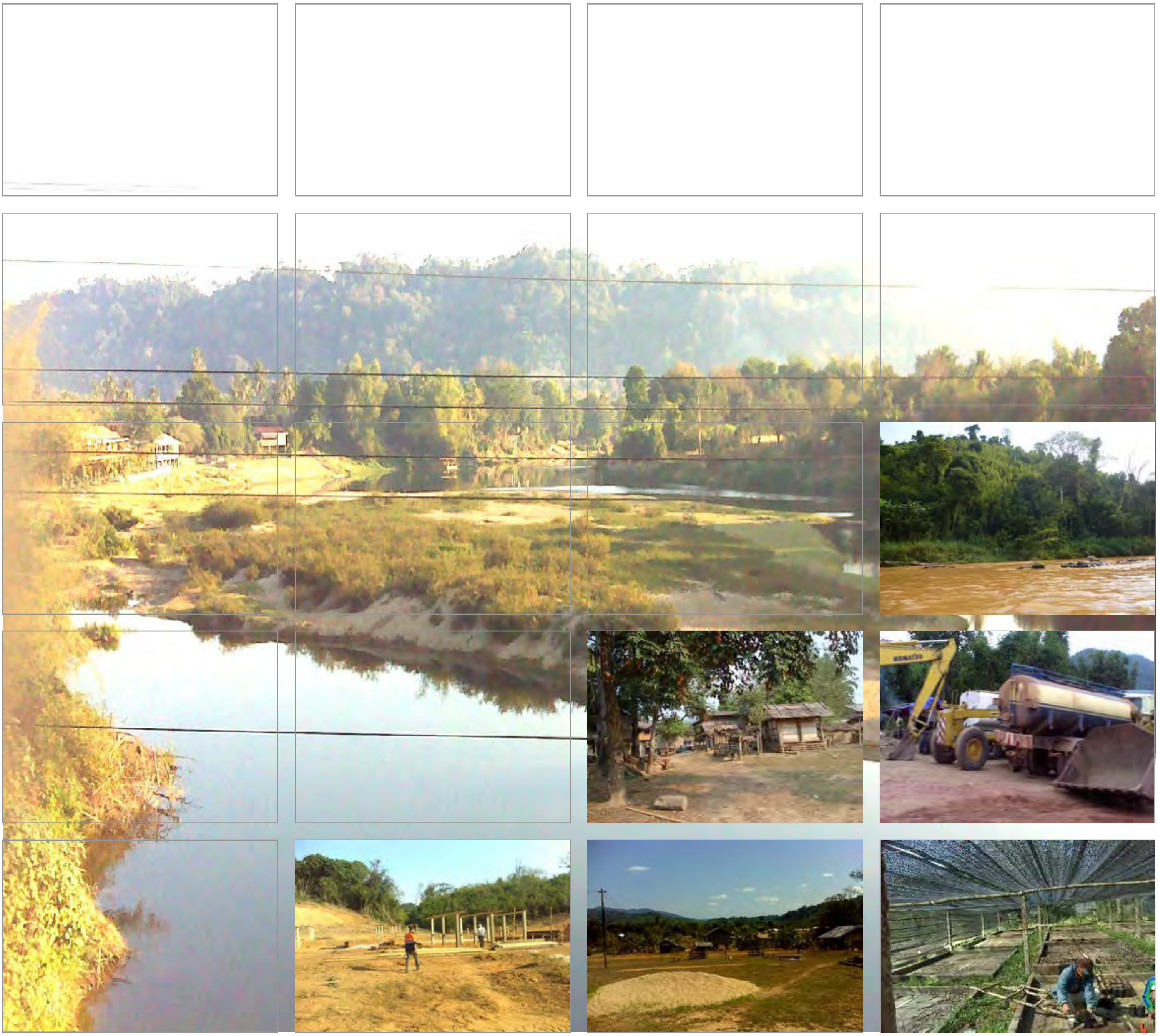
Draft Environmental Impact Assessment

Project Number: 41924
January 2014

LAO: Nam Ngiep 1 Hydropower Project

Prepared by Nam Ngiep Power Company Ltd. with assistance from ERM-Siam Co., Ltd. and Environmental Research Institute, Chulalongkorn University for the Asian Development Bank. This is an updated version of the draft originally posted in January 2012 available on http://www.adb.org/projects/documents/nam-ngiep-1-hydropower-project-results-eia



Nam Ngiep 1
Power Company Limited

Environmental Impact Assessment for Nam Ngiep 1 Hydropower Project

Updated Version

January 2014

ERM

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DRAFT REPORT

NAM NGIEP 1 POWER COMPANY LIMITED

Environmental Impact Assessment for Nam Ngiep 1 Hydropower Project: *Updated Version*

Prepared by Environmental Research Institute, Chulalongkorn University (ERIC, March 2012)

Updated by ERM-Siam Co., Ltd. (January 2014)

Reference TH0229598

For and on behalf of
ERM-Siam Co., Ltd.

Approved by:	Cristina Pellegrino
Signed:	
Position:	Partner
Date:	20 January 2014

IMPORTANT REPORT LIMITATIONS

The following information is provided regarding the limitations associated with this Environmental Impact Assessment (**EIA**).

The original EIA for the Nam Ngiep 1 Hydropower Project was prepared by Environmental Research Institute, Chulalongkorn University (**ERIC**) for the Kansai Electric Power Company, Inc., EGAT International Company, Ltd., and Lao Holding State Enterprise for the Asian Development Bank (**ADB**) in January 2012.

ERM has prepared this revised EIA following a request by the Nam Ngiep Power Company (the **Client**) in November 2013 (**Scope of Work**). This EIA is based on information collected by ERIC and contained in the original EIA, data and information collected and revised by ERM and ERM's sub-contractors and information provided by the ADB. In preparing this report for the Client, ERM has not considered any question, nor provides any information, beyond the Scope of Work.

This report was prepared between **November 2013** and **January 2014** and is based on conditions encountered and information reviewed at the time of preparation. The report does not, and cannot, take into account changes in law, factual circumstances, applicable regulatory instruments or any other future matter. ERM does not, and will not, provide any on-going advice on the impact of any future matters unless it has agreed with the Client to amend the Scope of Work or has entered into a new engagement to provide a further report.

This report is based on one or more site inspections conducted by ERM personnel and its sub-contractors, the sampling and analyses described in the report, and information provided by the Client or third parties (as described above). All conclusions and recommendations made in the report are the professional opinions of the ERM personnel involved. Whilst normal checking of data accuracy was undertaken, except to the extent expressly set out in this report ERM:

a) did not, nor was able to, make further enquiries to assess the reliability of the information or independently verify information provided by;

b) assumes no responsibility or liability for errors in data obtained from, the Client, ERIC or any third parties or external sources (including regulatory agencies).

Sources of data collected by ERM and its sub-contractors are outlined in ***Table I***

Table I. Sources of Data Collected for this EIA by ERM and its Sub-contractors

Sections in the Revised EIA Report	Originally Prepared by	Updated/ Amended by
Main Text (Chapter 1 to 15)	ERIC	ERM
Appendix A: Biodiversity Baseline Assessment Report	ERM	ERM
Appendix B: Biodiversity Offset Design Report	ERM	ERM
Appendix C: Cumulative Impact Assessment Report	ERM	ERM
Appendix D: Environmental Flow Assessment Report	Kansai	ERM
Appendix E: Environmental Assessment for Access Road	ERIC	ERM
Appendix F1: IEE for Transmission Line	ERIC	N/A
Appendix F2: IEE for Transmission Line Addendum	N/A	ERM
Appendix G1: Results of Soil Analysis	ERIC	N/A
Appendix G2: Water Quality Modelling Assumption and Results	ERIC	N/A
Appendix G3: Public Consultation Results	ERIC	N/A
Appendix H: EMP Sub-Plans	ERIC	ERM
Appendix I: Applicable Standards	Public Documents	Public Documents

Although the data that has been used in compiling this report is generally based on actual circumstances, if the report refers to hypothetical examples those examples may, or may not, represent actual existing circumstances.

Only the environmental conditions specifically referred to in this report have been considered. To the extent permitted by law and except as is specifically stated in this report, ERM makes no warranty or representation about:

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b) the presence, absence or otherwise of any environmental conditions at the site(s) or elsewhere; or

c) the presence, absence or otherwise of asbestos, asbestos containing materials or any hazardous materials on the site(s).

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a) has been prepared and is intended only for the Client and any party that ERM has agreed with the Client in the Scope of Work may use the report;

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c) does not purport to recommend or induce a decision to make (or not make) any purchase, disposal, investment, divestment, financial commitment or otherwise in or in relation to the site(s); and

d) does not purport to provide, nor should be construed as, legal advice.

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ABBREVIATIONS

AAU	Assigned Amount Unit
ACF	Action Contre la Faim
ADB	Asian Development Bank
AGAC	Airborne GPS Aero Control System
APs	Affected Peoples
ARI	Acute Respiratory Infection
ASL	Above Sea Level
B	"Ban" Village in Laotian Language
B/C	Benefit – Cost, Economic efficiency
BAT	Best Available Techniques
BOD	Biological Oxygen Demand
BOT	Built-Operate-Transfer
CA	Concession Agreement
CC	Combined Cycle Power Plant
CDEP	Committee for Development of Electric Power
CDM	Clean Development Mechanism
CEC	Cation Exchange Capacity
CEM	Construction Environmental Manager
cent/kWh	Cent per kilo watt
CER	Certified Emission reduction
CFRD	Concrete Faced Rock fill Dam
COD	Commercial Operation Date
CPS-NSC, 2002	CPS-National Statistical Center, 2002
CPC	Committee for Planning and Cooperation
DAFEO	District Agriculture and Forestry Extension Officer
DAFO	District Agriculture Forestry Office
dB	Decibels
dBA	Decibels Adjusted
DBH	Diameters at Breast Height
DBST	Double Bituminous Surface Treatment
DCCs	The District Coordination Committees
DFRM	Department of Forest Resource Management
DHO	District Health Office
DLF	Department of Livestock and Fisheries
DMH	Department of Meteorology and Hydrology
DNA	Designated National Authority
DO	Dissolved Oxygen
DOE	Department of Electricity
DOF	Division of Fisheries
DOL	Department of Land
DRWG	District Resettlement Working Groups
DSCR	Debt Service Cover Ratio
DSRP	Dams Safety Review Panel
EAC	Environmental Assessment Committee

ABBREVIATIONS

EAMP	Environmental Assessment and Management Plan
EAP	Emergency Action Plan
EB	Executive Board of the CDM
ECCD	Early Childhood Care for Development
ECRD	Earth Core Rockfill Dam
EDL	Electricite du Laos
EFOs	Environmental Field Officers
EGAT	Electricity Generating Authority of Thailand
EHS	Environment, Health and Safety
EIA	Environmental Impact Assessment
EIRR, FIRR	Economic/Financial Internal Rate of Return
EL () m	Meters above Sea level
EM	Environmental Manager
EMC	Environmental Management Committee
EMO	Environmental Management Office
EMP	Environmental Management Plan
EMU(s)	Environmental Monitoring Unit(s)
EO	Environmental Officers
EPC	Engineering, Procurement and Construction
EPF	Environmental Protection Fund
EPL	Environmental Protection Law (National Law 02/99)
EPMs	Environmental Protection Measures
ERIC	Environmental Research Institute, Chulalongkorn University
ERU	Emission Reduction Unit
ES	Environment Section
ESD	Environmental and Social Division
ESIA	Environmental and Social Impact Assessment
ESM	Environmental and Social Manager
ESMMU	Environment-Social Management and Monitoring Unit
ESO	Environmental and Social Officer
E&S	Environmental and Safety
ESMMP-CP	Environmental and Social Management and Monitoring Plan for the Entire Construction Works
ESMMP	Environmental and Social Management and Monitoring Plan
ET	Emission Trading
EU	European Union
FAO	Food and Agriculture Organization of The United Nations
F/C	Forage species/carnivorous species ratio
FDR	Family Dispute Resolution
FIMC	Foreign Investment Management Committee
FRCD	Forest Resource Conservation Division
FS, F/S	Feasibility Study

ABBREVIATIONS

FSL	Full Supply Level of Reservoir
FTA	Federal Transit Administration
FWL	Flood Water Level
GDP	Gross Domestic Product
GHG	Green House Gas
GPS	Global Positioning System
GOL	Government of Lao PDR
GRC	Grievance Redress Committee
GRM	Grievance Redress Mechanism
GW	Giga Watt
GWh	Gigawatt Hour
ha	Hectare
HH	Household
Hz	Hertz
IAP	Independent Advisory Panel
IEC	International Electrotechnical Commission
IEE	Initial Environmental Examination
IFC	International Finance Corporation
IMR	Infant Mortality Rate
IPDP	Indigenous Peoples Development Plan
IPP	Independent Power Producer
IRR	Internal Rates of Return
ISO	International Organization for Standardization
IUCN	World Conservation Union (Switzerland)
JBIC	Japan Bank for International Cooperation (JBIC)
JI	Joint Implementation
JBIC	Japan Bank for International Cooperation
JICA	Japan International Cooperation Agency (Japan)
JSC	Joint Steering Committee
JTU	Jackson Turbidity Unit
KANSAI	Kansai Electric Power CO.,INC.
km	Kilometers
km^2	Square meter
kV	Kilovolts
LA	Loan Agreement
L/day	Liter per day
Lao IRRI	Lao International Rich Research Institute
Lao PDR	Lao People's Democratic Republic
LDC	Least Developed Country
LECS	Lao Expenditure and Consumption Surveys
LHSE	Lao Holding State Enterprise
LLDC	Least Less-Developed Countries
LNCE	Lao National Committee for Energy
LWU	Lao Women's Union

ABBREVIATIONS

m	Meters
m^3 /s	Cubic meter per second
MAF	Ministry of Agriculture and Forestry
MAF-DOF	Ministry of Agriculture and Forestry- Department of Forestry
MAP	Mean Annual Precipitation
MAR	Mean Annual Runoff
MCTPC	Ministry of Communication, Transportation, Post and Construction
MCH	maternal and child health
MCM	Multi-Chip Modual
mg/m^3	Milligram per Cubic meter
mg/l	Milligram per liter
MIH	Ministry of Industry and Handicrafts
mill.m^3	Million cubic meters
mm	Millimeter
mm^3	Cubic Millimeter
MOH	Ministry of Health
MOI	Ministry of Industry
MOL	Minimum Operation Water Level
MONRE	Ministry of Natural Resources and the Environment
MOU	Memorandum of Understanding
MRC	Mekong River Commission
MSL	Mean Sea Level
MW	Megawatts
NA	Not Available
NAFRI	National Agriculture and Forest Research Institute
NBCA	National Biodiversity Conservation Area
NC	Non-Compliance
NCC	National Consulting Company
NCR	Non-Compliance Report
NEAP	National Environmental Action Plan
NEM	New Economic Mechanism
NEPO	National Energy Policy Office
NESMC	National Environment and Social Management Committee
NE-SW	Northeast-Southwest
NGOs	Non-Governmental Organizations
NGPES	Nation Growth and Poverty Eradication Strategy
NHWL	Normal High Water Level
NNP1	Nam Ngiep 1 Project
NNP1PC	Nam Ngiep 1 Power Company Limited
NNT	Nakai Nam Theun
NPA	National Protected Area
NTEC	Nam Theun 2(NT2) Electricity Company

NTFPs	Non-Timber Forest Products
NTPC	Nam Theun 2(NT2) Power Company
NWL	Normal Water Level
°C	Degree Celsius
OCHA	(The United Nations) Office for the Coordination of Humanitarian Affairs
O&M	Operation and Maintenance
OC	Ownership Company
ODA	Official Development Assistance
OE	Operational Entity
PAFO	Provincial Agriculture and Forestry Office
PAPs	Project Affected Persons
PDA	Project Development Agreement
PDD	Project Design Document
PDP	Power Development Plan
PESMC	Provincial Environment and Social Management Committee
PHO	Provincial Health Office
PICAD	Participatory Integrated Conservation and Development
PM 10	Particulate Matter 10
PMF	Probable Maximum Flood
PMO	Prime Minister's Office
PMP	Probable Maximum Precipitation
PPA	Provincial Protected Area
PPE	Personal Protective Equipment
PPV	Peak Particle Velocities
PRC	People's Public of China
PRLRC	Provincial Resettlement Management and Living Condition Restoration Committee
PRP	Preliminary Resettlement Plan
RAP	Resettlement Action Plan
RC	Resettlement Committee
RCC	Roller Compacted Concrete
RMU	Resettlement Management Unit
ROE	Return on Equity
ROW	Right of Way
RS	Resettlement Section
RWG	Resettlement Working Group
RWL	Rated Water Level
SBST	Single Bituminous Surface Treatment
SCADA	Supervisory control and data acquisition
SDS	Social Development Section
SIA	Social Impact Assessment
SLC	Salvage Logging Committee

SMO	Social Management Office
SP	Sub-plan
SPC	Special Purpose Company
SS	Suspended Solid
SSESMMP-CP	Site Specific Environmental and Social Management and Monitoring Plan for Construction-Phase
ST	Station
STEA	Science, Technology and Environment Agency
SWL	Surcharge Water Level
$t/km^2/yr$	Tons per Square Meter per Year
TISTR	Thailand Institute of Scientific and Technological Research
ton/ha	Tons per Hectare
TOR	Terms of Reference
TPA	Third Party Access
TWL	Total water level
UNDP	United Nations Development Program
UNEP	United Nations Environment Program
UNFCCC	UN Framework Convention on Climate Change
UNICEF	United Nations Children's Fund
UR	Upper Reservoir
US$	US Dollar
USBM	United States Bureau of Mines
UXO	Unexploded Ordinance
VDC	Villages Development Cluster
VDCCs	The Village Development Coordination Committees
VFA	Village Forest Associations
VFLUPA	Village Forest And Land Use Planning and Allocation
VHV	Village Health's Volunteers
WB	World Bank
WCD	World Commission on Dams
WHO	World Health Organization
WMCA	Watershed Management Conservation Agency
µm	Micrometer

1 INTRODUCTION

1.1 PURPOSE

ERM Siam Co Ltd (ERM) has been engaged by Nam Ngiep 1 Power Company Limited (NNP1PC) to provide a revision of the Environmental Impact Assessment Report (March 2012), which was prepared by Environmental Research Institute, Chulalongkorn University (ERIC).

This Revision takes into account a number of comments and requests for revision made by Asian Development Bank (ADB) and Lenders' Technical Advisor (LTA), dating from 2011 through 2013.

This Revised EIA Report presents an assessment of the potential environmental impacts associated with the proposed Nam Ngiep 1 Hydropower Project in Bolikhamxay Province, Lao PDR ('the Project').

1.2 GENERAL PROJECT BACKGROUND

The development of hydropower facilities is seen as an opportunity for Lao PDR to enhance its economic prosperity and improve the lives of its people. Lao PDR possesses a large, underutilized hydropower potential, and has a central location in a regional market of the Greater Mekong Sub-region, characterized by expanding electricity demand. As a result, one of the pillar policies of the government of the Lao PDR (GOL) is to utilize its plentiful water resources to implement hydropower projects.

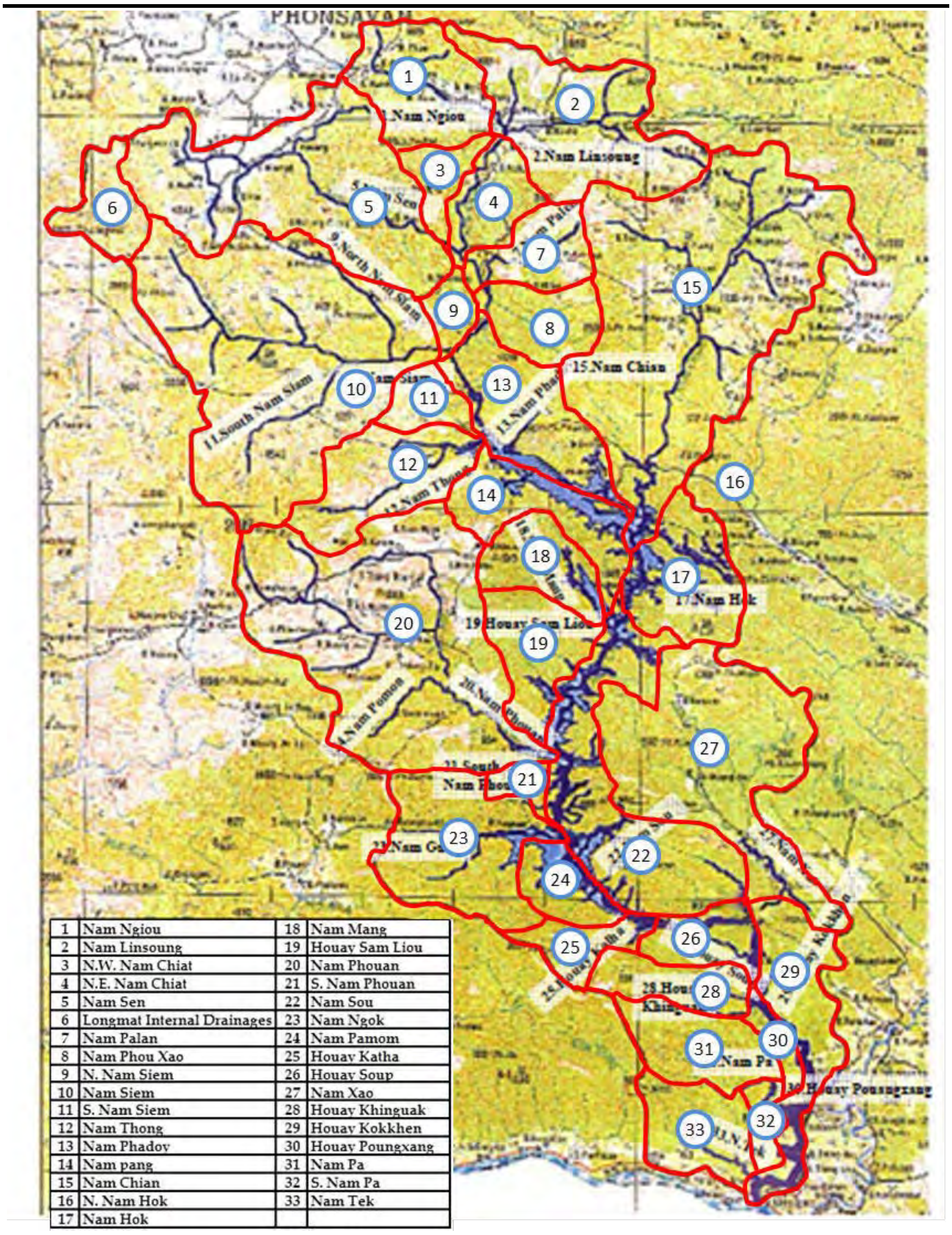
The government-owned Electricite du Laos (EDL) currently owns and operates a number of hydropower projects. With its policy of domestic and rural electrification, EDL's primary objective is to supply power within the country, but it also exports excess power to Thailand and other neighboring countries in order to earn foreign exchange. According to EDL, the theoretical hydropower potential of Lao PDR amounts to about 26,000 MW (excluding the mainstream Mekong River), but this assessment of the total exploitable potential is only an estimate, and limitations in hydrological, geological and other technical information render the estimate approximate.

The development of the Nam Theun 2 Hydropower Project, with a capacity of 1,070 MW, was considered by independent experts as having greatest immediate potential to achieve the country's development objectives as a major source of foreign exchange. The World Bank awarded a loan to the Lao PDR in March 2005 for the construction of the Nam Theun 2 Project. Following five years of construction, the Nam Theun 2 Project was commissioned in 2010. The decision of the World Bank to provide support for the Nam Theun 2 Project is believed to have greatly encouraged other hydropower development plans, and the Lao PDR is now proceeding with several other projects, among them the Nam Ngiep 1 Hydropower Project (NNP1).

The Project is located on the Nam Ngiep River, a left bank tributary of the Mekong River, with the confluence about 7 km upstream of the town of Pakxan (also spelled Paksane) in Bolikhamxay Province, Lao PDR. The source of the river is located near the town of Phonsavanh in Xieng Khouang Province. The river flows from north to south from its origin on the Tra Ninh plateau at EL 1,200 m, down to the Mekong plain at EL 160 m. The maximum altitude of the ridge surrounding the catchment area west of the Nam Ngiep River basin is 2,819 m. The river flows for nearly 160 km, and it drops a total of 1,030 m along its course. At its confluence with the Mekong, the Nam Ngiep has a total catchment area of 4,494.7 km^2, and is composed of 33 tributaries (sub-catchments), as shown in ***Figure 1.1***.

The main objective of the proposed NNP1 is to provide commercial electricity to neighboring countries of the Lao PDR to earn foreign exchange needed for national development, with a secondary objective of providing electricity for the national grid.

Figure 1.1 Tributaries of Nam Ngiep Watershed Area



1.3 *OBJECTIVES OF THIS EIA*

The objectives of this Environmental Impact Assessment (EIA) study are to:

1) Identify the environmental, social, and economic conditions in the Project area.
2) Evaluate potential impacts of the Project and the characteristics of the impacts, including factors such as the magnitude, distribution, and duration of the impacts, and the affected elements of the human and natural environment.
3) Identify potential mitigation measures to minimize the impacts, including compensation costs.
4) Assess the best alternative Project, with consideration of the financial, social, and environmental costs.
5) Formulate an environmental management plan.

1.4 *SCOPE OF THE STUDY*

The Department of Electricity (DOE) requires official approval of an environmental assessment (EA) statement for electricity development projects by the Ministry of Natural Resources and Environment (MONRE)[1]. Overall co-ordination and overview of environmental affairs in the Lao PDR has been assigned to the MONRE, which is under the Prime Minister's Office (PMO) of the Lao PDR, as designated in The Environmental Protection Law (National Law 02/99) 1999.

The EA statement must consist of environmental effects on the physical, biological, and socio-economic and cultural environments, as well as measures to prevent or mitigate any adverse environmental effects that are expected from the design, construction, operation and closure of the Project. According to DOE's regulations as declared in 2001, an investor in a power generation project must apply for the permits to build the hydropower plant before starting any of its activities that may cause impacts to the environment.

The scope of the EIA for the Project has been defined to follow closely the Environmental Management Standard prescribed by the DOE, Ministry of Energy and Mines, Lao PDR and by the environmental assessment guidelines and the environmental and social safeguards of the Asian Development Bank (ADB). The main components of the EIA study are:

1) Analyze the Project description, the defined study area, site maps, and other maps for the study area, which were provided by EGAT.
2) Collect environmental baseline data.
3) Identify potential environmental impacts based on the information obtained on the proposed Project and the baseline environmental conditions of the study area.

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1 Until recently the Water Resources and Environment Agency (WREA), which had earlier been the Science, Technology and Environment Agency (STEA)

4) Identify alternatives and analyze the environmental impacts of each alternative and propose measures to avoid or prevent impacts.
5) Estimate the magnitudes of environmental impacts and assess the significance of impacts. The assessment of the significance includes consideration of whether the impacts are (a) acceptable and in compliance with applicable laws and standards, (b) acceptable after mitigation measures are applied, or (c) unacceptable because of significant adverse impacts to people and their livelihoods or because of irreversible adverse impacts on the ecosystem. This assessment will be conducted based on applicable laws and standards, and on the past experience of hydropower construction projects in Lao PDR.
6) Recommend environmental impact mitigation measures and estimate the mitigation costs, including the Environmental Monitoring and Management Program.
7) Prepare the EIA and Executive Summary of EIA Reports.
8) Prepare an Environmental Management Plan (EMP) to be implemented by the Project proponents during Project implementation and operation.

1.5 *RATIONALE OF EIA*

According to DOE regulations mandated in 2001, project developers must acquire environmental permits before undertaking an electricity project in the Lao PDR. This can only be done after adequate environmental assessment (EA) has been completed. The EA must consider environmental (physical and biological) as well as socio-economic and cultural effects, and recommend measures to prevent or mitigate adverse environmental or social effects in the design, construction, operation and closure/abandonment of the electricity project. The major steps of the EA process, in order to obtain certificate approval, include project description and screening, completion/review of an Initial Environmental Examination (IEE), and, when determined necessary, completion/review of an EIA.

This environmental impact assessment for the Project is based on information provided in the feasibility studies completed by Nippon Koei in 2000 and 2002. These studies recommended the proposed alternative for the dam with a full supply level (FSL) at EL 320 m as the most promising design for the Project. This alternative is able to provide an economically viable and financially attractive project, while also minimizing environmental and social impacts.

1.6 *STUDY AREA AND METHODOLOGY*

1.6.1 *Study Area*

The proposed Project area has been divided into five zones, according to the locations of major features created by the Project. ***Figure 1.2*** shows the zones in the Project area, as follows:

- Zone 1 - Upstream area (upstream from the reservoir)
- Zone 2 - Reservoir area (the area covered by the reservoir)
- Zone 3 - Construction area (the area where the dam and associated facilities will be built)
- Zone 4 - Downstream area (downstream from the dam)
- Zone 5 - Resettlement area (the sites where communities will be resettled)

The status and potential impacts of other projects currently operating in the same watershed area can be found in the "*Nam Ngiep 1 Hydropower Project Cumulative Impact Assessment*" (*Appendix C*), consistent with the IFC's Draft (External Peer Review)-*Cumulative Impact Assessment Guidance Note for Private Sector in Emerging Markets.* The CIA report focused on the identified Valued Environmental and Social Components (VECs) (ESSA&IFC 2012)[1].

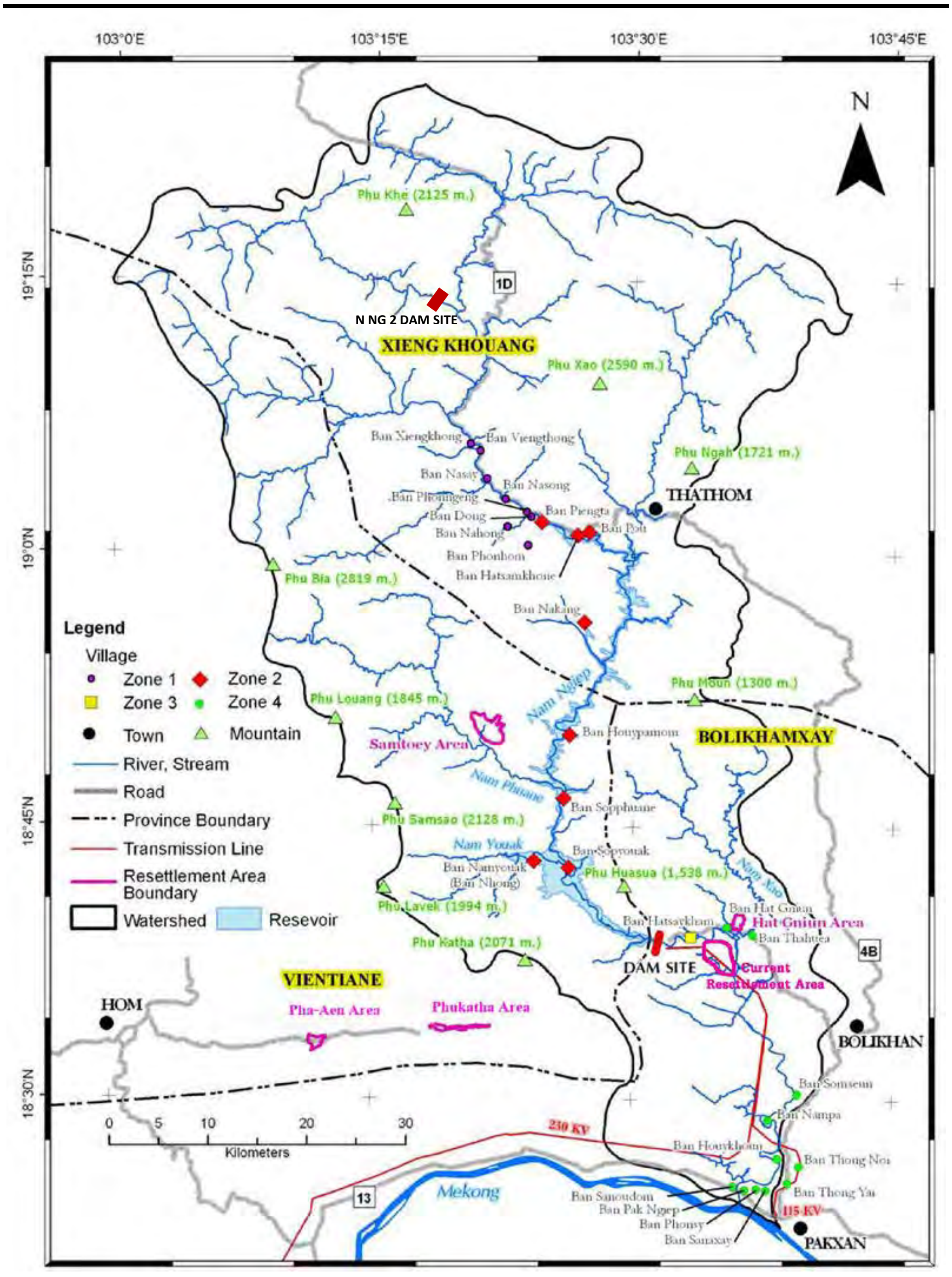
[2] Valued Environmental and Social Components (VECs) are environmental and social attributes that are considered important in assessing risk. The VECs identified as a result of the literature review are:

[3] VEC1: Terrestrial biodiversity and habitats

[4] VEC2: Aquatic biodiversity and habitats

[5] VEC 3: Ecosystem services

Figure 1.2 Zones in the Study Area



1.6.2 *Methodology*

The methodology for the EIA study of the Nam Ngiep 1 Hydropower Project consists of several stages, as follows:

1) Determination of the baseline environmental values and significant environmental issues associated with construction and operation of the dam.
2) Evaluation of each of these in terms of an assessment of the potential for environmental impacts.

