Includes cyprinids, cichlids, nothobranchiids, mormyrids and catfish.

New to Science

- *Chiloglanis sp. aff. occidentalis,* undescribed, new to science species from the family Mochokidae. *Chiloglanis occidentalis* within different West African river systems probably represent separate endemic species; therefore likely to be endemic to Sierra Leone.
- *Epiplatys sp.nov.,* undescribed, new to science species from the family Nothobranchiidae. Common in the Yiben study area, so further populations elsewhere are to be expected. However, in the absence of further information on distribution, it must be treated as a restricted range data deficient endemic.
- *Epiplatys sp. aff. njalaensis,* undescribed, new to science species from the family Nothobranchiidae. In the absence of further information on the distribution of this species, it must be treated as a restricted range, data deficient endemic.
- *Scriptaphyosemion cf. chaytori*, undescribed, new to science species from the family Nothobranchiidae. In the absence of further information on the distribution of this species, it must be treated as a restricted range, data deficient endemic.
- *Scriptaphyosemion wieseae*, recently described Sierra Leone endemic nothobranchiid, recorded only from the Seli River basin. In the absence of further information on the distribution of this species, it must be treated as a restricted range, data deficient endemic.

Potentially undescribed

- In addition to the new to science species, an additional three species were collected during project surveys which are potentially undescribed and require further investigation, including *Enteromius* cf *trispilos*, which may have been misidentified as *Enteromius liberiensis* during earlier surveys to inform the Bumbuna ESHIA

Based on the findings of the baseline characterisation, the Project AoI supports both natural and critical habitat as defined by IFC PS6. The Project AoI supports critically endangered and endangered and restricted range plant and animal species that meet critical habitat Criteria 1 and 2 and highly threatened ecosystems that meet Criteria 5. A summary of those biodiversity features which meet the criteria for critical habitat is presented in *Volume II, Annex F; Biodiversity*.

7.8.4 *Summary of Significant Construction and Operation Impacts*

A number of impacts to flora and fauna in and around the Project area will occur. The key predicted impacts are summarised below. A full presentation of the assessment of impacts is provided in *Volume II, Annex F; Biodiversity.*

Construction Impacts

During construction the following impacts on terrestrial biodiversity receptors are predicted.

- Permanent loss of terrestrial and riparian habitat under the direct footprint of Project infrastructure (including the Yiben dam, Bumbuna Extension, access roads, quarry and transmission line) and within the inundation zone.
- Deterioration of habitat through fragmentation and increased edge effect.
- Permanent loss of individuals and populations of plant species within the Project footprint and inundation zone.
- Introduction and spread of terrestrial invasive species.
- Permanent loss of supporting terrestrial habitat and associated impacts on mammals, birds, reptiles, amphibians and invertebrates of conservation concern and/or restricted range species.
- Disturbance and displacement of mammals, birds, reptiles, amphibians and invertebrates of conservation concern from the Project footprint and inundation zone.
- Fragmentation of habitat and populations of mammals of conservation concern and or/restricted range species.
- Direct mortality of mammals, birds, reptiles, amphibians and invertebrates due to collision/interaction with Project construction traffic or mobile equipment.
- Increased hunting pressure from construction of new roads, induced access and population influx.

During construction the following impacts on aquatic biodiversity receptors are predicted.

- Permanent loss of aquatic riverine habitat in the inundation zone and Bumbuna tailrace footprint.
- Temporary loss of downstream aquatic habitat during reservoir filling.
- Introduction and spread of aquatic invasive species.

- Degradation and loss of surface and ground water habitats due to sedimentation and pollution.

- Creation of barriers to migration and fragmentation of aquatic habitat as a result of construction of Project infrastructure.

Operation Impacts

During operation, the following impacts on terrestrial biodiversity receptors are predicted.

- Direct mortality of mammals, birds, reptiles, amphibians and invertebrates due to collision/interaction with Project operation traffic or mobile equipment.

- Increased hunting pressure from construction of new roads, induced access and population influx.

- Collision and electrocution with transmission line by birds.

During operation, the following impacts on aquatic biodiversity receptors are predicted.

- Loss of aquatic species in the inundation zone from the development of eutrophic conditions.

- Degradation of habitat and associated mortality of aquatic species downstream of Yiben dam and between Bumbuna dam and tailrace due to operational hydrological modifications.

- Degradation of habitat and associated mortality of aquatic species due to sedimentation and pollution from operational areas.

- Mortality of aquatic species due to entrainment by reservoir intakes and turbine strikes.

- Depletion of aquatic species populations as a result of overexploitation due to population influx and induced access.

The Major and Moderate significant impacts from construction and operation within the inundation area, Yiben dam, transmission line and Bumbuna Extension are summarised in *Table 7.29.*

7.8.5 *Mitigation Measures*

In line with the mitigation hierarchy approach, measures have been identified to avoid, reduce and restore the effects of the Project. Mitigation by design has been incorporated into the Project where possible. A number of potential mitigation measures which were considered (eg mitigation of the tailrace tributary along an alternative channel or decreasing flow output from the

Bumbuna Extension HEP to prevent downstream habitat degradation) were not possible to enact due to operational requirement or because they are not practicable. A summary of the key mitigation measure is presented below, and full details of all mitigation measures are presented in *Volume II Annex A Air Quality* and in *Volume II, Annex F; Biodiversity*.

Avoidance

- Clear demarcation of work areas and micro-siting to avoid sensitive habitat wherever possible.
- Practical and policy measures to prevent the introduction and spread of alien invasive species.
- Prohibition of hunting, fishing and gathering of forest products by Project personnel.
- Installation of anti-climb devices on electricity pylons within primate habitat.
- Exclusion zones around nesting species of conservation concern.
- Carcass removal procedure to safely remove the carcasses of any road killed animals from road sides, to discourage scavengers.
- Unless access to watercourses is essential as part of the construction activity, 50 m vegetated buffer areas will be maintained on either side of aquatic habitat.
- Construction in the Seli River channel and barrier creation will be avoided through the use of suspension towers for the main bridges.
- Hazardous substance storage/handling and water management measures to intercept and treat suspended sediments and potential pollutants, including foul water and sewage.

Minimisation

- Micro-siting and demarcation of work areas to minimise fragmentation.
- Implementation of a Vegetation Clearance Plan to displace animals from the inundation area and areas of habitation in advance of flooding and check surveys prior to clearance works; including check surveys and a watching brief by an ecologist during clearance itself to manage encounters between fauna and construction crews.
- Translocation of faunal species of conservation concern to suitable receptor sites.

- Staff training and community engagement to raise awareness of biodiversity issues.

- Location of noise and light-generating equipment to minimise disturbance impacts on fauna.

- Management of the reservoir for the benefit of species likely to remain within the area following inundation, including retaining a proportion of trees within the area to be inundated through managed clearance, to increase habitat diversity.

- Erosion control measures; including the avoidance of construction during peak rains to the extent possible and minimisation of the time between biomass clearance and inundation and thus restrict downstream sediment transport due to runoff.

- Slow, gradual filling of the reservoir to allow aquatic species which require flowing water more time to seek refuge upstream.

- Access road crossings on tributaries will use fords or open span bridges where possible/appropriate to minimise impacts and any culverts necessary will be installed at a level such that they will not become a barrier to movement of aquatic fauna, and will be appropriately sized and maintained to prevent blockage.

- Trash screens fitted to the intake structures will be sized to be as small as practical whilst maintaining hydraulic head, to minimise entrainment of aquatic species.

- A Reservoir Fisheries Management Plan will include measures to educate local communities and enforce practices to promote the sustainability of the fishery, including the establishment of no-take zones to protect juveniles and closed season to protect spawning adults and important breeding grounds.

Restoration

- Restoration of temporarily disturbed areas following construction to maximise biodiversity value and stabilise ground.

- Translocation and, where this is not possible, propagation of important botanical species to be lost to the Project footprint.
- Maintenance of an environmental flow downstream of Yiben dam during construction, reservoir filling and maintenance.

- Maintenance of an optimal environmental flow as necessary downstream of Bumbuna dam to the deprived reach between the dam and the tailrace.

In addition to the Project mitigation commitments, a long term Biodiversity Monitoring Programme will be developed, with results feeding into adaptive management of biodiversity impacts.

7.8.6 Residual Impacts

A number of the Project effects on biodiversity receptors relate to impacts which cannot be avoided, reduced or restored despite the application of mitigation measures (eg inundation of the reservoir area). As a result despite the application of the mitigation measures summarised above, some residual impacts remain of the same magnitude pre and post mitigation. A summary of the residual impacts following the implementation of mitigation on moderate and major significant impacts is provided in *Table 7.29.*

Significant residual impacts were identified including those relating to high sensitivity/value receptors set out in *Box 7.8*.

The final stage of the mitigation hierarchy provides opportunity to consider additional conservation actions and compensation/offsetting for impacts with the aim of achieving no net loss (NNL) and for critical habitats, net gain (NG)

The Biodiversity Offsets Strategy (*Section F7* of *Annex F; Biodiversity*), and summarised below, provides the application of this final stage in the aim of minimizing impacts to biodiversity. In the absence of biodiversity offsets the residual impacts presented in *Table 7.29* remain significant.

Table 7.29 Pre-Mitigation and Residual Biodiversity Impact Summary

Impact	Significance Before Mitigation	Residual Significance
Permanent terrestrial habitat loss and associated loss (including mortality) of supported plant species of conservation concern.	*Major Negative Effects on High Sensitivity Receptors: Riparian Forest, River Channel Vegetation and EN species*	*Major Negative*
	Moderate Negative Effects on Medium Sensitivity Receptors: Hillslope Forest VU Species	*Moderate Negative*
Habitat fragmentation effects, reducing the connectivity of habitats and causing habitat deterioration through edge effects	*Major Negative effects on High Sensitivity Receptors: Riparian Forest and River Channel Vegetation*	*Major Negative*
	Moderate Negative Effects on Medium Sensitivity Receptors: Hillslope Forest	*Moderate Negative*
Introduction and spread of invasive species during construction and landscaping works.	*Moderate Negative effects on High Sensitivity Receptors: Riparian Forest and River Channel Vegetation*	*No Significant Effects*
Permanent terrestrial habitat loss and associated impact on faunal species of conservation concern and/ or restricted range species.	*Major Negative Effects predicted on Ziama horseshoe bat, Neoromicia* aff. *Nana and West African Chimpanzee.*	*Major Negative*
	Major Negative Effects on High Sensitivity Receptors: Freetown long-fingered frog, Cameroon grassland frog and two Ptychadena sp. frogs	*Major Negative*
	Moderate Negative Impacts on Pygmy Hippopotamus	*Moderate Negative*
	Moderate Negative Effects on Medium Sensitivity Receptors hinged tortoise, forest hinged tortoise and fire-sided skink	*Moderate Negative*
	Moderate Negative Effects predicted on cave roosting bat species.	*Minor Negative*
	Moderate Negative Effects on aberrant Themis Forester butterfly	*Minor Negative*
Disturbance to faunal species of conservation concern and/ or restricted range species due to noise, vibration and human presence causing disturbance/ displacement / exclusion of species from important areas (foraging, congregatory areas) and associated habitat 'squeeze'.	*Moderate Negative Effects predicted on West African Chimpanzee*	*Minor Negative*
	Moderate Negative Effects on High Sensitivity Freetown long-fingered frog and Cameroon grassland frog	*No Significant Effects*
Habitat fragmentation and impacts on population territories and connectivity	*Major Negative Effects predicted on Pygmy Hippopotamus*	*Major Negative*
Increased hunting pressure from construction of new roads, induced access and population influx	*Moderate Significant Effects predicted on West African chimpanzees*	*No Significant Effects*
	Moderate Significant Effects predicted on medium sensitivity cave roosting bat species and	*No Significant Effects*

Impact	Significance Before Mitigation	Residual Significance
Collision and possible electrocution with transmission lines	*Major Significant Effects on West African chimpanzee*	*No Significant Effects*
	Moderate Negative Significant Effects predicted on hooded vulture	*No Significant Effects*
Mortality of faunal species due to collision with Project traffic or mobile equipment.	*Major Negative Effects on High Sensitivity Freetown Long-Fingered Frog*	*Minor Negative*
	Moderate Negative Effects on Medium Sensitivity frog, tortoise and skink species	*No Significant Effects*
	Moderate Negative Effects on aberrant Themis Forester butterfly	*Minor Negative Effects*
Permanent loss of riverine habitat in the inundation area due to replacement with lacustrine habitat and associated mortality/community shift of aquatic fauna	*Major Negative Effects on High Sensitivity Receptors: New to science, Potentially new to science and RR species*	*Major Negative*
	Major Negative Effects on Medium Sensitivity Receptors: VU, DD and NT species	*Major Negative*
Permanent loss of tributary habitat in the tailrace footprint and associated mortality/community shift of aquatic fauna	*Moderate Negative effects on High Sensitivity Receptors: RR species*	*Moderate Negative*
Community shift in freshwater habitat due to release and spread of invasive aquatic species	*Major Negative effects on High Sensitivity Receptors: EN, RR, New to Science and Potentially New to science species*	*No Significant Effects*
	Major Negative Effects on Medium Sensitivity Receptors: VU, DD and NT species	*No Significant Effects*
	Moderate Significant Effects on Low Sensitivity Receptors: LC species	*No Significant Effects*
Temporary loss of riverine habitat and mortality of aquatic species due flow cessation on the Seli downstream of Yiben dam during initial reservoir filling	*Moderate Negative effects on High Sensitivity Receptors: EN, RR, and Potentially New to science species*	*No Significant Effects*
Habitat degradation and mortality of aquatic species due to sedimentation and pollution from construction areas	*Major Negative effects on High Sensitivity Receptors: EN, RR, New to Science and Potentially New to science species*	*No Significant Effects*
	Moderate Negative Effects on Medium Sensitivity Receptors: VU, DD and NT species	*No Significant Effects*
Indirect loss of aquatic habitat and species due to groundwater contamination and loss	*Moderate Negative Effects on High Sensitivity Receptors: EN, RR, New to Science and Potentially New to Science species*	*No Significant Effects*
Creation of barriers to migration caused by construction of the Yiben dam and access road/transmission line water crossings	*Moderate impact on High Sensitivity Receptors: EN, RR and Potentially New to Science species*	*No Significant Effects*
Loss of aquatic species due to water quality deterioration as a result of the development of	*Major Negative Effects on High Sensitivity Receptors: RR species*	*Moderate Negative*