3) Identification of opportunities and clear directions for implementation of mitigation measures, offsetting measures and enhancements.

The EIA involves an inventory and description of the baseline environment, the predicted impact on those baseline conditions, and the prescription of mitigation measures to address these impacts.

Each environmental issue is evaluated as a subsection, with the evaluation comprising the following:

1) Reference to information available from earlier (or ongoing) studies.
2) A background of the approach used for making the assessment.
3) Description of links between the various environmental issues and other sectors of assessment.
4) Presentation of results and recommendations.

Key environmental issues evaluated for this study include:

1) Potential hydrological impacts, which includes investigation of extreme events like flood, drought and typhoon conditions.
2) Potential impacts on water quality, including both the impact of the Project on water quality and the impact of these changes in water quality on various water uses.
3) Evaluation of terrestrial habitats that are an essential environmental resource in the Project area and assessment of impacts on such habitats, including potential impacts on forests, biodiversity and wildlife.
4) Potential impacts on aquatic habitat, including physical impairment of the habitat in terms of temperature changes and consequent impacts on aquatic life and fisheries.
5) A comparative analysis between Project impacts on forests, woodlands and other land covers with analogous habitats unaffected by the Project.
6) Potential threats to the forest resources in the absence of the Project.

The detailed methodology is discussed further in *Chapter 2 – Methodology*.

1.6.3 Authors

The following table presents the list of authors that contributed to the original Environmental Impact Assessment Report (March 2012) prepared by Environmental Research Institute, Chulalongkorn University.

As described in *Section 1.1*, this Revised EIA Report has been revised by ERM in January 2014.

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1.7 *STRUCTURE OF THE REPORT*

This EIA generally conforms to the preferred outline for environmental assessment. There are 15 chapters in this EIA, as follows:

Chapter 1 – Introduction: provides a brief description of the Project, including background context of the Project and the development of the EIA. It establishes the need for the Project, focusing on its economic viability for Lao PDR as well as its environmental and social acceptability. This chapter also includes the objectives as well as the scope of this EIA.

Chapter 2 – Methodology: provides detailed methodology for this EIA divided into two main categories which are Physical Environment and Biological Environment.

Chapter 3 – Legal and Policy Framework: provides the policy, legal and administrative framework for the Project. It contains a description of the implementation framework proposed for Project to undertake mitigation actions through the Head Contractor. It also contains descriptions of existing and proposed policies and laws related to the environment, as well as the management of forests and watersheds and river systems in general. It describes the institutions that are responsible for administering national instruments of policy and provides a description of relevant policies and laws related to resettlement and human impacts.

Chapter 4 – Project Description: presents the main Project features and the associated facilities of the Project in detail. This chapter enables the reader to obtain a clear understanding of the Project. A description is presented of the study areas that were identified to evaluate the Project impacts.

Chapter 5 – Existing Environment: provides baseline information relating to existing environmental issues including Topography, Meteorology, Geology, Landforms, Seismology, Soils, Erosion and Sedimentation, Surface Water and Groundwater Quality, Mineral Resources, Noise and Vibration, Air Quality, Potential Contaminated sites, Hydrology, Terrestrial Ecology / Wildlife, Forests, Vegetation Cover, Aquatic Biota and Wetland.

Chapter 6 – Environmental Impacts and Mitigation Measures: provides a description of the potential impacts on key environmental issues during construction and operation phases which are expected to result from the proposed project, as well as mitigation measures to be implemented during construction and operation period.

Chapter 7 – Study of Alternatives: provides a detailed description of the Project alternatives and justification for the proposals put forth by NNP1PC.

Chapter 8 – Information Disclosure, Consultation and Participation: This section describes the process of disseminating information about the Project to the various stakeholders, the main outputs of these briefings and meetings, and how feedback has been incorporated into the Project.

Chapter 9 – Grievance Redress Mechanism: describes the process for receiving and facilitating resolution of queries and grievances from affected communities or stakeholders related to Project activities, policies or programs at the level of the community or country.

Chapter 10 – Environmental Management Plan: describes how the Project will manage and ensure the implementation of the proposed mitigation measures and how achievement of the required standards of environmental performance will be monitored and audited through the Project's Environmental Management System.

Chapter 11 – Environmental Monitoring Plan: describes the details of the environmental monitoring activities that are planned to be carried out for the Project.

Chapter 12 – Budget for Environmental Issues: this section provides an indicative budget for the environmental management and monitoring of the Project.

Chapter 13 – Institutional Arrangement: this section details the Project's means to implement the environmental and social or economic mitigation measures, development activities, and monitoring most effectively, while also building the capacity of local residents, administrative organizations, and government agencies.

Chapter 14 – Reporting and Review: this section provides indicative reporting and review procedures for the Project.

Chapter 15 – Conclusions and Recommendations: provides a summary of Project information as well as the major findings and key recommendations from the environmental assessment of the proposed Project.

References

Appendices: contains supporting documentation for various issues addressed in the report.

2 METHODOLOGY

The study components for the EIA are organized into two main categories according to their general environmental aspects, as follows:

1. Physical Environment

- Topography;
- Meteorology;
- Geology, Landforms, Seismology;
- Soils;
- Erosion and Sedimentation;
- Surface Water and Groundwater Quality;
- Mineral Resources;
- Noise and Vibration;
- Air Quality;
- Potential Contaminated Sites; and
- Hydrology.

2. Biological Environment

- Terrestrial Ecology / Wildlife;
- Forests, Vegetation Cover;
- Aquatic Biota; and
- Wetlands.

Analysis of Socio-Economic and Cultural Environment is carried out in the separate *"Social Impact Assessment Report- Nam Ngiep 1 Hydropower Project"* (Sriburi et al, 2012).

2.1 PHYSICAL ENVIRONMENT

2.1.1 Topography

Topography is vital to the assessment of environmental impacts of the hydropower project. The topography of Nam Ngiep's catchment varies in altitude, slope, and inclination. The variations depend on geological structure, geology, minerals, rock-compositions, as well as ecological systems and other environmental factors. Building a dam will alter the topography, which will not only affect the ecology of the river but may also require that communities along the river modify some aspects of their ways of living.

2.1.1.1 Objectives of Study

- To study topographic changes expected to occur due to the Project.
- To provide information on potential impacts requiring further assessment alongside other study components.

2.1.1.2 *Methodology for Collection of Baseline Information*

- Topographical data around the Project site was studied by reviewing existing works, in particular the previous feasibility studies, and data provided by NNP1PC.
- Project details were studied on water level dynamics (during fill up and operation periods), civil structures, and construction access routes. The study focuses on the Project activities involving modification of landscape.

2.1.1.3 *Methodology for Impact Assessment and Mitigation Measures*

- Maps have been prepared, depicting the modified topography and recommended mitigation measure to minimize negative impacts.

2.1.2 *Meteorology*

Changes in meteorological conditions depend on many factors, including present conditions, a variety of local and external impacts, and new activities within and surrounding the area. Although operating a hydropower project has a relatively minor impact on the weather, this section attempts to describe the local meteorological condition representative of the Project area. Possible impacts of the Project can be determined from weather parameters such as air temperature, wind speed and direction, cloud cover, and stability.

2.1.2.1 *Objectives of Study*

- To determine baseline meteorological data of the study area.
- To assess potential impacts to baseline weather.
- To suggest mitigation measures and action plans if required.

2.1.2.2 *Methodology for Collection of Baseline Information*

- Meteorological data, including atmospheric pressure, air temperature, relative humidity, precipitation, wind speed and direction, were collected from secondary sources, such as the Department of Meteorology and Hydrology, Lao PDR.

2.1.3 *Geology, Landforms and Seismology*

Geology is an important aspect to consider for dam construction. Geological information, including regional structure and rock formation, is useful for indicating potential mineral deposits and geohazards (e.g., seismic risks, rock falls and landslides). Geohazards may cause a significant threat to the loss of lives and infrastructure; hence, dam stability is included in the detailed designs of dam structure to minimize the risks of dam failure. Geological structures and rock types were analyzed for the potential of rock falls, flows and landslides. Geological information was also used for assessing the vulnerable and geological risk areas, which are indicated as requiring future monitoring. Long-term records of earthquake occurrences in the country were collected and interpreted along with tectonic setting and structural geology of both local and regional areas.

2.1.3.1 *Objectives of Study*

- To compile and integrate geological data (e.g., rock formation, structure and tectonic) of the Project area and regional area.
- To assess seismic hazards affecting the Project site and adjoining areas.
- To propose mitigation measures and alternatives if any potential problems are found.

2.1.3.2 *Methodology for Collection of Baseline Information*

- Results of the previous feasibility studies were investigated to determine the geological setting of the area.
- Compiled information on regional geology and seismic source zones from Lao and international literature.
- Delineated geological features of the regional Project area from satellite images.
- Reviewed field surveys conducted around the Project site to confirm and enhance the interpretations of the previous studies.

2.1.3.3 *Methodology for Impact Assessment and Mitigation Measures*

- Where potential problems were identified, appropriate mitigation measures were developed to minimize the impacts.

2.1.4 *Soils*

The Project development could potentially lead to the loss of large areas of forest and agricultural lands for reservoir and resettlement sites. Soil fertility of agricultural lands in resettlement sites is crucial to the viability of crop production, livestock rearing, and other livelihoods. The aim of studying soil fertility is to evaluate whether or not the areas provided for resettlement allow people to continue their traditional agricultural practices. Additional soil analysis was also carried out to assess the possibility of soil loss from erosion. The tributaries of the rivers which would be obstructed by a coffer dam could have an impact on soil fertility.

2.1.4.1 *Objectives of Study*

- To determine soil fertility and suitability by using both primary and secondary data in order to understand soil characteristics at the Project site and other key areas, especially resettlement sites.
- To assess the probable effects and impacts from the Project on soil fertility and suitability during construction and operation phases.
- To develop mitigation measures and monitoring plans for possible adverse effects.

2.1.4.2 *Methodology for Collection of Baseline Information*

- Investigated soil types and chemistry of the resettlement sites and Project area.
- Conducted field survey and soil sampling at 2 different depths: 0-15 cm and 15-30 cm, by composite sampling method. Soil samples were air dried, under shade, crushed and sieved through 2 mm sieve. They were then prepared and analyzed for chemical and physical properties as follows:
  - Chemical properties: pH, Lime requirement (LR), Organic matter (OM), Total Nitrogen (N), Available Nitrogen (NO^-_3-N and NH^+_4-N), Available Phosphorus (Avail. P), Cation Exchange Capacity (CEC), Exchangeable base (K, Ca, Mg).
  - Physical properties: soil texture (particle size distribution).

2.1.4.3 *Methodology for Impact Assessment and Mitigation Measures*

- Project activities were assessed for their potential impacts on soil fertility.
- Mitigation measures were determined wherever necessary.

2.1.5 *Erosion and Sedimentation*

The quantity of sediment carried into a reservoir depends on the rainfall patterns and land cover characteristics. Generally, the amount of sediment being carried is at its highest during and after a particularly intense rainfall event. Mudslides can also have a dramatic and unpredictable effect on reservoir sedimentation.

The actual process of sediment deposition is unique to every reservoir. In general, the coarser, heavier sediments (gravel and sand) tend to settle out at the upper end of the reservoir, forming a "backwater" delta, which gradually advances toward the dam. The lighter sediments (silt and clay) tend to be deposited nearer the dam.

2.1.5.1 *Objectives of Study*

- To determine sedimentation and erosion of the Nam Ngiep River from the existing flow.
- To assess possible impacts of the NNP1 Project on sedimentation and erosion.
- To develop mitigation measures and environmental management plans to ensure minimum and controllable impacts of the Project on sedimentation and erosion.

2.1.5.2 *Methodology for Collection of Baseline Information*

- Secondary data on soil erodibility and texture was collected from a survey by Soil Survey and Land Classification Centre in 1994.

- Primary suspended sediment sampling was carried out at water sampling stations at Ban Hat Gniun.
- Sediment load and yield was estimated based calculations on the suspended sediment concentration and discharge as a lognormal distribution.
- Comparison of annual sediment yields estimates was made with data from major hydropower project sites in Lao PDR.

2.1.5.3 *Methodology for Impact Assessment and Mitigation Measures*

- Project activities were assessed for their potential impacts on soil erosion and sedimentation.
- Mitigation measures were determined wherever necessary.

2.1.6 *Surface Water and Groundwater Quality*

A range of impacts on water quality may occur in different stages of Project during construction and operation phases. During construction, the activities that are likely to cause changes in the water body and its characteristics are dredging, excavating, filling, canalizing and camp settling. The placement of the dam will result in impoundment of the water body, which is significantly different from that of a natural stream. This consequently affects the aquatic environment downstream, where the river receives water released from the impoundment. The direct physical impacts on the water include increased water depth, increased water retention time, and potential thermal stratification. The changes caused by the Project have the potential to affect a broad spectrum of water quality parameters for both the impounded water and the water released downstream.

2.1.6.1 *Objectives of Study*

- To forecast and assess the impacts on existing water quality of the Nam Ngiep River that could be caused by Project activities.
- To propose mitigation measures and monitoring plans to prevent or mitigate the impacts on water quality.

2.1.6.2 *Methodology for Collection of Baseline Information*

- Reviewed discharge sources and other relevant water quality data of the Nam Ngiep River, focusing on the segment passing through Xieng Khouang, down to the Mekong River.
- Planned location of water sampling stations by using a topography map scale 1:100000 for conducting the pre-survey. Locations of surface water and groundwater sampling stations are shown in ***Table 2.1*** and ***Figure 2.1***.
- Sampled the surface water twice during the year, to compare late hot and dry season (low flow) and late rainy season (high flow) conditions. The first sampling survey was carried out on 24 April 2007 toward the end of the hot season, and the second sampling survey was carried out

on 17 October 2007 in the later part of the rainy season. Groundwater quality was observed on 17 October 2007 at Ban Xomxeun and Ban Hat Gniun; however, only the well-water of Ban Xomxeun was collected.

- Sampling procedures were carried out carefully to avoid cross contamination. Grab sampling was conducted by using a water sampler lowered to approximately 1 meter below the water surface. Samples were cooled to 4 degrees Celsius and carried by hand to the laboratory for further analysis. Temperature, pH, conductivity, salinity, turbidity, and DO were measured at the field sites, whereas other characteristics (as indicated in ***Table 2.2***) were analyzed in a laboratory at the National University of Lao.
- Results of surface water quality of the collected water samples were compared to Ambient Water Standards of the Lao PDR (***Table 2.3***). In addition, results were also compared to the Surface Water Quality Standards of Thailand (***Table 2.4***), because the Thai standards include a more robust standard which incorporates several levels of water quality, indicating whether the water is appropriate for drinking, agriculture, or other uses. Results of groundwater quality were compared to Groundwater Standards for Drinking Purposes of Lao PDR (***Table 2.5***).

Table 2.1 Location of Water Sampling Stations

Station No.		Coordinate	
		N	E
1.	Ban Xiengkhong	19°06′01.80″	103°20′51.30″
2.	Ban Phonngeng	19°02′25.67″	103°23′40.14″
3.	Ban Pou	19°01′04.58″	103°27′25.53″
4.	Ban Houypamom	18°47′04.53″	103°26′08.67″
5.	Ban Sopphouan	18°46′53.60″	103°25′56.82″
6.	Ban Sopyouak	18°42′52.61″	103°26′01.74″
7.	Hat Sakhua	18°41′11.22″	103°27′03.87″
8.	Ban Hat Gniun	18°39′15.25″	103°35′22.44″
9.	Ban Xomxeun	18°30′17.54″	103°39′31.81″
10.	Nam Ngiep Bridge	18°25′03.77″	103°36′11.30″

Figure 2.1 Location of Surface Water Sampling Stations

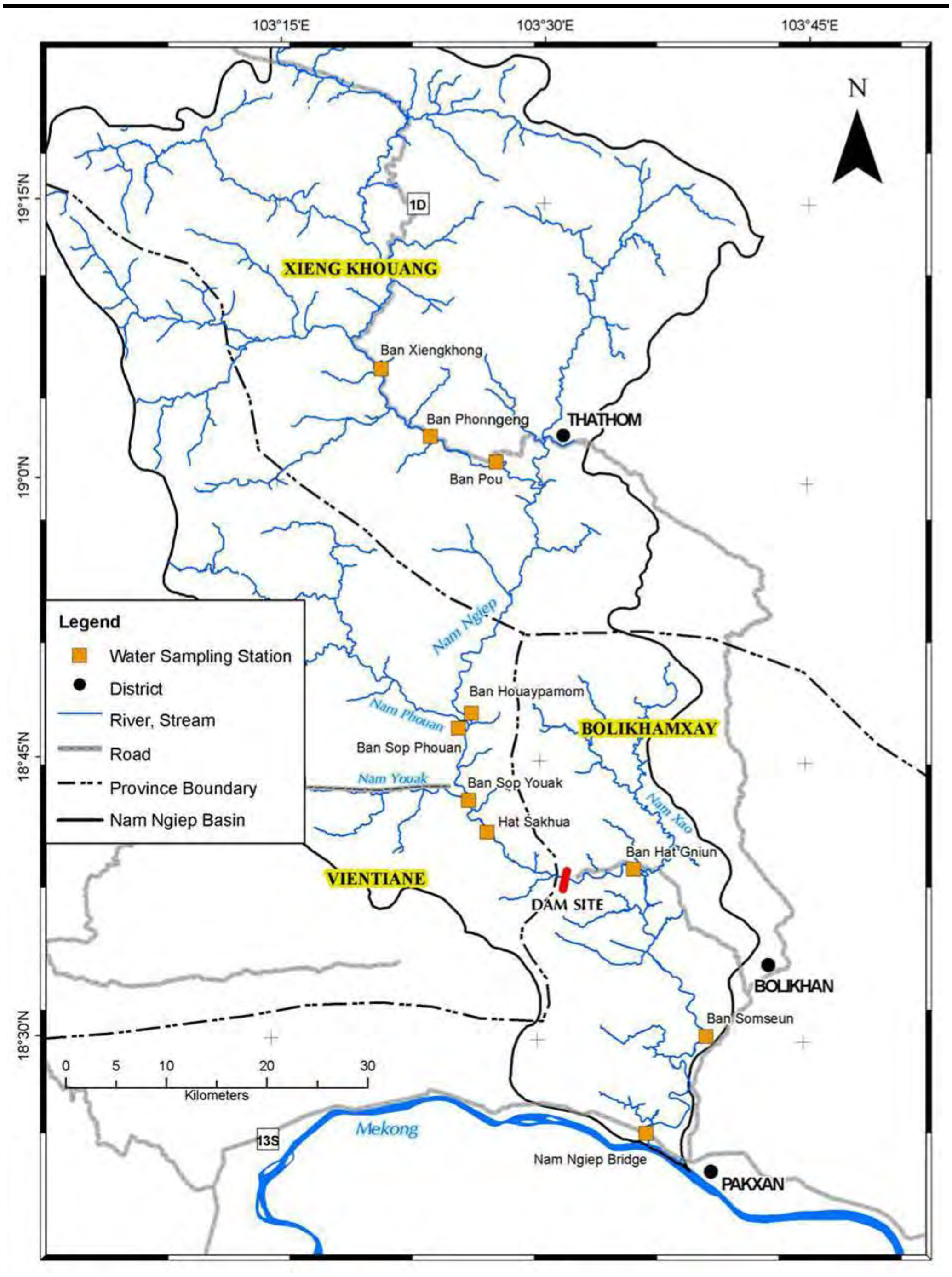


Table 2.2 Analytical Methods of Water Quality

Parameters	Unit	Methods
Temperature	°C	Thermometer
pH		pH meter
Alkalinity	meq/L	Microtitration
DO	mg/L	Azide modification
BOD_5	mg/L	Azide modification
Oil and Grease	mg/L	Partition gravimetric
Turbidity	FTU	Turbidity meter
Suspended solids	mg/L	at 180 ºC
TDS	mg/L	at 105 ºC
Hardness	mg/L	EDTA
Conductivity	µS/cm	Conductivity meter
Phosphate-P	mg/L	Vanadomolybdophosphoric acid
Total P	mg/L	Simultaneous oxidation of phosphorus cpds with persulphate
Ammonium-N	mg/L	Nesslerization
Nitrate-N	mg/L	Cadmiun reduction
Total N	mg/L	Simultaneous oxidation of nitrogen compounds with persulphate
Total coliform	MPN/100	Multiple-tube Fermentation Technique
Fecal coliform	MPN/100	Multiple-tube Fermentation Technique
Cadmium, Cd	mg/L	AAS-direct aspiration
Mercury, Hg	mg/L	AAS-Cold vapor
Copper, Cu	mg/L	AAS-direct aspiration
Iron, Fe	mg/L	AAS-direct aspiration
Manganese, Mn	mg/L	AAS-direct aspiration
Nickel, Ni	mg/L	AAS-direct aspiration
Lead, Pb	mg/L	AAS-direct aspiration
Zinc, Zn	mg/L	AAS-direct aspiration
Arsenic, As	mg/L	AAS-direct aspiration

Table 2.3 Ambient Water Quality Standards of Lao PDR

Parameter	Unit	Standard
pH		5-9
Dissolved Oxygen	mg/L	>5.0
BOD_5	mg/L	1.5
COD	mg/L	5.0
Nitrogen as nitrate ($N\text{-}NO_3$)	mg/L	5.0
Nitrogen as ammonia ($N\text{-}NH_3$)	mg/L	0.2
Sulfate	mg/L	500
Total coliform bacteria	MPN/mL	5,000
Total faecal coliform	MPN/mL	1,000
Phenols	mg/L	0.005
Arsenic (As)	mg/L	0.01
Cadmium (Cd) $CaCO_3 \leq 100$ mg/l	mg/L	0.005
Cadmium (Cd) $CaCO_3 \geq 100$ mg/l	mg/L	0.05
Chromium (VI) (Cr^{6+})	mg/L	0.05
Copper (Cu)	mg/L	0.1
Cyanide	mg/L	0.005
Lead (Pb)	mg/L	0.05

Parameter	Unit	Standard
Mercury (Hg)	mg/L	0.002
Nickel (Ni)	mg/L	0.1
Zinc (Zn)	mg/L	1.0
Manganese (Mn)	mg/L	1.0
Alpha ¬Radioactivity	Becquerel/L	0.1
Beta ¬ Radioactivity	Becquerel/L	1.0
Total Organochlorine	mg/L	0.05
DDT	mg/L	1.0
Alpha-BHC	mg/L	0.02
Dieldrin	mg/L	0.1
Aldrin	mg/L	0.1
Heptachlor and Heptachlor Epoxide	mg/L	0.2
Endrin	mg/L	0

Source: MONRE, GOL

Table 2.4 Thailand's Surface Water Quality Standards

Parameter	Units	Statistics	Standard Value for Class					Methods for Examination
			Class 1	Class 2	Class 3	Class 4	Class 5	
Temperature	°C		n'	n'	n'	n'	-	Thermometer
pH			n	5-9	5-9	5-9	5-9	Electrometric pH Meter
DO	mg/L	P20	n	6	4	2	-	Azide Modification
BOD_5	mg/L	P80	n	1.5	2.0	4.0	-	Azide Modification at 20 ^{o} C , 5 days
Coliform bacteria								Multiple Fermentation Technique
- Total coliform	MPN/100 mL	P80	-	5,000	20,000	-	-	-
- Fecal coliform	MPN/100 mL	P80	n	1,000	4,000	-	-	-
NO_3 -N	mg/L	Max. allowance	n	0.5	0.5	0.5	-	Cadmium Reduction
NH_3-N	mg/L	-	n	0.5	0.5	0.5	-	Distillation Nesslerization
Copper (Cu)	mg/L	-	n	0.1	0.1	0.1	-	Atomic Absorption -Direct Aspiration
Nickle (Ni)	mg/L	-	n	0.1	0.1	0.1	-	Atomic Absorption -Direct Aspiration
Manganese (Mn)	mg/L	-	n	1.0	1.0	1.0	-	Atomic Absorption -Direct Aspiration
Zinc (Zn)	mg/L	-	n	1.0	1.0	1.0	-	Atomic Absorption -Direct Aspiration
Cadmium (Cd)	mg/L	-	n	0.005* 0.05**	-			Atomic Absorption -Direct Aspiration

Parameter	Units	Statistics	Standard Value for Class					Methods for Examination
			Class 1	Class 2	Class 3	Class 4	Class 5	
Lead (Pb)	mg/L	-	n	0.05	-			Atomic Absorption -Direct Aspiration
Total Mercury	mg/L	-	n	0.002	-			Atomic Absorption-Cold Vapour Technique

Classification	Objectives/Condition and Beneficial Usage
Class 1	Extra clean fresh surface water resources used for : 1. conservation not necessary pass through water treatment process require only ordinary process for pathogenic destruction 2. ecosystem conservation where basic organisms can breed naturally
Class 2	Very clean fresh surface water resources used for : 1. consumption which requires ordinary water treatment process before use 2. aquatic organism of conservation 3. fisheries 4. recreation
Class 3	Medium clean fresh surface water resources used for : 1. consumption, but passing through an ordinary treatment process before using 2. agriculture
Class 4	Fairly clean fresh surface water resources used for : 1. consumption, but requires special water treatment process before using 2. industry
Class 5	The sources which are not classification in class 1-4 and used for navigation

Note:
- P Percentile value
- n naturally
- n' naturally but changing not more than 3 °C
- * when water hardness not more than 100 mg/l as $CaCO_3$
- ** when water hardness more than 100 mg/l as $CaCO_3$
- \- not indicated

Based on Standard Methods for the Examination of Water and Wastewater recommended by APHA : American Public Health Association, AWWA : American Water Works Association and WPCF : Water Pollution Control Federation

Source: Notification of the National Environmental Board, No. 8, B.E. 2537 (1994), issued under the Enhancement and Conservation of National Environmental Quality Act B.E.2535 (1992), published in the Royal Government Gazette, Vol. 111, Part 16, dated February 24, B.E.2537 (1994).

Table 2.5 Groundwater Standards for Drinking Purposes of Lao PDR

Characteristics	Parameters	Symbol	Unit	Permitted Standard Value	
				Suitable	Maximum
Physical	1. Colour	-	Platinum-Cobalt (Pt-Co)	5	15
	2. Turbidity	-	JTU	5	20
	14. Total solids	TS	mg/l	≤600	1,200
Chemical	3. Acidity	pH	-	7.0-8.5	6.5-9.2
	4. Iron	Fe	mg/L	≤0.5	1
	5. Manganese	Mn^{2+}	mg/L	≤0.3	0.5
	6. Copper	Cu^{2+}	mg/L	≤1.0	1.5
	7. Zinc	Zn^{2+}	mg/L	≤5.0	15
	8. Sulphate	SO_4^{2-}	mg/L	≤200	250

Characteristics	Parameters	Symbol	Unit	Permitted Standard Value	
				Suitable	Maximum
	9. Chloride	Cl^-	mg/L	≤250	600
	10. Fluoride	F^-	mg/L	≤0.7	1
	11.Nitrate	NO_3^-	mg/L	≤15	45
	12. Total Hardness as $CaCO_3$	Total $CaCO_3$	mg/L	≤300	500
	13.Non-carbonate hardness as $CaCO_3$	Non $CaCO_3$	mg/L	≤200	250
	15. Arsenic	As^{3+}, As^{5+}	mg/L	None	0.05
	16. Cyanide	CN^-	mg/L	None	0.1
	17. Lead	Pb^{2+}	mg/L	None	0.05
	18. Mercury	Hg	mg/L	None	0.001
	19. Cadmium	Cd^{3+}	mg/L	None	0.01
	20. Selenium	Se	mg/L	None	0.01
Bacteria	21. Coliform bacteria	Coliform	MPN/100 mL	<2.2	<2.2
	22. E. coli bacteria	E. coli	MPN/100 mL	None	None
	23. Standard plate count	-	Colonies/mL	≤500	-

Source: MONRE, GOL

2.1.6.3 *Methodology for Impact Assessment and Mitigation Measures*

- Assessed potential impacts to water quality from Project implementation. The water standards mentioned above, together with results of water quality models conducted by Kansai Electric Power Co., Inc, were integrated to evaluate the following:
    - Construction Phase
        - Effects of water diversion.
        - Effects of the construction camp and other construction activities.
    - Operation Phase
        - Short-term impact due to degradation and settling in water impoundment.
        - Long-term impact caused by operation.
- Suggested mitigation measures and monitoring plans for impacts expected from Project construction and operation.

2.1.7 *Mineral Resources*

Before the establishment of the Lao PDR in 1975, a number of foreign countries and international corporations conducted geological surveys to determine the potential mineral resources of the country. After the Lao PDR opened for foreign investment in mineral resources, these surveys were disclosed. They revealed that Lao PDR has considerable potential geological resources, and in particular deposits of economic minerals. For this reason, the

Project area and its vicinity were assessed for any potential economic mineral deposits that may have been identified in these earlier surveys.

The primary objectives of mineral resources assessment were to evaluate potential sites of deposits within and around the Project area, and to estimate the probable sizes of those mineral prospects. The study attempted to find the most up-to-date information, though it is necessarily limited by the lack of an adequate mineral resource database and the relative inaccessibility of some of the Project area. In many cases, indirect data collection through interviews was the best method possible where it was too difficult to find information from other sources.

Another concern is the possible presence of toxic elements that could affect the water supply. The possibility of these toxic elements, particularly heavy metals that might occur within a mineral deposit, would also need to be reported.

2.1.7.1 Objectives of Study

- To review the potential occurrence of economic mineral deposits in the Project area, and to estimate the size and value of those deposits.
- To indicate if any toxic elements could accumulate within particular mineral deposits found in the Project area.

2.1.7.2 Methodology for Collection of Baseline Information

- Compiled information on regional geology and mineral resources from Lao and international literature.
- Collected data on mineral occurrences, mining history, and other appropriate geological data to indicate prospective sites of economic minerals.
- Conducted field interviews to verify secondary data and resolve any problematic or conflicting information.

2.1.8 Noise and Vibration

The NNP1 Project is located in an area that consists mostly of degraded natural habitat. Project activities, both during construction and in normal operation, will changes patterns and amplitude of noise and vibration. This has the potential to disturb wildlife, as well as affected people in the vicinity. Excavation, other digging, blasting, construction of foundations, and operation of heavy machinery may cause adverse impacts on wildlife, on local residents, and on workers. Without sufficient protection, these activities can also cause hearing loss to workers. In addition, movement of heavy machinery and other traffic along the access routes of the Project may affect residents and any wildlife living nearby.

2.1.8.1 *Objectives of Study:*

- To determine the potential noise and vibration sources during construction and operation.
- To determine the levels of noise and vibration generated from Project construction activities at the Project site.
- To assess the potential noise and vibration impacts due to other construction and operation of the proposed Project.
- To recommend mitigation measures to maintain the noise and vibration levels within appropriate international standards.
- To recommend an appropriate noise and vibration monitoring program for the proposed Project.

2.1.8.2 *Methodology for Collection of Baseline Information*

- Identified sensitive areas such as schools, temples and medical centers in residential areas.
- Identified noise and vibration sources in the Project area.
- Compared noise levels with common sound levels for various equipment provided by The Ministry of Agriculture Food and Rural Affairs of the Government of Ontario.
- Background sound and vibration levels in similar rural areas were also reviewed. The background sound levels of the Hutgyi Hydropower Project area were reviewed because of the many similarities with the areas near NNP1 with regard to existing background noise and vibration sources and their impacts.

2.1.8.3 *Methodology for Impact Assessment and Mitigation Measures*

- Reviewed Project description concerning noise and vibration created by equipment used during construction and operation phases.
- Assessed potential noise impacts associated with grading and construction using methodology developed by FTA and integrating with Guidelines for Community Noise of WHO.
- Selected appropriate parameters to evaluate noise and vibration impacts on local affected people and workers, as follows:
  - Noise parameters
    - Leq 24 hr
  - Vibration parameters
    - Frequency
    - Peak Particle Velocities (PPV)
    - Displacement
- Proposed appropriate mitigation measures and monitoring programs for the construction phase.

2.1.9 *Air Quality*

Dust from construction activities may potentially impact air quality. Ambient air monitoring equipment was identified for this study to enable measurement of existing ambient air quality; however, the use of the monitoring equipment was not possible for the study because the permits required for the equipment were not yet granted by GOL.

Emissions from vehicles and equipment used for construction of the NNP1 Project and its infrastructure might affect air quality. Dust from unpaved roads and working areas may also have an impact, and should be controlled. Burning of waste or burning during clearing of biomass may also cause significant impacts to air quality. All significant parameters on air quality have been studied and examined, and an appropriate dust and emissions control plan is recommended.

2.1.9.1 *Objectives of Study*

- Suggest measures to mitigate air pollutants, especially dust produced at construction sites. Of greatest concern for the construction of the Project will be the creation of particulate matter (PM_{10}) to the atmosphere. Because Lao PDR has not yet adopted national ambient air quality standards, international measures are used for the analysis.
- The WHO annual standards for particulate matter (PM_{10}) are now set at 0.20 $\mu g/m^3$, while those of Thailand are 0.50 $\mu g/m^3$. According to European Union directives 1999/30/EC and 96/62/EC, the annual standards for EU nations from 2005 was set at 0.40 $\mu g/m^3$, while from 2010 they will be 0.20 $\mu g/m^3$.

2.1.9.2 *Methodology for Collection of Baseline Information*

- Preliminary study - Conducted field survey to indicate potentially sensitive sites for dust and other emissions.
- Meteorological data at the selected site was limited in air quality data, and on-site measurement could not be conducted because the government had not yet granted permission for use of air monitoring equipment. For this reason, the study had to rely on presentation of, and comparison between, the ambient air qualities found for similar land uses.

2.1.9.3 *Methodology for Impact Assessment and Mitigation Measures*

- Reviewed Project description concerning emissions created by equipment used during construction.
- Project activities were assessed for their potential impacts on air quality.
- Mitigation measures were determined wherever necessary.

2.1.10 *Potential Contaminated Site*

Several hazardous substances, such as fuels, oils, paints, solvents, and pesticides, will be used during the construction and operation of the NNP1 Project. Consequently, the construction site, as well as nearby areas, will have a high potential to become contaminated. To protect the health of workers and nearby residents, and to protect the surrounding ecosystems, the study investigated potential contaminated sites. There will also be potential impacts associated with handling, storage, use and disposal of chemicals during construction. Relevant mitigation measures and chemical waste and spillage management plans have been prepared.

2.1.10.1 *Objectives of Study*

- To examine the Project area and determine whether there is the potential for existing contaminated sites.
- To investigate the sources and activities that could lead to environmental contamination during construction and operation of the NNP1 Project.
- To assess the potential impact to contaminated sites from Project activities.
- To prepare chemical waste and spillage management plan, site remediation plan, and chemical monitoring plan.

2.1.10.2 *Methodology for Collection of Baseline Information*

- Through observations and secondary data, acquired information to evaluate present conditions and use of hazardous substances.

2.1.10.3 *Methodology for Impact Assessment and Mitigation Measures*

- Identified Project activities that may lead to site contamination.
- Evaluated the types of waste that may be generated during construction and operation of the Project.
- Determined the areas that could be contaminated by the Project, and potential spread of contamination to the environment.
- Prepared protection and mitigation measures and proposed monitoring plans.

2.1.11 *Hydrology*

Hydrological impacts caused by the Project are a major concern for a hydropower Project because the existing hydrological condition of the Nam Ngiep River will be controlled and altered for power generation. Therefore, the hydrological operations must be conducted with sufficient understanding of how the hydrological conditions influence other environmental aspects. For example, the extent of river fragmentation can degrade stream habitats and pose barriers to the migration of aquatic species and transport of sediment[1].

2.1.11.1 Objectives of Study

- Evaluate the impacts due to the change of hydrological phenomena during Project construction and operation.
- Suggest mitigation measures to minimize the impacts on the environment and local affected people.

2.1.11.2 Methodology for Collection of Baseline Information

- Reviewed secondary hydrological data for the Project area, including data on the Nam Ngiep Basin, geography along the Nam Ngiep River, analysis of rainfall and water level records, low flow and flood analysis, and hydrogeology.

2.1.11.3 Methodology for Impact Assessment and Mitigation Measures

- Evaluated potential hydrological changes due to the Project development regarding existing natural condition & resources, people, and their living circumstances.
- Recommended mitigation measures.

2.2 BIOLOGICAL ENVIRONMENT

2.2.1 Baseline Biodiversity Survey

The baseline biodiversity values of the Study area have been determined using a number of information sources including:

- Flora and fauna survey across the Study area;
- Desktop sources (published and grey literature, available reports, geospatial datasets and species profiles);
- Geospatial datasets; and
- Detailed flora survey of the access road corridor.

These sources provide description of vegetation communities and habitats, and species that may occur in the Project area. The data collated for the purposes of this report can be categorised into two types:

- *Direct:* Species recorded during biodiversity field surveys undertaken during 2007 and 2013 are considered direct counts. In general the location and details of this data has been recorded and a higher level or certainty can be inferred.

1. Anne Chin; Laura R. Laurencio; Adriana E. Martinez. 2008. The Hydrologic Importance of Small- and Medium-Sized Dams: Examples from Texas. The Professional Geographer, 60(2), 238 – 251pp.

- *Indirect:* Species reported from village surveys or within reports (secondary data) using a more regional study area are considered indirect records. These data sources provide a valuable understanding of the biodiversity of the locality and region however should be afforded further analysis or applicability considered. Data obtained from village surveys can contain errors in some instances, especially when considering identification of species with more challenging diagnostic features.

The reliability of the records has been considered throughout the report and the data category of species records is denoted.

2.2.2 *Direct Biodiversity Data Sources*

2.2.2.1 *NNP1 Environmental Impact Assessment 2012*

The NNP1 Project Environmental Impact Assessment (EIA) document was completed in 2012, which included an ecological investigation undertaken by the Environmental Research Institute of Chulalongkorn University (ERIC). The investigation included studies on the biological environment of the Project area covering terrestrial ecology and wildlife, forest and vegetation cover, aquatic biota and wetlands.

ERIC surveyed the Project area in March and October 2007 in order to identify threatened species occurring in or near the Project area, and whether the project has potential to impact their habitats.

The assessments were carried out through visual inspection (direct data), interviews with villagers (indirect data) and utilisation of secondary data sources. Results of the surveys reported that current clearing and general habitat disturbance has resulted in many species not occurring in the Project area.

The forest types within the project sub-catchment were classified according to the classifications and definitions from Forest Inventory and Planning Division, Department of Forestry (DOF). The forest and land use data used for the study was based upon imagery (the Assessment of Forest Cover and Land Use during 1992-2002 (Department of Forestry, 2005)) that has now been superseded by land cover mapping data prepared by the Department of Forest and Resource Management (DFRM) in 2010 (DRFM, 2010).

2.2.2.2 *Thailand Institute of Scientific and Technological Research Biodiversity Survey*

Field investigations were undertaken in March and July 2013 by the Thailand Institute of Scientific and Technological Research (TISTR) to collect data representative of wet and dry season biodiversity conditions. The TISTR team as a subcontractor to ERM were engaged to undertake survey design, field survey and deliver a field survey biodiversity report. The TISTR report has been used in the development of this biodiversity baseline assessment report.

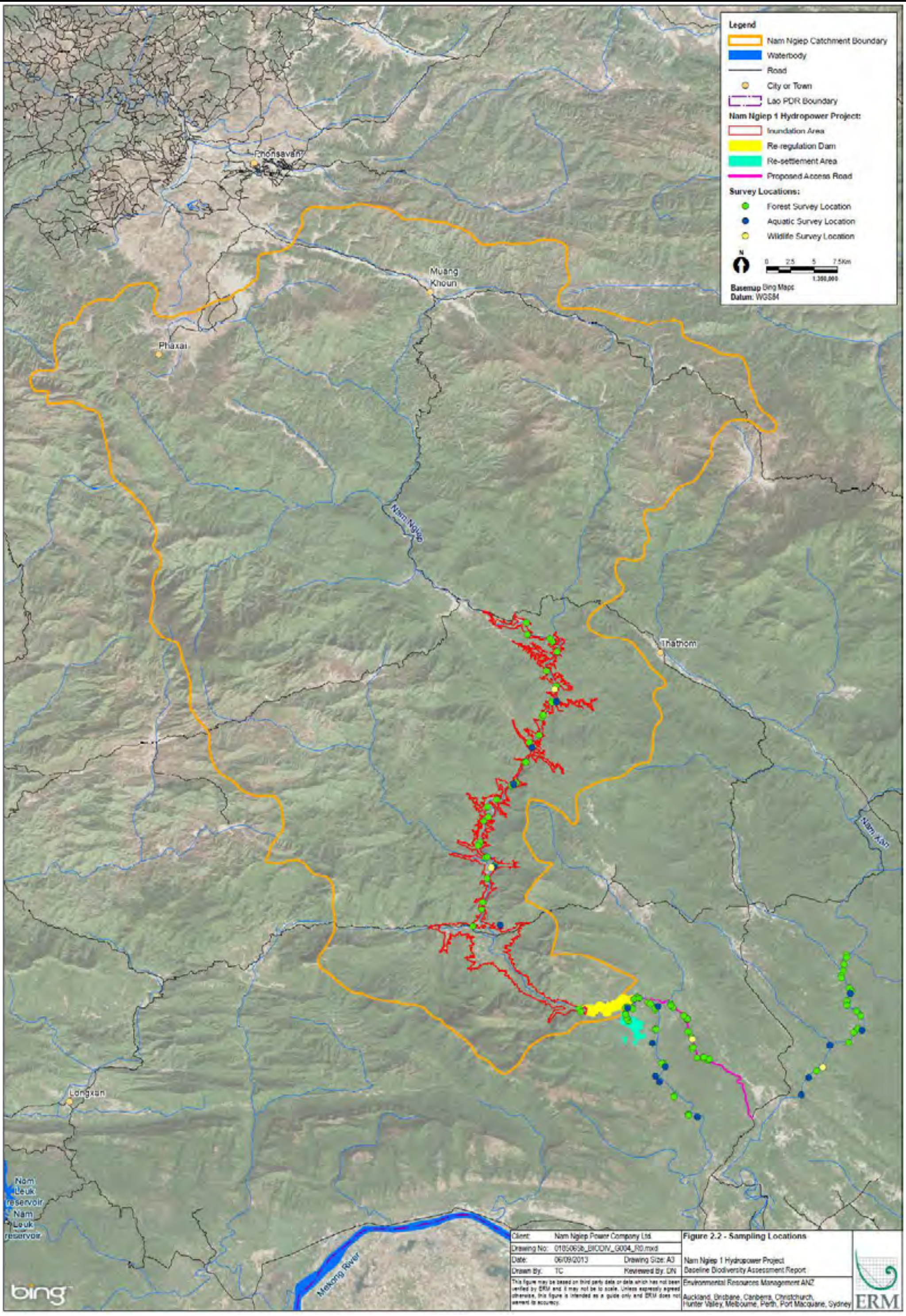
Surveys were undertaken by teams targeting separate taxa: vegetation (team of 7 people), terrestrial wildlife (team of 6 people) and aquatic biota (team of 5 people). The surveys incorporated detailed assessments that included forest and vegetation cover survey and assessment, wildlife survey and assessment, and aquatic ecology survey and assessment.

Surveys were undertaken at four of the investigation areas that include:

- The Project area (main dam site and reservoir, re-regulation dam site, resettlement site/lower Nam Ngiep);
- Upper Nam Ngiep River; and
- Huay Ngua Provincial Preserved Area.

Sampling locations are shown in ***Figure* 2.2.**

Figure 2.2 Biodiversity Sampling Stations



Forest and Vegetation Survey

The forest survey team surveyed for species diversity along trails and in sampling plots. Unknown plants were collected and three duplicates of leave with flowers or fruits for further analysis in the laboratory. Botanists recorded necessary information i.e. morphology, habit, colour of flowers and ecology, georeferenced location, and compiled photographic records.

Across the survey the sampling plots consisted of 3 types of temporary plots:

- A circular sample plot with a radius of 17.85 meters (or 0.1 ha);
- Square plots of 5x5 meters (25 square meters or 0.0025 ha); and
- Square plots of 2x2 meters (4 square meters or 0.0004 ha).

Analyses of the data collected included specialised laboratory investigations to establish identification of voucher specimens.

Terrestrial Fauna Survey

The terrestrial fauna survey aimed to describe the baseline wildlife diversity of the NNP1 Project area impact zones for the purposes of assessing the potential Project impacts to terrestrial wildlife. Survey and sampling work involved developing an inventory of wildlife species (amphibians, reptiles, birds, and mammals).

The inventory of each fauna group was collected through direct and indirect counts.

Direct counts were carried out to determine numbers of amphibians, reptiles, birds, and mammals by sightings during the field surveys at the survey station. Observations and records of animal signs such as tracks, nets, burrows, droppings, hair and feathers, were also recorded. Details of the techniques used for each group include:

- Amphibians and reptiles: species searches were undertaken in habitats such as under logs, rocks, bark as well as digging in the buttress of trees. At night, spotlighting was used to detect nocturnal species along rivers, around poundages, and within tree canopies.
- Birds: were directly observed using binoculars during day time. Some species of birds were identified using call identification during the morning or evening, when they are the most active. Birds were also caught using mist-nets under tree canopies or cross the creeks these were identified, photographed, and released.
- Mammals: were observed from their signs such as tracks, scats, scratches on trees, burrows, etc. small mammals, were captured using live-traps or Sherman's traps. Bats were surveyed at night using mist-net and harp traps placed under tree canopies or cross creeks. Some species of mammals were identified from local hunters.

For all wildlife species the habitats were recorded. In the case of unidentified individuals these were collected and preserved and later analysed at the laboratory in the Natural History Museum-Nation Science Museum, Prathum Thani, Thailand.

Indirect counts were used to obtain supplementary information on fauna by interviewing local residents who lived in or near by the area. Some local villagers may hunt animals for food or for sale. Local households as well as local markets were also sampled.

Relative abundance of wildlife was calculated from numbers obtained in the direct and indirect counts, species were assigned as abundant, common, and less common using a calculation formulated by Pettingil (1969).

<u>Aquatic Biota Survey</u>

Aquatic biota sampling was conducted at different locations in Nam Ngiep, Nam Xan, Huay Ngua PPA and the resettlement area. Survey techniques included:

- collection of phytoplankton and zooplankton species using multiple plankton net surveys at each location, followed by preservation, identification and laboratory analysis at TISTR;
- collection of benthos at multiple replicate sites using an Ekmann dredge, followed by identification and abundance counts at the TISTR laboratories; and
- capture and identification of fish species within the main rivers and their tributaries using the help of local fishermen using multi-mesh gillnets, electrofishing, cast nets, gun and hook, as well as discussions with fishermen and other information sources.

2.2.2.3 *National University of Laos Ground-truth of Natural Habitat Survey (Access Road Corridor)*

Specific to the proposed disturbance area for the access road network Nam Ngiep 1 Power Company engaged Pheng Phengsintham, a local botanist and lecturer of the National University of Laos (NUL) to undertake survey to ground-truth flora species and delineate natural/modified habitat.

The November 2013 assessment aimed to identify areas of natural and modified habitat within the Proposed Road. Some stretches of temporary and permanent roads in the vicinity of the re-regulation dam were not able to be assessed. The assessment involved survey at 53 temporary sampling plots where the vegetation type and tree species were recorded each side of the proposed access road. The temporary sample plots were set within the proposed access road area with the ten closest trees recorded and measured. The outcomes of NUL assessment have been incorporated in baseline data.

2.2.3 *Indirect Biodiversity Data Sources*

2.2.3.1 *Desktop Review*

Desktop review was undertaken to collate and assess other data sources. The desktop review included an assessment of:

- Online reports relating to the Project area and biodiversity of Lao PDR;
- Threatened species profiles and online species distribution information; and
- Published literature relating to threatened species and Lao PDR biodiversity.

Information collated through desktop review was used to provide additional background information relating to the biodiversity values associated with the Study area. Key desktop documents included:

- Huay Ngua Provincial Preserved Area Management Plan (MP) 2011-2015 by the Provincial Agriculture and Forestry Office of Bolikhamxay (PAFO) (December 2010) – species identified have been considered to have potential to occur in habitat associated with the Access road (indirect data). The management plan reports species based on some field survey and village interview results;
- Nam Ngum 3 Hydropower Project: Final Environmental Impact Assessment, October 2011 prepared by NN3 Power Company;
- The Status and Distribution of Freshwater Biodiversity in Indo-Burma compiled by D.J. Allen, K.G. Smith and W.R.T. Darwall for the International Union for Conservation of Nature (IUCN);
- Wildlife in Lao PDR, 1999 Status Report compiled by J.W. Duckworth, R.E. Salter and K. Khounboline for the IUCN, Wildlife Conservation Society and Centre for Protected Areas and Watershed Management; and
- Significant Wildlife and Wildlife Habitats of Bolikhamxay Province April 2011, Integrated Ecosystem and Wildlife Management Project: Bolikhamxay Province Provincial Agriculture and Forestry Office and the Wildlife Conservation Society.

2.2.3.2 *Geospatial Analysis*

Geospatial analysis was undertaken to assist in understanding the biodiversity values in the Project area and candidate offset sites. Primarily this was based on interpretation of a variety of spatial layers provided by DFRM and Rapideye Imagery. The analysis included land cover mapping, production forest and vegetation community mapping that delineates land cover types.

In order to further understand the biodiversity values represented within the Project area and candidate offset sites, remote sensing analysis was undertaken to map the variation in vegetation condition. Rapideye Imagery was used to identify the normalised difference vegetation index (NDVI) across the area. NDVI is a remote sensing indicator that provides a measure of vegetation density and condition by indicating the photosynthetic capacity of the land surface cover.

The imagery outputs provide a NDVI in grid formation (5m x 5m) across the Project area and candidate offset sites. For the Project condition classes (for a range of NDVI) were defined and applied to each forest type. The condition classes are shown in ***Table 2.6***. These condition classes were used to refine land cover calculations. Area within the Impacted NDVI range was removed from the habitat area calculations.

Table 2.6 Condition Class NDVI Range

Condition	NDVI Range
Benchmark	0.8 to 1.0
High	0.6 to 0.8
Moderate	0.4 to 0.6
Low	0 to 0.4
Impacted	-ve to 0

<u>Limitations</u>

For this Project, NDVI has been used as a remote sensing tool to indicate vegetation condition. As with all remote sensing techniques there are limitations associated and all information has not been ground-truthed. The outcomes of this assessment should be interpreted on a regional scale and note that the data is based on image capture at one specific time. Similarly, as discussed NDVI is an indicator of photosynthetic capacity of the surface and does not distinguish between vegetation communities.

The inherent benefit of utilising NDVI relates to the remote sensing accessibility of information from areas that may be difficult to access on the ground or when considering larger areas for a local and regional context. The index allows for comparison of vegetation photosynthetic capacity along the length of the corridor in the context of the surrounding landscape.

The NDVI and land cover calculations are based on 5 metre square pixels. The RapidEye satellite imagery provided was at 5 metre square pixels and this same level of accuracy was used in generating the NDVI and land cover calculations presented in this report.

2.2.3.3 Species Specialist Consultation

In addition to desktop sources, a number of species specialists were consulted to assist in developing an understanding of the importance of the Project area for the critical habitat candidate species. Each specialist contacted provided advice via email response to queries clearly identified as related to this Project. The specialists that provided advice are listed in *Appendix A* and advice is referenced as appropriate.

Key input was provided by Dr J.W Duckworth and Dr M Kottelat. Comments was provided on some species texts however it is acknowledged that the final content remains the responsibility of the report compilers.

A number of primate species were determined candidates for critical habitat and Dr Phaivanh Phiapalath of the IUCN SSC Primate Specialist Group was engaged to undertake further site survey and advice relating to critical habitat for primate species. The method of assessment and discussion relating to habitat value is provided in *Appendix A* and the advice has been incorporated into the critical habitat assessment.

2.2.3.4 *Social and Cultural Surveys*

An assessment of the ecosystem services was undertaken to supplement the biodiversity assessment completed for the NNPI Project. The aim was to provide a social context to the establishment of biodiversity offsets.

The assessment included two field visits. The first visit was conducted in February and March 2013. It involved engagement with key government and non-government officials to understand current land use and tenure as well as use and threats to biodiversity in the Nam Ngiep River catchment and potential offset site. In addition, village and market surveys were undertaken. These were used to gather data on the utilisation of ecosystem services by Project affected people (PAP), including the use of threatened flora and fauna. The village surveys included focus group discussions and in-depth interviews with relevant community representatives (e.g. hunters, gatherers); while the market surveys involved visual surveys and informal discussions with stall operators.

The second field visit was conducted in July 2013. The focus was on understanding and assessing the ecosystem services in the potential offset site as well as community acceptance of the proposed offset measures. The survey approach was similar to that conducted in the first field visit – e.g. focus group discussions, in-depth interviews and visual surveys.

In total, 18 villages and four markets were surveyed. The outcome was an understanding of stakeholder opinions and concerns as they relate to the potential offset site and proposed offset measures and an understanding of ecosystem services utilised by local community members.

Other sources reviewed included:

- NNP1 Social Impact Assessment Draft Report, which provided initial baseline information for the Project area (2012);
- Physical Cultural Resources: Preliminary Archaeological Survey in the proposed Nam Ngiep 1 Hydropower Project (NNP1), an archaeological survey report written in October 2007 provided by Mr Viengkeo Souksavatdy, Deputy Head of the Archaeology Department, MICT;

- Village surveys to determine the socio-economic context for the biodiversity offsets. This included focus groups and in-depth interviews with relevant representatives from communities in the Project area and proposed offset catchment;
- Market surveys in the Project area and proposed offset catchment to further understand and quantify the threat to flora and fauna; and
- Engagement with relevant stakeholders (e.g. representatives from government and non-governmental organisations) to confirm local land use activities, including the presence and use of biodiversity.

3 ADMINISTRATIVE FRAMEWORK

One of the main priorities of the Nam Ngiep 1 Hydropower Project (NNP1) is to ensure that the Project conforms to the environmental and social statutes and policies of the GOL. This EIA has been prepared in conformance with these statutes, policies, directives and procedures.

The Project will also conform to international treaties to which the Lao PDR is signatory, and to standards and safeguard policies of the Asian Development Bank (ADB) and to the Equator Principles. Where there are legal gaps in terms of standards, the ADB or other international standards or other relevant local standards will be used, whichever is the most stringent.

3.1 NATIONAL LAWS AND DECREES

The key laws and decrees relevant to environment assessment and protection issues for NNP1 are:

1) The Law on Environmental Protection (1999);
2) The Law on Water and Water Resources (1996);
3) The Forestry Law (2007);
4) The Wildlife and Aquatic Law (2007);
5) The Land Law (2003);
6) The Electricity Law (2008);
7) The Road Law (1999);
8) The Decree on Environmental Impact Assessment (2010);
9) The Decree on State Land Lease or Concession (2009);
10) The Decree on Compensation and Resettlement of People Affected by Development Projects (2006);
11) The Technical Guidelines on Compensation and Resettlement of People Affected by Development Projects;
12) The Regulation on EIA for Road Projects (2004); and
13) The Decree on the Environmental Protection Fund.

3.1.1 *Environmental Protection Law (1999)*

The Environmental Protection Law (National Law 02/99) (EPL) was approved by the President on April 3, 1999. This law provides a legal framework for environmental management of development projects. It establishes the framework for unified environmental management with the aim of preserving the environment and making rational and sustainable use of natural resources. The sustainable use of natural resources is to contribute to the national socio-economic development and to the guaranteed health and improved quality of life of the people of Lao PDR. The Ministry of Natural Resources and the Environment (MONRE)[1] is responsible for the implementation of EPL. While

[1] Previously the Water Resources and the Environment Administration (WREA), which was formerly the Science Technology and Environment Agency (STEA)

other ministries issue guidelines for implementing provisions of the EIA and of environmental protection, it is MONRE that is responsible for review of the EIA and that will issue the environmental compliance certificate.

Governmental Decrees, Regulations, and Standards relevant to the EPL are:

- The Implementing Decree of 2002, which provides the legal tool for implementation of the law, and
- The Environmental Management Standard of 2001, which stipulates the minimum environmental standards to develop a project.

Water Resource and Environment Administration (WREA, now MONRE) also developed a set of regulations for conducting the EIA of proposed hydropower projects (2000 and 2001). These regulations and standards established general impact assessments requirements, including timing of the EIA in the project development cycle. They stipulate detailed project screening, Initial Environmental Examination (IEE) and Environmental Impact Assessment (EIA) requirements, including content and format of reporting, and approval of the report.

3.1.2 Law on Water and Water Resources (1996)

The Law on Water and Water Resources (1996) is intended to assure sustainable water use through policies related to ownership, preservation, use and management of water and water resources. It establishes a basis for classifying water according to use, defining catchments, and setting requirements for EIA for any 'large scale uses', inclusive of construction of water reservoirs for the purpose of irrigation, consumption, and energy production. In this respect, the law mandates the requirement for the current Environmental Monitoring and Assessment Programme (EAMP) work and should necessitate a review of the EAMP among the appropriate groups within GOL. The Water Resources Committee under the Prime Minister's Office administers the Water Law and is responsible for the review and evaluation of EIAs related to use of water resources.

3.1.3 Amended Lao Forestry Law (No. 06/NA-Dec.2007)

The Amended Forestry Law, No 06/NA (Dec. 2007) stipulates the basic principles, regulations and measures concerning forest conservation, management, and use. It aims to make the forests and forestland a stable source of livelihood and use for the people, by ensuring sustainable preservation of water sources, preventing soil erosion and maintaining soil quality, conserving plant and tree species and wildlife species, preserving the environment, and contributing to national socio-economic development.

The Amended Forestry Law (2007) confirms that natural forests and forestlands are the property of the national community and that these are centrally managed by the State (GOL). The State can grant individuals or organizations the right to plant and own trees. Forests are classified into three general categories: Protection Forest, Conservation Forest (or National Biodiversity Conservation Areas), and Production Forest. Each category of forest is designated a different and distinct zone and area, within which there can be rich or dense forest, degraded forest, bare forestland and village use forest according to each zoning plan.

Conversion of public forestland to another land use type is only possible, when allowed, if it is to bring maximum benefits to the nation and to the wellbeing of people and is included in the national socio-economic development plan. Such conversion is only allowed in designated areas. Entities given approval for forestland conversion are responsible for paying fees for technical service, royalties and conversion fees. For temporary conversion such as mining exploitation and other production activities, the land must be restored and trees must be replanted. If the State converts the forestland, which is allocated to individuals or organizations for agreed upon and determined purposes, the State shall compensate according to laws and regulations. For permanent forestland conversion into another land use type for long-term purposes, such as for roads or hydropower construction, the State owns the timber and forest resources that are cut or harvested in those forests or forestlands.

The law stipulates which administrative authorities have the right to approve conversion of degraded forestland that cannot naturally regenerate or of barren forestland. While district, municipal, or provincial authorities can approve conversion of smaller areas of forestland, the conversion of between 100 ha and 1,000 ha of degraded forestland per activity, or between 200 ha and 10,000 ha of barren forestland per activity, must be approved by the government, through proposals by the National Land Management Authority and agreement by the Ministry of Agriculture and Forestry and the Provincial Agriculture and Forestry Office. The National Assembly Standing Committee must endorse the conversion of forestland greater than those amounts (1,000 ha of degraded forestland or 10,000 ha of barren forestland).

3.1.4 Wildlife and Aquatic Law, No 07/NA (2007)

The Wildlife and Aquatic Law restricts and regulates the management, monitoring, conservation, and protection of wildlife and aquatic species in their natural habitats. Wildlife and aquatic species living within the territory of the Lao PDR are considered property of the national community, with the State representing the national community in managing those species. If an individual or organization has permission to raise and reproduce any of these species, it is then considered their own property so long as they abide by the laws and regulations.

Wildlife includes both terrestrial and aquatic life, and all forms of animal life, whether mammals, birds, reptiles, amphibians, or insects. Wildlife are classified into three categories for protection: 1) prohibition, 2) management, and 3) common or general. Whether any species are classified as prohibition or management depends upon the level of threat to them (endangered, threatened, rare), the condition of their habitat, and the condition of their regeneration and reproduction. The Ministry of Agriculture and Forestry recommends to the government for consideration and approval the list of species under the prohibition and management categories. The Ministry of Agriculture and Forestry has authority to include or remove species itself from the list of animals in the common or general category.

3.1.5 Land Law (2003)

The Land Law was enacted on October 23, 2003. The law determines the management, protection and use of land to ensure its efficient use and to conform with land-use objectives, with other laws and regulations, to contribute to national socio-economic development, and to contribute to the protection of the environment.

3.1.6 Electricity Law (2008)

The Electricity Law No 03/NA, dated 8 Dec 2008, requires a license for the generation and transmission of electricity. The Law also requires:

- That EIAs be prepared for at least the larger hydroelectric dams, along with budget estimates for environmental mitigation measures.
- That transmission lines and related activities are done in such a way as to limit any damages to natural environment and people's property
- That the concessionaire is required to pay compensation for damages to the environment and to the lives and property of people, if any resettlement or other movement of people is required.