Impact	Significance Before Mitigation	Residual Significance
undesirable eutrophic conditions	*Moderate Negative Effects on Medium Sensitivity Receptors: NT species*	*Minor Negative*
Downstream habitat degradation and mortality of aquatic species due to sedimentation and pollution from operational areas	*Major Negative effects on High Sensitivity Receptors: EN, RR, New to Science and Potentially New to science species*	*No Significant Effects*
	Moderate Negative Effects on Medium Sensitivity Receptors: VU, DD and NT species	*No Significant Effects*
Habitat degradation and mortality of aquatic species downstream of Yiben dam due to hydrological modifications during operation	*Major Negative effects on High Sensitivity Receptors: EN, RR, and Potentially New to Science species*	*Major Negative*
Habitat degradation and mortality of aquatic species on the Seli River between Bumbuna dam and the Bumbuna Extension tailrace outfall due to hydrological modifications during operation	*Major Negative effects on High Sensitivity Receptors: RR species*	*No Significant Effects*
	Major Negative Effects on Medium Sensitivity Receptors: VU, DD and NT species	*No Significant Effects*
	Moderate negative Effects on Low Sensitivity Receptors: LC species	*No Significant Effects*
Habitat degradation and reduction in diversity of aquatic species on the Seli River downstream of the Bumbuna Extension tailrace outfall due to prolonged decreases in inter-annual flow variation	*Major Negative effects on High Sensitivity Receptors:RR species*	*Major Negative*
	Major Negative Effects on Medium Sensitivity Receptors: VU, DD and NT species	*Major Negative*
	Moderate Negative Effects on Low Sensitivity Receptors: LC species	*Moderate Negative*
Mortality of aquatic species due to entrainment by reservoir intakes and subsequent turbine strike	*Moderate Negative effects on High Sensitivity Receptors: RR species*	*No Significant Effects*
Depletion of aquatic species populations as a result of overexploitation due to population influx and induced access and the associated potential for invasive species introductions	*Major Negative effects on High Sensitivity Receptors: EN, RR, New to Science and Potentially New to science species*	*No Significant Effects*
	Major Negative Effects on Medium Sensitivity Receptors: VU, DD and NT species	*No Significant Effects*
	Moderate Significant Effects on Low Sensitivity Receptors: LC species	*No Significant Effects*

Box 7.8 Habitats and Species which meet Critical Habitat Criteria with Significant Residual Impacts

Habitats
- Riparian gallery forest
- River channel

Plants
- CR plant *Ledermanniela sp nov*
- EN plants *Ledermanniella aloides*, *Stylochaeaton pilosus* and *Vepris felicis*
- RR plants *Dialium pobeguinii*, *Gilbertiodendron tonkolili, Turraea leonensis, Trichoscypha longifolia, Landolphia macrantha* and *Placodiscus pseudostipularis*

Mammals
- EN Ziama horseshoe bat
- RR bats *Neoromicia aff. Nana* and Aellen's roundleaf bat
- EN pygmy hippopotamus
- EN West African chimpanzee

Amphibians
- EN Freetown long-fingered frog
- DD Cameroon Grassland frog
- Not Evaluated *Ptychadena* sp. frogs

Reptiles
- CR slender snouted crocodile

Fish
- EN fish *Marcusenius meronai* and potentially *Enteromius liberiensis*
- New to Science fish species *Epiplatys sp aff njalaensis*, *Scriptaphyosemion cf chaytori, Epiplatys sp nov* and *Chiloglanis sp af occidentalis*
- RR fish *Scriptaphyosemion wieseae, Rhexipanchax kabae, Prolabeo batesi, Petrocephalus levequei, Raiamas scarciensis, Leptocypris guinensis; Coleotilapia joka* and *Synodontis tourei*
- Potentially New to Science fish species *Enteromius cf trispilos*, *Archiaphyosemion cf guineense* and *Ctenopoma* sp.

7.8.7 Biodiversity Strategy

The assessment of impacts on biodiversity receptors has identified a number of significant residual impacts, including impacts on natural habitat and critical habitat, as defined by IFC PS6.

In areas of natural habitat, mitigation measures will be designed to achieve NNL where feasible. In areas of critical habitat, there are more stringent requirements, including a requirement to ensure no measurable adverse impacts on critical habitat features, and an expectation that the Project demonstrate NG of the biodiversity for critical habitat features. A detailed explanation of the requirements for Projects in critical and natural habitat are set out in *Section F7* of *Annex F; Biodiversity*.

A number of actions are required to meet the requirements of PS6, and these will be set out in a Project Biodiversity Strategy. *Section F7* of *Annex F; Biodiversity* sets out a preliminary Biodiversity Strategy which includes the following key measures:

- Undertake additional surveys to further quantify the predicted loss of biodiversity, further inform impacts on critical and natural habitat biodiversity values and inform the development of biodiversity offsets.

- Update the assessment of impacts on critical habitat using the results of the additional surveys. This should include an updated assess of whether or not project alternatives exist which are not in critical habitat.

- Based on the additional survey information and updated assessment of impacts on critical habitat, further develop the Project approach to biodiversity offsetting requirements.

7.8.8 *Recommended Additional Surveys*

In order to further quantify the predicted loss of biodiversity, further inform impacts on critical and natural habitat biodiversity values and inform the development of biodiversity offsets, a suite of additional surveys are proposed. *Section F7.3* of *Annex F; Biodiversity* sets out the proposed further surveys for critical habitat features, which are summarised in the *Box 7.9* below:

Box 7.9 Proposed Additional Surveys to Further Inform Critical Habitat Assessment and Offsets

Flora surveys upstream of the inundation area along the Seli River and along the Mawoloko River to search for other locations of:

- CR *Ledermanniela sp* nov;
- EN species *Ledermanniella aloides* and *Stylochaeaton pilosus* and *Vepris felicis*; and
- areas of riparian gallery forest

Fauna surveys will be undertaken upstream of the inundation area along the Seli River and within the Project AoI including:

- surveys for EN Ziama horseshoe bat, and medium sensitivity cave roosting bat species to provide additional data on the location and use of caves in the inundation zone and surrounding area and the location of other cave roosts;
- additional surveys to determine the population structure and connectivity of EN West African chimpanzee in and around the inundation zone;
- additional surveys along the Seli River upstream of the inundation area and in neighbouring catchments for EN pygmy hippopotamus and for EN, DD and undescribed restricted range amphibian species;
- vantage point surveys of transmission line corridor to validate predicted activity levels of species of bat and bird species of conservation concern;
- surveys for un-evaluated butterfly species in suitable habitats upstream in the Seli River catchment and neighbouring catchments;
- surveys of tributary habitat within the Seli catchment and adjacent catchments to search for the new to science fish species *Epiplatys sp. aff. njalaensis* and *Scriptaphyosemion cf. chaytori* which to date have only been recorded in the inundation zone:
- surveys at sites where secondary data suggests the EN fish species *Enteromius liberiensis* was found to investigate whether all such records are a misidentification.
- further aquatic ecology surveys downstream of Bumbuna dam during the dry season to further inform the Ecological Flows Assessment; which was based on a wet season survey only. This will improve the robustness of the ecological flows model and clarify if the proposed operational discharge regime is likely to result in significant degradation compared to the current situation.

7.8.9 *Identification of Offset Requirements and Potential Areas*

Notwithstanding the further work required to further characterise the status and distribution of natural and critical habitat qualifying biodiversity values, offsets are likely to be required as a results of the residual impacts predicted. Three separate locations have been identified as potential offset areas. No single area has been identified to date which supports or is capable of supporting all of the critical habitat features. As a result additional studies are proposed to provide further information on the suitability of each of the three areas set out below. Further information on each of the areas is presented in *Section F7 of Annex F Biodiversity*.

- **Loma Area –** Located approximately 30 km west of the Yiben inundation area. Habitats in the area surveyed around Sinikoro in 2016 which includes a portion of the Loma Mountains National Park, and lower lying land directly abutting the park to the west, are similar to those to be lost in the inundation area, with a generally comparable flora and fauna. This area is therefore considered broadly suitable as an offset location for the proposed Yiben dam and reservoir, on the basis of information currently available.

- **Lake Sonfon Area -** An alternative mitigation option identified during the survey of the inundation zone is the area around Lake Sonfon proposed National Park, which lies approximately 5 km south of Yisaia. Suitable forested habitat for chimpanzees is present here and this species was recorded in the hills to the north of the lake, adjacent to the inundation area. Preliminary investigations by other specialists also suggest that the Lake Sonfon area may be suitable as an offset for other biodiversity elements to be lost to the inundation area; with the probable exception of plants and fish.

- **Upper Seli River** - Given that neither Loma Mountains or Lake Sonfon occur in the Seli River Basin, it is possible that some species; notably those which have been found only on the Seli River itself, may not be occur in the proposed offset areas. This may apply, for example, to *Ledermanniella sp nov* which occurs on one rapid in the Seli River within the inundation zone and is known only from this location to date.

Summary of Potential Offset Areas and Actions

Given current knowledge of the potential offset areas, offsetting options, which could be used in combination, are considered to include the following.

- Enhance protection of existing Loma Mountains National Park.

- Extend the Loma Mountains National Park boundary to the west, to cover habitats and flora/fauna which are more similar to those to be lost to the inundation area.

- Enhance protection and extend the boundary of the existing Lake Sonfon *proposed* National Park to include the surrounding forested hills. This would protect existing chimpanzee populations, including those whose territory overlaps the inundation area. In addition, this is likely also to be the most suitable offset site for bats and potentially other species.

- Protect an area of the Seli River, upstream of the inundation zone, to allow offsetting for specific species of conservation concern which may only occur on the Seli River itself.

- Investigate the feasibility of establishing a sustainable financing mechanism to pay for the on-going management of the offset areas potentially derived from a percentage share of revenue from the Project.

- Investigate the feasibility of the management of the offset areas through a partnership between GoSL and international conservation NGOs with an established presence in Sierra Leone.

- Develop approaches that take into the account to support local communities encroaching on, or likely to encroach on, protected areas develop and use alterative resources. This is necessary both to effective management of protected areas and to mitigate a potential negative impact of the Project on community use of land and resources.

The suite of options above and how they can be implemented, will be discussed between Joule Africa, the Government of Sierra Leone and other stakeholders to identify and progress in a stage wise mode to implement the most feasible actions that will deliver the net biodiversity gains required.

7.8.10 Proposed Next Steps

The assessment of Project impacts on biodiversity receptors has identified a number of significant residual impacts. The following actions are recommended.

- Finalisation of the Project Biodiversity Strategy (set out in *Section F7 of Annex F Biodiversity*) to outline the Project Biodiversity and Ecosystem Services (BES) commitments and principles that will be adopted throughout Project lifetime.

- Once resettlement areas for communities displaced by the Project are identified, the impact assessment will be revisited to check that these areas are within the current assumed Project AoI and to assess any additional potential impacts on biodiversity receptors.

- Undertake further targeted survey work, as identified in *Box 7.9* above and discussed in *Section F7 of Annex F Biodiversity*), for high priority species.

- Once surveys have been undertaken and the data has been reviewed, revisit the Project Critical Habitat Determination to apply quantitative and qualitative criteria to the new information, and involve species experts as appropriate.

- Undertake work to determine the status of potentially new species including *Ledermanniella* sp.nov.

- Based on the results of the surveys and revised assessment, a clear Biodiversity Offsetting Strategy should be developed, based on the potential options identified to date, to achieve Net Gain for Critical Habitat qualifying biodiversity values and no net loss for Natural Habitat.

The final suite of additional biodiversity actions and offsetting strategy will be set out in the Project Biodiversity Action Plan (BAP) which will be developed in parallel with the follow on surveys. The BAP will set out further quantification of the impacts on critical habitat features to inform the calculation of loss of biodiversity, outline the requirements for further surveys, and set out further details of the proposed offsets.

7.9 ECOSYSTEM SERVICES

7.9.1 Introduction

This Section summarises identified ecosystem services impacts and dependencies for the Bumbuna II Project comprised of the Bumbuna Extension and Yiben project components. A detailed assessment is presented in *Volume II Technical Annex G*, which describes how priority ecosystem services were identified and categorised into:

- intermediate ecosystem services; and
- final use ecosystem services.

7.9.2 Impact Assessment of Intermediate Ecosystem Services

Priority intermediate ecosystem services in the Project AoI include:

- regulation of water timing and flows;
- freshwater quality (freshwater for household use, irrigation and livestock);
- erosion control; and
- habitat provision.

Table 7.30 provides a summary of the impact assessment findings for priority intermediate services. The findings have been presented by ecosystem service, but the receptors and impact ratings remain unchanged from the results in each topic area section.

Table 7.30 Summary of Potential Impacts and Recommended Mitigation and Management Measures – Intermediate Services

Ecosystem Service	Phase/Project Component	Resource/Receptor – Impact	Impact Significance	Mitigation	Residual Significance
Regulation of Water Timing and Flows	**Yiben Project**				
	Construction	*Downstream surface water* – Short-term prevention of flow downstream	Major	Over-pumping during construction	Negligible
	Construction	*Groundwater* - flow paths locally intercepted	Negligible	No mitigation proposed	Negligible
	Operation	*Seli River* - long-term regulation of flows	N/A		N/A
	Operation	*Groundwater* - increase in table and spring flow from inundation of reservoir	Negligible	No mitigation proposed	Negligible
	Bumbuna Extension				
	Construction	*Surface water and groundwater* -enhanced runoff over works area and new drains	Negligible	No mitigation proposed	Negligible
	Operation	*Surface water downstream of the tailrace* - increase in dry season flows	Major	No mitigation proposed	Major
	Operation	*Groundwater* - flow paths intercepted	Negligible	No mitigation proposed	Negligible
	Transmission Line				
	Construction	*Surface water and groundwater* -enhanced runoff over works area and new drains	Negligible	No mitigation proposed	Negligible
	Operation	*Surface water and groundwater*- newly roads or crossings may interrupt or constrict flows	Negligible	No mitigation proposed	Negligible
Freshwater quality	**Yiben Project**				
	Construction	*Seli River and Yiben reservoir* - potential pollution from construction activities	N/A	Managed clearance to reduce the risk of the decomposition of organic matter in the reservoir as outlined in the Vegetation Clearance Plan to be developed by the Project referenced in *Chapter 8; ESHMP.*	N/A
	Operation	*Yiben reservoir* - eutrophication following the saturation of shallow soils in the inundation area	Major	Modelling of reservoir, injection of oxygen and other measures outlined in *Annex E; Water Resources.*	Negligible
	Bumbuna HEP Extension & Transmission Lines (TR)				
	Construction *Bumbuna Extension*	*Seli River and Bumbuna reservoir* - water pollution risks from enhanced runoff over works area, new drains, and use of fuels, oils and foul wastes on site	Negligible	No mitigation proposed	Negligible
	Construction & Operation - *TR*	*Seli River and Bumbuna reservoir* - pollutants introduced during construction and release of	N/A		N/A

Ecosystem Service	Phase/Project Component	Resource/Receptor – Impact	Impact Significance	Mitigation	Residual Significance
		sediments			
Erosion regulation	**Yiben Project**				
	Operation	*Yiben reservoir shoreline* – potential increase in soil erosion and sedimentation	Moderate	Water Resources, Drainage and Erosion Management Plan	Moderate
	Operation	*Agricultural land downstream of Yiben dam* – reduction in soil fertility from reduced sediment transferred	Not assessed - this impact is nullified by the immediate downstream presence of Bumbuna I dam		
Terrestrial habitat	Construction	Loss of high sensitivity habitat (riparian forest and river channel vegetation) and medium sensitivity receptors (hill slope forest, grassland, wooded grassland and woodland and inland valley swamp), from permanent land take and habitat fragmentation	Moderate to Major	Mitigation and residual impacts on habitats and flora are presented in *Section 7.8.5* above Measures include: •Strict demarcation of work areas, and prohibition of any activity outside these areas • Erosion control measures around construction works • Reduce transmission line wayleave at all river crossings • Mitigate the loss of the tailrace tributary at the Bumbuna Extension by permanently diverting the tributary along an alternative channel In areas of Critical Habitat the Project is expected to demonstrate net gains of the biodiversity values for which the Critical Habitat was designated. A summary of biodiversity receptors which require offsets and additional conservation actions is provided in *Annex F; Biodiversity.*	Moderate to Major (offset req.)
	Construction and Operation	Loss of high and medium sensitivity habitats from the introduction of invasive species.	Minor to Moderate	The mitigation and residual impacts on habitats and flora are presented in *Annex F* and include: prohibit the introduction of alien/exotic plants or animals within Project facility areas; reduce transmission line wayleave at all river crossings to 40 m and microsite to avoid removal of riparian forest trees.	Negligible

Ecosystem Service	Phase/Project Component	Resource/Receptor – Impact	Impact Significance	Mitigation	Residual Significance
Aquatic habitat	Construction -	*Riverine habitat in the inundation area* - permanent loss due to replacement with lacustrine habitat and associated mortality and community shift of aquatic fauna	Major	Further baseline characterisation and recommendation for impact avoidance / minimisation and restoration are provided in *Annex F Biodiversity*. In areas of Critical Habitat the Project is expected to demonstrate net gains of the biodiversity values for which the Critical Habitat was designated. A summary of biodiversity receptors which require offsets and additional conservation actions is provided in *Annex F Biodiversity*. .	Major (offset required)
	Construction -	*Tributary habitat in the tailrace footprint* - permanent loss of tributary habitat and associated mortality and community shift of aquatic fauna	Minor to Moderate		Minor to Moderate (offset req.)
	Construction -	*Freshwater habitat in the wider Rokel/Seli System* mortality/community shift in freshwater habitat and species due to introduction of invasive species; sedimentation	Up to Major		Negligible
	Construction -	*Freshwater habitat in the Project AoI* – mortality / community shift in freshwater habitat and species due to sedimentation and pollution; and groundwater contamination and loss	Up to Major		Negligible
	Construction	*Downstream of Yiben dam* - Temporary loss of riverine habitat and mortality of aquatic species during initial reservoir filling and creation of barriers to migration caused by the Yiben dam and access road/transmission line crossings	Moderate		Negligible
	Operation	*Aquatic species in the inundation area* - Loss of species due to water quality deterioration as a result of eutrophication;	Moderate	Further baseline characterisation and recommendation for impact avoidance/minimisation and restoration are provided in *Annex F.* A summary of biodiversity receptors which require offsets and additional conservation actions is provided in *Annex F Biodiversity*.	Negligible
	Operation	*Aquatic species in Project AoI* - overexploitation due to population influx and induced access and the associated potential for invasive species introductions	Up to Major		Up to Moderate
	Operation	*Aquatic habitat in the Seli River downstream of the Bumbuna Extension tailrace outfall* – habitat degradation and reduction in diversity of due to prolonged decreases in internal flow variation	Up to Major		Major (offset required)
	Operation	*Aquatic species in Bumbuna and Yiben reservoirs* – mortality of species due to entrainment by reservoir intakes and turbine strike	Moderate		Negligible
	Operation	*Downstream aquatic habitat* - degradation and mortality of aquatic species sedimentation and pollution from operational areas and hydrological modifications during operation	Up to Major		Negligible

Ecosystem Service	Phase/Project Component	Resource/Receptor – Impact	Impact Significance	Mitigation	Residual Significance
	Operation	*Downstream aquatic habitat* - degradation and mortality of aquatic species from hydrological modifications during operation	Up to Major	No mitigation possible for the permanent extension of the Bumbuna reservoir inundation footprint.	Negligible
	Operation	*Aquatic habitat in the Seli River between Bumbuna dam and the Bumbuna Extension tailrace outfall* – degradation and mortality of aquatic species due to hydrological modifications during operation	Up to Major	Due to the required electricity output to maintain project financial viability there is no viable engineering solution to decrease dry season flow output from Bumbuna Extension to meet the EFR.	Negligible

7.9.3 *Impact Assessment of Final Use Ecosystem Services*

Priority final use services include:

- Economic displacement due to land take;
- Crop cultivation impacts as a result of change in water timing and flows;
- Impacts on fish;
- Impacts on ecosystem services as a result of increased pressure on land;
- Impacts on disease regulation; and
- Impacts on living heritage.

Table 7.39 provides a summary of the impact assessment findings for priority final use ecosystem services in the Project AoI. The findings have been by ecosystem service, though the receptors and impact ratings remain unchanged from the results in each topic area section.

Table 7.31 Summary of Potential Impacts and Recommended Mitigation and Management Measures – Final Use Services

Ecosystem Service	Phase/Project Component	Resource/Receptor – Impact	Impact Significance	Mitigation	Residual Significance
Agriculture	Construction & Operation - *Footprint of all project components*	*Farmers within the Project footprint, particularly in the inundation area* - economic displacement from land-take, increased pressure on land and reduced water quality and availability	Major	Measures to avoid and minimise displacement, including the development of a Resettlement Action Plan (RAP), are detailed in *Annex H; Social, Section H4.3*	Positive to Minor
	Operation - *Bumbuna Extension*	*Downstream communities of the Bumbuna dam* an increase in the constant flow of water downstream may result in regained access to fertile land along Seli River	Positive	Monitor downstream water levels and flow described in the monitoring plan (see *Volume I Chapter 7; Analysis of Impacts* and *Chapter 8; ESHMP*).	Positive
Livestock farming	Construction & Operation - *Yiben Project*	*Fula herders within the inundation area* - reduced available grazing land and an increase in land pressure from resettlement	Major	Develop and implement a RAP in line with the Resettlement Framework (see *Annex H; Social Section H4.7.2*)	Minor
Fish (wild caught)	**Yiben Project**				
	Construction	*Fisherman on the Seli River* - temporary drop in water quantity during construction of the Yiben dam	Major	Further baseline characterisation and recommendation for impact avoidance/minimisation and restoration are provided *Annex F; Biodiversity.*	Minor
	Construction & Operation	*Fisherman within and around the inundation area*- the development of a productive fishery is possible in the inundation area, however potential surface and groundwater pollution and development of eutrophic conditions may impact fish stock and diversity	Major		Negligible
	Operation	*Fisherman downstream of the Yiben dam* - barrier effects, inundation of the river and discharge of deoxygenated (eutrophication) waters into Bumbuna Reservoir	Major		Negligible
	Bumbuna Extension & Transmission Line (TR)				
	Construction *Bumbuna Ext. and TR*	*Fisherman downstream of the Bumbuna dam*- surface and groundwater pollution may impact fish stock and diversity	Negligible	Further baseline characterisation and recommendation for impact avoidance/minimisation and restoration are provided in *Annex F; Biodiversity.*	Negligible
	Operation *Bumbuna Ext.*	*Bumbuna Reservoir* - operational effects on surface water	Negligible		Negligible
	Operation *Bumbuna Ext.*	*Fisherman downstream of the Bumbuna dam*- prolonged decreases in intra-annual flow variation likely to be beneficial for fish stocks between Bumbuna dam and the tailrace outfall due to improved habitat diversity, but a decrease in habitat diversity downstream of the tailrace is likely to decrease available habitat niches with potential consequent impact on fish available for catch. Fishing activity downstream of Bumbuna is currently limited due to concerns over flash flooding, the risk of which will decrease following implementation of the new flow regime.	Negligible		Negligible

Ecosystem Service	Phase/Project Component	Resource/Receptor – Impact	Impact Significance	Mitigation	Residual Significance
Freshwater for household use and irrigation	**Yiben Project**				
	Construction	*Communities / settlements within and around the inundation area* - short term prevention of flow downstream of Yiben dam	Major	Over-pumping during construction - see *Annex E; Water Resources and Ecological Flow, Section E5* for more details	Major
	Construction	*Groundwater*- drainage and/or dewatering of foundation and tunnel operations locally intercept groundwater flow paths, re-shape the ambient groundwater table, and locally reduce existing spring flows.	Negligible	N/A	Negligible
	Operation	*Communities / settlements within and around the inundation area*- reduction of surface water quality in Yiben reservoir (compared to Seli River quality) due to eutrophication within the reservoir due to changes in chemical composition following the saturation of shallow soils in the inundation area.	Major	Modelling of reservoir. Reaeration Injection of oxygen Multi-level selective withdrawal structures	Negligible
	Operation	*Groundwater* - Dam foundations and tunnel(s) intercept groundwater flow paths, re-shape the ambient groundwater table, impact spring flows. Inundation of Yiben reservoir results in increase in local groundwater table and spring flow.	Negligible	N/A	Negligible
	Bumbuna Extension & Transmission Lines (TR)				
	Construction	*Settlements downstream of Bumbuna dam* - effect on surface and groundwater from construction activities	Negligible	N/A	Negligible
	Operation.	*Communities downstream of the Bumbuna HEP* - regulation of flows within the Rokel River/Seli River would increase water supply	Positive	Recommendations provided in *Annex H; Social, Section H4.7.1*	Positive
Disease regulation	Construction and Operation - *Yiben Project*	*Communities within 5km of the inundation area* - modifications to the physical environment can offer new breeding grounds and patterns for mosquitos and other water-related vector borne diseases	Major	Development and implementation of an Integrated Vector Control, Prevention and Treatment Programme (see *Annex H; Social, Section H4.2*)	Minor
Spiritual or religious value	Construction - *Footprint of all Project components*	Loss of sacred sites (ie sacred trees, rocks, shrines, bushes, water bodies	Moderate to Major	RAP surveys and stakeholder engagement to identify appropriate mitigation measures.	Minor to Moderate

Ecosystem Service	Phase/Project Component	Resource/Receptor – Impact	Impact Significance	Mitigation	Residual Significance
Non-use value of terrestrial species and habitats	Construction - *Footprint of all Project components*	Six globally Endangered and Critically Endangered species are present in the AoI 32 species IUCN or Kew assessed Vulnerable species recorded in the AoI Direct and indirect wildlife mortality	Major	Habitat specific mitigation measures are described in *Table G4.2*, Intermediate Ecosystem Services.	Major
Non-use value of aquatic species and habitats		This ecosystem service is covered under Aquatic Habitat in *Table 7.30.*			

7.10 SOCIAL ASSESSMENT

7.10.1 Introduction

The full Social Impact Assessment is presented in *Volume II, Annex H* of this ESHIA Report. The Social impact assessment presents a detailed description of the socio-economic environment, significant Major, Moderate and positive impacts and mitigation measures. The sections below summarise the findings of the Social Impact Assessment.

7.10.2 Summary of Baseline Findings

A summary of the social and health baseline including population, demographics and livelihoods etc for the Project AoI is included below for detailed descriptions see *Volume II; Annex H Social*.

- **Affected Population**: Estimates indicate approximately 44 settlements within the Yiben reservoir potential inundation area, with an approximate population of 5,600 and approximately eight settlements with a population of 350 individuals in 135 households located within the footprint of the other project components including early works, extension of the Bumbuna dam, Yiben dam etc. Average household size is estimated to be 5 to 6 individuals. Households in the surroundings of project footprint are also at risk of economic displacement due to accessing the land for farming and other ecosystem services. Koranko is the dominant ethno-linguistic group, followed by the Limba, reported to come from a neighbouring District. The GoSL does not recognise any peoples as indigenous.

- **Customary hierarchy:** Customary leadership is structured with the Paramount Chief as the key authority. Section Chief and Village/Town Chiefs perform leadership roles at the local level. The entire potential inundation area and most access roads are within Diang Chiefdom, Koinadugu District. The transmission line route is largely within the Kasunko Chiefdom, while a few villages along the southern section of the transmission line corridor are within Kalasonkia Chiefdom, Tonkolili District.

- **Gender:** Men are the key household decision-makers especially in polygynous households and in relation to economic decisions. Women are the main drivers behind sending children to school, paying fees by selling farm produce.

- **Lend tenure:** Land tenure is customary in nature. It is controlled by Paramount Chief who can allocate land-use rights to extended families for their further division among households. In principle, the Paramount Chiefs hold the land in trust for those within their chiefdom and future generations and no significant land-related decision is final until the principal members of the families and the Paramount Chief approves.

- **Access:** Most settlements lie along unimproved access tracks or footpaths, some only reachable on foot, especially in the wet season. The road network linking Kabala to Kondembaia and south to Yarah is graded featuring the only bridge over the River Seli within the study area. This road is the major transport 'artery' across the study area, used by people travelling from Kania to Kabala and to visit weekly markets in Badala or Kondembaia.

- **General livelihoods:** Farming, cattle herding, fishing and artisanal mining are the dominant livelihoods activities; however, people also carry out oil palm processing, selling of produce, palm wine tapping and hunting.