3.1.7 Road Law (1999)

The Road Law (1999) requires that the environment be protected during road construction and related activities and in the maintenance of roads, and that the national as well as the provincial levels of the Ministry of Communication, Transport, Post and Construction (MCTPC) have duties to protect the environment in relation to roads.

3.1.8 Prime Ministerial Decree No. 112/pm on Environmental Impact Assessment (2010)

The 2010 Prime Ministerial Decree No. 112/PM established the procedures and guidelines for conducting Environmental Impact Assessments in Lao PDR. It stipulates the rights of those affected by projects, including their rights of participation. The decree outlines the process, both for WREA (now MONRE) and the developer of projects, of conducting the EIA, preparing environmental management and monitoring plans, social management and monitoring plans, issuing environmental compliance certificates, monitoring compliance with the various plans, and establishing the institutional framework for implementing the environmental and social components of projects, and for hearing and deciding on grievances of affected parties.

3.1.9 Decree on State Land Lease or Concession (2009)

The Decree on State Land Lease or Concession, dated May 25, 2009, establishes the principles, procedures and measures for the leasing or providing concessions of land, for purposes of development for agriculture, industry, tourism, and other activities.

Among the obligations of those leasing or obtaining a concession are that they should not cause damages to the land quality, nor cause negative impacts to the environment or society.

3.1.10 Decree on Compensation and Resettlement of People Affected by Development Projects (2006)

The Decree on Compensation and Resettlement of People Affected by Development Projects defines the principles, rules, and measures to mitigate adverse social impacts and to compensate for damages that may result from involuntary acquisition or repossession of land and of fixed or movable assets, including changes in land use and restrictions to access of community or natural resources, which would affect sources of community livelihood and income. This decree aims to ensure that people affected by a project are compensated fairly and are assisted in ways to improve or maintain their pre-project incomes and living standards, so that they are not worse off than they would have been without the Project.

3.1.11 Technical Guidelines on Compensation and Resettlement of People Affected by Development Projects (2005)

Pursuant to Prime Ministerial Decree No. 112/PM, GOL endorsed the Technical Guidelines on Compensation and Resettlement of People Affected by Development Projects, first issued in November 2005. These guidelines were initially adopted under the Decree on Compensation and Resettlement of People Affected by Development Projects in 2006, and have now been endorsed and promulgated as official GOL policy and procedure for the assessment, planning, and mitigation of environmental as well as social impacts from development projects.

These guidelines include detailed procedures for the conduct of public consultation and other participatory processes, to inform affected people of the environmental and social impacts, and to assure their involvement in all aspects of the mitigation and compensation process, from planning to implementation.

3.1.12 Regulation on EIA of Road Projects in Lao PDR (2004)

This regulation clarifies the principles and methodologies for environmental impact assessment of road projects, including setting out necessary and appropriate mitigation measures to avoid or reduce negative environmental impacts on the natural environment and society resulting from the implementation of road projects in the Lao PDR.

3.1.13 *Decree on the Environment Protection Fund (2005)*

This Decree defines the principles, rules and procedures for the organization and operation of the Environmental Protection Fund (EPF). The fund is to finance eligible activities that can strengthen environmental protection, sustainable natural resources management, and specifically, biodiversity conservation and community development in Lao PDR. Among the objectives of the EPF are to implement Chapter V of the Environmental Protection Law, Article 47 of the Forestry Law, and Article 15 of the Decree to Implement the Law on Water and Water Resources. Sources of funds for the EPF are grants and loans from domestic and foreign entities, State budget, development projects and other activities, and interest or benefits accrued from investing the EPF endowment.

3.1.14 *Key Provisions of Lao PDR Laws and Decrees Pertinent to Environmental Aspects of the NNP1 Project*

The table below provides a brief summary of the key provisions of the various laws and decrees of the Lao PDR, as they relate to the environmental components of the Project.

Table 3.1 *Key Provisions in the Laws, Decrees and Regulations of the Lao PDR Pertinent to the EIA of the Nam Ngiep 1 Hydropower Project*

Law or Decree	Article	Relating To	Content
Constitution of the Lao People's Democratic Republic (1991, amended 2003)	Article 17	Environment in general	"All organisations and citizens must protect the environment and natural resources: land, underground, forests, fauna, water sources and atmosphere."
Environmental Protection Law (1999)	Article 5	Environment in general	Conservation takes priority over mitigation and restoration.
			Socio-economic development planning must include planning for environmental protection
Environmental Protection Law (1999)	Article 8	EIA Process	MONRE is main agency to issue regulations for EIA.
			People affected by projects, mass organizations, and local administrations are to be involved in the EIA process
	Article 10	Responsibility of those engaged in development works	Those engaged in development works must adhere to safeguards, and to standards and regulations issued by GOL agencies
	Article 14	Responsibility of those engaged in development works	Those engaged in development works must abide by laws on land, forests, water, etc.

Law or Decree	Article	Relating To	Content
	Article 16	Responsibility toward cultural, historical, natural heritage sites	Those engaged in development works must abide by laws and regulations to protect such heritage sites
	Article 22	Pollution control	All are responsible for control of pollution, and applying technologies appropriate to control such pollution
	Article 23	Hazardous wastes / emissions	Restrictions to hazardous wastes and means to control such wastes and emissions
	Article 28	Damage to environment	Those causing damage to environment are responsible for repair through appropriate GOL agencies
	Article 38, 39	Local environmental management and monitoring	Stipulates responsibilities of local administrations (provinces, municipalities, special districts, districts) to establish environmental management and monitoring units
	Article 40	Local environmental responsibilities	Stipulates responsibilities of village administrations to follow environmental regulations
Water and Water Resources Law (1996)	Article 4	Rights to use water resources	Defines rights, obligations, and procedures to gain approval for use of water resources
	Article 18	Permission for use	Stipulates that medium and large scale uses require feasibility studies, EIAs, and mitigation plans, before permission is granted for use of the resource
	Article 22	Principles in water resource development management	Stipulates that water resource development must be consistent with national and sector plans, must ensure preservation of the natural beauty of the resources, and must protect against harmful effects of water
Water and Water Resources Law (1996)	Article 25	Promotion of Watershed and Water Resource Protection for Hydropower Development	Stipulates that 'hydropower projects must be developed with due concern for environmental protection, flood protection, water supply, irrigation, navigation, fisheries and others."
	Article 29	Water and water resource protection	Requires that water resources be protected from becoming spoilt, polluted, or drying up, and that forest and land resources be protected to help protect the water resources
Lao Forestry Law (amended 2007)	Article 5	Policy on forest and forest land	The GOL has the policy to preserve, regenerate, and develop forests and forest land to help preserve the environment, water resources, biodiversity, and people's livelihoods.
	Articles 9 to 13	Forest types	Classify the various types of forests according to use, including forests for village use
	Article 26	Preservation of water resources in	Stipulates the preservation of water resources in forest zones for those areas

Law or Decree	Article	Relating To	Content
		forest zones	where waterways originate and flow, including strict management and regulations to control logging, shifting cultivation, and destructive forest uses
	Article 70	Conversion of forestland	Stipulates that forestland can be converted to other land type if it brings a high level of benefits to the nation and to livelihoods of the people, and is included in the national development plan
	Article 71	Types of converted forestland	Stipulates that for uses such as dam construction, the timber and forest resources to be harvested in those areas are property of the State
Wildlife and Aquatic Law (2007)	Article 31	Use for Household purposes	Allows use by village households of wildlife and aquatic species in the common and general category list in particular seasons or permitted areas, using tools or equipment that do not adversely affect habitats or compromise the species population.
	Article 32	Customary Use	Allows use of wildlife or aquatic species in the common and general category list by village households for "necessary cultural beliefs."
	Article 52	Prohibitions	Prohibits taking of wildlife, including parts of the animals, from their habitats; tormenting wildlife and aquatic species; illegal catching, hunting, trading and possession; catching aquatic species and hunting in conservation zones, in breeding season, or when pregnant; devastation of habitats and feeding zones.
Land Law (2003)	Article 6	Protection of Land and Environment	Declares that all individuals and organizations are obliged to protect the land from degradation,
	Article 14	Changes in Land Category	Land use can be changed if it does not cause social or environmental harm and if prior approval is obtained from the authorities.
Decree on Land Lease or Concession (2009)	Article 39	Obligation of Person or Legal Entity Who Leases or Obtains Concession	The person or legal entity who leases land or obtains a concession is obligated, among other things, "not to cause any damage to the quality of land and negative impact to the natural environment and the society."
Electricity Law (1997)	Article 6	Environmental Protection	Stipulates the need to assess the impact of electricity enterprises on the natural environment, ecological system, society and wildlife habitats
	Article 13	Feasibility Study	Requires a feasibility study and indicates the contents to be included in such a study
	Article 14	Environmental	Requires an environmental impact assessment and indicates the contents to

Law or Decree	Article	Relating To	Content
		Impact Assessment	be included in such an assessment
	Article 18	Obligations of Concessionaires	Includes the obligations to protect the environment and to pay compensation for any damage to the environment, or to the lives and property of people, or for resettlement
	Article 27	Transmission Lines	Installation and construction of electricity transmission lines to be done in ways to limit damage to environment and to people's property.
Road Law (1999)	Article 15	Public Road Construction	Construction of public roads must include protection of the environment
Prime Ministerial Decree No. 112/PM on Environmental Impact Assessment (2010)		Stipulates the need for Environmental Impact Assessment	Stipulates rights of those affected by projects, and need for participation. Outlines the process of conducting the EIA, preparing environmental management and monitoring plans, social management and monitoring plans, issuing environmental compliance certificates, monitoring compliance with the various plans, establishing the institutional framework including grievance procedures.
Decree on Compensation and Resettlement of People Affected by Development Projects (2006)		Establish the procedures for compensation and resettlement for project affected people	Defines the principles, rules, and measures to mitigate adverse impacts and to compensate for damages that may result from involuntary acquisition or repossession of land and of fixed or movable assets, including changes in land use and restrictions to access of community or natural resources

3.2 *INTERNATIONAL TREATIES*

The Lao PDR is party to several major international environmental treaties, which oblige it to abide by conditions of those treaties. Among those potentially relevant to this Project are:

3.2.1 *Convention on Biological Diversity*

The government of the Lao PDR acceded the Convention on Biological Diversity in September 1996. Under this convention, the Lao PDR accepted several obligations, among them the establishment of protected areas, management of those areas, identification of key components of biological diversity, monitoring of those key components, increase public awareness and participatory management of biodiversity, and assessment of proposed projects that could have an adverse impact on biological diversity. The Prime Minister Decree 164 of 1993 to establish National Biodiversity Conservation Areas, the Environmental Protection Law of 1999, the Wildlife and Aquatics Law of 2007, and the Amended Forestry Law of 2007 were all enacted in part to meet the obligations of the Convention on Biological Diversity.

In 2004, the Lao PDR prepared a Biodiversity Strategy to 2020 and Action Plan to 2010. Recognizing the importance of hydropower for national development, the strategy and action plan found that most hydropower projects to date did not take adequate measures to assure protection of biodiversity. Issues of particular concern were that:

- Watershed management and protection is currently inadequate.
- Hydropower development often results in reduced forest cover, wildlife habitats and biodiversity resources.
- Dam construction has a direct impact on fisheries and local income, especially in downstream areas.
- Some hydropower construction has occurred without prior detailed studies.
- The resettlement of the local people can have a direct and indirect impact on biodiversity.
- Dam construction changes the natural water flow.
- The compensation schemes for lost land and property are not clearly defined according to different scale.[1]

The report recommends addressing these issues through several options:

- Ensure that hydropower development takes social and environmental concerns into consideration.
- Manage and protect forests in watershed areas.
- Effectively enforce relevant laws and regulations.
- Ensure that environmental and social impact assessments are effectively applied for hydropower projects. Promote effective and economical energy use, as well as the utilisation of renewable energy.[2]

3.2.2 *Convention on Climate Change*

Having ratified the Convention on Climate Change in January 1995, the Lao PDR is obligated to mitigate greenhouse gas emissions. Of concern to this Project are the possible impacts of the reduction of forest area, the emission of greenhouse gases from organic matter in the reservoir, the development of renewable sources of energy, and the promotion of sustainable forms of agriculture.

3.2.3 *Agreement on the Cooperation for Sustainable Development of the Mekong River Basin*

In April 1995, the Lao PDR ratified the Agreement on the Cooperation for Sustainable Development of the Mekong River Basin. This agreement, between the countries of Cambodia, Lao PRD, Thailand and Vietnam, established the Mekong River Commission and formed the basis for the joint

1 Science, Technology and Environment Agency, National Biodiversity Strategy to 2020 and Action Plan to 2010, STEA, GOL: 2004, p. 35.

2 Ibid.

management and development of the water resources of the Mekong River and its tributaries.

The four signatory countries agreed "to cooperate in all fields of sustainable development, utilization, management and conservation of the water and related resources of the Mekong River Basin including, but not limited to irrigation, hydro-power, navigation, flood control, fisheries, timber floating, recreation and tourism, in a manner to optimize the multiple-use and mutual benefits of all riparians and to minimize the harmful effects that might result from natural occurrences and man-made activities." (Article 1)

Key provisions that concern this Project are:

- "To promote, support, cooperate and coordinate in the development of the full potential of sustainable benefits . . . and the prevention of wasteful use of Mekong River Basin waters . . . through the formulation of a basin development plan . . ." (Article 2)
- "To protect the environment, natural resources, aquatic life and conditions, and ecological balance of the Mekong River Basin from pollution or other harmful effects resulting from any development plans and uses of water and related resources in the Basin." (Article 3)
- In cases of utilization of waters "On tributaries of the Mekong River, . . . intra-basin uses and inter-basin diversions shall be subject to notification to the Joint Committee." (Article 5, Paragraph A)
- "To cooperate in the maintenance of the flows on the mainstream from diversions, storage releases, or other actions of a permanent nature . . ." (Article 6)
- "To make every effort to avoid, minimize and mitigate harmful effects that might occur to the environment, especially the water quantity and quality, the aquatic (eco-system) conditions, and ecological balance of the river system, from the development and use of the Mekong River Basin water resources or discharge of wastes and return flows." (Article 7)

3.2.4 *Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES)*

The Lao PDR joined the Convention on International Trade in Endangered Species of Wild Fauna and Flora (or CITES) in March 2004, with it coming into force on 30 May 2004. The Wildlife and Aquatics Law of 2007 includes provisions that meet the obligations of the Lao PDR to CITES.

3.2.5 *Inter-Governmental Agreement on Regional Power Trade in the Greater Mekong Sub-Region*

The Inter-Governmental Agreement on Regional Power Trade in the Greater Mekong Sub-Region between Cambodia, China, Lao PDR, Myanmar, Thailand and Vietnam sets the framework for electricity development and trade among the countries of the sub-region. The agreement is based on principles of:

i) Cooperation: That issues related to regional interconnection be handled in a spirit of cooperation and mutual benefit, that the Parties have equal rights and obligations, act in solidarity, and refrain from taking advantage of one another;
ii) Gradualism: That the Parties consider the progressive development of regional electricity trade; and
iii) Environmentally Sustainable Development: That regional electricity trade is operated within a framework of respect for the environment. (Article 2, Paragraph 2.2)

3.2.6 Convention Concerning the Protection of the World Cultural and Natural Heritage (World Heritage Convention, 1972)

The government of the Lao PDR ratified the Convention Concerning the Protection of the World Cultural and Natural Heritage on 20 March 1987. Under this Convention, the government agrees to take the appropriate legal, scientific, technical, administrative and financial measures necessary for identification, protection, conservation, presentation and rehabilitation of designated heritage sites in the Lao PDR. The following articles are pertinent:

I. Definition of the Cultural and Natural Heritage

Article 1

For the purposes of this Convention, the following shall be considered as "cultural heritage":

- monuments: architectural works, works of monumental sculpture and painting, elements or structures of an archaeological nature, inscriptions, cave dwellings and combinations of features, which are of outstanding universal value from the point of view of history, art or science;
- groups of buildings: groups of separate or connected buildings which, because of their architecture, their homogeneity or their place in the landscape, are of outstanding universal value from the point of view of history, art or science;
- sites: works of man or the combined works of nature and man, and areas including archaeological sites which are of outstanding universal value from the historical, aesthetic, ethnological or anthropological point of view.

Article 2

For the purposes of this Convention, the following shall be considered as "natural heritage":

- natural features consisting of physical and biological formations or groups of such formations, which are of outstanding universal value from the aesthetic or scientific point of view;
- geological and physiographical formations and precisely delineated areas which constitute the habitat of threatened species of animals and plants of outstanding universal value from the point of view of science or conservation;
- natural sites or precisely delineated natural areas of outstanding universal value from the point of view of science, conservation or natural beauty.

II. National Protection and International Protection of the Cultural and Natural Heritage

Article 4

Each State Party to this Convention recognizes that the duty of ensuring the identification, protection, conservation, presentation and transmission to future generations of the cultural and natural heritage referred to in Articles 1 and 2 and situated on its territory, belongs primarily to that State. It will do all it can to this end, to the utmost of its own resources and, where appropriate, with any international assistance and co-operation, in particular, financial, artistic, scientific and technical, which it may be able to obtain.

Article 5

To ensure that effective and active measures are taken for the protection, conservation and presentation of the cultural and natural heritage situated on its territory, each State Party to this Convention shall endeavor, in so far as possible, and as appropriate for each country:

1. to adopt a general policy which aims to give the cultural and natural heritage a function in the life of the community and to integrate the protection of that heritage into comprehensive planning programmes;
2. to set up within its territories, where such services do not exist, one or more services for the protection, conservation and presentation of the cultural and natural heritage with an appropriate staff and possessing the means to discharge their functions;
3. to develop scientific and technical studies and research and to work out such operating methods as will make the State capable of counteracting the dangers that threaten its cultural or natural heritage;
4. to take the appropriate legal, scientific, technical, administrative and financial measures necessary for the identification, protection, conservation, presentation and rehabilitation of this heritage; and
5. to foster the establishment or development of national or regional centres for training in the protection, conservation and presentation of the cultural and natural heritage and to encourage scientific research in this field.

Article 6

1. Whilst fully respecting the sovereignty of the States on whose territory the cultural and natural heritage mentioned in Articles 1 and 2 is situated, and without prejudice to property right provided by national legislation, the States Parties to this Convention recognize that such heritage constitutes a world heritage for whose protection it is the duty of the international community as a whole to co-operate.
2. The States Parties undertake, in accordance with the provisions of this Convention, to give their help in the identification, protection, conservation and presentation of the cultural and natural heritage referred to in paragraphs 2 and 4 of Article 11 if the States on whose territory it is situated so request.
3. Each State Party to this Convention undertakes not to take any deliberate measures which might damage directly or indirectly the cultural and natural heritage referred to in Articles 1 and 2 situated on the territory of other States Parties to this Convention.

3.2.7 United Nations Convention to Combat Desertification (1970)

The United Nations Convention to Combat Desertification in Those Countries Experiencing Serious Drought and/or Desertification, Particularly in Africa (UNCCD) has the objective of combatting desertification and mitigating the effects of drought. Lao PDR ratified the convention in 1996. Articles 3 to 19 of the Convention, together with Annex II, are of particular importance to the Lao PDR[1] and specifically address the following issues:

Article 3. Principles. Emphasizes the importance of ensuring full participation of local communities in decisions on the design and implementation of programme.

Article 4. General obligations. Discusses the need for integrated approaches that address the physical, biological and socio-economic aspects of the processes of desertification and drought. Emphasizes integration of strategies for poverty eradication.

Article 5. Obligations of affected country Parties. Highlights that affected country Parties must give due priority to combating desertification and mitigating the effects of drought.

Article 8. Relationship with other conventions. Coordination is encouraged, in particular with the UNFCCC and UNCBD.

[1] Report on National Capacity Needs Self-Assessment for Global Environment Management for the three Rio Conventions, Lao People's Democratic Republic, UNDP, WREA, GEF, April 2009

Section 1. Action Programme

Article 9. Basic Approach. Requires that a National Adaptation Plans (NAP) be prepared and continuously updated using participatory processes and on the basis of lessons learned.

Article 10. National Adaptation Plans (NAP) aim to identify the factors contributing to desertification and practical measures necessary to combat desertification and mitigate the effects of drought.

Article 11. Sub-regional and regional action programme.

Articles 12 – 14. Emphasis is placed on cooperation and coordination in the development and implementation of action programme.

Section 2. Scientific and technical cooperation

Article 16. Information collection, analysis and exchange.

Article 17. Covers research and development in the fields of combating desertification and/ or mitigating the effects of drought.

Article 18. Discusses transfer, acquisition, adaptation and development of environmentally sound, economically viable and socially acceptable technologies relevant to combating desertification and/ or mitigating the effects of drought.

Section 3. Supporting measures

Article 19. Capacity building, education and public awareness.

Annex II of the Convention presents the Regional Implementation Annex for Asia. It provides guidelines and arrangements for the effective implementation of the Convention in the affected country parties of the Asian region.

3.3 ADB ENVIRONMENTAL SAFEGUARD POLICIES

With funding expected from the Asian Development Bank (ADB), the key environmental safeguard policies of the ADB that should be addressed by this Project are noted in this section. Social safeguard policies are presented in the volume on "*Social Impact Assessment Report- Nam Ngiep 1 Hydropower Project*", completed in 2012.

The ADB has a single comprehensive environmental policy. The policy consists of five main components: (1) Environment Interventions for Poverty Reduction, (2) Mainstreaming Environmental Consideration in Economic Growth, (3) Maintaining Global and Regional Life Support Systems, (4) Building Partnerships, and (5) Integrating Environmental Consideration in ADB Operations.

According to the ADB environmental category, the Project is categorized into category A, implying occurrence of significant adverse environmental impacts that are irreversible, diverse, or unprecedented. With respects to the Safeguard Policy Statement (2009), a Category A project is required to develop a comprehensive environmental assessment of the potential negative and positive impacts and assessments of alternatives, recommended mitigation measures, and extensive participation of affected people and other stakeholders.

The ADB stresses the link between natural resources and pro-poor development, since most of the rural poor depend upon these resources for their livelihood, be it agriculture, fishing, or use of forest products. To do so, the ADB directs its activities to the "(i) protection, conservation, and sustainable use of natural resources to maintain the livelihoods of the poor; (ii) reduction of air, water, and soil pollution that directly impacts the health and productivity of poor people; and (iii) reduction of vulnerability to natural hazards and preventing disasters."[1]

The ADB also requires that the borrower carry out a consultation process for category A projects, to consult with and provide information on the environment assessment process to project affected persons and to local NGOs. This consultation should be carried out at least twice: once during the early stages of the EIA field work to be able to incorporate the views of the affected people, and then again after the draft EIA is prepared (before the loan appraisal by the ADB).[2]

Among the key environmental concerns of the ADB noted in its policy that need to be addressed in the NNP1 Project EIA are: deforestation and land degradation, biodiversity loss, aquatic resources, water pollution, and climate change.

3.4 EQUATOR PRINCIPLES

Private banks now do a large amount of the lending for international development. Initiated by several of the world's largest banks, the Equator Principles were established to assure that borrowers from the private banks for development projects abide by similar environmental and social standards as those applied by the World Bank, the ADB and other international financial institutions. The Equator Principles incorporate the International Finance Corporation's Environmental and Social Performance Standards. Of particular relevance to the environmental aspects of the NNP1 Project are the need and means for biodiversity conservation and sustainable natural resource management, and pollution prevention and abatement. More than 60 of the

1 ADB, Environment Policy of the Asian Development Bank, 2002, p. 9

2 Ibid, p. 18

world's leading banks have adopted the principles, which require them to stop lending if the borrower is found not to abide by the processes.

As with the ADB, projects deemed to have potentially great environmental impact, such as dams, are classified as Category A projects. These are required to have social and environmental impact assessments, adequate consultation with project affected people and local organizations, and adequate management and grievance mechanisms, similar to those required by the ADB.

Some of the environmental issues of concern in the Equator Principles that relate to the NNP1 Project are:

1) Protection and conservation of biodiversity, including endangered species and sensitive ecosystems in modified, natural and critical habitats, and identification of legally protected areas.
2) Sustainable management and use of renewable natural resources (including sustainable resource management through appropriate independent certification systems).
3) Use and management of dangerous substances.
4) Major hazards assessment and management.
5) Consideration of feasible environmentally and socially viable alternatives.
6) Pollution prevention and waste minimization.[1]

These issues are not considered exhaustive, but indicative of the types of issues to be addressed.

[1] The Equator Principles, July 2006, Exhibit II: Illustrative list of potential social and environmental issues to be addressed in the Social and Environmental Assessment documentation, p. 7.

4 PROJECT DESCRIPTION

4.1 PROJECT BACKGROUND

Lao PDR's hydropower resources are expected to be a primary source of income for the future, primarily through selling generated electricity to neighboring countries, including Thailand. The foreign exchange earned from sale of electricity from hydropower may in turn spur additional economic and social development in the Lao PDR, while the electric network will be a key infrastructure for that development. Thailand has considerable demand for electricity, with domestic supply unable to keep up with the growing demand. Most of the alternatives available to Thailand for additional large-scale electrical production in country are much more costly than hydropower, both financially and environmentally.

For the Nam Ngiep 1 Hydropower Project (NNP1), several pre-feasibility studies have been carried out. The JICA Feasibility Study (JICA F/S), which was completed between 2000 and 2002, consisted of a First (Initial) Environmental Impact Assessment and various technical studies. The JICA F/S stated that the Nam Ngiep 1 Hydropower Project would help cope with peaks or intermediate peaks in the load curve, and that it would be able to maintain price competitiveness among other power sources.

NNP1 has been planned as a Build-Operate-Transfer (BOT) project by a private/public company, targeted to sell electricity to EGAT and the Lao PDR government-owned Electricite du Laos (EDL) for 27 years. This is to be done under a concession provided by the Government of Laos (GOL) and Power Purchase Agreements with EGAT and EDL.

Nam Ngiep 1 Power Co., Ltd. (NNP1PC) has been established under a shareholder agreement in order to sign loan agreements with lenders and begin work on the Project. The sponsors of NNP1PC are a consortium consisting of The Kansai Electric Power Co., Inc. from Japan, EGAT International Co., Ltd. from Thailand, and Lao Holding State Enterprise (LHSE) from the Lao PDR. Provision of detailed designs, construction plans, commissioning, operations and maintenance are among the objectives of the company. The company is expected to repay its loans and recover its investment from power sales. At the end of the concession period, the facilities are to be transferred to GOL under specified conditions, either at zero value or at an amount agreed in the concession agreement.

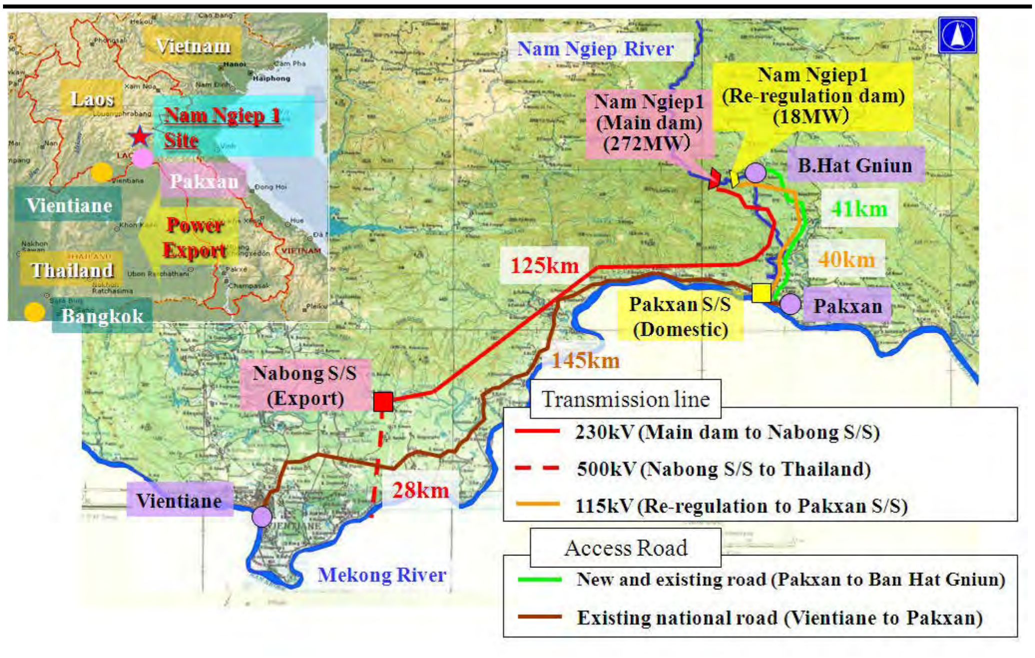
Current Project cost is estimated to be approximately 0.9 billion USD. According to the results of more detailed studies of the environmental and social impacts, environmental and social costs recommended for the various mitigation measures would be around 52.5 million USD.

4.2 *PROJECT LOCATION*

The main dam site will be located on the Nam Ngiep River, approximately 145 km north-east of Vientiane, and about 40 km north of Pakxan, as shown in ***Figure 4.1***.

The main facility of the Project will be located in Bolikhamxay Province, although the reservoir will cover parts of Vientiane and Xieng Khouang provinces. The reservoir will have a surface area of 66.9 km² when at full supply level of EL320 m. The reservoir will have an effective storage capacity of 1,192 million m³, and is designed to drop around 130 m to a power station downstream from the main dam. Water discharged from the power station will flow into a re-regulating pond, then be discharged downstream daily through the 20 m high re-regulation dam.

Figure 4.1 Project Location



4.3 *PROJECT GENERAL LAYOUT AND INFRASTRUCTURE*

Under the management of NNP1PC, the Project plans to construct a 148 m high concrete gravity dam on the Nam Ngiep River, and will build a main power station having 272 MW and annual power generation of 1,546 GWh at substation. A re-regulation power station, located downstream of the main power station, will have 18 MW and annual power generation of 105 GWh.

Average annual rainfall throughout the catchment area is estimated at about 1,900 mm. The area south of the mountains receives nearly double the rainfall compared to the northern part of the river basin. The catchment area at the dam site is estimated to be 3,700 km², with average inflow of 148.4 m³/s or 4.68 billion m³/year.

The main features of the Project are presented in ***Table 4.1*** and ***Figure 4.2***.