- **Agriculture:** Subsistence agriculture is the primary livelihood. People typically have farms a reasonable walking distance from their community. Agricultural practices and crop type depend on the farm land under cultivation: riverine (typically perennial), swamp or hillside (typically slash and burn). Farming activities are governed by the seasons.

- **Trading and Market Access:** Trading of surplus agricultural produce, fish and dairy products is an important source of income. There are few formal market places in the area.

- **Fishing:** Fishing is typically carried out from river banks, mainly by women. Downstream of the Bumbuna dam fishing is reported to be carried out using boats, usually in the dry season when the water is considered safer.

- **Artisanal mining:** Artisanal mining is a common dry season livelihood activity with a number of seasonal mining settlements within the AoI, along the Seli/Rokel Rivers. Artisanal miners typically are not licenced/ permitted though it is an activity that remains under authority of the Paramount Chief.

- **Cattle herding:** Cattle herding is a livelihood commonly practiced by the nomadic Fulani who migrate seasonally. Conflict between cattle herders and farmers has been reported. Fulani typically do not have land ownership (customary or title), relying on agreement with customary leadership or land holders to access grazing land and water source for cattle.

- **Forest products and other ecosystem services:** Forest products are accessed on a communal basis. They can include medicinal and edible plants, firewood for cooking, timber for house construction. Hunting is also practiced for subsistence purposes.

- **Energy:** Wood is used for cooking. Battery torches provide light. Electrification is limited to larger settlements and is intermittent.

- **Water and sanitation:** Water for consumption and domestic use is largely drawn from unimproved sources, mainly streams and shallow wells. There are few latrines in the area; most people use the bush or streams.

- **Health:** Infectious diseases dominate the local epidemiology, including malaria, diarrhoeal and respiratory diseases. Of the few health facilities in the study area, all offer basic primary care only. Cost, quality of care and distance are the main barriers to accessing a health facility.

- **Education:** Educational access and achievement in the Project area is weak due to lack of primary and secondary schools, distance to get to school, lack of teachers and the need to pay fees. Few of the settlements surveyed were found to have a primary school (10 out of 44 in the inundation area; 3 out of 14 along the transmission line corridor). One settlement (Kondembaia) has a junior secondary school.

- **Cultural Heritage:** There are a number of tangible and intangible sites of cultural and religious importance in the area, usually located close to settlements. These include burial sites, sacred trees, stones and forests, as well as secret society 'bushes' where initiation rites take place for male (Poro society) and female (Bondo society) youths separately. The latter also serve as forums to discuss and resolve issues.

7.10.3 Summary of Significant Construction and Operation Impacts

This section summarises all identified social impacts. The full assessment of impacts is detailed in *Volume II, Annex H; Social.*

Physical and Economic Displacement Impacts

The construction of the Project will result in a change of use of land use currently dedicated to housing, farmland, pasture, etc. This change will result in both *physical displacement* and *economic displacement*.

Social impacts associated with unmanaged physical and economic displacement include:

- homelessness caused by loss of shelter and reduced access to shelter;

- impoverishment from loss of workplaces, productive land or assets and/or other income sources;

- reduced food security from loss of access to, or increased pressure on, forest products;

- social impacts from loss of cultural identity and changes to family structure, social networks and traditional governance;

- reduced access to education, health infrastructures and public services; and

- social tensions and increased rates of crime, disease and mortality in impacted and host areas.

Local Power and Governance

The Project is likely to have an impact on local power and governance due to physical displacement, leading to a loss of ties to the traditional/local governance system, and changes to mobility and access causing severance from the traditional authority.

These sources of impacts are likely to cause a weakening of the local traditional governance system and increase in risk of poor financial management.

Through the resettlement process and the Project's regulatory contributions the finances managed by the local authorities will increase. In addition project affected households will receive compensation payments and will therefore have comparatively large financial packages to manage.

In the absence of a strong local culture of good budgetary management and transparency, poor financial management practices and fund misappropriation could develop.

In addition, whether or not funds are poorly managed, the local authorities may be accused of poor management of funds dedicated to development if the communities feel that they are not sufficiently benefiting.

Demographics and Social Dynamics

The Project is could impact demographics and social dynamics in the Study area due to:

- the resettlement of villages located within the Project footprint;
- the creation of salaried jobs by the Project during construction; and
- the migration of people from within or outside the Study area in search for work during the construction phase.

These sources of impacts are likely to cause the following impacts:

- changes to the traditional family structure, social networks and cultural identity;
- in-migration into the study area; and
- an increase in social tensions.

The creation of jobs may attract people outside of the Study area to migrate into the Chiefdom in hope of receiving work or other benefits. These may be persons foreign to the area, but also individuals or families returning in the hope of being able to find a job with the Project. Only some of these people will be able to be employed, given the limited labour requirements of the

Project. The persons not employed might find themselves without resources and large scale population increase could increase pressure on social infrastructure and services (sanitation, education, health etc).

Following the resettlement of villages the area will include three types of settlements: resettled settlements, host community settlements and settlements not affected by the resettlement. Perceived or actual unequal treatment of these three types of communities could lead to tensions between communities.

Land

The Project will cause of loss of land presently used by local inhabitants for their livelihoods, mainly for farming, herding, NTFP collection, fishing and mining.

It is expected that the resettlement process, especially in the inundation area, and to a lesser extent population influx, will have the following indirect and induced impacts:

- increased pressure on land; and
- increased inequality of access to land.

The resettlement of 1,200 households (or 52 settlements) in the areas outside of the Project Area is likely to increase pressure on land if not managed carefully. Increased pressure on land may cause the following impacts for host and hosted communities:

- reduced access to good farmland;
- increased cost of access to farmland;
- reduction in fallow time and increased deforestation;
- reduced harvest;
- increase in walking time to reach available farmland; and
- conflicts around access to land.

In the context of growing land pressure, the land lending system between lineages and settlements might be affected. The following changes to land tenure might be triggered:

- Restricted access to land for households with land related vulnerabilities (eg migrants, holders of land use rights only, and vulnerable populations), who usually depend on annual loans with 'founding families' for land access.

- An increase in the demand for land and land transactions causing an inflation in the value of land - resulting in inequality in access to land for people without the financial means to access the land.

Agriculture and Livestock Rearing

The Project is likely to result in the following additional induced impacts on agriculture and cattle herding:

- increase in available land downstream of Bumbuna dam because the Project will likely reduce the large one off or sudden releases of water and increase the constant flow of water downstream; and

- increase in conflicts between farmers and cattle herders caused by an increase competition over land.

As a result, it is expected that settlements downstream of Bumbuna dam, currently experiencing flooding of their farmland along Rokel River will regain access to these fertile riverine land. This is likely to result in a positive impact in the form of increased agricultural outputs, revenues and food security. In addition it is expected that settlements downstream of Bumbuna dam will regain access to water access points, further exacerbating this positive impact.

The impounding of the inundation area will remove seasonal grazing land used by Fula herders. In addition, an increase in land pressure from resettlement will likely make it more difficult for Fulas to access replacement grazing land. This might be accentuated by an increase in travel time as the road crossing the Seli River at Badala will be re-routed further east of the Inundation area.

As a result conflict between farmers and cattle herders (already existing in the area and often resulting to the payment of fees or exclusion) could increase given the reduction in pasture land and the climate of competition around different land uses.

Access to Natural Resources

It is expected that the resettlement process, especially movement of people and economic activities away from the inundation area, will cause a loss of income from artisanal mining and timber and non-timber forest products.

The Project will impact the collection of timber and non-timber forest products within the new inundation area due to:

- loss of access to communal areas for gathering of timber and non-timber forest products ; and
- increased competition for forest products gathered in or surrounding new Host Communities.

Socio-Economics

People employed by the Project will benefit from stable monthly income and for local people this means no longer being as exposed as now to economic uncertainties related to agriculture. Access to services such as health care may also be increased due to increased disposable income.

However, jobs will mainly be temporary during the construction phase (three to four years) and positions during operations and maintenance will only require a few dozen people.

Mobility and Transport

The inundation of the reservoir will result in the inundation of the main road between Badala II and Konderoh resulting in a severe reduction in mobility that will further worsen the situation for the most isolated settlements in the Project Area. The inundation of the reservoir area will increase the natural barrier in the centre of the Diang Chiefdom presently provided by the Seli River that marks the boundary between Gbaria and Fogo Sections. The reservoir will increase this natural barrier and further isolate settlements and sections one from each other.

The construction of new roads and the maintenance or upgrade of existing roads by the Project has the potential to increase households' mobility. In particular, villages along the transmission line corridor have no access to the road network. An increase in mobility will improve access to markets and public infrastructure and services (education, health) and is likely to improve local economic development and households' wellbeing. This impact will only occur to the extent that the Project ensures continuous access to local people to the Project roads during the construction and operation phases.

Education

Access to education may be affected by the Project due to:

- reduced mobility caused by the inundation of the reservoir;
- reduced income of Project Affected People;
- isolation of resettled villages in areas with reduced access to education;
- increased mobility for settlements along the Project access roads; and any positive investments in education infrastructures and services.

Community Benefit Impacts

It is expected that the Project will deliver reliable electricity to industry and households of Sierra Leone and particularly in Freetown. Improved access to electricity, particularly at night when energy shortages occur, have the following positive impacts.

- Allows education and home work to occur after daylight hours (where not displacing other forms of lighting).
- Frees large amounts of human time and labour thereby increasing households' revenues.
- Reduction in isolation through telecoms.
- Improve safety with the implementation of street lighting, lit road signs.
- Improve healthcare by reducing risks of electricity shortages.
- Reduces cost of electricity generators and improves businesses reliance and costs associated to energy shortages.

In addition, people employed by the Project can expect to gain skills and marketable experience as well as income; and local traders can expect to benefit from increased business.

Joule Africa is committed to developing Projects that improve access to energy for communities in the area. The specifics of the programme will be defined through a consultative process and drawing on what is economically and technically feasible during the Project construction period.

Health and Safety

As a result of the Project (during construction and operation), there will be a number of health and safety impacts which are discussed below. These include:

- increase in the transmission of communicable diseases;
- traffic accidents;
- drowning; and
- health, safety and hygiene risks from construction camp accommodation

During the construction phase when the workforce is likely to be largest and when in-migration may peak; there may be an increase in the transmission of communicable diseases. These include acute respiratory infections (ARI) and tuberculosis (TB), as well as sexually transmitted infections (STIs) including HIV/AIDS. In addition, new diseases (eg pandemic influenza and meningococcal meningitis) may be introduced into the area. Poor access to, and quality of, health care services could contribute to the rapid spread of these diseases if people fail to seek treatment in a timely manner. The expected increase in disease transmission will be largely due to:

- interactions between local people and workers from outside the community;

- overcrowding as a result of increased pressure on existing housing infrastructure and water services – but note that the non-local workforce will live in construction camps and not inside local communities;

- in-migrants and the Project workforce coming to the area bringing new diseases or varying disease profiles compared to the existing community;

- greater disposable incomes increasing a risk of engaging in high risk sexual activities with commercial sex workers both in local communities and on transit routes to / from site, acting as a vector for the disease;

- transport drivers, who typically have higher rates of HIV or STIs than the general population, may engage in casual high risk sexual activity along transport routes and at their end destination; and

- the presence of commercial sex workers with higher rates of STIs and HIV, may increase near construction sites.

During the construction phase, modifications to the physical environment can create small water pools (eg in wheel ruts and footprints) offering new breeding grounds for mosquitos and other vectors, leading to increased vector density and increased human vector (mosquito) interaction. Modifications to the environment may also change the breeding patterns of mosquitoes extending the high risk season for transmission. There is the potential for other vector borne diseases (eg yellow fever) to develop if different mosquito species are attracted to the area as a result of the creation of breeding sites.

The in-migration of people may play an indirect role in increasing the malaria burden through an increase in pressure on medical facilities, inadequate waste management and establishment of make-shift housing (reducing natural protection to mosquitoes).

The establishment of a reservoir, as well as the reduction of water flow velocity upstream has the potential to create new mosquito breeding grounds. For deeper waters in particular, there is the potential for water to become stagnant. Potholes may also develop along roads used by Project staff, which could collect pools of stagnant water in which mosquitoes and other vectors breed. The potential impact of the Yiben reservoir on malaria can be assumed to be negligible beyond 5 km due to limited flight range of mosquitoes. As with the construction phase, there is the potential for other vector borne diseases to develop if different mosquito species are attracted to the area as a result of the creation of breeding sites.

The presence of Schistosomiasis may become distributed over a wider area as a result of the dam. As the snails that carry the parasite tend to prefer slow moving water, they may become prevalent in the reservoir area. They may also be moved downstream in fast flowing water.

Once the Yiben dam is commissioned and fully operational, the natural flow of water downstream will be disrupted and released in a controlled manner, altering seasonal water flows. It is possible that at times of increased/peak water releases (for example due to increased demands for power generation), the river will flood the surrounding area, as is reported to happen downstream of the Bumbuna dam. Given that in some places water is drawn from shallow manually dug wells and that the main sanitation infrastructure in the area are open pit latrines, it is possible that flooding may lead to

flooding of these wells and latrines, leading to cross-contamination of drinking water sources with human waste.

Following dam completion, the impoundment of the Seli River and the filling of Yiben reservoir will result in a large body of predominantly non-flowing water. This will have wide-ranging direct and indirect effects, including on the health, sanitation and hygiene profile in the inhabited areas surrounding the reservoir.

During construction, there will be vehicle movements from the transport of construction materials and to a lesser extent, from local traffic movements associated with workers. This will reduce during the operational phase. The numbers of daily vehicle movements for the construction and operation period have not been confirmed.

With the movement of Project vehicles there is the potential for traffic accidents to occur which could result in injuries or fatalities to other road users, cyclists, pedestrians or livestock. Although the exact location of the roads has not yet been confirmed, there is the potential that they may be located close to local communities and schools which would increase the likelihood of a collision occurring, given that communities are not accustomed to high levels of traffic.

Drowning is a recognised (1) risk associated with dams particularly in the reservoir area due to people being attracted to the water for domestic, recreational and other activities. Although no community accident data or information is available it is anticipated that there will be an increase in accidents on or close to the water and in relation to construction activities involving local community members.

The Project workforce will be housed in construction camps. Poor accommodation standards could expose workers to health, safety and hygiene risks. Camp staff (including those in kitchens, laundry, cleaning and maintenance) will be variously exposed to a range of physical, chemical, and biological hazards.

During the operation phase, the risk of workforce exposure to health and safety hazards will be significantly reduced and mainly relate to maintenance of the dam.

Exposure of workforce to health and safety incidents could lead to serious injury or even death. Individuals who are injured are at risk of losing their jobs through inability to physically undertake required activities. They may also struggle to undertake other livelihood activities due to their ill health. This can have knock on effects on their household income, food security and standard of living.

(1) WHO (2000) Human Health and Dams.

The Project will need dedicated medical staff to meet its own occupational health needs, particularly during construction. As skilled medical staff are in short supply in Sierra Leone, and if they chose to join the Project due to higher wages, this may have a detrimental effect on access to health care for local people within the region.

It is possible that the Project may contribute to the development of health inequalities through the provision of health initiatives in selected communities and due to the fact that employees / contractors and their dependents may be able to access site based medical services which are better equipped and staffed then community based services.

Increased pressure and decreased access to health care facilities is likely to occur due to in-migration and due to changes in the disease profile in the Projected Affected Area. As such the impact is likely to be long term but mainly felt during construction. The impact is considered to be certain to occur as the existing facilities are insufficient for the current needs of the community. Decreased access to health care facilities will result in worsening health outcomes as such the magnitude of the impact is considered to be large.

Cultural Heritage

No archaeological sites have been conclusively identified within the footprint of the project components. However, there are still archaeological anomalies that have not been ground-truthed and there has been no pedestrian survey by archaeologists. There is still the potential that archaeological sites exist within the footprint of any of the project components. Taking a precautionary approach the potential for the presence of these sites must be considered.

Currently, the Project footprint (ie inundation area and other Project sites) will physically impact intangible and living heritage sites identified during the baseline surveys. It is possible that other project components, such as the transmission line, could also impact currently undocumented living heritage sites.

Summary

The significance of construction and operation impacts within the inundation area, Yiben dam, transmission line and Bumbuna Extension is summarised in *Table 7.32.*

Table 7.32 Summary of Potential Impacts during Construction and Operation

Impact	Direct? (D) Indirect (ID) Induced (IN)	What / Who is Impacted	Project Area	Construction Phase Impact Significance	Operations Phase Impact Significance
Resettlement: A total of approximately 1,200 households in 52 settlements are likely to be displaced by the Project in the inundation area, Yiben dam, transmission line and Bumbuna Extension. Some households may lose agricultural land. As part of the relocation process, host communities may experience impacts from the resettlement.	**D**	Households in the Project Area	Inundation area, Yiben dam, transmission line and Bumbuna Extension	**Major**	**Major**
Local governance: Communities will be displaced and relocated by the Project. This could result in the weakening of local governance.	**D**	Local Governance	Inundation area, Yiben dam, transmission line	**Major**	**Major**
Financial Management: In the absence of a strong local culture of good budgetary management and transparency, poor financial management practices and fund misappropriation could develop related to households receiving compensation packages and local authorities receiving tax contributions.	**D**	Financial Management	Inundation area, Yiben dam, transmission line	**Major**	**Major**
Grazing land: A reduction in available grazing land and increased pressure on land following inundation of the reservoir area and resettlements is likely to decrease access to grazing land for itinerant Fula herders and increase conflicts with farmers.	**D**	Fula herders and farmers	Inundation Study Area	**Major**	**N/A**
Available farmland: Increase in available riverine farmland due to improved operations at Bumbuna dam ending to sudden water releases by the dam.	**D**	Available farmland	Bumbuna Downstream Study Area	**N/A**	**Positive**
Artisanal Mining: Due to the flooding of the Inundation area there will be a loss in mining livelihood for a proportion of communities.	**D**	Artisanal miners	Yiben dam, Inundation Study Area	**Major**	**Major**
NTFPs: Loss of access to and income from timber and non-timber forest products. The impact will be experienced by local communities within the Inundation area and downstream of the Bumbuna Expansion.	**D**	Households using timber and NTFPs	Bumbuna downstream users	**Moderate**	**Moderate**
Income from employment: New employed staff will benefit from stable monthly income. Unemployment is high in the Project area and in Sierra Leone in general.	**D**	Recruited persons	Inundation area, Yiben dam, transmission line and Bumbuna Extension	**Positive**	**Positive**
Development Initiatives: Increase in local development initiatives as a consequence of an increase in public revenues (related to local taxes) and projects financed by the Project. Households in the Project area have a low access to health, education and other public infrastructures.	**D**	Households in the Project Area	Inundation area, Yiben dam, transmission line and Bumbuna Extension	**Positive**	**Positive**

Impact	Direct? (D) Indirect (ID) Induced (IN)	What / Who is Impacted	Project Area	Construction Phase Impact Significance	Operations Phase Impact Significance
Transport patterns: Increased isolation and decreased mobility for some communities as a result of the inundation of the reservoir area creating a natural barrier and resulting in the flooding of the main north-south road and bridge over Seli River. Increased mobility for other communities as a result of the construction and maintenance of Project access roads to Yiben dam, Bumbuna dam and along the transmission line.	**D**	Settlements within Project Area	Inundation area, Yiben dam, transmission line and Bumbuna Extension	**Major**	**Positive**
Communicable diseases: Increased prevalence of communicable diseases would largely be attributable to the presence of the construction workforce and of opportunistic in-migrants. The transmission of diseases has the potential to extend beyond the Project Area given the presence of migrant workers. However, it will be felt most in local communities where health facilities are poor and where the greatest concentration of in-migration will occur as a result of the Project.	**D**	Local population	Inundation area, Yiben dam, transmission line and Bumbuna Extension	**Major**	**Major**
Malaria: Increased transmission of malaria and other water-related vector borne diseases. Without mitigation, the potential to contract malaria will be increased as a result of creation of the reservoir and reduced water flow. The impact will be local (predominantly within 5 km of the area of inundation for malaria), impacting local residents and the Project workforce.	**D**	Local population	Inundation area, Yiben dam, transmission line and Bumbuna Extension	**Major**	**Major**
Water-borne diseases: Transmission of water-borne diseases such as cholera as a result of increases in population and lack of improved drinking water sources and sanitation.	**D**	Local population	Reservoir area (primarily)	**Major**	**Major**
Road traffic accidents: Increase in road traffic accidents due to the presence of construction and other vehicles associated with the Project, as well as the potential increase in use and ownership of motorised vehicles among local communities. This is compared to a baseline of very limited accident numbers due to limited vehicular movement in the local area.	**D**	Local population	Inundation area, Yiben dam, transmission line and Bumbuna Extension	**Major**	**Major**
Worker Health and safety: Health and safety risk exposure to the workforce during project construction and ongoing maintenance activities associated with the operation of the dam. The impact will be contained to the local or regional level from which the Project will strive to source the majority of its workforce. It is likely that a small proportion of staff will be employed from overseas during the construction phase to provide specific expertise and management capacity.	**D**	Workforce	Inundation area, Yiben dam, transmission line and Bumbuna Extension	**Major**	
Drowning: Risk of drowning due to use of reservoir for recreation and other activities by local communities. Access to the reservoir will need to be controlled on an ongoing basis.	**D**	Local population	Reservoir Area	**N/A**	**Moderate**

Impact	Direct? (D) Indirect (ID) Induced (IN)	What / Who is Impacted	Project Area	Construction Phase Impact Significance	Operations Phase Impact Significance
Access to healthcare: Access to health care facilities is already limited in the Project Affected Area, with few facilities and limited resources available. The potential in-migration of people seeking employment opportunities during the construction and operational phase of the Project may put pressure on the already weak health infrastructure.	**D**	Local population and workforce	Inundation area, Yiben dam, transmission line and Bumbuna Extension	**Moderate**	**Moderate**
Electricity: Improved access to electricity	**D**	Wider population of Sierra Leone	Freetown and the wider country	**N/A**	**Positive**
Family structure and networks due to resettlement: Change in traditional family structure, social networks and cultural identity. Potential impacts on family structure and social networks of resettled households include: •change to dependency relationships within households; •loss of access to social networks; •loss of support to vulnerable people.	**ID**	Households from villages within the Project footprint only.	Inundation area, Yiben dam, Bumbuna Extension	**Major**	**N/A**
Family structure and networks due to migration: Change in traditional family structure and social networks due to job seeking migration. It is likely that young men from the study area will migrate in search for an unskilled position. Other migrants from the Province or elsewhere in the country may migrate to the Project area in search of work. The construction phase peak will employ approximately 1,200 people at the Bumbuna Extension, and 1,150 at the Yiben site. It is likely that employees will be sourced country-wide for skilled (230 positions) and semi-skilled (1020), unskilled labour (1,100) may partially be sourced from the Study area. The operations team will approximately 35 to 40 persons at Bumbuna Extension and 15 to 20 persons at Yiben HEP.	**ID**	Individuals in the Chiefdom	Yiben dam, and Bumbuna Extension study areas mainly, inundation area to a lesser extent	**Moderate**	**N/A**
Social tensions: Increase in social tensions may arise from: • recruitment of non-local migrants; • perceived unequal treatment with regard to access to jobs; • Changes to family structures and increase in risky practices due to an increase in households headed by single-young male.	**ID**	Workforce	Yiben dam, and Bumbuna Extension study areas	**Moderate**	**N/A**

Impact	Direct? (D) Indirect (ID) Induced (IN)	What / Who is Impacted	Project Area	Construction Phase Impact Significance	Operations Phase Impact Significance
Pressure on land: An increase pressure on land is expected following the resettlement of approx. 1,200 households (52 settlements) to an area with lower land fertility and available livelihood sources. Job seeking immigration may also increase pressure on land. Land transactions and compensations for land take in the context of the resettlement may exacerbate tensions around the land resource in a context of superimposition of the customary land rights and in the absence of land register.	**ID**	Local inhabitants	Yiben inundation and Yiben dam study areas. Bumbuna Extension area to a lesser extent.	**Major**	**N/A**
Land tenure systems: An increase in land pressure may result in changes to the traditional land tenure system and increased inequality of land access caused by: • new strategies to secure land by existing landowners; • inflation of the "price" to use land (through sharecropping, donations or loans).	**IN**	Landless households subject to land lending arrangements	Yiben inundation and dam study areas. Bumbuna Extension area to a lesser extent.	**Moderate**	**N/A**

7.10.4 Mitigation Measures

Details on the embedded mitigation and additional mitigation measures are provided in *Chapter 8* (Environmental, Social and Health Management Plans) and in *Volume II, Annex H Social* and *Annex I Resettlement Framework*. A number of potentially moderate and minor residual impacts related to social and cultural heritage will require further consideration during the construction and operation of the Project. These are presented in full in *Volume II, Annex H; Social* and summarised below in *Table 7.46.*

7.10.5 Residual Impacts

A summary of the residual impacts is provided in *Table 7.33* below.

Table 7.33 Summary of Residual Impacts

Impact	Residual Significance Rating
Physical and economic displacement	*Major*
Increased risk of poor financial management	*Moderate*
Weakening of methods of traditional governance	*Minor*
Change in traditional family structure and social networks	*Negligible*
Increase in social tension related to resettlement and employment	*Minor*
Increased pressure on land and inequality of access to land	*Minor*
Increase in available farmland downstream of Bumbuna Extension	*Positive*
Decreased access to grazing land and conflicts with farmers	*Minor*
Loss of income from artisanal mining	*Minor*
Loss of access/income from timber and non-timber forest products	*Minor*
Decrease in income of local communities households	*Minor*
Increase in income of recruited persons	*Positive*
Increase in local development initiatives	*Positive*
Isolation of settlements around the reservoir area	*Minor*
Increased mobility from new/maintained project roads	*Positive*
Increase in transmission of disease	*Minor*
Transmission of malaria and other water related diseases	*Minor*
Transmission of disease related to water, hygiene and sanitation	*Minor*
Risks of accidents from road traffic and transport	*Minor*
Risks of drowning, Employee Safety risks	*Minor*
Access to health services	*Minor*
Noise and vibration/ Air quality	*Minor*
Improved access to energy	*Positive*
Loss of High Sensitivity Archaeological Sites	*Moderate*
Loss of Low to Medium Sensitivity Archaeological Sites	*Minor*
Loss of High Sensitivity Burial Grounds	*Moderate*
Loss of Low to Medium Sensitivity Burial Grounds	*Minor*
Loss High Sensitivity Sacred Sites (ie sacred trees, rocks, shrines)	*Moderate*
Loss of Low to Medium Sensitivity Sacred Sites (ie sacred trees)	*Minor*
Loss of Churches and Mosques	*Negligible*

It can be seen from the table above, that the residual impact relating to physical and economic displacement remains *Major* even after implementation of a Resettlement Action Plan (RAP). The Project has already developed a Resettlement Framework (*Volume II; Annex I*) that has identified all the

affected villages and sets out an approach to compensating the affected households.

Despite the implementation of the RAP, it must be acknowledged that the changes to the lives of those affected by resettlement will be significant and permanent. The resettlement programme will therefore aim to provide the affected communities with new villages and ways of making a living that are an improvement on what they currently have. Support will also be given to people to enable them to re-establish themselves after they have moved to their new locations. This will include new economic opportunities that might come from increased access to energy and increased fishing in the new Yiben reservoir for example.

During construction, the Project will require over 2,300 workers many of whom will come from the local area. This will improve the local economy and will provide people with new skills. The Project will also deliver reliable year round electricity into the Sierra Leone power grid which will benefit many households and businesses and contribute to the economic development of the country.

The other impacts that are *Moderate* (eg access to cultural sites and burial grounds) are related to this impact.

It should be clear that resettlement anywhere in the world is challenging and will take a long time to manage effectively. Even when resettlement programmes are well executed, its impact on the lives of the people affected is profound and permanent. While well implemented resettlement programmes can have some positive impacts on some aspects of people's lives (such as access to education or healthcare or clean water), the affected people still suffer a loss of their ancestral lands and their "sense of place" is changed forever.

7.11 TRAFFIC

7.11.1 Introduction

The full Traffic Impact Assessment is presented in *Volume II*, *Annex K* of this ESHIA Report. The Traffic Impact Assessment presents a detailed description of the road and transport network, significant impacts and mitigation measures. The sections below summarise the findings of the Traffic impact assessment. *Annex K* describes the baseline traffic and transportation conditions in the Project area.

7.11.2 Summary of Significant Construction Impacts

Traffic Function

Construction of the Project could affect both traffic capacity and transportation safety.