Table 4.1 Main Features of the Project

Facility	Items	Unit	Specifications
Main Power Station			
Main Reservoir	Flood water level	EL. m	320.0
	Normal water level	EL. m	320.0
	Rated water level	EL. m	312.0
	Minimum operating level	EL. m	296.0
	Available depth	m	24.0
	Reservoir surface area	km^2	66.9
	Effective storage capacity	10^6 m^3	1,192
	Catchment area	km^2	3,700
	Average annual inflow	m^3/s	148.4
		10^6 m^3	4,680
Main Dam	Type	-	Concrete gravity dam (Roller-Compacted Concrete)
	Dam height	m	148.0
	Crest length	m	530.0
	Dam volume	10^3 m^3	2,034
	Crest level	EL. m	322.0
Spillway	Gate type	-	Radial gate
	Number of gates	-	4
	Design flood	m^3/s	5,210 (1,000-year)
Intake	Type	-	Bell-mouth
	Number	-	2
	Discharge capacity	m^3/s	230.0
Penstock	Type	-	Embedded and concrete-lined
	Number	-	2
	Length	m	185.81
	Diameter	m	5.2
Powerhouse	Type	-	Semi-underground
	Length	m	25.0
	Width	m	62.5
	Height	m	47.2
Turbine and Generator	Maximum plant discharge	m^3/s	230.0
	Maximum plant discharge (for simulation)	m^3/s	34.5
	Gross head	m	132.7
	Effective head	m	130.9
	Type of turbine	-	Francis
	Rated output	MW	272 (at Substation)
	Annual power generation	GWh	1,546 (at Substation)
	Peak operation hour	hrs	16 (Monday to Saturday)
Transmission Line	Voltage	kV	230
	Distance	km	125
	Connecting point	-	Nabong S/S
	Width of right of way	m	80 (40 m each side of CL)
	Number of towers	-	262
Re-Regulation Power Station			
Re-Regulation Reservoir	Flood water level	EL. m	185.9
	Normal water level	EL. m	179.0
	Rated water level	EL. m	179.0
	Minimum operating level	EL. m	174.0

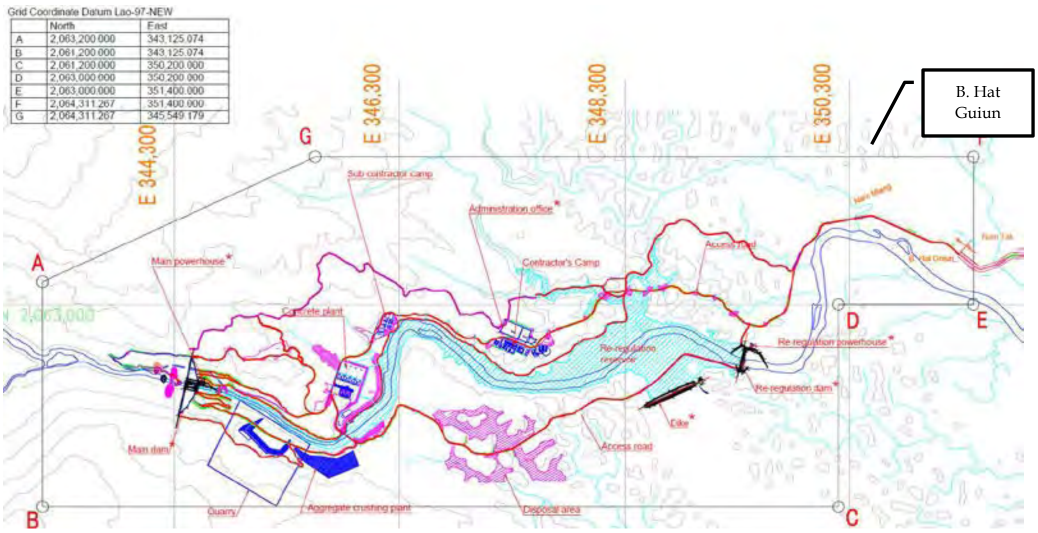
Facility	Items	Unit	Specifications
	Available depth	m	5.0
	Reservoir surface area	km^2	1.27 at NWL
	Effective storage capacity	$10^6 m^3$	4.6
	Catchment area	km^2	3,725
Re- Regulation Dam	Type	-	Concrete Gravity dam
	Dam height	m	20.6
	Crest length	m	90.0
	Dam volume	10^3 m^3	23.9
	Crest level	EL. m	187.0 (non-overflow section)
Re-Regulation Gate	Type	-	Fixed wheel gate
	Number	-	1
	Discharge capacity	m^3/s	5,210 (1,000-year)
Saddle Dam	Type	-	RCC associate with rockfill dam
	Crest length	m	507.1
	Dam height	m	14.6
Spillway	Gate type	-	Ungated spillway (Labryrinth type)
	Design flood	m^3/s	5,210 (1,000-year)
Intake	Type	-	Open
	Number	-	1
	Discharge capacity	m^3/s	160.0
Powerhouse	Type	-	Semi-underground
	Length	m	46.4
	Width	m	22.05
	Height	m	49.1
Turbine and Generator	Maximum plant discharge	m^3/s	160.0
	Maximum plant discharge (for simulation)	m^3/s	40.0
	Gross head	m	13.1
	Effective head	m	12.7
	Type of water turbine	-	Bulb
	Rated output	MW	18 (at Substation)
	Annual power generation	GWh	105 (at Substation)
	Peak operation hour	hrs	24 (Monday to Sunday)
Transmission Line*	Voltage	kV	115
	Distance	km	40
	Connecting point	-	Pakxan S/S
	Width of right of way	m	50 (25 m each side of CL)
	Number of towers	-	110
Supporting Facilities			
Diversion Tunnel	Length	m	653
	Inside diameter	m	10
	Number	-	1
	Velocity	m^3/s	11.5
Access Road	Vientiane – "Friendship Bridge" – Pakxan Distance	km	161.7
	Width	m	6
	Number of bridge	-	2
	Type of road	-	Asphalt paved
	Type of bridge	-	Pre- casted
	Pakxan – Ban Nonsomboun Distance	km	19.9
	Width	m	6
	Number of bridge	-	1

Facility	Items	Unit	Specifications
	Type of road	-	Asphalt paved
	Type of bridge	-	Pre- casted
	Ban Nonsomboun – Ban Hat Gniun Distance	km	21.2
	Width	m	5.7
	Ban Hat Gniun – Dam Site Distance	km	11.2
	Width	m	3.7-13.5
Spoil Disposal Area	No.1 permanent road Sta. 29+400 Capacity	m^3	151,000
	Expected disposal volume	m^3	130,000
	No.2 permanent road Sta. 28+100 Capacity	m^3	810,000
	Expected disposal volume	m^3	88,000
	No.3 permanent road Sta. 27+700 Capacity	m^3	42,000
	Expected disposal volume	m^3	N/A
	No.4 permanent road Sta. 26+400 Capacity Expected disposal volume	m^3 m^3	12,000 N/A
	No.5 permanent road Sta. 25+800 Capacity	m^3	20,000
	Expected disposal volume	m^3	N/A
	No.6 right bang soil disposal road Capacity	m^3	2,400,000
	Expected disposal volume	m^3	2,100,000
Quarry	Location	-	Right bank of main dam downstream 1000 m.
	Area	ha	46

Source: Technical Report on Nam Ngiep 1 Hydropower Project Kansai, 2013

* It shall be noted that the 115kV Transmission Line and Pakxan Sub-station will be the responsibility of EDL, even though they are considered as the associated facilities of the Project. They are outside the scope of this assessment.

Figure 4.2 *Location of Main Features of Nam Ngiep 1 Hydropower Project*

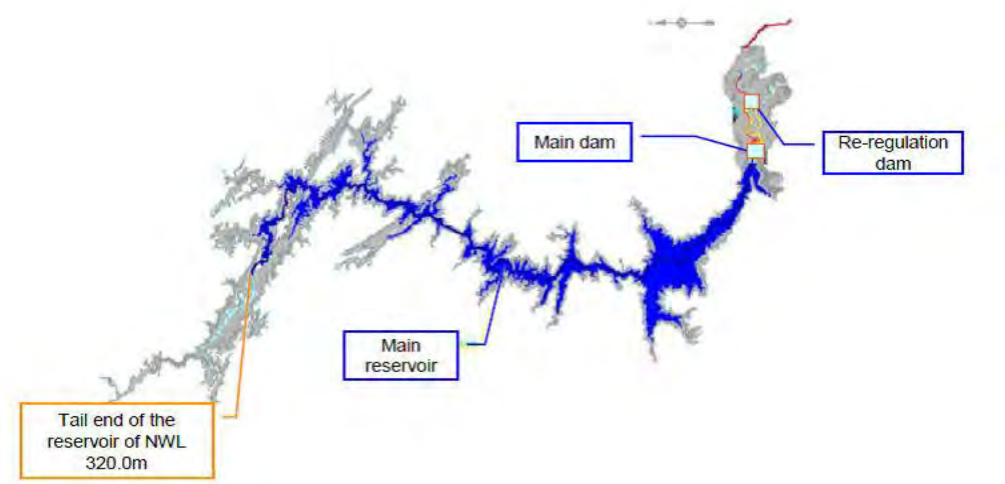


4.4 MAIN DAM AND RELATED FACILITIES

4.4.1 Main Dam Site Reservoir

The dam location is planned to be 1.7 km upstream from the end of a narrow gorge, and 11.2 km from Ban Hat Gniun. The main dam reservoir will inundate the main river (length 72 km) and its tributaries. The main dam reservoir is illustrated in ***Figure 4.3***.

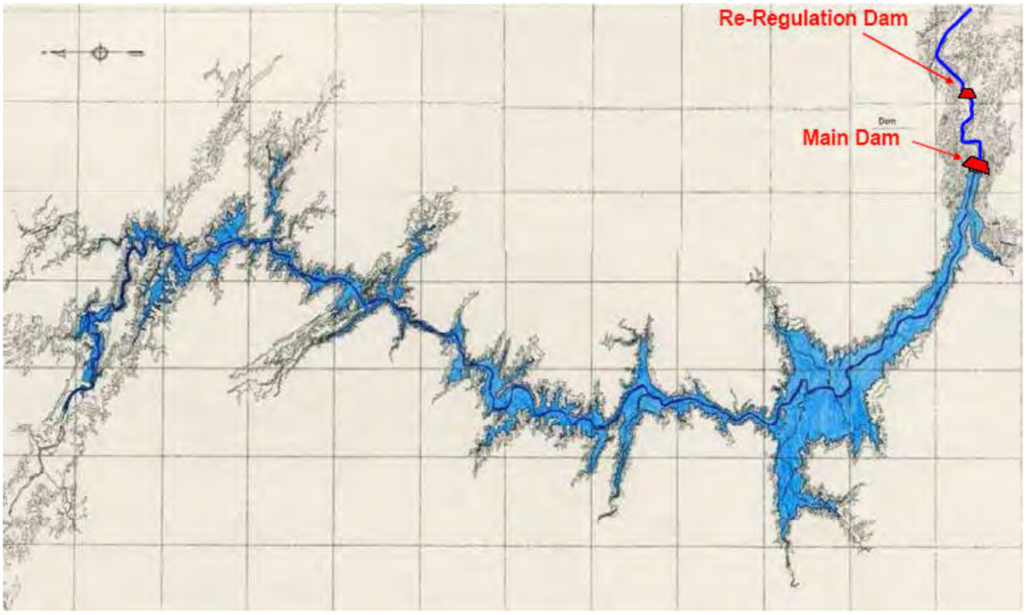
Figure 4.3 ***Main Dam Reservoir***



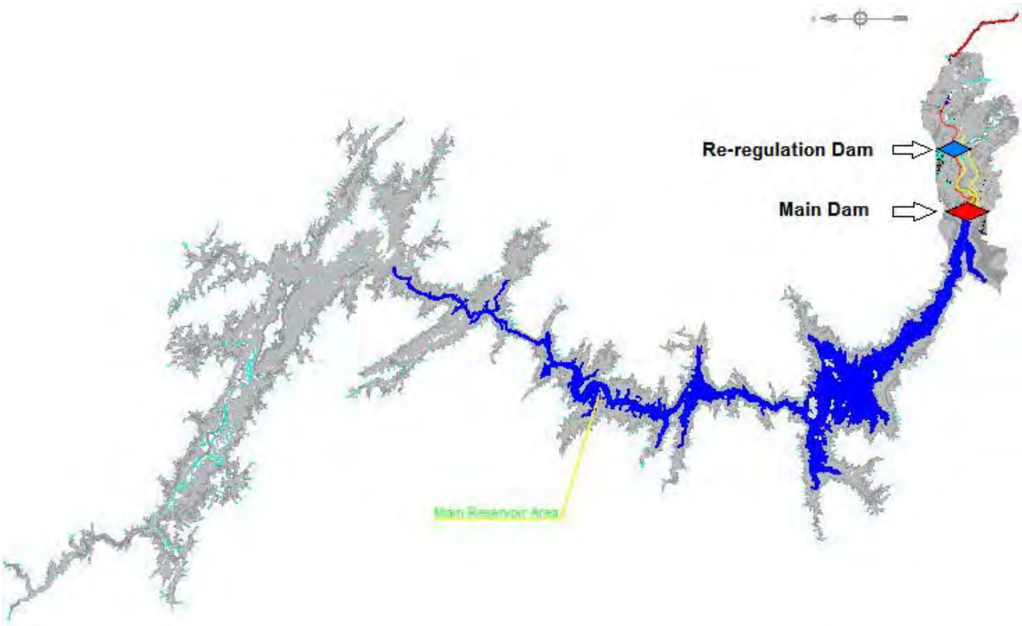
Source: Kansai and EGAT, Technical Report, 2011

The reservoir is quite narrow along most of its length. During normal operations (with water level EL 320 m), the reservoir will cover an area of 66.9 km^2. Most of the inundation (36.8 km^2, or 55 %) would take place within the first 20 km upstream from the main dam. During the minimum operation level (with water level EL 296 m), the reservoir will cover an area of 37.4 km^2. The inundation areas for normal water level (NWL) and minimum operational level (MOL) are illustrated in ***Figure 4.4***.

Figure 4.4 Inundated Area of Main Reservoir



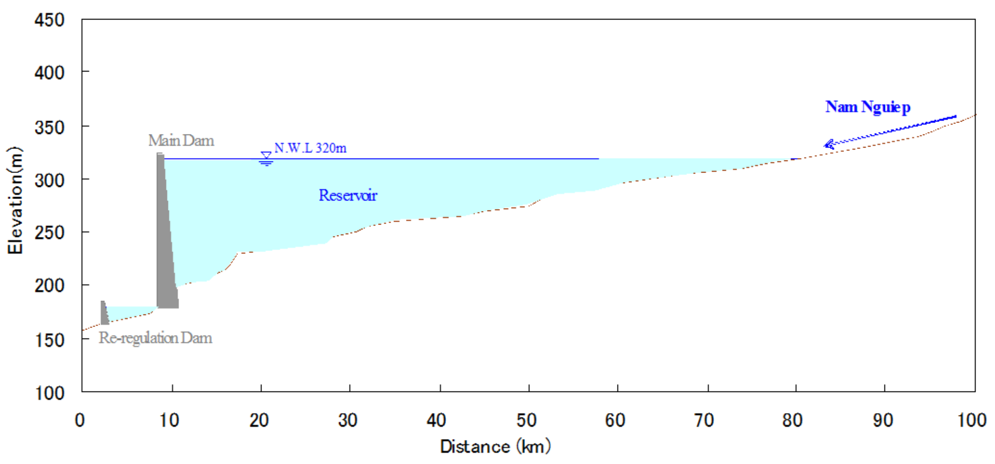
(a) Normal Water Level (EL 320 m)



(b) Minimum Operation Level (EL 296 m)

As shown in the longitudinal profile (***Figure 4.5***), the river floor at the location where the main dam will be constructed is at EL 180 m. The reservoir depth at the deepest point, directly behind the dam, will be equal to the dam height, which is about 140 m. The average depth of the reservoir would be about 70 m, ranging from a maximum of 140 m at the dam, to a minimum of just a few meters at the furthest point from the dam (approximately 70 km upstream).

Figure 4.5 *Longitudinal Profile of Main Reservoir*



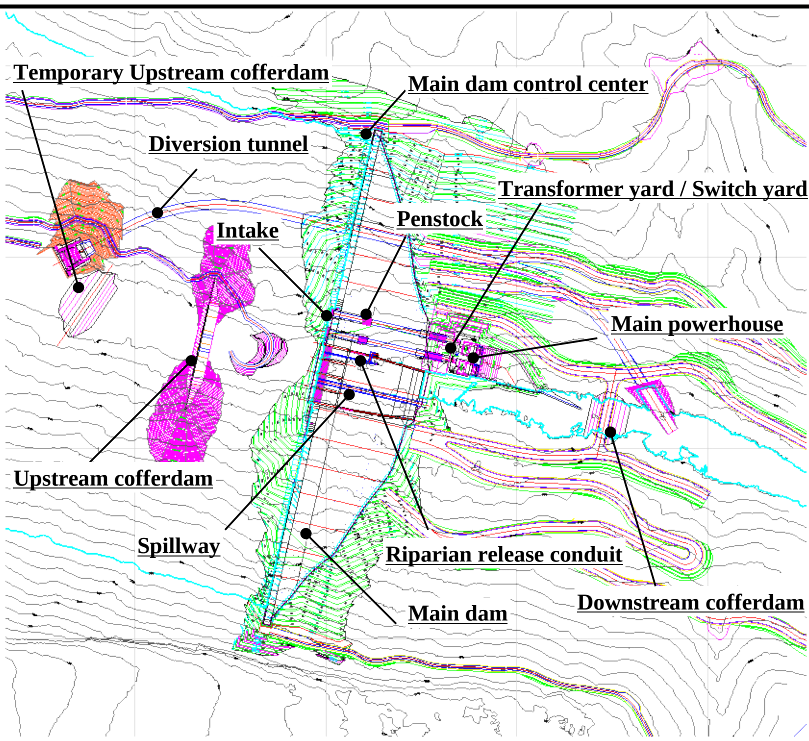
Source: Kansai and EGAT, Technical Report, 2011

4.4.2 *Main Dam*

4.4.2.1 Layout

The structures of the main dam will consist of the main dam body, a single lane river diversion tunnel with an intake/outlet, cofferdams located upstream/downstream of the diversion tunnel, the main power station, and a tailrace. Intakes, penstocks, a spillway, a riparian release conduit, and valve are to be located in the main dam body. ***Figure 4.6*** shows the layout plan in the periphery of the main dam.

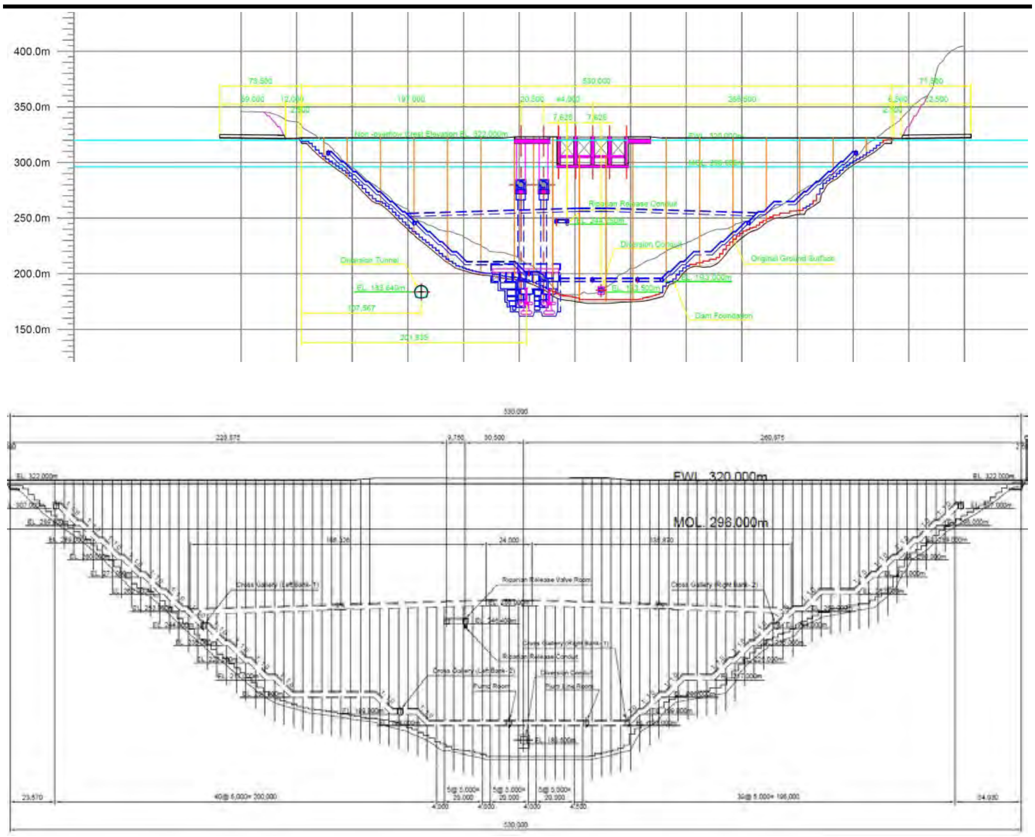
Figure 4.6 *Dam Periphery Layout Plan*



Source: Kansai and EGAT, Technical Report on Nam Ngiep 1 Hydropower Project, 2013

The main dam facilities will be located on the left bank (when facing downstream) to avoid the folded zone on the right bank and to minimize the impact caused by the extensive adjustment that would be required for the facilities to fit on the slopes. The main dam will be located in the gorge, 1.2 km downstream from the junction where the Nam Katha River joins the Nam Ngiep River. The main structure will be formed by the construction of a concrete gravity dam, with a crest length of approximately 530 m and a crest height of 148 m. Dam crest elevation will be EL 322.0 m. The elevation will be set in order to avoid overflow caused by the historical maximum flood level. Grouting is also planned to improve the water cut-off effect of the dam foundation (***Figure 4.7***).

Figure 4.7 Upstream Cross-Section of Main Dam



Source: Kansai and EGAT, Technical Report on Nam Ngiep 1 Hydropower Project, 2013

4.4.2.2 *Main Dam Type Selection Details*

The planned dam axis has been set by considering the surrounding topography and geology of the Project site. A roller-compacted concrete (RCC) dam of 148 m height has been selected as the most economical of the various dam type options. Conversely, if a rockfill dam type had been selected, there would be considerable difficulties in the arrangement of a spillway and the procurement of materials such as core or asphalt/concrete, as well as difficulties in scheduling of construction relating to filling soil/rock materials during the rainy season.

The reservoir water level has been set at EL 320.0 m. Although higher water levels would be more economical, the EL 320.0 water level was selected in order to reduce the impacts on the environment and on residents around the reservoir.

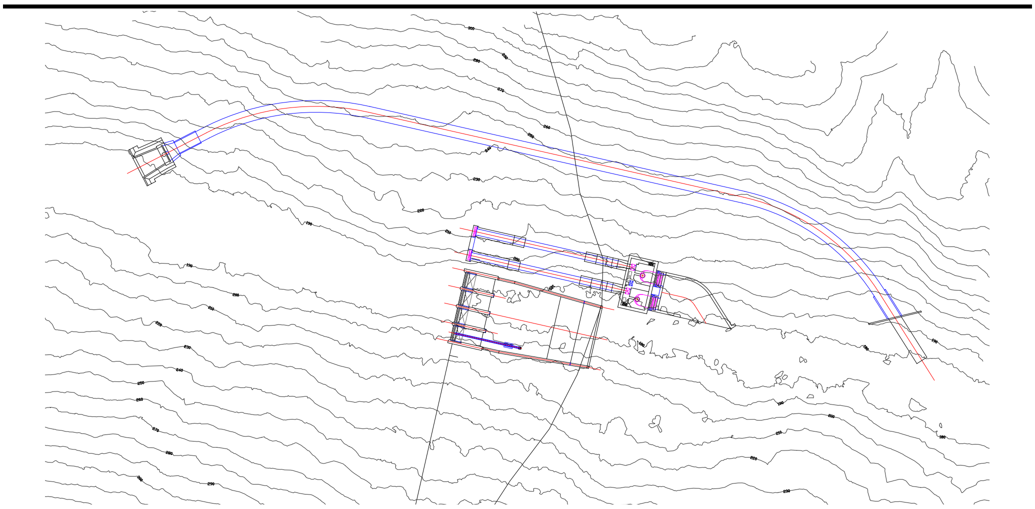
A spillway with four (4) gates will be mounted in the middle of the RCC dam. A ski jump type spillway was selected to mitigate the effects of discharged water around the powerhouse downstream, though a hydraulic type dissipater was originally planned. A dam control center will be located near the dam crest on the left bank. The dam control center will operate the spillway gate, which allows monitoring the reservoir water level during floods. A diversion tunnel having the capacity to discharge flood waters during construction will be laid inside the left bank mountain, taking into consideration the more favorable geology of that location.

Further details on alternative designs considered for the Project are presented in *Chapter 7: Study of Alternatives*.

4.4.3 River Diversion Tunnel (during Construction)

The river profile at the dam site is a V-shape, with a riverbed width of 30−40 m. Based on this, a tunnel construction method has been selected as the most appropriate technique for river diversion. The left bank route has been selected to avoid the folded zone in the middle of the right bank, which is about 90 m wide and runs in upstream/downstream direction (***Figure 4.8***).

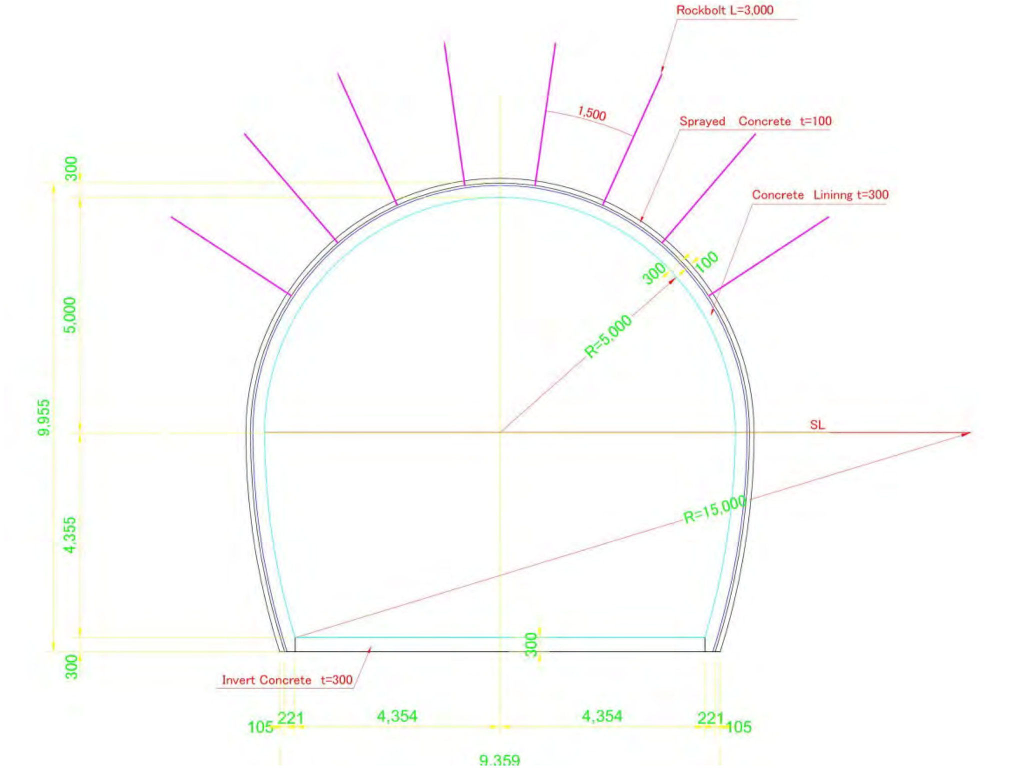
Figure 4.8 River Diversion Tunnel Layout



Source: Kansai and EGAT, Technical Report on Nam Ngiep 1 Hydropower Project, 2013

The river diversion will be carried out via a single-row water pressure tunnel with inner diameter of 10.0 m, length of 653 m, consisting of a horseshoe cross-section, and structurally capable of passing a 1.5-year probable flood discharge of 1,000 m^3/s. The tunnel will be concrete-lined; the thickness of the concrete lining will be 0.7 m for the intake section, outlet section and the plug section, and 0.3 m for the remainder of the tunnel. The tunnel will be blocked up at two sections: the intake section and the section below the dam axis. A cross-sectional view of the diversion tunnel is shown in ***Figure 4.9***.

Figure 4.9 Diversion Tunnel Cross Section



4.4.4 *Spillway*

The spillway for the dam, which will provide controlled release of flows to the Nam Ngiep River, is designed to consist of four (4) radial gates, each with 12.25 m breadth and 16.0 m radius. The spillway is designed for 5,210 m^3/s (1,000-year probability) flood discharge in fully open conditions. The gated spillway type has been selected to be in accordance with the spill design flood discharge at NWL. A spillway chute and energy dissipater will mitigate downstream impacts of the main dam.

The crest and chute of the spillway will be configured and designed to mitigate negative pressure created under all conditions. The falling pattern and other conditions of the design flood discharge are confirmed by hydraulic model simulation tests. The ski-jump style projection end, which is to act as an energy dissipater, has been set at EL 206.4 m. This level was selected by considering the flood level of EL 192.1 m derived by non-uniform flow computation from the re-regulation dam using flow of 8,980 m^3/s (peak flood discharge for 72-hour Probable Maximum Flood), plus additional allowance.

4.4.5 *Intake*

Intakes will be located on the upstream surface of the main dam. The sill level of the intakes will be set at EL 276 m, which is 19.9 m below minimum operation level (MOL), but above the assumed 50-year sedimentation level of EL 233.0 m. The intake structure and its current proposed sill level have been designed to minimize water head loss and to avoid generation of air bubbles and vortexes, which are harmful hydraulic phenomena for the turbine. Considering these conditions, the proposed intake location will have enough water depth from the MOL of EL 296.0 m. Generally, a depth of two times the inlet diameter is required in power intake design. To minimize head loss, a bell mouth inlet is planned to be used for the intake.

4.4.6 *Penstock*

Two rows of penstocks are planned to be located near the center of the river. The diameter of the penstocks will be 6.76 m at the beginning point, gradually reducing to 5.20 m, and then rapidly reducing to 3.7 m just upstream of the inlet valve. The penstocks on the dam body are covered with concrete, to prevent rupture of penstock.

4.4.7 *Conduit for Riparian Release*

A conduit is planned for riparian release, which is intended to enhance environmental protection of the downstream area, primarily during impoundment. After normal operation commences, water can be released by both the spillway gate and turbine, and the riparian conduit would only be used in extreme or emergency cases (e.g. if the spillway gate was broken or the turbine was malfunctioning, or in extreme drought conditions when the turbine cannot operate).

During impoundment, the riparian release conduit will be used to release water downstream. Water velocity inside the pipe will be set at 20 m/s. The velocity in the slide valve section needs to be limited to within 10 m/s under any conditions in order to avoid harmful vibrations. Considering these conditions, a 0.8 m diameter discharge pipe and two (2) sluice valves, each 1.1 m in diameter, will be installed inside the dam body.

The upstream slide valve is intended to be used as a back-up. The sill level of the gate chamber will be set at EL 244.6 m, which is lower than MOL (296.0 m) and higher than the assumed sedimentation level of EL 233.0 m. The discharge of the riparian release conduit is designed for an average flow rate of 5.5 m^3/s. The principal rationale for selecting the 5.5 m^3/s minimum flow during impoundment is that (i) it is larger than the minimum flow of other similar projects, and (ii) it will create a minimum downstream flow depth of 0.5 m, which will be adequate for fish movement and boat navigation.

The range of flow for the riparian conduit is 0.0-9.3 m^3/s, depending on the water level. At NWL (EL 320 m) and MOL (EL 296 m), the conduit capacity is 9.3 m^3/s and 5.5 m^3/s, respectively.

The reasons for setting the sill level at EL 244.6 m are as follows:

1. The elevation is above the sedimentation level, meaning that the conduit can function throughout the Project's life.
2. The water in dead storage can be circulated to improve its quality.
3. There will be reserve water for the riparian release of 969 mcm.

Based on the above, the current level of the conduit is optimal; if the conduit was installed at a higher level, there would be a risk of impeding downstream flows.

4.4.8 Main Power Station

The layout of the main power station and the spillway are designed so that they are closer to the river center, considering that water from the spillway and the tailrace merge into the river. The upstream end of the main power station, elongated from the dam axis, is 143.5 m long. The main power station, a four-storey building, is approximately 25.0 m long, 62.5 m wide, and 47.2 m high. The tailrace is 48.5 m long.

Two (2) Francis turbine units will be installed at the main power station, which will generate energy for delivery to EGAT. Technical data for the turbine units is shown in ***Table 4.2***.