Receptors for traffic function are existing road users, including drivers, passengers, cyclists, and pedestrians. In general, these receptors have Low sensitivity to traffic impacts: most road users will be able to cope with increased Project-related traffic volumes, congestion, and delay with no need for external mitigation.

Construction traffic is unlikely to exceed the carrying capacity of existing public roads. Within and near the Project area, Project-related traffic volumes are likely to substantially exceed existing traffic volumes. Non-project users of public roads may experience delays while waiting for or traveling behind heavy trucks hauling equipment, excavated materials, or concrete.

Existing traffic volumes along the main highways between Freetown and Bumbuna are upwards of 2,300 vehicles per day. Although the exact Project-related traffic volumes are unknown, deliveries and other Project-related trips from Freetown would be unlikely to exceed the carrying capacity of these highways and ferries, and are unlikely to exceed 25 percent of existing traffic volumes (ie 600 vehicle trips per day on the highway segment near Rogbere).

Overall, the Project's construction-phase impacts on traffic function would be **Minor**. Project-related traffic will temporarily increase overall traffic volumes and could cause noticeable delay—particularly near the Project site; however, these changes would not meaningfully change daily life for other road users.

Transportation Safety

Receptors for transportation safety are the same as for traffic function: existing road users, including drivers, passengers, cyclists, and pedestrians. Most road users, particularly in the Project area, are unaccustomed to using roads in the presence of large trucks. Due to the size and weight of the trucks involved, people would likely experience injury in the case of a crash, regardless of the safety measures in place.

Given the medium to high sensitivity of the receptors and range in magnitude of effect, impacts on transportation safety from Project construction would be **Moderate** along the regional haul route, and **Moderate** to **Major** in and near the Project area, prior to mitigation.

7.11.3 Summary of Significant Operation Impacts

Estimates of the total number of operations-phase trips are not available; however, they are expected to be minimal. As a result, the magnitude of both traffic operations and transportation safety impacts is expected to be **Negligible**, with a **Negligible** overall impact.

7.11.4 *Mitigation Measures*

Details on the embedded mitigation and additional mitigation measures are provided in *Chapter 8 (Environmental, Social and Health Management Plans)* and in *Volume II, Annex K Traffic.*

7.11.5 *Residual Impacts*

Implementation of the management and mitigation measures described in *Table 7.48* would likely result in the following impacts.

- Construction traffic function: impacts would remain **Minor**.
- Construction transportation safety: impacts would be **Moderate** for all areas.
- Operations: impacts would remain **Negligible**.

7.12 *CUMULATIVE IMPACTS*

This section summarises the expected cumulative impacts associated with the Project. These are also outlined in the separate Technical Annexes of Volume II of this Report.

Bumbuna II is known to be in the vicinity of other major projects which could have the potential to result in cumulative impacts. A summary of these projects is presented below. Cumulative impacts from this Project and other projects have been assessed for each topic and summarised below.

Where there is a potential for any significant intra-project cumulative impacts on receptors within the Project area which may be impacted by the construction of more than one of the Project components they are described below.

Iron Ore Mines and Associated Facilities, Tonkolili and Marampa

Shandong Steel iron ore mine and China Kingho Iron Ore Project (which includes a 250 km railway and 350 MW hydropower project and smelting facility); both with operations centred in Tonkolili District some 40 km south of Bumbuna.

In addition, iron ore mining could recommence in the Marampa area (London Mining and Cape Lambert Resources Iron Ore mines), over 70 km downstream of the Bumbuna II.

Addax Bioenergy/Sunbird Energy, Makeni

Addax Bioenergy has developed a renewable energy and agriculture project in Makeni that will produce bio-ethanol for export as well as for domestic use, and electricity for the national grid. The total processing capacity of the plant

is 1 million tons of sugarcane per year. Makeni is located over 40 km downstream of the Bumbuna II.

West African Power Pool Project

The West African Power Pool (WAPP) wishes to establish a reliable power grid for the region and a common market for electricity. It aims to re-develop the hydro resources and interconnect Cote d'Ivoire, Liberia, Sierra Leone and Guinea with a 1,359 km interconnection line, connecting at Bumbuna Extension II. It is planned that construction of this interconnection will be concurrent with the construction Bumbuna II.

A summary of the potential cumulative impacts for each topic is presented below.

7.12.1 Air Quality

The proposed development is known to be in the vicinity of other major development including iron ore mining. There is therefore the potential for cumulative impacts where the impacts of other projects, including mining, are in the vicinity of the proposed project or where traffic is on shared roads. Specifically, cumulative impacts are a concern for the impacts described below.

- Increased PM_{10} and $PM_{2.5}$ from traffic movements on unpaved roads in the Project area might lead to impacts on which are potentially significant where the same unpaved roads are used any of the other projects described above during the same period. Impacts on human health might accumulate up to 200 m from these roads.

- Dust, PM_{10} and $PM_{2.5}$ impact on human health during earthworks are potentially of concern where any of the other projects described above need to perform dust-raising activities within 200 m from the earthworks for the Project, impacts on human health 200 m from these activities will be accumulated.

- Impacts on human health due to combustion emissions from vehicles are potentially of concern where any of the other projects described above will also generate traffic. This is potentially a significant issue in towns and villages along the Project transport route (See *Annex K Traffic*) where there tend to be congested streets and receptors close to the roadside. Where this is the case, the Project should seek to minimise traffic generated, and use the most up to date vehicles available in order to minimise the Project contribution.

7.12.2 Greenhouse Gasses and Climate Change

No cumulative impacts from GHGs emitted from Bumbuna II and any other projects in the area are predicted.

7.12.3 *Noise and Vibration*

There are Noise Sensitive Receptors which may be impacted by the construction of more than one of these components. Where these intra-project cumulative impacts are predicted to be significant, they are described below.

Significant intra-project cumulative noise levels are expected to affect the O&M Camp from works to construct the headrace tunnel and surge shaft as well as, to a lesser extent, works to construct the penstock and manifold, powerhouse and tailrace canal. The highest noise levels expected as a result of these activities is predicted to be 56 dB, resulting in a minor impact during the day and a large magnitude impact at night. Further mitigation to reduce the significance of these large magnitude impacts is discussed in *Annex C Noise and Vibration.*

Significant intra-project cumulative noise levels are expected to affect Kamator 1 from works to construct the headrace tunnel, surge shaft, penstock and manifold, powerhouse, tailrace canal and batching plant. The highest noise levels expected as a result of these activities is predicted to be 65 dB, resulting in a moderate impact during the day and a large magnitude impact at night. Further mitigation to reduce the significance of these large magnitude impacts is discussed *Annex C Noise and Vibration.*

Significant intra-project cumulative noise levels are expected to affect the nearest NSRs at the northern end of Kamator 2 from works to construct the penstock and manifold, powerhouse, tailrace canal and batching plant as well as, to a lesser extent, works to construct the headrace tunnel and surge shaft. This is predicted to increase the number of properties experiencing a large magnitude impact by approximately 10. No additional properties are expected to experience minor or moderate impacts as the northern end of Kamator 2 is characterised by a narrow line of properties extending along the Bumbuna I access road, away from the powerhouse and there are therefore no properties set further back that would otherwise experience noise at these levels.

No other projects are expected to result in cumulative noise or vibration impacts with this Project.

7.12.4 *Geology and Soils*

No cumulative impacts relating to soils have been identified other than the cumulative impact this Project would have had on distant downstream soils in the Seli River valley and estuary due to a reduction in sediment transport. The presence of the Bumbuna reservoir and dam means this effect is already occurring and its presence mitigates any negative effect from this Project.

7.12.5 *Water Resources and Environmental Flows*

Of the projects within Sierra Leone which have the potential to result in cumulative effects in combination with this project, six have been identified

within the same watershed, and are thus considered to have the potential to result in cumulative impacts. A summary of these potential cumulative impacts is presented below.

Shandong Steel, Iron Ore mine in Tonkolili, Bumbuna

This Project is located within the Tonkolili catchment, which discharges into the River Rokel approximately 10 km downstream of Bumbuna II tailrace. As such, there is no hydraulic connection between the Shandong Steel mine and Bumbuna II and as such, it is not possible that the Project could have any impact on the operation of this mine.

The environmental flows assessment has shown that the operation of the Bumbuna Extension will result in a significant adverse effect on aquatic ecology downstream of the tailrace. These effects are likely to have attenuated within 10 km downstream of the tailrace, at which point the Tonkolili enters the River Rokel. As such, cumulative impact on aquatic ecology downstream of the confluence has been assessed as not resulting in a significant in-combination effect.

London Mining and Cape Lambert Resources, Iron Ore mines in Marampa

As stated above, all adverse impacts from Bumbuna II are expected to have attenuated within 10 km of the tailrace, and as such, it is not anticipated that the Project would result in any cumulative impacts in-combination with any affects resulting from the operation of these mines.

China Kingho Iron Ore Project, Mugabara, Tonkolili

As with the existing Shandong Steel mine, this mine will be located within a catchment which flows into the River Rokel well downstream of Bumbuna II. As such, there will be no hydraulic connection between the China Kingho mine and Bumbuna II and as such, it is not possible that the Project could have any impact on the operation of this mine or vice versa.

Addax Bioenergy/Sunbird Energy, Makeni

This project is located over 40 km downstream of Bumbuna II. As stated above, all adverse impacts from Bumbuna II are expected to have attenuated within 10 km of the tailrace, and as such, it is not anticipated that the Project could result in any cumulative impacts in-combination with any affects resulting from the this agricultural project.

West African Power Pool Project

As stated above, this interconnection will connect at Bumbuna Extension. It is planned that construction of this interconnection will be concurrent with the construction of Bumbuna II.

This cumulative assessment has assumed that the construction of the WAPP project which consists of the construction and operation of a transmission line,

will have similar negligible impacts as the transmission lines to be constructed as part of Bumbuna II.

It is assumed that the WAPP project will adopt similar construction methodologies as those for this project, including the production of a detailed Water Resources Management Plan. Should this be the case, it is likely that this project will not have any significant effect on the water environment, and as such there would be no cumulative impacts in combination with Bumbuna II.

7.12.6 *Biodiversity*

The projects listed above have been considered to have the potential to result in cumulative biodiversity impacts.

Table 7.34 provides a summary of the residual Project biodiversity impacts that have the potential to contribute to cumulative effects in combination with other projects.

Table 7.34 Potential Cumulative Effects of the Project in Combination with other known development in the Seli Catchment (where an 'X' is shown a potential for cumulative effects exists)

Significant Residual Project Impact	Shandong Steel, Tonkolili	China Kingho Iron Ore Project, Mugabara, Tonkolili	Marampa Iron Ore Mines	Addax Bioenergy, Makeni	West African Power Pool Project
Permanent terrestrial habitat loss and loss of plant species of conservation concern	X	X	X	X	X
Habitat fragmentation effects and associated loss of terrestrial fauna	X	X	X	X	X
Disturbance of western chimpanzee and yellow-casqued hornbill due to noise, vibration and human presence	Whilst the different components of the Project itself are likely to cause cumulative disturbance it is considered that other developments in the catchment are located at a distance which will not result in a cumulative disturbance effect.				
Terrestrial species mortality due to traffic collisions	X	X	X	X	X
Permanent aquatic habitat loss and associated aquatic species mortality	X	X	X	Not anticipated due to the nature of the Project	Not anticipated due to the nature of the Project
Loss of functional aquatic habitat and aquatic community shift due to hydrological modifications	X	X	X	X	Not anticipated due to the nature of the Project

Significant Residual Project Impact	Shandong Steel, Tonkolili	China Kingho Iron Ore Project, Mugabara, Tonkolili	Marampa Iron Ore Mines	Addax Bioenergy, Makeni	West African Power Pool Project
Loss of functional aquatic habitat and aquatic community shift due to eutrophication	Not anticipated due to the nature of the Project	X	Not anticipated due to the nature of the Project	X	Not anticipated due to the nature of the Project

Conclusion

There are several developments which will affect biodiversity resources in the Seli River catchment, and that could result in cumulative impacts with the Bumbuna Extension. However, there is currently insufficient information available about the current and / or predicted effects of these developments to allow an assessment of the cumulative effects.

7.12.7 *Ecosystem Services*

Cumulative impacts to ecosystem services are covered under the other sections in *Section 7.12*.

7.12.8 *Social*

Due to ongoing developments in the mining and agriculture sector as outlined by the projects mentioned above in the Districts of Tonkolili and Port Loko, cumulative social Project impacts are most likely to include the following:

- *Land take/economic displacement:* Planned projects are likely to increase land take/economic displacement and pressure on natural resources, primarily in Bumbuna and Mugbara. As such, the availability of land will be reduced. Previous developments in Bumbuna have caused both physical and economic displacement, which have led to ongoing legacy issues pertaining to food insecurity and loss of income. Such impacts significantly exacerbate the vulnerability of affected communities reliant on land for subsistence and income generation. Associated issues have been documented in Bumbuna I ESAP Mission Report 6, and human rights and media reports resulting from civil unrest in Bumbuna in April 2013, which occurred as a consequence of grievances associated with AML.

- *In-migration/pressure on social infrastructure:* Due to high expectations of direct and indirect employment opportunities in the main growth sectors (ie mining, tourism, agriculture and fisheries), Bumbuna, Mugbara and main town and cities along the Northern Growth Pole (ie Freetown to Tonkolili) have experienced rapid population growth. As such, these towns are expanding in order to accommodate job seekers in combination

with natural population growth. Other project developments in these areas are likely to create pressure on social infrastructure such as health, education, water resources, transportation and waste/sanitation.

- *Employment and economy:* While developments in the mining, power and agriculture sector create significant positive impacts that facilitate economic growth and employment at a local and national level, adverse impacts can be felt by those that do not have access to such opportunities. Inflation and the cost of living have increased over the last five years in Bumbuna but also in main cities of the Northern Growth Pole. Costs are likely to continue increasing resulting in a poverty gap between those benefiting and those that are not.

- *Access to power:* Depending on the beneficiaries of the Project in combination with the WAPP Project, the increased availability of electricity generation is likely to facilitate economic growth and development. An increase in the availability of power will allow for the establishment of new businesses and business growth, ultimately creating jobs and improving living standards.

- *Ecosystem services*: Mining and agriculture projects in the Project area are likely to have impacts on biodiversity, downstream water quality, air quality, etc that may result in reduced ability of ecosystem services to support local households (provision of food, water, other natural resources). Indirect impacts and mitigations from cumulative effects on Ecosystem services are discussed in the Technical Annexes on Water resources, Biodiversity and Air quality.

7.12.9 Traffic

In addition to the construction traffic to be generated by the Project, it is expected that increased construction activities in the region will result in additional traffic generation. The details of this additional traffic are currently unknown.

8 ENVIRONMENTAL, SOCIAL AND HEALTH MANAGEMENT PLANS

8.1 INTRODUCTION

In order to ensure that the social and environmental issues identified during the assessment are effectively managed, a series of environmental, social and health management and monitoring plans (ESHMPs or 'management plans') will be developed. These plans will outline mitigation and management measures through the construction and operation of the power plant. Some plans will be developed by Joule Africa, some by the Engineering Procurement Contractor (EPC).

This chapter sets out the approach that the project will take to management and monitoring and the guiding principles that will be used in the development of the plans.

A Project Environmental, Social and Health Management System (ESHMS) and associated ESHMP is being developed by Joule Africa to ensure that the social and environmental impacts set out in *Chapter 7*, as well as any other issues that might emerge during construction or operations are managed effectively through a clear system of responsibilities, policies, procedures, monitoring and reporting processes.

The following *(Box 8.1)* have been identified as the core project level plans that will be needed to manage the environmental and social impacts as identified by the ESHIA.

Box 8.1 Environmental, Social and Health Project Level Plans

	Plan Name	Timing	Issue/Impact Identified in Chapter 7 or International Good Practice	Responsibility	Related Performance Standard
Environmental	Air Quality Management and Monitoring Plan	Construction	• Air Quality/ Dust (Particulates) from construction activities • Air Quality/ Road traffic & Mobile equipment emissions	Engineering Procurement Contractor (EPC)	IFC PS 1, 3 & 4
	Noise and Vibration Management and Monitoring Plan	Construction	• Significant noise sources include earthworks, excavation (which may include drilling and blasting), concreting, foundation works, construction traffic, rock impacting nearby communities • Quarry noise impacting nearby community • New access roads will be constricted and some existing access roads upgraded resulting in noise impacting nearby communities	EPC	IFC PS 1, 3 & 4
	Water Resources, Drainage and Erosion Management Plan	Construction & Operation	Construction • Short term prevention of flow downstream of Yiben dam • Enhanced runoff from construction footprint. Diversion of runoff from adjacent land. • Downstream pollution caused by sediment erosion (and dust suppression) on site • Drainage and/or dewatering of tunnelling operations locally intercept groundwater flow paths, re-shape the ambient groundwater table, and locally reduce existing spring flows. Operation • Long term regulation of flows downstream of Yiben dam (higher flows in dry season, lower flows in wet season). • Reduction of surface water quality in Yiben reservoir (compared to Seli River quality) due to eutrophication within the reservoir. This is due to changes in chemical composition following the saturation of shallow soils in the inundation area • Dam foundations and tunnel(s) intercept groundwater flow paths, re-shape the ambient groundwater table, impact spring flows. • Inundation of the large area of land may mobilise potentially contaminated land. • Enhanced runoff from operational footprint. Diversion of runoff from adjacent land. Change in operational flow regime, increase in Seli River flows during dry season and reduction during wet season. • Bumbuna II tunnel(s) intercept groundwater flow paths, re-shape the ambient groundwater table, and locally reduce existing spring flows. • Change in groundwater flow paths caused by tunnelling may mobilise potentially contaminated land. Also, potential acid leaching from rock storage facilities.	EPC (Construction) Joule Africa (Operation)	IFC PS1, PS3 & PS6
	Soil Management Plan	Construction	• Timber clearance and temporary road construction • Excavation, site clearing and levelling works	EPC	IFC PS1, PS3 & PS6
	Vegetation Clearance Plan	Pre-construction& Construction	• GHG emissions associated with land use changes • GHG emissions associated with the decay of reservoir biomass material within the inundated area • Emissions of dust as a result of vegetation clearance	Joule Africa to determine (Preconstruction for inundation area) EPC (during construction)	IFC PS1, PS3, PS4& PS6

	Plan Name	Timing	Issue/Impact Identified in Chapter 7 or International Good Practice	Responsibility	Related Performance Standard

	Biodiversity Action Plan (BAP) including;
	• Offsetting strategy
	• Biodiversity Monitoring Programme (BMP)
	• Invasive Species Management Plan
		Pre-construction, Construction & Operation	Construction
			• Pollution risk to water and aquatic ecology arising from potential surface and groundwater quality impacts and temporary reduction of flow in Seli River to facilitate construction
			• During construction the following impacts on terrestrial biodiversity receptors are predicted:
			  • Permanent loss of terrestrial and riparian habitat under the direct footprint of Project infrastructure (including the Yiben dam, Bumbuna Extension, access roads, quarry and transmission line) and within the inundation zone.
			  • Deterioration of habitat through fragmentation and increased edge effect.
			  • Permanent loss of individuals and populations of plant species within the Project footprint and inundation zone.
			  • Introduction and spread of terrestrial invasive species.
			  • Permanent loss of supporting terrestrial habitat and associated impacts on mammals, birds, reptiles, amphibians and invertebrates of conservation concern and/or restricted range species.
			  • Disturbance and displacement of mammals, birds, reptiles, amphibians and invertebrates of conservation concern from the Project footprint and inundation zone.
			  • Fragmentation of habitat and populations of mammals of conservation concern and or/restricted range species. Direct mortality of mammals, birds, reptiles, amphibians and invertebrates due to collision/interaction with Project construction traffic or mobile equipment.
			  • Increased hunting pressure from construction of new roads, induced access and population influx.
			• During construction the following impacts on aquatic biodiversity receptors are predicted.
			  • Permanent loss of aquatic riverine habitat in the inundation zone and Bumbuna tailrace footprint.
			  • Temporary loss of downstream aquatic habitat during reservoir filling.
			  • Introduction and spread of aquatic invasive species.
			  • Degradation and loss of surface and ground water habitats due to sedimentation and pollution.
			  • Creation of barriers to migration and fragmentation of aquatic habitat as a result of construction of Project infrastructure.
			
			Operation
			• Discharge of deoxygenated (eutrophication) waters from Yiben reservoir into Bumbuna reservoir.
			• Regulation of river flow downstream of Bumbuna dam. Reduction of water quality and habitat diversity from environmental flow discharge.
			• The following impacts on terrestrial biodiversity receptors are predicted:
			  • Direct mortality of mammals, birds, reptiles, amphibians and invertebrates due to collision/interaction with Project operation traffic or mobile equipment.
			  • Increased hunting pressure from construction of new roads, induced access and population influx.
			  • Collision and electrocution with transmission line by birds.
			• During operation, the following impacts on aquatic biodiversity receptors are predicted:
			  • Loss of aquatic species in the inundation zone from the development of eutrophic conditions.
			  • Degradation of habitat and associated mortality of aquatic species downstream of Yiben dam and between Bumbuna dam and tailrace due to operational hydrological modifications.
			  • Degradation of habitat and associated mortality of aquatic species due to sedimentation and pollution from operational areas.
			  • Mortality of aquatic species due to entrainment by reservoir intakes and turbine strikes.
			  • Potential depletion of aquatic species populations as a result of overexploitation due to population influx and induced access
				Joule Africa/ BAP Specialists (Pre-Construction)
				
				Joule Africa & BAP specialist & EPC (Construction)
				
				Joule Africa (Operation)
					IFC PS6

Social and Health	Sustainable Fisheries Management Plan	Construction & operations	Construction • Pollution risk to fish arising from potential surface and groundwater quality impacts. Operation • Pollution risk arising from potential surface and groundwater quality impacts. • Need to change fishing patterns in response to changed water flows.	EPC (Construction) Joule Africa (Operation)	IFC PS5 & PS6

	Plan Name	Timing	Issue/Impact Identified in Chapter 7 or International Good Practice	Responsibility	Related Performance Standard
	Resettlement Action Plan (RAP) including Livelihoods Restoration Plan (LRP) (See *Vol II, Annex I, Resettlement Framework*)	Pre-construction& Construction & Operation	Early works/Construction • Identification of all communities and individuals (including migratory herders) affected by physical and /or economic displacement by the project or environmental impacts requiring their relocation • Development and implementation, via a consultative process, of programmes to provide replacement housing, land, access to resources, ecosystem services and community facilities and compensate for losses, eg standing crops and trees. • Livelihood restoration plan to ensure that people affected by resettlement are better off than prior to resettlement.	Joule Africa/ RAP Specialists	IFC PS5
	Integrated Vector Control Programme.	Construction and Operations	• Modifications to the physical environment can offer new breeding grounds and patterns for mosquitos and other water-related vector borne diseases to communities within 5km of the inundation area. • Standing water resulting from construction operations can create breeding grounds for mosquitos. • The presence of Schistosomiasis may become distributed over a wider area as a result of the dam. As the snails that carry the parasite tend to prefer slow moving water, they may become prevalent in the reservoir area.	EPC (Construction), Joule Africa (Operations)	PS4
	Cultural Heritage & Archaeological Chance Finds Procedure	Construction	• No archaeological sites have been conclusively identified within the footprint of the project. However, there are archaeological anomalies that have not been ground-truthed and there has been no pedestrian survey by archaeologists so there is still the potential that the project could affect archaeological sites. • Chance finds procedure in to investigate and properly handle any archaeological finds, eg during construction. • Loss of sacred sites (ie sacred trees, rocks, shrines, bushes, water bodies) • Loss of burial grounds.	EPC	PS1, 8
	Community Investment Plan	Construction and Operations	• Joule Africa contribution to development in the project area over and above mitigation of negative impacts	Joule Africa	Good Industry Practice
	Human Resources Policy and Procedures	Construction & Operation	• To ensure that people employed on the project (by Joule Africa or by contractors) are recruited through a fair and transparent process without discrimination • To ensure that any project commitments to employing Sierra Leone national and/or local residents are defined and implemented • To ensure that workers have contracts that set out their responsibilities, obligations and terms and conditions of employment, and that these terms and conditions comply with national labour law eg minimum wage, and international standards, eg ILO Core Conventions. • A grievance mechanism that provides all workers on the project with access to a fair and transparent means of reporting and resolving grievances.	EPC (Construction) Joule Africa (Operation) Any other contractors	IFC PS2
	Local Content Plan	Construction & Operation	• To ensure that any project commitments or regulatory requirements relating to the use of goods and services produced in Sierra Leone are implemented. • Support for the local economy through purchasing goods or services from the local area where available (and where this will not damage existing users/customers).	Joule Africa/EPC (Construction) Joule Africa (Operation)	PS 1, Good Industry Practice
	Water, Sanitation and Hygiene (WASH) Plan	Construction and Operations	• Existing access to water, sanitation and hygiene for resettled communities, host communities and others may be damaged by the project and will need to be restored to at least the same or preferably better quality.	EPC (Construction) Joule Africa (Operation)	IFC PS4
	Influx Management Plan	Construction	• Possible movement of people into the area in search of employment and business opportunities – especially during construction leading to excess demand on local services and housing and creating tensions between existing and new residents, for example, concerning employment on the project.	EPC (Construction)	IFC PS1
	Stakeholder engagement Plan (Volume II, Annex J; Stakeholder Engagement Plan)	Early Works, Construction and Operations	• Local authorities: local organisations, eg religious, health, educational); traditional authorities and community members will expect to be kept informed of the progress of the project and to be consulted on key issues affecting them. • Grievance mechanism to ensure that complaints or grievances about the impacts of the project are received and there is a fair and transparent process to resolve grievances.	Joule Africa	IFC PS1

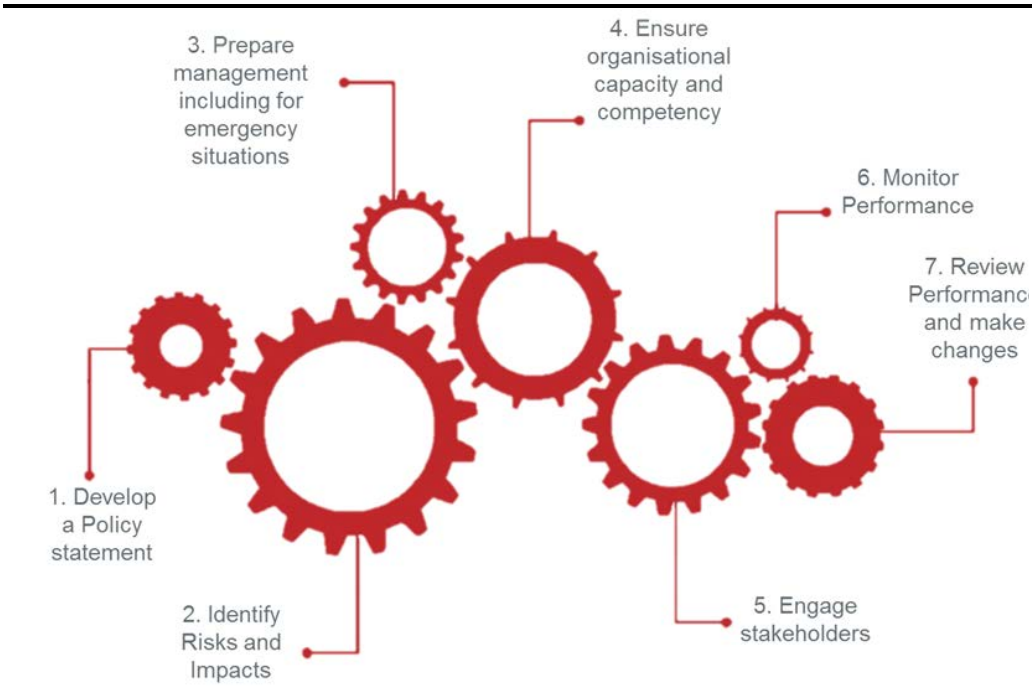
	Plan Name	Timing	Issue/Impact Identified in Chapter 7 or International Good Practice	Responsibility	Related Performance Standard
Environmental and Social	Camp Management Plan and Workforce Code of Conduct	Construction & Operation	• Much of the Project workforce will be housed in camps during construction. The camp management plan is to ensure good standards of accommodation and working systems, eg in the canteen, laundry, maintenance workshops that do that do not expose workers to health, safety or hygiene risks. • The Workforce Code of Conduct is designed to ensure there is a clear set of rules to ensure the safety and security of the camp and the avoidance of negative impacts of the camps on surrounding communities by controlling, for example, hunting and access to alcohol.	EPC (Construction) Joule Africa (Operation)	IFC PS 2&4
	Construction Environmental Management Plan (CEMP) and Construction Code of Conduct	Construction	• Detailed plans and procedures for application by the EPC contractor and sub-contractors to ensure that the environmental commitments, eg pollution controls, are adhered to.	EPC	IFC PS1 & 3
Environmental, Health and Safety	Traffic and Vehicle Management Plan	Construction	• Emissions associated with transport of raw materials • Potential for traffic accidents resulting in injuries or fatalities to other road users, cyclists, pedestrians or livestock	EPC	IFC PS1, 3 &4
	Emergency Prevention and Response Plan (EPRP)	Construction & Operation	• Risks of major incidents that could damage people or the environment, eg large spill, traffic accident, equipment or infrastructure failure.	EPC and Joule Africa	IFC PS4
	Hazardous Material Management Plan	Construction & Operation	• Accidental leakage or spills from the storage of fuels, oils or other hazardous materials impacting soil or water quality or presenting health and safety risks to workers/communities.	EPC (Construction) Joule Africa (Operation)	IF PS3
	Safety Instructions for Storage, Transportation and Usage of Hazardous Materials	Construction & Operation	Construction • Downstream water pollution, groundwater pollution and soil contamination caused by accidental spillage of hazardous materials such as fuel, oil and foul wastes. Operation • As above plus potential acid leaching from rock storage facilities.	EP EPC (Construction) Joule Africa (Operation)	IF PS3
	Occupational Health and Safety (OHS) Management Plan	Construction & Operation	Health and Safety • Exposure of workforce to health and safety risks could lead to serious injury or even death. • As a major construction project risks will include falls, slips, working in confined spaces, use of heavy equipment and hazardous materials etc. • The OHS Plan is designed to ensure that all work tasks in construction and operations are risk assessed and safe systems of work and associated training are in place according to best industry practice.	EPC (Construction) Joule Africa (Operation)	IFC PS2 Good Industry Practice
	Security Policy and Plan	Construction & Operation	• Risks to the security of people, equipment and facilities. • Potential risks to the security of people and communities outside the project from the presence of large numbers of people during construction and disturbance of communities through resettlement.	EPC (Construction) Joule Africa (Operation)	IFC PS4