Table 4.2 Turbine Technical Data (Main Dam)

	Main Power Station
Type of turbines	Francis turbine Vertical shaft
Number of turbines	2 (synchronous)
Nominal rotational speed	214 rpm
Nominal capacity at substation	272.80 MW
Generator terminal voltage	16.5 kV
Transformer	Special three-phase Set-up to 230 kV

All generating units will be isolated and protected from the pressurized water supply by inlet valves within the main power station. The draft tube gates of the Francis turbine units will also permit the isolation of a unit for inspection and maintenance, allowing the other units to remain in service.

Power supply to the main power station, including the power generating equipment, will be tapped from each of the Francis unit's busbars through auxiliary transformers.

The power transformers will be arranged next to the power station building. The power transformers of the main power station will be connected to the 230kV substation by means of overhead lines.

A Supervisory Control and Data Acquisition (SCADA) system will enable monitoring, supervision and control of the power stations and substations. This system will also enable analysis of power station conditions. All relevant information will be transmitted to EGAT's national and regional control centers. The SCADA system will enable automatic operation of both the main power station and the re-regulation power station.

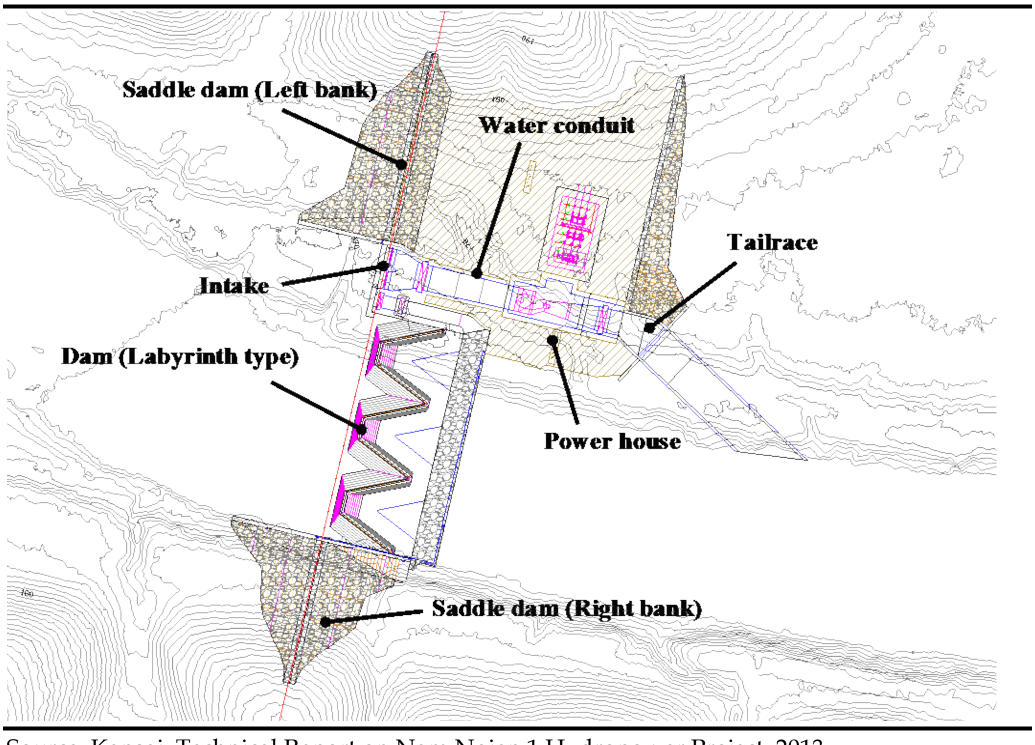
4.5 RE-REGULATION DAM AND RELATED FACILITIES

4.5.1 Re-Regulation Dam

A re-regulation dam is planned to be built at the site, 1.3 km downstream from Ban Hatsaykham, and 3.2 km upstream from Ban Hat Gniun. The dam site is in a hilly area, with approximate elevation ranging from EL 163 m to EL 200 m. On the left bank, a 90 m wide terrace plain rises 5-10 m above the river surface. The proposed dam crest elevation in the non-overflow section will be about 187 m, in order to be able to discharge design flood.

The layout of the main facilities for the re-regulation dam is shown in ***Figure 4.10***.

Figure 4.10 Re-Regulation Dam Layout



Source: Kansai, Technical Report on Nam Ngiep 1 Hydropower Project; 2013

The re-regulation dam is located 6.2 km downstream from the main dam, at a location where the foundation rock can be accessed for abutment, and the regulating capacity can be secured. The function of the re-regulating dam is to store discharged water from the main dam during power peaks, re-using it for power generation and releasing it downstream evenly on a 24-hour basis on weekdays. This will regulate downstream flows to mitigate environmental impacts caused by fluctuations in water level. The re-regulation reservoir will have 4.6 Mm^3 capacity (effective storage capacity). The main facilities of the re-regulation dam are a free overflow type concrete gravity dam, and a powerhouse, which will be located on the left river bank.

The re-regulation dam will be a concrete gravity dam (CVC), with a crest length of approximately 90.0 m and a crest height of 20.6 m. Dam crest elevation will be EL 187.0 m.

4.5.2 Cofferdams (during Construction)

To divert the river during construction, cofferdams will be required. Cofferdams are temporary enclosures built within a body of water, used to create an enclosed dry working area for major construction works to proceed. Cofferdams for this Project will be built to create primary and secondary diversions during construction.

To secure a five-year probable flood discharge (1,590 m^3/s), a cofferdam height of EL 173 m is required at the primary diversion. After construction of cofferdams on the left bank, it will then be possible to construct the re-regulation powerhouse, the re-regulation gate, and the intake.

Following that, river flow can be diverted to the waterway of the re-regulation gate by constructing a secondary diversion to secure a 10-year probable flood discharge during the dry season (230 m^3/s), during which time the re-regulation dam will be constructed. After construction of all facilities, upstream and downstream cofferdams will be removed.

The primary diversion system will have the following characteristics:

- Cofferdam elevation: EL 173.0 m

The secondary diversion system will have the following characteristics:

- Cofferdam elevation: EL 182.0 m (upstream side), EL 174.0 m (downstream side)
- Re-regulation gate discharge: Q = 230 m^3/s (10-year flood during dry season)

4.5.3 Spillway

The dam crest elevation will be set at EL 187 m in the non-overflow section to discharge design flood, and an ungated spillway has been selected to ensure safe and easy operation. During flooding, inflow from the main dam will be discharged downstream through the spillway. A submerged bucket type of energy dissipater has been selected to utilize high river water levels downstream (since the river water level downstream is higher than the water level of the hydraulic jump).

4.5.4 *Intake*

The intake has been designed to accommodate the maximum plant discharge of 160 m^3/s at any water level between NWL and MOL. The shape of the intake will be bell-mouth, so as to avoid vortexes at any water level between NWL and MOL.

4.5.5 *Re-Regulation Gate*

One (1) fixed wheel gate will be located at the left side of the re-regulation dam. The re-regulation gate is planned to release the regulated flow in the case of maintenance of the re-regulation dam.

4.5.6 *Re-Regulation Power Station*

The proposed re-regulation powerhouse has a length of 46.4 m, a width of 22.1 m and a height of 49.1 m. One unit of bulb type turbine and generator is installed at EL 154.4 m. The tailrace is an open channel type with length of 35.9 m and average bottom width of 9.8 m, which has a rectangular cross section with concrete walls and slab.

A bulb turbine unit will be installed at the re-regulation power station, and will generate energy for delivery to EDL, the re-regulation power station, the administration office and the operator's village (***Table 4.3***).

Table 4.3 Turbine Technical Data (Re-Regulation Dam)

	Re-regulation Power Station
Type of turbine	Bulb turbine Horizontal shaft
Number of turbine	1 (synchronous)
Nominal rotational speed	143 rpm
Nominal capacity at substation	18 MW
Generator terminal voltage	11 kV
Transformer	Special three-phase Set-up to 115 kV

Power supply to the re-regulation power station will be tapped from the bulb unit's busbar. The power transformer will be arranged next to the power station building. The power transformer of the re-regulation power station will be connected to the 115kV substation by an overhead line.

A Supervisory Control and Data Acquisition (SCADA) system will be implemented in the same manner as for the turbine of the main power station.

4.5.7 *Saddle Dam*

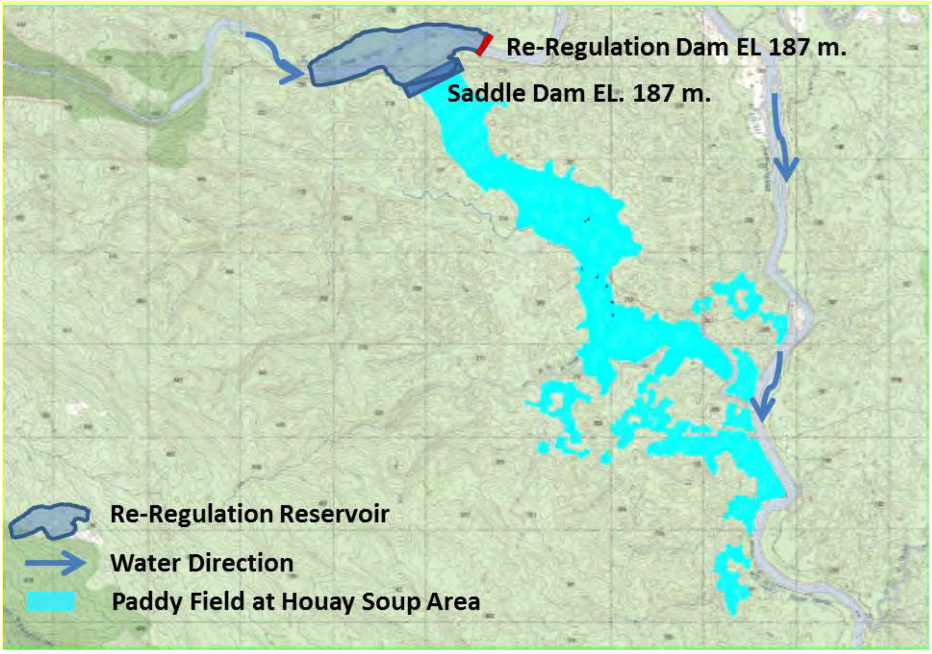
To secure an effective storage capacity of NWL EL 179.0 m, as well as prevent leakage, a saddle dam will be built on the right bank, and the area behind it will be utilized for the resettlement area. The saddle dam will be a formed

RCC associate with rockfill dam, with a crest length of approximately 507.2 m and a dam height of 14.6 m.

The saddle dam water level has been calculated by non-uniform flow analysis in case of 1,000- year flood of Nam Ngiep River. The estimated maximum water level in this case is EL 185.9 m. The crest elevation is designed to be higher than the maximum water level, at EL 187.0 m, which is lower than the paddy fields at Houay Soup Area. Accordingly, paddy fields and resettlement areas behind the dyke will be located higher than the elevation of the saddle dam crest, and therefore they will be secure during the rainy season. A diagram of the paddy field areas in relation to the saddle dam is shown in ***Figure 4.11***.

However, paddy fields and community in the re-regulating reservoir area will be resettled in agreement with both affected people and the Project. Further details regarding resettlement are presented in the document "*Resettlement and Ethnic Minority Development Plan Report – Nam Ngiep 1 Hydropower Project*".

Figure 4.11 Paddy Field Areas near Saddle Dam



4.6 *Ancillary Works*

4.6.1 *Quarry Site*

The quarry site will be located on the flat plain on the right bank, 500 to 1,000 m downstream from the main dam site. This flat area has elevation EL 250 to 340 m, is 50 to 250 m wide, and the site slopes toward the downstream at about a 10-degree angle.

4.6.2 *Access Road*

The main construction materials to be brought in from outside to the dam site include cement, fly ash and steel bars used for concrete, gates and penstocks for metal-work, turbines and generators for the power station, and other equipment. A promising quarry site for the concrete aggregates has been selected downstream on the right bank. The main construction equipment at the dam site will include earth transport and construction equipment, and an aggregate and a concrete plant. The majority of the equipment and materials will be imported from foreign countries. At present, it is expected that the cement, fly ash and steel bars will be imported from Thailand, and that construction equipment, transformers, gates, penstocks, and other equipment will be imported mainly from other industrialized countries.

The most promising transportation route for these imported equipment and materials would be through Thailand. They would first be unloaded at either the Bangkok Port or the Laem Chabang Port in Thailand; then taken by road to Vientiane, Lao PDR via the Friendship Bridge. From Vientiane, equipment and materials will be taken by Route 13 south to Pakxan, then to the north on a provincial road to Ban Nonsomboun before turning left onto the access road to the dam site. Full details of the access road are provided in "*NNP1 Access Road from Ban Nonsomboun to the Main Dam Environmental Assessment*", 2014 (*Appendix E*).

4.6.2.1 *Improvement of Existing Access Road*

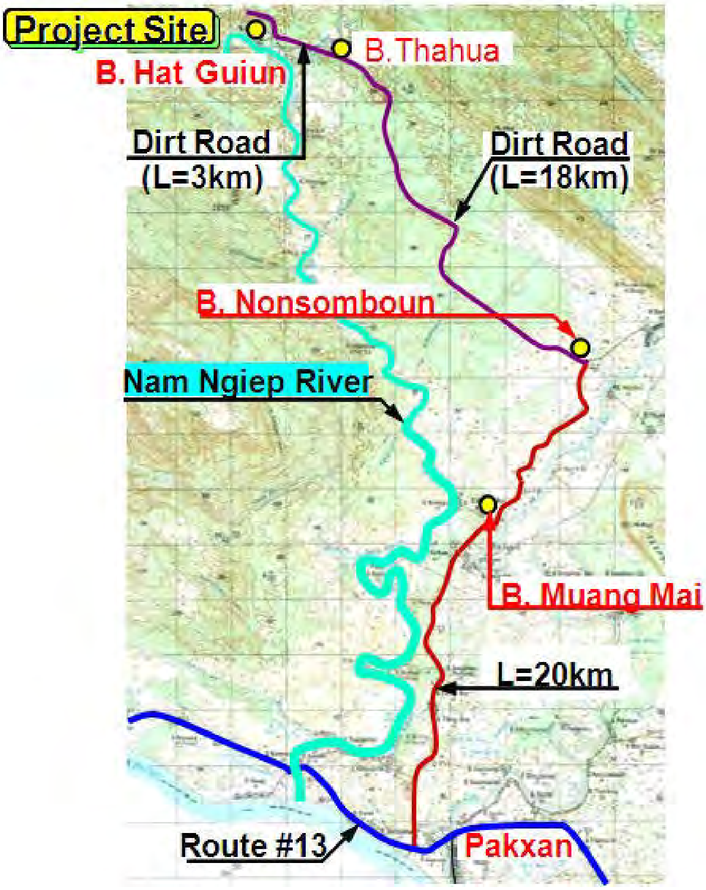
With reference to the EA for the Access Road (*Appendix E*), the transportation distance and road conditions for each section of the route between Vientiane and Ban Hat Gniun are shown in ***Table 4.4***. All equipment and materials will be transported during the construction period through the route outlined in ***Figure 4.12.*** Widening the existing road, constructing bridges or culverts at stream (marsh area) crossings, and stabilization work of the roadbed will need to be carried out as appropriate.

Table 4.4 Vientiane-Ban Hat Gniun Transportation Distance and Road Condition

No.	Road section	Distance (km)	Road condition
1	Vientiane–"Friendship Bridge"–Pakxan	161.7	All asphalt paving, width: 6 m, crossing 2 PC bridges on the way (Capacity: 80 t)
2	Pakxan–Ban Nonsomboun	19.9	Asphalt paving up to 3 km from Pakxan and the rest laterite paving, width: 6 m, crossing a steel-structured bridge on the way (Capacity: 20 t, Width: 4 m, Length: 25 m) * Currently conducting asphalt paving and constructing a PC bridge
3	Ban Nonsomboun–Ban Hat Guiun	21.2	Dirt, Width: 5-10 m
4	Ban Hat Gniun – Dam Site	11.2	Dirt, Width 4.5-13 m (Average 6.6 m.)
	Total	214	

Source: NNP1 Access Road from Ban Nonsomboun to Main Dam Environmental Assessment, December 2013.

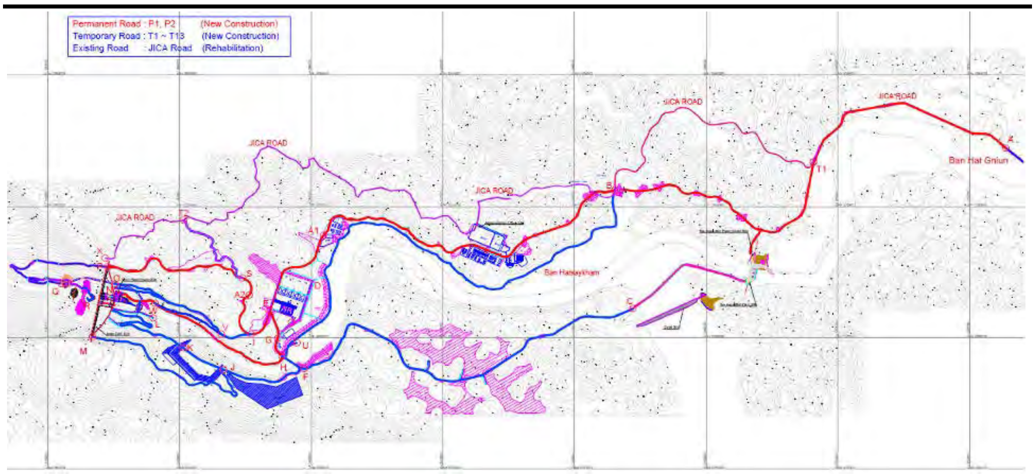
Figure 4.12 General Layout of Existing Road between Pakxan and Ban Hat Gniun



4.6.2.2 *Construction of Access Road*

A temporary road currently exists along the left bank of the Nam Ngiep River between Ban Hat Gniun and the dam site. This road was built for the geological surveys for the JICA-F/S. For access to the left bank of the dam site, this temporary road will be upgraded and used as a construction road during the construction period. However, it is not considered economically feasible to use this route for permanent access. Therefore, a new permanent access road is proposed to be constructed, which would reach the power station and the dam crest along the left bank from Ban Hat Gniun. The proposed design condition of the road and width would be determined to allow frequent transportation of construction materials. A 22 kV electricity line will also be installed adjacent to the access road, branching off from the existing line at Nonsomboon, to provide electricity during construction. The proposed road route plan is shown in ***Figure 4.13***.

Figure 4.13 New Access Road Route Plan



* Access road = red line

4.6.3 *Spoil Disposal Areas*

There are seven (7) proposed spoil disposal areas for the Project, totalling 24.6 ha. The capacity of all disposal areas is around 3,435,000 m^3. Spoil disposal area locations are shown in ***Figure 4.14*** and details of each location are presented in ***Table 4.5.***

According to Annex D2 of the Project Concession Agreement, the disposal area is a temporary functional area of the Project, until the construction period ends or until that area contains spoil at maximum volume capacity. The Project will shape and manage the spoil disposal area to maintain good conditions, such as slope, height and flatness. Management of the areas will include grassing and planting vegetation, before handing the areas over to GOL.

The EMP-Sub Plan 02 for spoil disposal is proposed as a guideline for safety precautions during construction, and for minimizing the environmental impact of spoil disposal areas of the Project.

Figure 4.14 Spoil Disposal Area Locations

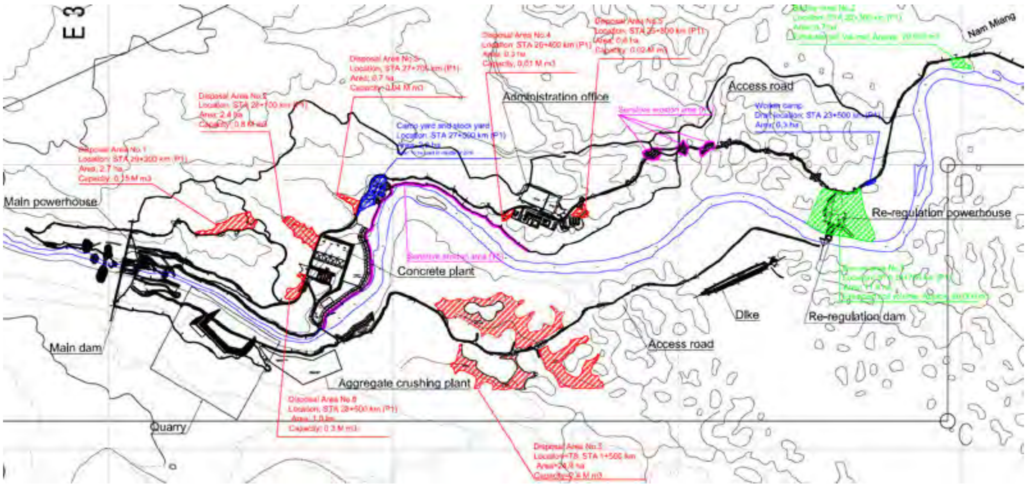


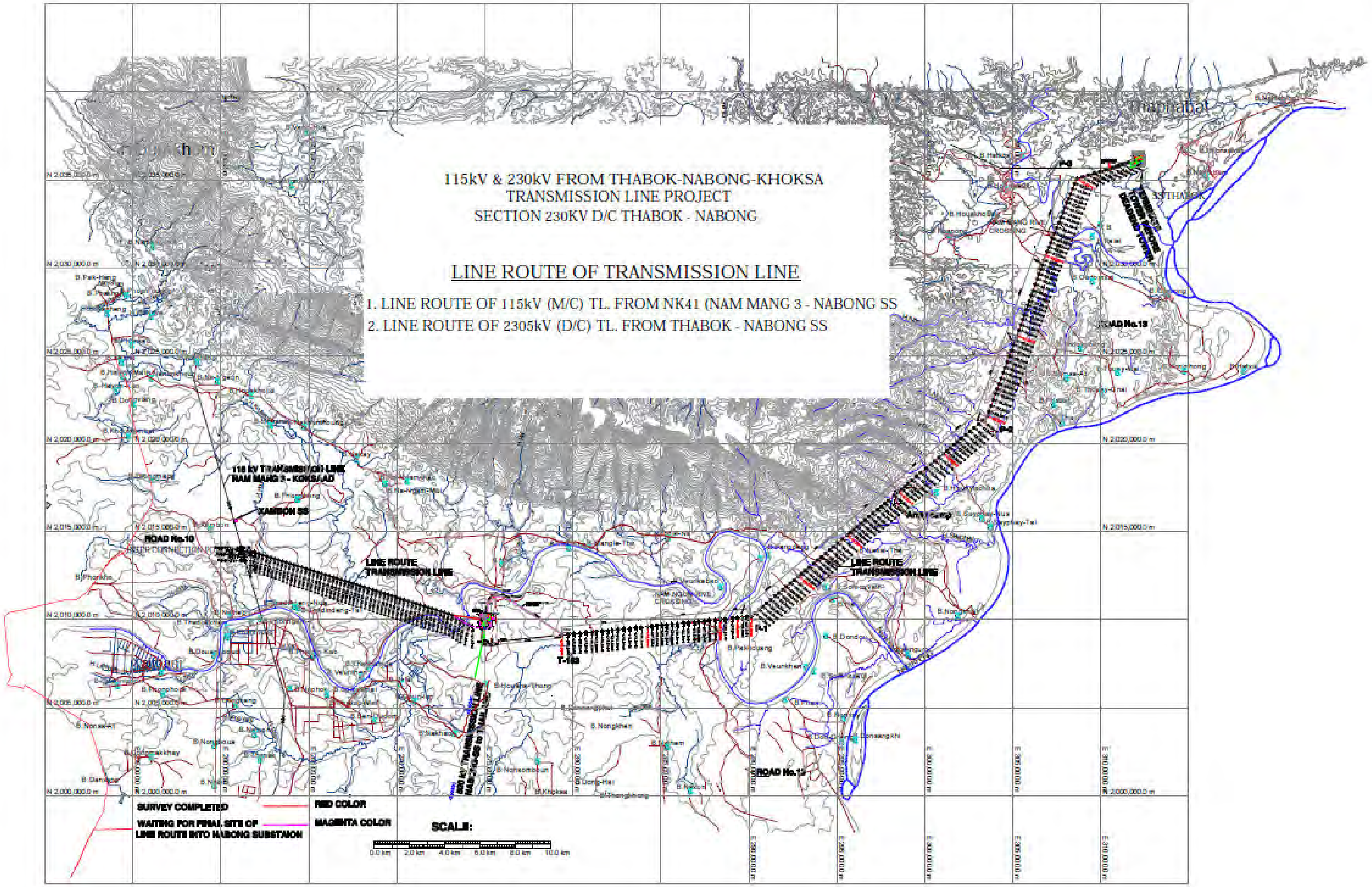
Table 4.5 Capacity of Spoil Disposal Areas

Description	Location	Area (ha)	Perimeter (m)	Capacity Volume (m³)	Expected Disposal Volume (m³)
Disposal No.1	Permanent Road STA. 29+300 km.	2.7	780	151,000	130,000
Disposal No.2	Permanent Road STA. 28+100 km.	2.4	790	810,000	88,000
Disposal No.3	Permanent Road STA. 27+700 km.	0.7	480	42,000	U/C
Disposal No.4	Permanent Road STA. 26+400 km.	0.3	260	12,000	U/C
Disposal No.5	Permanent Road STA. 25+800 km.	0.6	480	20,000	U/C
Disposal No.6	Right Bank Soil Disposal Road	25	6,100	2,400,000	2,100,000
Disposal No. 8	Permanent Road STA. 28 + 500 km	1.0	-	30,000	U/C
	Total	32.7	8,890	3,465,000	

4.6.4 *Transmission Lines*

There are two transmission lines for the Project, a 230 kV line from the power station from the main dam and a 115 kV from the power station at the re-regulation dam. The 230 kV line, constructed and operated by the Project, is proposed to run for approximately 125 kilometers from the main dam to the Nabong substation to contribute electrical power to Thailand in support of the increasing power demand of the Thai power grid. The 115 kV line, constructed and operated by EDL, is proposed to run 40 kilometers, starting at the re-regulation dam and ending at the Pakxan substation, providing domestic power supply. Transmission Line Route is shown in ***Figure 4.15***. Full details on the transmission lines are presented in "*NNP1 Transmission Line from the Main Dam to Vientiane Initial Environment Examination, 2014*" (*Appendix F*).

Figure 4.15 Transmission Line Route



4.7 PROJECT STAGES AND ACTIVITIES

4.7.1 Construction Plan Summary

This section provides an overview of the construction phase. Specific details regarding the construction of some features (i.e. diversion tunnel, cofferdam, and access road) were described previously in facility-specific sections of this chapter. This is because of the importance of their construction processes in relation to the overall Project facilities.

4.7.1.1 *Method and Procedure of Construction*

Construction procedures of the main power facility would be in the following order:

1) Construction of the new road (to reach the outlet of the diversion tunnel), rehabilitation/expansion of existing road, construction of labor camp, and administration facilities and lay-down area.
2) Excavation of the diversion tunnel from the outlet toward inlet.
3) Filling of gravel and soil to construct the primary cofferdam.
4) Construction of inlet structure of diversion tunnel and river flow diversion.
5) Construction of cofferdam by placing CVC concrete with appropriate foundation treatment.
6) Excavation of dam foundation and abutment. Construction of temporary roads, batching plant and crushing plant.
7) Placing consolidation/curtain grouting for dam foundation.
8) Placing dam concrete. Clearing major trees in proposed reservoir area with the cut and burn method.
9) Installation of turbines, generators, penstock, riparian release conduit and valve, intake structure, spillway gates and other related facilities once the placement of the dam concrete reaches appropriate elevation. Construction of transmission line.
10) Installation of transformer and switching facility.
11) Impoundment by closing the inlet gate of diversion tunnel.
12) Placement of concrete in diversion tunnel at the dam axis.
13) Performance test.

4.7.1.2 *Functional Areas*

Table 4.6 Sizes of Functional Areas during Construction Phase

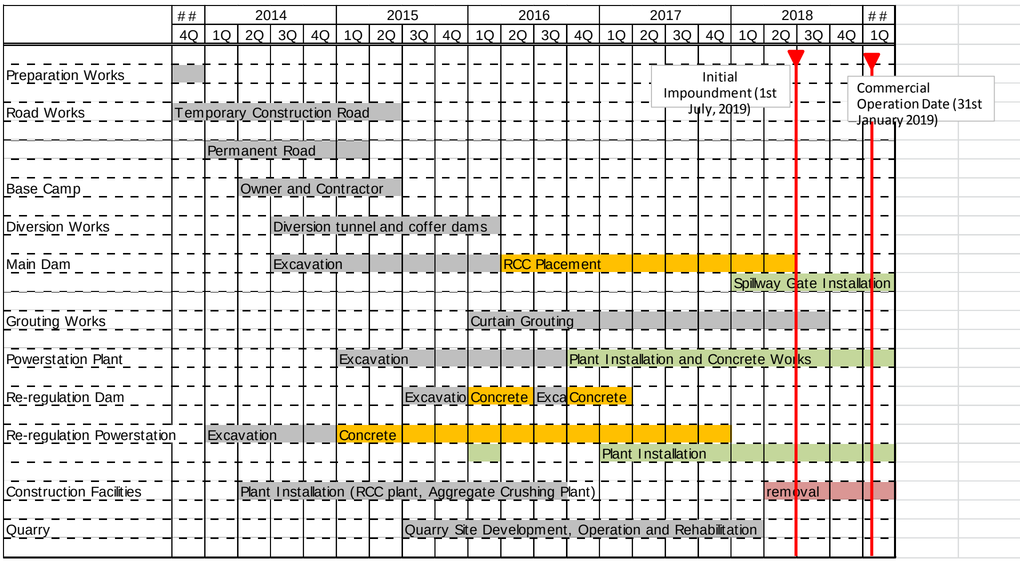
Functional area	Size (ha)	Size (m²)	Length (m)	Permanent Use
Main dam	4.32	43,200		Yes
Re-regulation dam	1.60	16,000		Yes
Cofferdams	0.67	6,700		Yes
Diversion tunnels	0.62	6,240		Yes
Main dam powerhouse	0.15	1,470		Yes
Re-regulation dam powerhouse	0.06	570		Yes
Quarry areas	46	460,000		No
Temporary yards	16.81	168,100		No
Switch yard	0.24	2,400		Yes
Access Road	-	-	30.45	Yes
Disposal areas	25.10	251,000		No
Office	1.60	16,000		Yes
Worker camps	12.00	120,000		No

Source: Drawing name: General plan, Aug, 2007 DWG # NNP1-C-03 and Technical Report, 2007

4.7.1.3 *Construction Schedule*

A tentative schedule for the construction is presented in ***Table 4.7*** Construction is planned to take a total of 70 months.

Table 4.7 Schedule for Construction



4.7.2 *Operation & Maintenance*

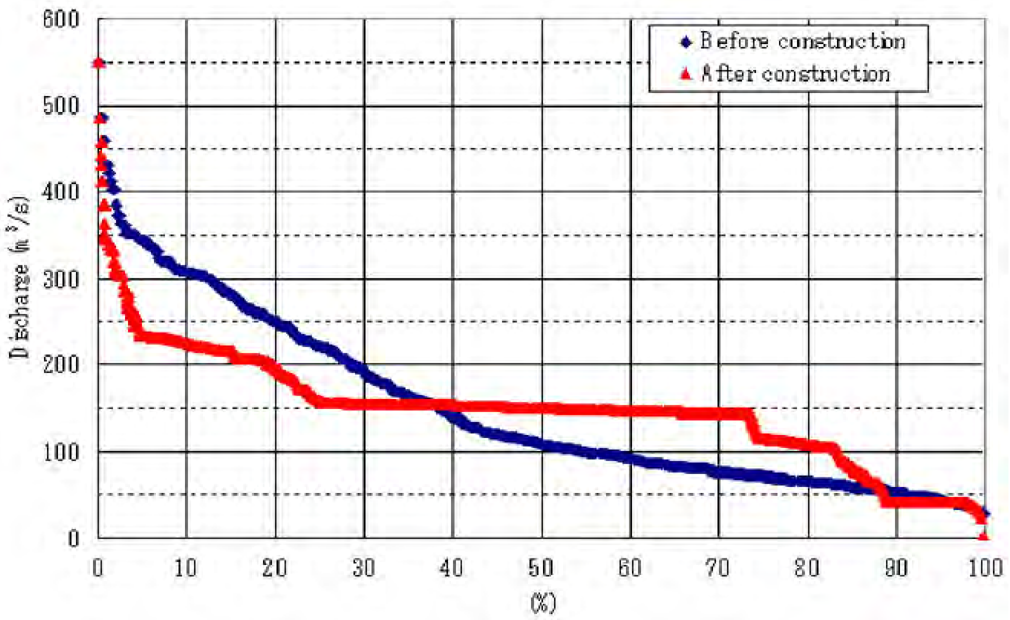
4.7.2.1 *Operation of Project Facilities*

The main 272 MW power station will be operated in accordance with the "Operation and Maintenance Manual", which will be prepared before the initial filling of the reservoir. The maximum discharge through the turbines of the main power station will be 230 m^3/s. The re-regulation power station will provide maximum power output of 18 MW for domestic power supply, and the maximum discharge will be 160 m^3/s. The electricity generated at the main power station will be delivered to EGAT via a 145 km long 230kV transmission line, owned by the Project owner, and via a 27 km long shared-ownership 500kV transmission line beyond the substation at Ban Nabong (stepped up from 230 kV at the Ban Nabong substation). Ownership of the shared 500kV facilities and their operation and maintenance will be determined in due course by the various developers, EGAT, and government authorities. In addition, a 115 kV line, constructed and operated by EDL, is proposed to run 40 kilometers, starting at the re-regulation dam and ending at the Pakxan substation, providing domestic power supply.

The maximum reservoir elevation of the main dam will be EL 320.0 m, and the minimum operating level will be EL 296.0 m. Drawdown of the reservoir normally occurs during the dry season, with filling taking place during the wet season. During periods of high inflow, the maximum reservoir elevation may be achieved, resulting in water discharge through the spillway gates.

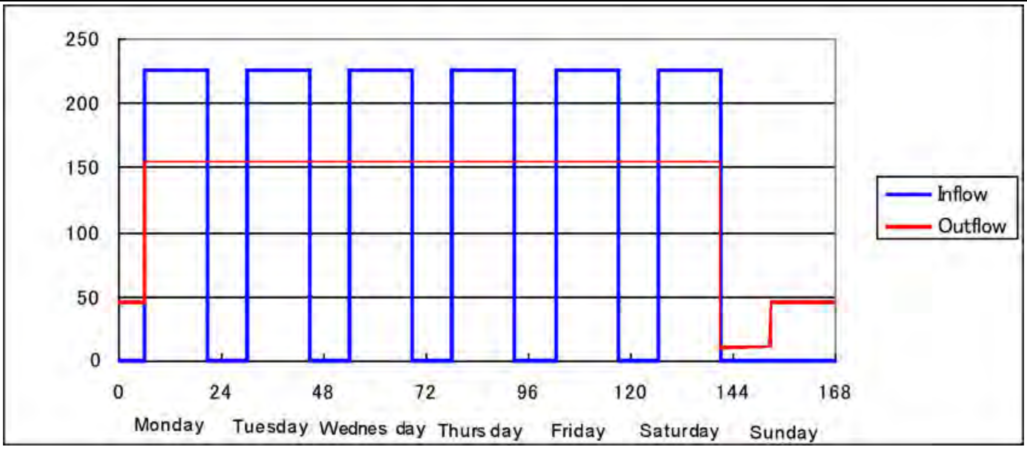
The re-regulation reservoir will be operated between a maximum reservoir elevation of EL 179.0 m and the minimum operating level of EL 174.0 m. The re-regulation reservoir will store water discharged from the main dam for 16-hour peak power generation, re-use it for additional power generation, and then release it downstream evenly on a 24-hour basis on weekdays and Saturday. This will regulate the downstream flow to maintain environmental requirements, by smoothing out the peak discharge. At the immediate downstream of the re-regulation dam, the change in water flow between before- and after-project conditions is shown in ***Figure 4.16***. Operation of both the main dam and re-regulation dam can create a typical flow pattern with decreased discharge in the rainy season and augmented flow in the dry season when compared to the natural river flow.

Figure 4.16 Change in River Flow Before and After Construction of Project



Discharge during normal operation of the main power station is designed to be at 16-hour peak generation on weekdays and Saturday. The main power station will not operate on Sunday. A typical operation case is shown in ***Figure 4.17***. The discharge from the main dam will be stored in the re-regulation reservoir.

Figure 4.17 Typical Operation of Main Dam



Note: Typical operation case of 230 m³/s 16-hour peak generation

Operation of the main dam would intentionally release water downstream during emergency events such as drought or flooding, when both turbines would be unable to release water. Spillway gates would be operated during flooding in accordance with the spillway gates operation rules, to minimize downstream impacts. Before operating the spillway gates, information regarding expected water level increases would be disseminated to those living downstream in accordance with the spillway gates operation rules and the emergency action plan.

4.7.2.2 Operation of Main Power Station

(1) Plant Discharge

The NWL and MOL of the main dam will be EL320.0 m and EL 296.0 m, respectively. Drawdown of the reservoir will normally occur during the dry season, with filling occurring during the rainy season as shown in ***Figure 4.18***. When the reservoir water level reaches NWL during floods, the spillway gates will be operated. Seasonal water level of the reservoir is presented in ***Figure 4.19***.

Figure 4.18 Seasonal Inflow and Outflow of Main Reservoir and Changes in Reservoir Volume

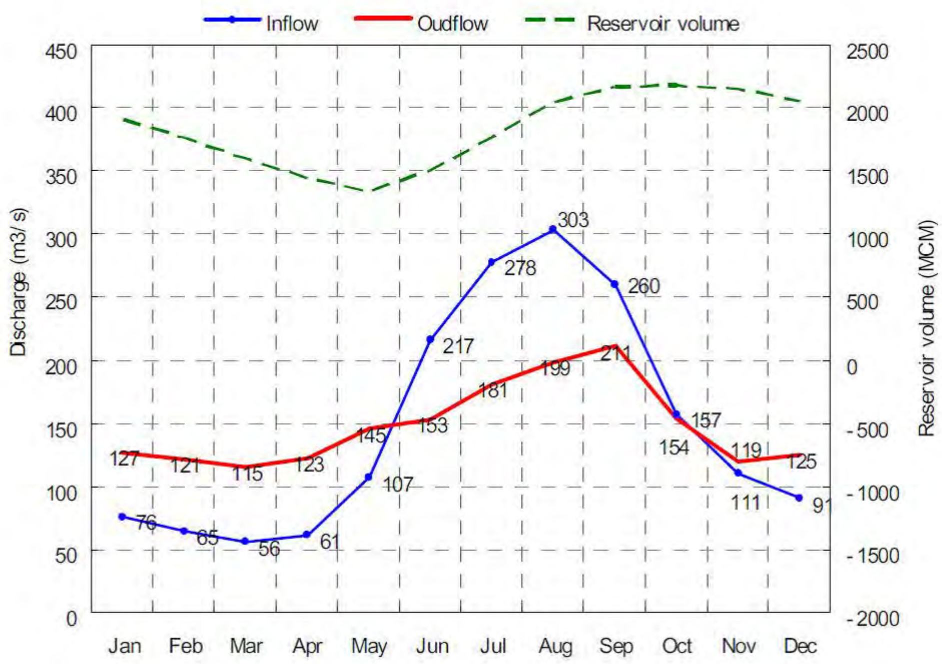
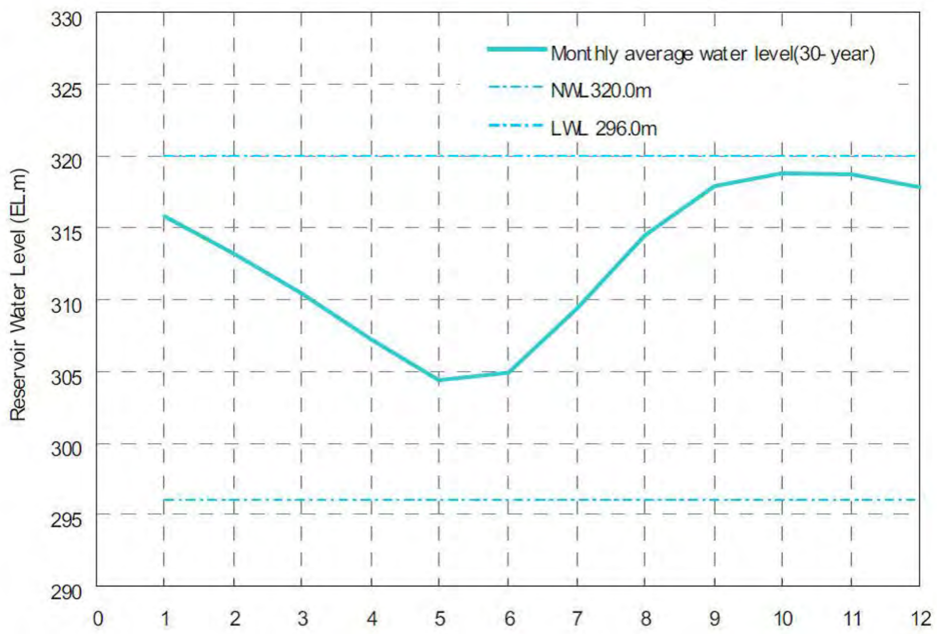


Figure 4.19 Seasonal Water Level of Reservoir



(2) Spillway Discharge from Main Dam

The spillway gates will be operated i) during flooding period, ii) for the preparation of flooding, and iii) in any situation required by laws or regulations or the Concession Agreement of the Nam Ngiep 1 Hydropower Project.

The spillway gates of the main dam will be operated in accordance with the spillway gates operation rules and the emergency action plan, which will be prepared prior to the initial filling of the main and re-regulation reservoirs.

Patterns of the spillway discharge from the main dam will be generally divided into the two (2) cases, as shown in ***Table 4.8***.

Case 1:

Whenever the WL is lower than NWL, the spillway gates will not be operated, and all river inflow will be stored in the main reservoir until the WL reaches NWL, unless there is any requirement for preparation of flooding routine and/or requirement by laws, regulations or the Concession Agreement. Such operation could result in a peak-cut operation of floods and then mitigate possible flood damages to the downstream areas.

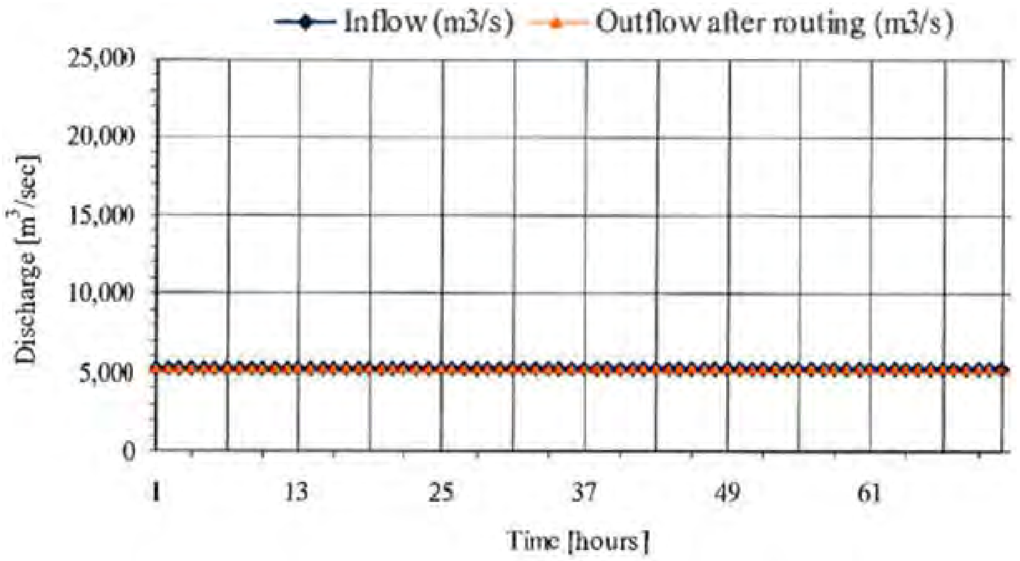
Table 4.8 Typical Operation Pattern of Spillway Gates of Main Dam

	Reservoir water level (WL)	River inflow (Q_{in}) into the main reservoir	Outflow (Q_{out}) from the spillway gates
Case 1	WL < NWL	Q_{in}	$Q_{out} = 0$ Note: the spillway gates will not be operated. River inflow will be stored in the main reservoir until the WL rises up to NWL.
Case 2	WL = NWL	Q_{in} < = 5,210 m^3/s (design flood)	$Q_{out} = Q_{in}$ Note: Opening/closing of the spillway gates will be performed in a manner that Q_{out} could be equal to Q_{in}. The WL will remain at NWL.

<u>Case 2:</u>

When the WL is at NWL and Q_{in} (or a flood) is equivalent to 5,210 m^3/s or less, the spillway gate will be operated so that the WL could remain at NWL. Water would be discharged through the spillway gates by the gate opening/closing such that Q_{out} could be equal to Q_{in}. Under the condition that the spillway gates are full-opened or in a free-flow condition, the spillway gates will be capable of discharging water at 5,210 m^3/s, corresponding to 1,000-year probable flood (defined as the design flood). Thus, in the event of a 1,000-year probable flood, the WL would not exceed NWL of EL 320 m, as shown ***Figure 4.20***.

Figure 4.20 Hydrograph at Dam Site



Note: (River inflow: 5,210 m^3/s, Reservoir water level: EL320m)

In the highly unlikely case that flood flows exceeding the design flood (5,210 m^3/s) occur, the project owner will maintain close contact with local governmental units in both the upstream and downstream areas through appropriate means and in appropriate manners.

4.7.2.3 *Operation of Re-Regulation Power Station*

(1) Re-Regulation Function

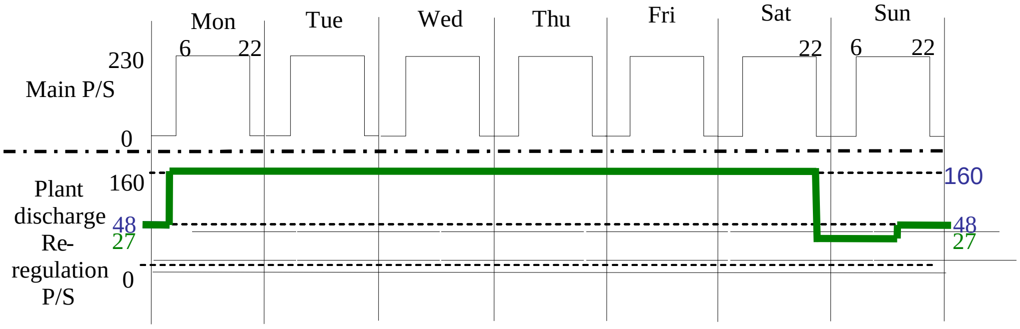
Large fluctuations in the river water level caused by the power generation of the main dam can be mitigated to a certain degree by the re-regulation dam.

The main power station will operate for only 16 hours on weekdays (from Monday to Saturday), and will halt operation for the remaining 8 hours on weekdays. If the re-regulation dam and reservoir (pondage) are not installed, this operation pattern of the main power station would cause large fluctuations in the downstream river water level. The re-regulation dam is planned to be constructed for the purpose of smoothing out this daily fluctuation of the water level downstream, thus mitigating environmental impacts caused by the change in water level.

(2) Plant Discharge

The re-regulation reservoir will be operated between NWL of EL 179.0 m and MOL of EL 174.0 m. The re-regulation reservoir will store part of the plant discharge from the main dam for 16-hours, re-use it for power generation, and release it downstream evenly on a 24-hour basis in order to augment the downstream river flow for the remaining 8-hours, flattening the peak discharge from Monday to Saturday. The re-regulation reservoir will release flow downstream in two steps from Saturday to Monday. Inflow and plant discharge pattern is as shown in ***Figure 4.21***.

Figure 4.21 Inflow and Plant Discharge Pattern in the Re-Regulation Reservoir



During normal operations, the outflow of the re-regulation reservoir will be 160 m^3/s or more throughout the week from Monday to Saturday. On the weekend, the outflow from the re-regulation reservoir will be reduced to 48 m^3/s for a period of 17 hrs, and reduced further to 27 m^3/s for a period of 15 hours (during which time it is released from the re-regulation gate). The flow pattern is illustrated in ***Table 4.9***, and the discharge pattern over the weekend is shown in ***Figure 4.22***. It should be noted that the minimum discharge for operation of the turbine of the re-regulation power station is 48m^3/s. For flows less than this, water would be stored in the reservoir and/or released downstream via the re-regulation gate as per above flow pattern.

During extreme drought conditions, the flow rate from the re-regulation reservoir may be lowered from normal operations. However, the minimum flow rate from the outflow of the re-regulation reservoir, during both normal operations and extreme drought conditions, will be 27 m^3/s.

Figure 4.22 Discharge Pattern from Re-Regulation Reservoir during Weekend

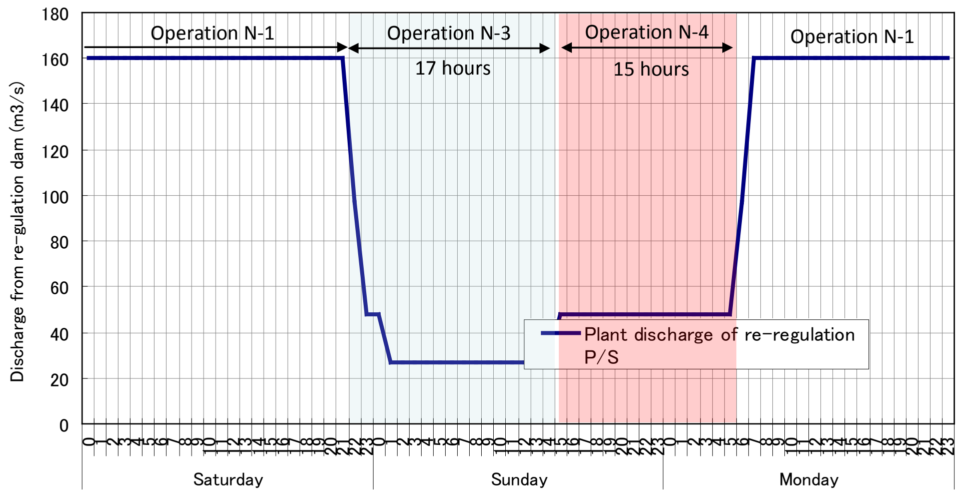


Table 4.9 Typical Operational Discharge Pattern from Re-Regulation Dam

No	Case	Timing	Duration	Discharge (m^3/s) Main P/S	Re-reg. P/S	Explanation/Notes
N-1	Normal operation (weekday)	6am-10pm Mon-Sat	16 hrs/day	230	160	Nearly maximum plant discharge re-regulation P/H
N-2		10pm-6am Mon-Sat	8 hrs/day	0	160	Nearly maximum plant discharge re-regulation P/H
N-3	Normal operation (weekend)	10 pm Sat - 14 pm Sun	17 hrs/week	0	27	Minimum plant discharge of re-regulation P/H during off-peak
N-4		14 pm Sun - 6am Mon	15 hrs/week	0	48	Riparian release and Water release through spillway during off-peak
E-1	Initial impounding	-	-	0	5.5	Riparian release during initial impounding

The operation to vary the quantity of water released from re-regulating dam will be controlled gradually, to prevent adverse environmental impacts downstream. The operational rules will be established before the initial impounding.

(3) Spillway Discharge from Re-Regulation Dam

During flood periods, the re-regulation reservoir will store water discharged from the main reservoir until the re-regulation reservoir water level reaches EL 179 m. After that, the water from the main reservoir will be released through the spillway of the re-regulation dam. It is capable of coping with 1,000-year probable flood discharge of 5,210 m^3/s, which is equal to the design flood adopted for the design of the spillway gates of the main dam.

4.7.3 Post-Operation and Decommissioning

There is no planned decommissioning for this project. After the concession period of 27 years, the project facilities will be transferred to the Government of Laos (GOL) for continuous hydropower generation. Any potential decommissioning activities taking place after the transfer would be the responsibility of the new owner (GOL), and would be outside the scope of the currently defined project.

However, there will be required decommissioning/rehabilitation activities for temporary and ancillary sites/facilities. Further information is provided in *Concession Agreement Annex C: Environmental and Social Obligation*. Specifically, the following excerpts are from the section titled "Decommissioning, Rehabilitation and Handover":

"39. Decommissioning and Rehabilitation Works

The Company shall be responsible for and shall carry out complete decommissioning and rehabilitation, including clean-up of any contamination, of all Temporary Sites and ancillary facilities within eighteen (18) months following COD. The Company shall be responsible for all costs associated with such rehabilitation and clean-up.

40. General Matters related to Rehabilitation Works and Decommissioning Activities

a) The Parties recognize that, despite adherence by the Company to Standards, it may nevertheless not be possible to return Temporary Sites to their pre-Project condition. At a minimum, though, immediately after such Temporary Sites are no longer in use by the Project they shall be decommissioned and returned to the condition of a viable, functioning and self-sustaining ecosystem compatible with a healthy environment and with human activities.
b) A functioning and self-sustaining ecosystem is one that is stable (i.e., not subject to high rates of erosion), effective in retaining water and nutrients, and self-sustaining, taking into consideration what the final land-use will be.
c) Such decommissioning and rehabilitation of all Temporary Sites and ancillary facilities shall return all Project-impacted areas to a safe and stable condition, free of safety hazards (such as buildings, equipment, open holes, etc.) and health hazards.
d) There shall be no ongoing pollution from the Site.
e) The Company shall ensure the appropriate separation and storage of different types of waste rock and topsoil.
f) Rehabilitation and future use of land and natural resources at the Site shall be compatible with and complementary to surrounding use of land and natural resources and functions.
g) The Company's decommissioning and rehabilitation plan for the Temporary Sites and ancillary facilities and its implementation shall take into account the broader spatial pattern, spatial plans and protection of nature and rehabilitation plans.
h) Such decommissioning and rehabilitation plan shall be scheduled and specified in the ESMMP-CP or the ESMMP-OP as the case may be."

5 EXISTING ENVIRONMENT

5.1 PHYSICAL ENVIRONMENT

5.1.1 Topography

From the study of various sources, such as maps, reports and field surveys of the Nam Ngiep watershed, the Nam Ngiep catchment is to cover an area of about 4,533 square kilometers (453,300 ha). The Nam Ngiep River runs 160 kilometers in a generally south to southwest direction to the Mekong River. The source of the Nam Ngiep River lies at 2,819 meters above mean sea level (MSL). For most of its flow, the river passes through steep valleys down to a level of 150-160 MSL, where it then enters a low plain for the final segment to the river mouth at the junction with the Mekong River. Relief along the river differs in each part of the stream; though it can be clearly divided into two main segments, based on physical conditions, upstream and downstream from the main dam.

5.1.1.1 Upstream of Main Dam

The main dam of the NNP1 Project is located on the Nam Ngiep River at latitude 18^{o} 39′ N and longitude 103^{o} 30′ E, at a ground elevation about 180 meters MSL. In general, a mountainous terrain with some intermittent narrow plains marks the area upstream of the main dam. These plains are all inhabited.

High mountains can be found on both sides of the Nam Ngiep, notably Phu Xao at 2,590 meters and Phu Khe at 2,125 meters MSL. These are sources of tributaries to the Nam Ngiep, providing continuous supplies of large amounts of water throughout the year. Elevated water levels during the rainy season may cause rocky and sandy banks in the river, as well as invisible rapids.

5.1.1.2 Downstream of Main Dam

Most of the river downstream from the main dam has an elevation of less than 180 meters. A re-regulation dam will divide the downstream into two parts, one between the two dams and the other downstream of the re-regulation dam.

(1) Between the main dam and the re-regulation dam

The re-regulation dam is located about 6 kilometers downstream from the main dam in a part of the river that runs from west to east. The basal elevations of these two dams are lower than 20 meters MSL. Physical appearance of the area is still characterized by valleys, but the slopes are not as steep as upstream from the main dam. The terrain on both sides of the river widens and consequently forms flatter plains. Ban Hatsaykham is the only village located between the two dams that would be directly affected by the Project. The villagers of Ban Hatsaykham will be resettled for their safety and to minimize long-term deterioration of livelihoods.

(2) Downstream of the re-regulation dam

The terrain downstream of the re-regulation dam is rather flat and tilts gradually towards the Mekong River. Tributaries from Phu Keng, Phu Ngou to Phu Pha Mela merge in this section of Nam Ngiep. The major tributaries are Nam Pha and Nam Tek.

The flat area from Ban Nam Ngiep towards the Mekong River has an average relief between 150 and 160 meters. In this area, the Nam Ngiep runs parallel to the Nam Xan before it merges with the Mekong at Pakxan. Both rivers help create a fertile plain which is one of the most important agricultural areas of the country.

5.1.2 Meteorology

5.1.2.1 Climate conditions

The Lao PDR is a landlocked country surrounded by Myanmar, Cambodia, China, Thailand, and Vietnam. The total land area of the country is 236,800 square kilometers (km^2) with a largely mountainous topography. The country is bordered on the west by the Mekong River, has a tropical monsoon climate, characterized mainly by a rainy season (May to October) and dry season (November to April) and temperatures ranging from 5°C to 40°C depending on the altitude. Humidity is generally high (in the 70 to 80% range).

The Nam Ngiep1 Hydropower Project is located in the Bolikhamxay Province, Lao PDR, which is influenced by a Southwestern monsoon climate regime. The Project area is located in a tropical climate. Weather is dominated by monsoons, which divides the year into clearly defined wet and dry periods. The wet season begins from May and extends until October, while the dry season runs from November to April.

The NNP1 project area generally experiences better weather conditions than elsewhere in the Lao PDR, with less extremes of temperature. The EIA study found that for the months of March to the end of May, temperatures ranged from 17°C to 38°C (Department of Meteorology and Hydrology, 2005). In the wet season from the beginning of June to the end of September, temperature ranged from about 19°C to 36°C, and from December to February (considered to be the dry season) temperatures ranged from about 11°C to 29°C. ***Table 5.1*** shows climate data at Pakxan station, Bolikhamxay province.

Table 5.1 Climate Data at Pakxan Station, Bolikhamxay Province

Description	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average
Max. (^{o}C)	27.0	28.9	30.9	35.5	37.4	35.9	35.4	35.6	29.9	27.0	28.8	25.1	31.45
Min. (^{o}C)	11.7	13.9	17.9	20.6	22.7	23.2	23.7	22.1	19.5	18.3	17.1	15.2	18.83

Sources: Department of Meteorology and Hydrology (DMH), 2005

5.1.2.2 Rainfall

Rainfall records were reviewed for the hydrological study and dam designs. The records of hydrological gauging locations in areas peripheral to the planned basin were also evaluated.

Average annual rainfall in Lao PDR in selected locations in the country is as follows:

- In Vientiane – about 1,600 mm
- In Luang Prabang Province – about 1,200 mm
- In Savanakhet – ranging from about 1,500 mm to 2,000 mm
- In mountainous areas and in the western highlands of Anamit Mountain about 2,000 to 3,000 mm

Rainfall data were collected from 3 gauging stations – Ban Thoun in M. Khoun (R5), Ban Hokai in M. Pakxay (R7), and Ban Thaviang (R14), all located within the Project basin area. Data were also collected from another 11 stations peripheral to the Project basin, as shown in ***Table 5.2*** and ***Figure 5.1***. For the Feasibility Study for the Project, conducted by Kansai in 2007, rainfall data from these sites were assessed for the years 1971 to 2000. The study concluded that there was average rainfall of 1,870 mm/year between 1971 and 2000. The detailed information about rainfall is presented below in *Section 5.1.11* on hydrology.

Figure 5.1 Location of Hydrological Gauging Locations within and Peripheral to the Project Basin Area

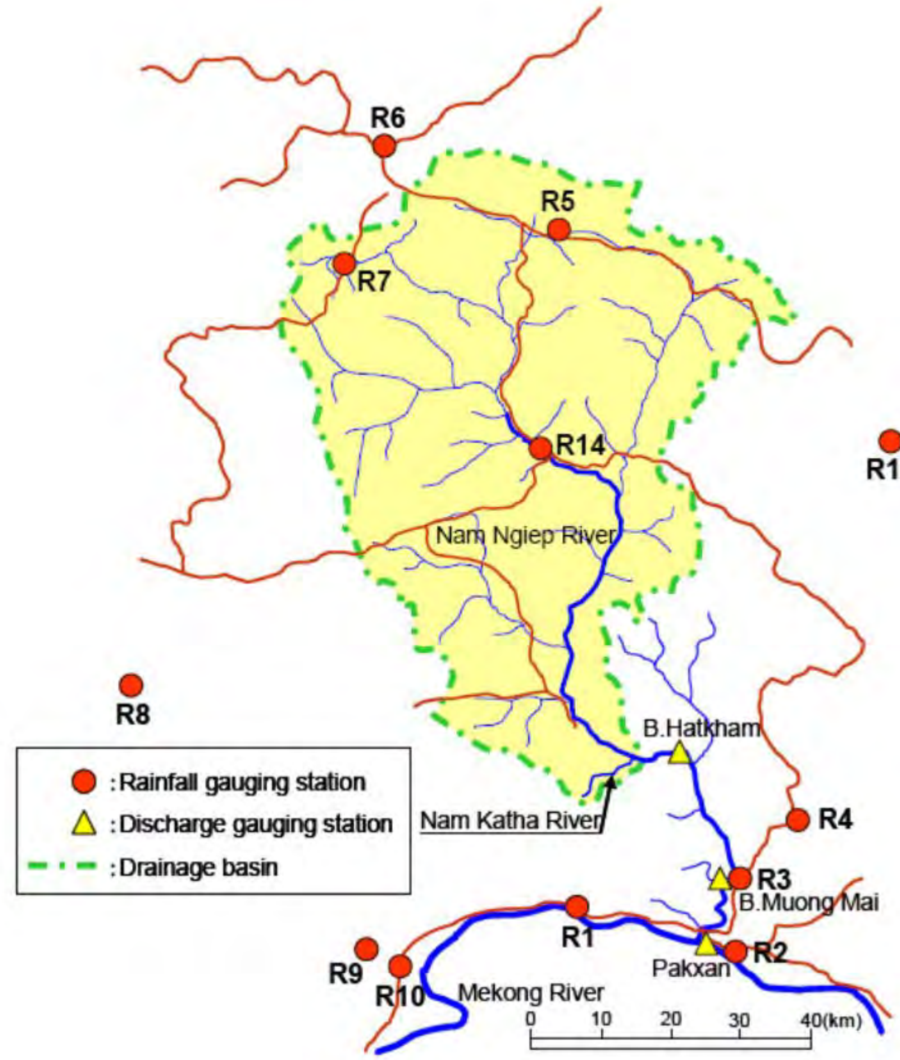


Table 5.2 List of Hydrological Gauging Stations within and Peripheral to the Project Basin Area

Gauging Station		Elevation (m)
Rainfall		
R1	B. Nakham (B. Pakthouei)	159
R2	Pakxan	155
R3	Muong Mai	158
R4	Muong Kao (Bolikhan)	158
R5	M. Khoun (B. Thoun)	1,110
R6	Xieng Khouang	1,050
R7	M. Phaxay (B.Hokai)	1,100
R8	B. Naluang	460
R9	Houayleuk (Tadleuk)	220
R10	B. Thabok	160
R11	Vientiane	170
R12	Vangvieng	215
R13	Muong Mork	900

	Gauging Station	Elevation (m)
R14	B. Thaviang	370
Discharge/River water level		
	B. Hat Gniun	-
	Muong Mai	153
River water level		
	Pakxan	142

The mean rainfall in the Nam Ngiep River basin is lower than that of Pakxan because of the topographical characteristics of the region. According to the meteorological data of Pakxan District (DMH, 2005), the seasonal variation of monthly rainfall follows the general pattern of the Southeast Asia monsoon, with about 90% of rainfall during the six month wet season from May to October. In the dry season from November to April, the monthly precipitation levels are quite low, ranging from 3.7 mm to 67.5 mm, or about 10% of the annual precipitation for this region.