The management plans developed for the Project will be practical and fully integrated into the Project's Environmental, Social and Health Management System (ESHMS).

Joule Africa will include in the EPC contract requirements that the EPC lead contractor develop its own detailed management plans to implement the elements of the Project ESHMS that come under their control and to ensure that the requirements are also followed by sub-contractors. Joule Africa will monitor this aspect of contractor performance.

The basic process of the development of an ESHMS and its key components is summarised in *Figure 8.1* below.

Figure 8.1 Basic Process of the Development of an ESHMS



Source: ERM

Plans will be 'living documents' that are regularly reviewed and updated as necessary. Joule Africa is in the process of putting the Project ESHMS and the relevant mitigation plans for construction in place. In addition to the key Project- level management plans and documents, Joule Africa is also developing a Corporate Environmental, Social and Governance (ESG) Management System.

8.2 KEY COMPONENTS OF MANAGEMENT AND MONITORING PLANS

The management plans for the Project will be developed to align with national regulatory requirements and Good International Industry Practice (GIIP),

including policies of IFC, EIB, World Bank Group and AfDB Operating Standards. The plans incorporate the following components.

- **Activity**: a short description of the activity that is expected to result in significance impacts/risks and the phase of the project the plan applies to.
- **Issue / Risk**: an overview of the issue or risk that needs appropriate mitigation and/or management.
- **Action / Mitigation Measure**: a description of the mitigation/ management measures that will be implemented to manage each significant impact/risk.
- **Monitoring:** what monitoring (and with what frequency) will be undertaken to track implementation of the plan and how monitoring results will be assessed and acted on, eg if monitoring shows exceedances of water pollution limits.
- **Performance Measure**: measurable indicators that show the extent to which the desired outcomes are being achieved, and definition of incidents/near misses/ accidents/enhanced risks that require internal and/or external reporting.
- **Responsibility**: the party responsible for implementing the action.
- **Control, review and revision**: the party responsible for the plan, the status of the plan, and the frequency of review (and revisions as needed).

8.3 ENVIRONMENTAL AND SOCIAL (E&S) MANAGEMENT ORGANISATION

Joule Africa will establish an environmental and social management organisation based on the roles and responsibilities shown in *Table 8.1*.

Table 8.1 Environmental and Social Management: Typical key Roles and Responsibilities

Position	E&S Responsibility
Joule Africa Team	
General Manager/ Managing Director	Ultimately responsible for EHS including ensuring that the EHS function has adequate budget and appropriately skilled and experienced staff; ensuring that contractors comply with project EHS requirements and there is effective communication with all stakeholders.
Construction Manager & Operations Manager	Understanding Project EHS commitments and responsibilities and ensuring these are incorporated into all construction and (once Bumbuna II is completed) operational plans and procedures and roles and responsibilities, including contractors.

Position	E&S Responsibility
	Responsible for the Emergency Response Plan including regular testing.
EHS Manager	Ensuring that the Project, including EPC contractor develops and implements management plans. Managing the EHS team (including any consultants). Monitor implementation of environmental and social protection measures, and assist with technical input into spill response requirements. The Project will deploy a resettlement manager in addition during the period of RAP implementation.
Community Liaison Officers (CLO)	Liaise with local communities ensuring two way flow of information between the Project and communities. Implements EHS awareness and education programmes with communities. Provide the first point of call for complaints and grievances.
EPC contractor	
Project Manager	Responsible for EHS performance and compliance including assuring that adequate budget, resources and authority are provided to the EHS team.
Environmental Health and Safety (EHS) Manager	Ensures that environment, health and safety and social project requirements (including but not limited to regulatory compliance) are met.

8.3.1 *Training and Awareness*

Joule Africa will identify, plan, monitor, and record training needs and delivery for their personnel whose work may have a significant adverse impact upon the environment or social conditions. The EPC has the same responsibility for identifying and implementing training for their personnel.

This training will include awareness and competency as relevant to the personnel involved with respect to:

- environmental and social impacts that could arise from their activities (including dust, loss of biodiversity and soil/water contamination);
- the necessity of conforming to the requirements of the ESHIA and ESHMP, in order to avoid or reduce those impacts;
- roles and responsibilities to achieve that conformity, including those in respect of change management and emergency response; and
- systems to ensure that social and environmental aspects are included in induction for new staff and visitors to the site.

The Joule Africa Project EHS Manager will be responsible for coordinating training, maintaining Joule employee-training records and checking contractor records, and ensuring that these are reviewed on a regular basis. The EHS

Manager will also periodically establish a system to verify that EHS staff are performing competently, and ensure that staff responsible for EHS supervision and inspections have the training needed.

Joule Africa will require that the EPC institutes training programmes for its personnel and those of sub-contractors. The subcontractors are also responsible for identification of any additional training requirements to maintain required competency levels.

8.3.2 *Communication*

Joule Africa will maintain a procedure for EHS related communications with the regulatory authorities and communities. Meetings will be held, as required, between Joule Africa and the appropriate regulatory agency and community representatives to update stakeholders on the project and review EHS performance, areas of concern and emerging issues.

Grievance Mechanism

The Project will develop and implement a grievance mechanism whereby community members can raise any issues of concern, grievances (complaints) or suggestions about the way that the Project is being implemented.

Grievances can be raised verbally (eg to a Community Liaison Officer), by phone, email or in writing. Joule Africa will disseminate information on how to make a complaint, or suggestion. If complainants feel it necessary to do so, complaints can be made anonymously, though this does make it harder to follow up.

When a grievance, comment or suggestion has been brought to the attention of the Project team it will be logged and evaluated. In the case of grievances, the person or group with the grievance is asked to provide details so that a proper and informed evaluation can be made.

Where a complaint or claim is considered to be valid, then steps are required to be undertaken to rectify the issue or agree compensation for the loss. In all cases the decision made and the reason for the decision will be communicated to the relevant stakeholders and recorded.

Joule Africa will establish a recourse mechanism overseen by a third party for any cases where there remains disagreement on the outcome.

The grievance mechanism is further outlined in *Volume II*; *Annex J Stakeholder Engagement Plan*.

8.3.3 *Documentation*

Joule Africa will establish a formal system to control E&S documentation, including management plans; associated procedures; and checklists, forms and reports.

The EPC will be required to develop an equivalent system.

8.3.4 *Emergency Preparedness and Response*

Joule Africa will prepare plans and procedures to identify the potential for, prevention of and response to environmental health and safety emergency situations. These plans will be reviewed by appropriate experts appointed by Joule Africa. Emergency preparedness and response will also be reviewed by Joule Africa on at least an annual basis and after the occurrence of any accidents or emergency situations or 'near misses' to ensure that lessons learnt inform continuous improvement.

Exercises to test emergency response will be undertaken on a regular basis to confirm the adequacy of planned responses. Investigations of accidents, incidents or near misses will follow formal documented procedures.

8.3.5 *Managing Changes to Project Activities*

The Project will implement a formal procedure to manage the environmental and social aspects of changes in the Project. The objective is to ensure that the impact of changes on the health and safety of personnel, the environment or communities and their livelihoods are identified and assessed prior to changes being implemented.

The procedure will apply, for example, to project design changes; changes in sites for facilities, infrastructure, camps, laydown areas; changes in the sequencing of major activities such as land take; change of contractors; significant changes in working hours such as additional night working.

The management of change procedure will require that:

- proposed changes are notified in advance to the EHS manager;
- the EHS manager ensures there is, as appropriate, a rapid or an in-depth review of E&S impacts and this is documented;
- the EHS Manager advises the responsible manager of any changes required in EHS policies and procedures to manage the change – or if there are unacceptable EHS risks associated with the proposed changes;
- changes are communicated to personnel who are provided with the necessary skills, via training, to effectively implement changes; and

- the appropriate Joule Africa person accepts the responsibility for the change.

8.4 GUIDING PRINCIPLES

Guiding Principles used in the development of the management plans for the Project are presented below.

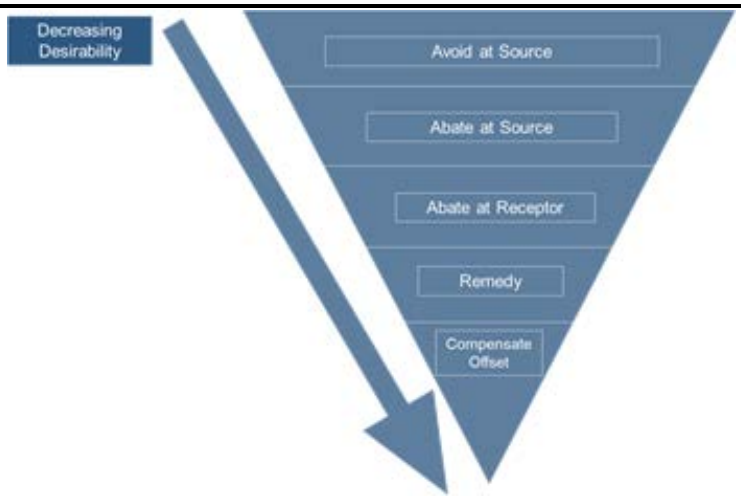
8.4.1 *Planning and Risk Identification*

- Compliance with the laws and regulations of Sierra Leone and the standards and requirements of lenders to the Project and Joule E&S policies.
- Completion of any required E&S policies, plans or procedures prior to the commencement of the relevant works or activities.
- No use of land before any required resettlement actions have been undertaken, eg provision of replacement land and livelihood means for people subject to involuntary resettlement.

8.4.2 *Management and Control*

- Commitment to the mitigation hierarchy in *Figure 8.2* (below) with respect to impacts and risks from the Project.
- Regular internal reporting to senior management at project and corporate level on social and environmental performance.
- Action to remediate any problems/corrective actions identified in internal/external audits and inspections.
- Application of relevant and appropriate design standards and controls.
- Use of competent and qualified EHS staff (including by sub-contractors) who have the necessary level of authority and resources to perform their roles.
- Commitment to the provision of advance training for all staff (including sub-contractors) as part of their induction and also in advance of all works.
- Being prepared for emergency incidents and having adequate and tested response plans in place (including health, safety, environment and community response).

Figure 8.2 Mitigation Hierarchy



8.4.3 Monitoring and Improvement

Monitoring is essential to provide feedback on the efficacy of social and environmental mitigation and management measures.

The Project will ensure that:

- each social or environmental management plan will specify the regular monitoring associated with the plan;
- there is regular review of the implementation of the management plans and the undertaking of remedial actions where needed. Results will be reported internally and made available externally as required by regulators and lenders or as determined by the Project;
- all incidents and near misses will be reported and corrective actions will be taken as necessary according to management plan recommendations and Joule Africa's procedures, and
- all grievances received will be addressed and investigated.

8.4.4 Ownership and Maintenance

Joule Africa will have ultimate responsibility for ensuring the implementation of the management plans and for ensuring, via contract conditions and supervision, that the EPC is obliged to implement their management plans and all mitigation measures relevant to their activities.

The management plans will be live, working documents and as such will require periodic review and updates if there are:

- applicable changes or updates to Sierra Leonean legislation or regulations;

- changes to the Project's social or environmental impact profile as a result of Project expansion, or other aspects with the potential for significant impacts on the environment or communities;

- applicable changes or updates to lender social and environmental requirements or standards; and

- lessons learned from incidents, non-compliances, audits or grievances.

8.5 REPORTING TO GOVERNMENT AND OTHER STAKEHOLDERS

Throughout the Project, Joule Africa and their EPC will keep regulatory authorities informed of the Project performance with respect to EHS matters by way of written status reports and face-to-face meetings, as required in the Project documents, project licenses or permits and other lender related documents (such as the loan documents or lenders ESAP).

In addition to regular reporting, official notification shall be made to the government for any of the following:

- significant modifications to this ESHMP or the ESHIA;
- significant design, routing or implementation changes;
- results of environmental monitoring;
- community incidents; and
- safety incidents or accidents.

Joule Africa will make accessible to government authorities, lenders and other stakeholders, or provide upon request appropriate documentation of EHS related activities, including internal inspection records, training records, and reports. The EPC contractor is also required to provide EHS performance reporting to Joule Africa on a regular basis through weekly and monthly reports, as required in the EPC contract and their Construction Management Plan. This will be used as input to the above.