5.1.3 *Geology, Landforms and Seismology*

Although seismic events in the Project area have been rare, and the area where the dam and reservoir are located are classified as being of only moderate risk (level VI) on the Modified Mercalli Intensity Scale, geological structures in the region seem to indicate joints and fractures of rock formations, which suggest seismic activity in the past. Therefore, detailed mapping and coring explorations have been carried out prior to detailed design and dam construction.

5.1.3.1 *Seismology*

Seismic investigations of the proposed dam sites were conducted (see *Section 2.1.3*) for project design. During the past 20 years, there has been no record of an earthquake in the area exceeding magnitude of 5. It can be concluded that the investigated region is characterized by a geological structure with good stability and that seismic activities in the Nam Ngiep river basin are rare. This conclusion is supported by the report on "Lao PDR: Natural Hazard Risks", edited by the OCHA Regional Office for Asia Pacific, issued on 08 March 2007.[1] As shown in ***Figure 5.2***, the entire area of the Nam Ngiep 1 Hydropower Project is located in an area with earthquake intensity of I to V and VI on a Modified Mercalli Intensity Scale. The dam and reservoir area are located in the area which is shown as having an earthquake possible at level VI intensity, which is considered of only moderate risk with possibility of only slight damage. Most of the area downstream of the dam is in the area indicated as having risk of earthquakes of I to V intensity, which is considered to be of low risk with no damage.

1 Datum: WGS84, Map data source: UN Cartographic Section, Global Discovery, FAQ, Smithsonian Insitute, Pacific Disaster Center, UNISYS, Munich Reinsurance Group.

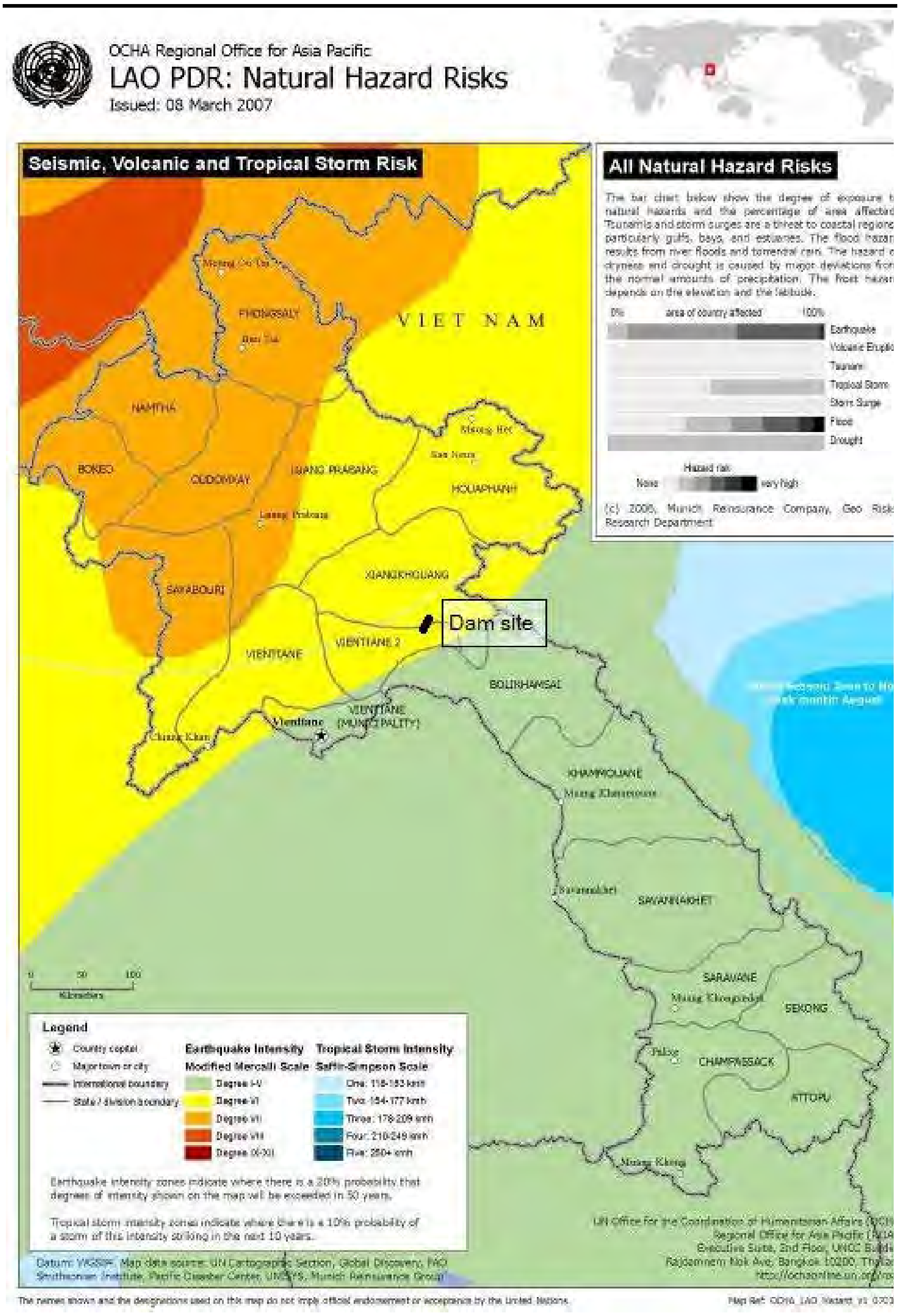
Available regional geological information shows that earthquake evens in the Project area and adjoining areas have been rare. Structural geology indicates no active fault in the Project area. Seismic impact to the Project appears to be low.

However, the existing data are at a regional scale, and so any detailed assessment at this stage is limited. A preliminary assessment of the geological structures in the region has shown there are possibly joints and fractures in the rock formations. These would suggest seismic activity some time in the past. In order to assure utmost safety in the design of the dam, it is strongly recommended that detailed mapping and coring explorations should be carried out prior to detailed design and dam construction.

The Nam Ngiep basin is located in central Lao PDR. The proposed dam site is surrounded mainly by Mesozoic-Palaeogene flat formation. Outcrops are usually found along high cliffs in the area. Older rock formations, mostly grouped as Palaeozoic rocks, are also found in the region, which was controlled by geological structures of significant folding and faulting. Lineaments were observed along NW-SE, W-E and NE-SW directions, but these are believed restrict to and relate to the old geological structure and tectonic movements. Active faults have never been reported within this area (see ***Figure 5.3***).

Rock formations found in the region can be divided into four main sedimentary sequences and one period of igneous activity as described below.

Figure 5.2 Map of Natural Hazard Risks in the Lao PDR, 2007



5.1.3.2 *Sedimentary Sequences*

Palaeozoic (Devonian to Permian) formations, including shales, mudstones, sandstones and schists are consolidated and hardly permeable. These formations are suspected to be the oldest rocks in this project area. Their occurrence was folded and separated into blocks caused by faulting during the Late Palaeozoic. These formations are found in the middle to upper parts of the reservoir area.

Mesozoic (Triassic to Jurassic) sandstones, shales and conglomerates, which are partly fractured and deeply weathered. These rocks are found in the middle part of the reservoir area. They are exposed parallel to the folded Palaeozoic basement formations.

Masozoic (Jurassic to Cretaceous) flat formations contain sandstones, conglomerates and mudstones which are located around the proposed dam site and the lower part of the reservoir area. Massive beds of sandstones and conglomerates are found homogeneously on the upper formations. Besides, mudstones and rather thin siltstones can be embedded with sandstones and conglomerates.

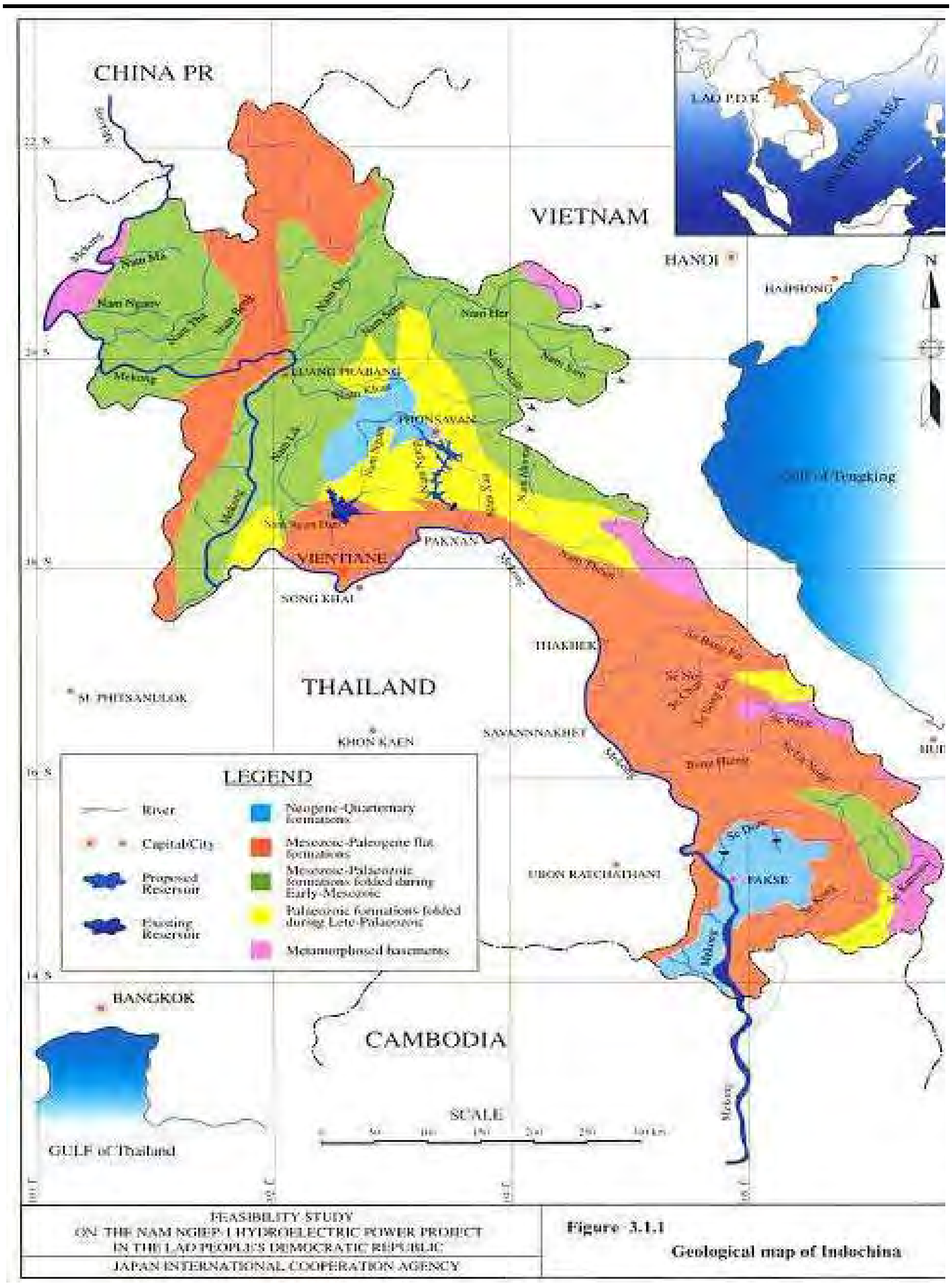
Quaternary sediments are characterized by river deposits and talus deposits. They are young unconsolidated sediments found along the river and riverside depending on geographical landforms. Although these materials have not been inspected in detail, they have high potential use for construction of this project.

5.1.3.3 *Igneous Rocks*

Late Palaeozoic granites intruding into Palaeozoic formations are found in the middle part of the reservoir area. These rocks are highly fractured and deeply weathered in some areas.

Based on the geologic setting reviewed above, it seems likely that there is a very low potential for economic mineral deposits in the Project area. Only construction materials (sandstone, conglomerate, sand and gravel) are available at some sites. Detailed testing still needs to be carried out to determine if these materials have the appropriate properties.

Figure 5.3 *Geological Map of Lao PDR*



Source: JICA-F/S, 2002

5.1.4 *Soils*

Soil surveys found that the soils around the proposed construction sites and camps are also prone to wind and water erosion. Soils near the reservoir are generally acidic, low in nutrients, and also susceptible to erosion. Soil surveys in the proposed resettlement areas found that the soils generally had low to medium levels of nutrients. Measures will need to be taken during construction, resettlement, and operation to avoid erosion of the topsoil and to maintain or enhance soil nutrients.

Soil fertility is of course a key element for farming, and where nearly all of the population depends on near subsistence agriculture for food and cash income, soil fertility is of critical importance. The depletion of the natural fertility of the soil from loss of soil nutrients in the agricultural lands of communities affected by the Project is the chief concern. Once natural vegetation is removed to convert the land to agriculture, the most fertile soil strata, the topsoil, can easily be eroded, or soil nutrients can easily be depleted from the soil through leaching. Trying to improve soil fertility with chemical inputs may also adversely affect local residents and water quality. Soil fertility should be maintained or enhanced in order to maintain agricultural productivity.

5.1.4.1 *Soil Type in the Nam Ngiep Watershed*

There are four dominant great soil types found in the Project area:

- Lithosols (shallow soils) occur on steeply sloping rock outcrops where soil formation is limited by natural erosion processes.
- Ferralsols and acrisols (lateritic type soils) form on the upper ridge slopes of the escarpment and plateau areas. The soils are derived from weathered weak sandstone. These soils are characterized by a dark red loamy clay surface horizon overlying a slightly bleached horizon. Clay content is found to increase with depth. Their properties are moderately acidic, low fertility and poor internal drainage.
- Luvisols, cambisols and acrisols form lower down on slopes where water tables are likely variable. The soils are composed of dark brown loamy topsoil, which changes to a massively structured yellowish brown clay loam with depth. Their acidic condition depends on their base saturation. This determines their classification. In terms of base saturation and inherent fertility, the soils were ranked in decreasing order as follows; luvisols > cambisols > acrisols. Small occurrences of these soils are expected below the ridges and slopes adjacent to watercourses above the Nam Ngiep valley. Some of these soils are utilized for paddy cultivation.
- Fluvisols are classified as young, frequently well drained soils that occurred on newly formed terrace areas adjacent to the Nam Ngiep River. They are reasonably fertile and can be observed in the lower reservoir.

The general soil systems of the Nam Ngiep watershed are acrisols and alisols. The major soils in the upstream areas are acrisols (Ferric Acrisols: ACf, Haplic Acrisols: ACh) and alisols (Ferric Alisols: ALf). Downstream soils are similar except that the dominant soils are Haplic Alisols (ALh). The luvisol and fluvisol great soil groups are found adjacent to the Nam Ngiep River.

5.1.4.2 *Soil Characteristics of the Reservoir and Surrounding Areas*

Soils in the Project area reflect variations in parent material and can be divided into fluvial environments (subject to river processes) or colluvial environments (subject to in situ weathering of bedrock initiated by rainfall). Small-scale spatial variation in soil depth is large for all soil types, with soil depths varying from less than 25 cm to over 1 m, but seldom exceeding 2 m over short distances. A deep solum (material between the effective root growth layer and bedrock) can exist up to a depth of 2 to 3 m in the highly weathered, but not easily eroded material.

The skeletal soils (lithosoils), in more shallow horizons, are soils with a lithic or paralithic contact within 25 cm of the surface or with more than 50 percent rock fragments within this depth. Such shallow soils are susceptible to erosion after vegetation is removed. The structure of red-yellow podzolic soils is massive to weakly coarse or medium blocks. They are acidic (i.e., pH < 5) and have low base saturation. The small percent of soils that are not podzolic are most often lateritic. These soils are well drained, still shallow (less than 2 m), and consist of yellow to red clay-loam material. They are also acidic (pH < 5.5), and have a high sesquioxide (Fe-Al) content, but a low base content and therefore poor in nutrients. One difference between the two is that lateritic soils are more highly permeable when undisturbed thus making these soils less susceptible to erosion (Whitmore, 1984).

Preservation of surface soil with its all-important organic matter is imperative. Low input farming on Acrisols, in their present leached condition, is not very successful. Mechanical clearing of the natural forest by extraction of root balls and filling of holes with surrounding surface soil produces land that is largely sterile because toxic levels of aluminum in the former subsoil kill off new growth. All exposed soils erode at a faster rate, increasing the risk and adverse impact of greater sediment discharge rates into local waterways.

Adapted cropping systems with complete fertilization and careful management are required if sedentary farming is to be taken up on Acrisols. Recent agricultural production research (Lao-IRRI, 1995) and shifting cultivation studies (UNDP, 1994) confirm this, and show soils in Lao lack sufficient mineral content. The studies indicate that soils are acutely deficient in phosphate, which is needed to help plants fix nitrogen.

Studies in 2000 regarding the paddy areas around the planned reservoir showed there is a consistent yield response to an incremental increase in P (phosphate) application rate (Lao-IRRI, 2000). There is also a need for K (potassium) in the fertilizer recommendations for this site. The application of limestone to correct soil acidity will also improve availability of phosphorus and potassium. Commonly used slash and burn agriculture (as a form of shifting cultivation) for upland plots may utilise large areas of marginal lands, but can represent a well adapted type of land use. The proven practice has been developed over centuries of trial and error. If occupation periods are short (one or two years) and followed by a sufficiently long regeneration period (up to 15 to 20 years), this system probably makes the best use of the limited possibilities of Acrisols (Driessen and Dudal, 1991). Due to limited access to new land and government regulations, coupled with a growing population and increased food demand, the length of fallow is being shortened considerably to only a few years. This results in reduced yields.

Gravel for stabilising roads is available from the lateritic red soils. Presently, existing erosion is limited due to the protective forest cover. Erosion increases with road construction, particularly roads built with steep grades, with the removal of such protective forest cover. Soils around the proposed construction sites and camps are also prone to wind and water erosion. Therefore, as construction starts, care must be taken to implement appropriate measures to control erosion in work areas and camps. Appropriate measures vary by soil type, and monitoring will be necessary to determine the effectiveness of mitigation measures.

5.1.4.3 Soil Stability of Reservoir Slope

The risk of slope stability issues will be limited to the reservoir area after it has been cleared. Generally, only steep areas with slopes in excess of 45 degrees will be at risk of erosion. According to observation of the topography on 1:50,000 scale aerial photographs of the Project reservoir area (***Figure 5.4***) there are no steep slopes in the reservoir area, except for the gorge around the dam site. The gradient of the slopes of the gorge is relatively gentle, with an estimated maximum 35 degrees. Additionally, no presence of regular landslides was observed.

Some small localised landslide areas may occur, but these are not expected to be significant. The probability of landslides will be further evaluated by the survey of reservoir slopes, which will be carried out to make sure that possible slope instabilities will not impact the safety of the Project structures.

The main basement rocks in the Project area are composed of sedimentary rock, which formed from Jurassic to Cretaceous period, and few unconsolidated layers are seen in the area. Accordingly, unstable portions on the slopes would have collapsed or been eroded to result in gentle slopes in the area.

In addition, the soil in this location is not easily eroded, due to the distribution of soil being classified as 65 % of CL and LL (clay soils). Soils with high clay content are less susceptible to erosion than sandy soils (FAO[2]).

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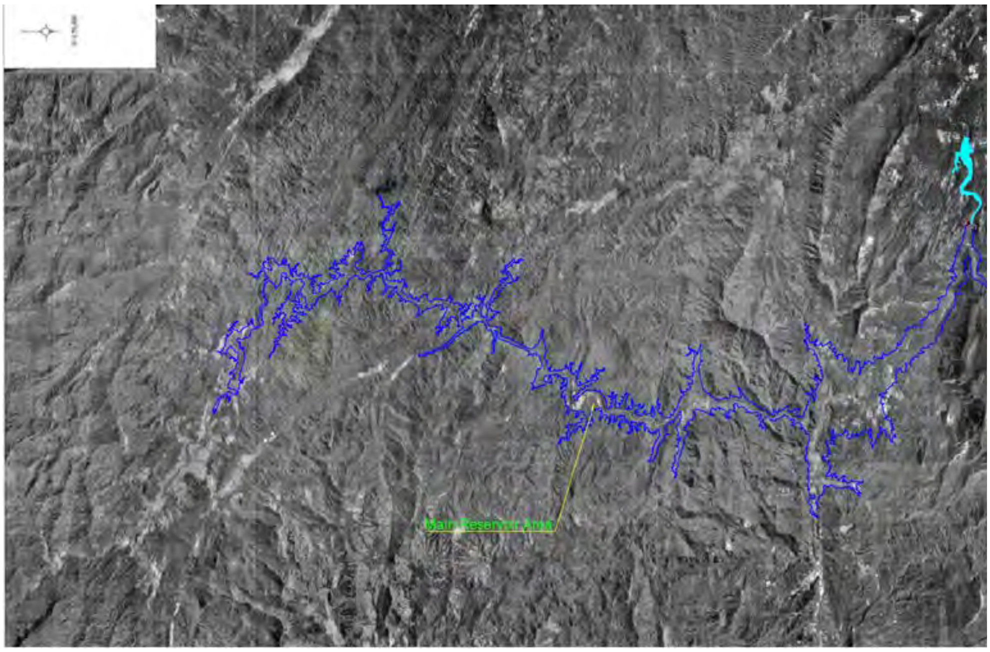
[2] http://www.fao.org/docrep/t1765e/t1765e0f.htm

Figure 5.4 Aerial Photograph of the Project Reservoir Area



5.1.4.4 Soil Properties of Resettlement Sites

As a part of site selection criteria, initial soil surveys were conducted in December 2007 and July 2011 to determine soil fertility. The result of physical and chemical soil properties are shown in ***Table 5.3*** and ***Table 5.4***. Soil fertility was selected as a key indicator for the potential land productivity of the proposed resettlements sites: these were the area near Hat Gniun, and across the river, in the area on the right bank of re-regulation dam.

The initial surveys of soil fertility found conditions were similar in the 2 proposed sites: soil pH was very acidic; soil organic matter and total nitrogen were at low to medium levels, whereas available phosphorus and CEC were found at low levels. Most of the soils were found to have a texture of medium coarseness.

All the potential agricultural areas in these proposed resettlement sites have considerable potential for the soil fertility to be improved, so there would be more than sufficient agricultural productivity for those who resettle in the area. Other possible resettlement sites were studied in great detail, in particular the areas near Pha-Aen, near Phukatha (Nam Poung), and near Samtoey in Hom District of Vientiane Province. These sites in Hom District were considered by the affected people to have insufficient land and inadequate productive area. On the basis of available land and soil fertility, two sites, the areas near Hat Gniun and across the river from Hat Gniun on the right bank of re-regulation dam, were selected as potential resettlement sites.

After public consultations on resettlement site selection with representatives of all the villages to be relocated, and including provincial and district authorities, representatives of the developer (from KANSAI and EGAT), and representatives of ERIC, it was determined that the most appropriate resettlement sites would be the proposed area on the right bank of re-regulation dam for the APs of Ban Houypamom, Ban Sopphouan, Ban Sopyouak and Ban Namyouak; and the Hat Gniun area for the APs of Ban Hatsaykham.

In order to improve re-settled villagers' agriculture yields and ensure a better livelihood after the resettlement, the Project has in place a Livelihood Restoration Program, which provides training to the resettled villagers, as well as rice supplementation and a focus on ways to improve soil fertility. Full details of the program are explained in the *"Resettlement and Ethnic Minority Development Plan (REDP)"*.

(1) Soil Properties for Agriculture in the Hat Gniun Area

Hat Gniun village: soil in this village was very strongly acidic; pH and KCI ranged from 3.71-5.18 and 3.02-4.92. Organic matter content of the analyzed soil sample was medium to high at 1.21-4.24%, and with the same level of total nitrogen 0.07-0.21%. However, the available N (NH_4^+ and NO_3^-) and available phosphorus and CEC were, respectively, very low and low. Sandy loam, loam, clay loam and sandy clay loam soil were found in this village.

Table 5.3 Physical Soil Properties of Four Villages for Initial Site Selection

No. Lab	**Sample station (No. Profile)**	**Soil Unit**	**Province**	**District**	**Village**	**Soil Texture (%)**				
						Coarse Sand	Sand	Silt	Clay	Texture
Ban Hat Gniun										
91	1	Dinh Na	Bolikhamxay	Bolikhan	Hat Gniun	0.41	34.29	32.65	32.65	Clay loam
92	2	Dinh Harp Phieng	Bolikhamxay	Bolikhan	Hat Gniun	1.02	54.22	24.42	20.35	Sandy clay loam
93	3	Dinh Loup	Bolikhamxay	Bolikhan	Hat Gniun	2.55	56.72	28.51	12.22	Sandy clay loam
94	4	Dinh None Noy Neung	Bolikhamxay	Bolikhan	Hat Gniun	1.93	41.04	36.66	20.37	Clay loam
95	5	Dinh None	Bolikhamxay	Bolikhan	Hat Gniun	1.63	37.27	36.66	24.44	Clay loam
96	6	Dinh Harp Phieng	Bolikhamxay	Bolikhan	Hat Gniun	1.12	53.89	16.36	28.63	Sandy loam
97	7	Dinh Khoy Sanh	Bolikhamxay	Bolikhan	Hat Gniun	3.58	47.40	28.60	20.43	Sandy clay loam
98	8	Dinh Tum Suud	Bolikhamxay	Bolikhan	Hat Gniun	3.83	76.01	8.06	12.10	Sandy loam
99	9	Dinh Harp Phieng	Bolikhamxay	Bolikhan	Hat Gniun	4.49	38.43	24.46	32.62	Loam
100	10	Dinh Harp Phieng	Bolikhamxay	Bolikhan	Hat Gniun	1.94	40.80	28.63	28.63	Clay loam
101	11	Dinh Harp Phieng	Bolikhamxay	Bolikhan	Hat Gniun	1.84	10.78	28.69	28.69	Clay loam
102	12	Dinh Harp Phieng	Bolikhamxay	Bolikhan	Hat Gniun	0.62	33.54	32.92	32.92	Clay loam
103	13	Dinh Harp Phieng	Bolikhamxay	Bolikhan	Hat Gniun	1.85	32.30	28.81	37.04	Clay loam
104	14	Dinh None	Bolikhamxay	Bolikhan	Hat Gniun	1.63	61.71	20.37	16.29	Sandy clay loam
105	15	Dinh Sanh Phou	Bolikhamxay	Bolikhan	Hat Gniun	4.65	41.63	33.06	20.66	Sandy clay loam

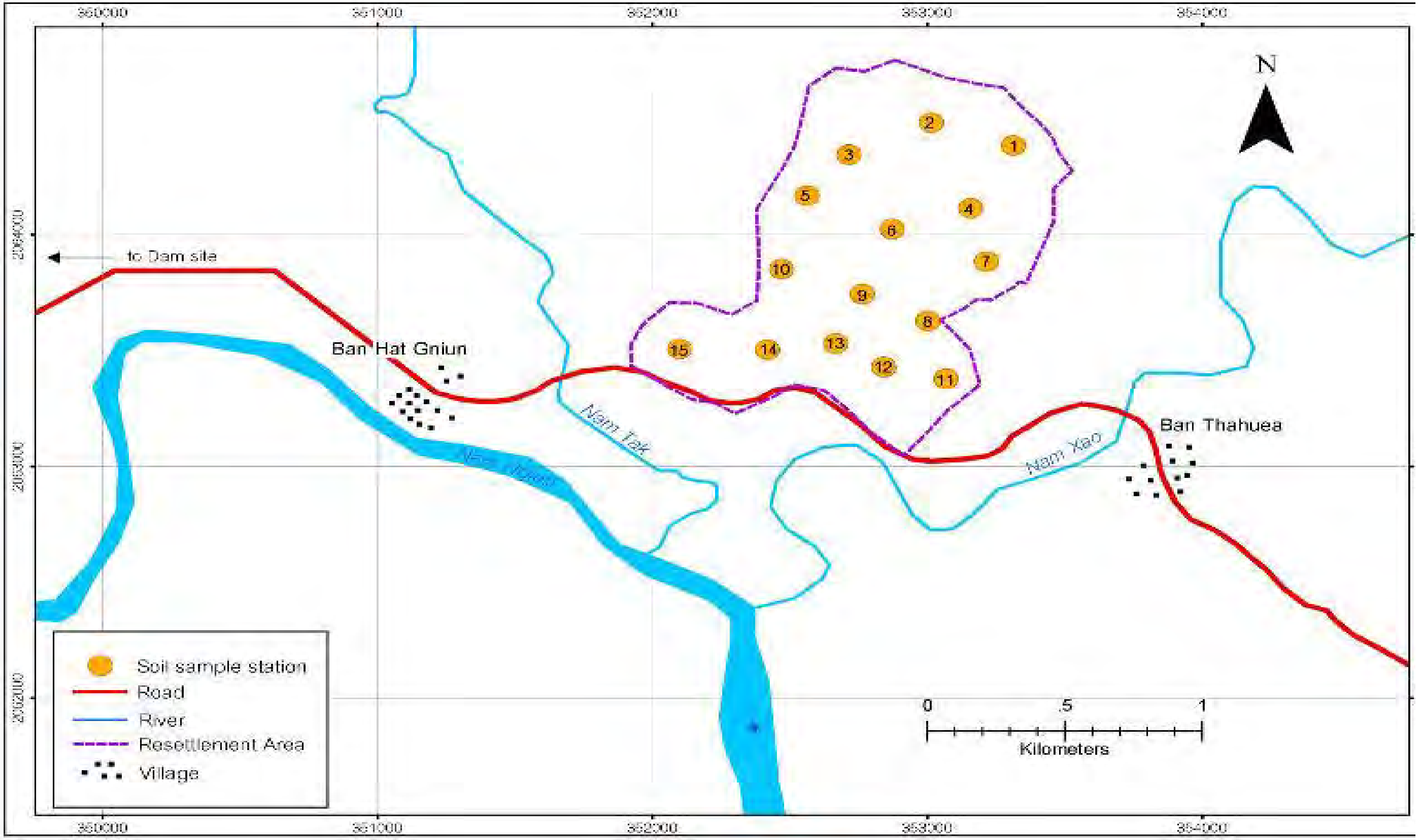
Source: Agriculture and Forestry Scientific Research Institute, Lao PDR, December 2007

Table 5.4 Chemical Soil Properties of Four Villages for Initial Site Selection

No. Lab	Sample station (No. Profile)	pH		% OM	Nitrogen N			Phosphorus		Potassium		meq/100g of Soil				
		H_2O	KCI		%N Total	NH_4 ppm	NO_3 ppm	$\%P_2O_5$ Total	P-ppm P-Avail	$\%K_2O$ K_Total	K-ppm K-Avail	Ca^{++}	Mg^{++}	K^+	Na^+	CEC
Ban Hat Gniun																
91	1	3.90	3.54	2.02	0.112	8.40	4.20	0.046	3.58	0.104	30.23	1.12	0.40	0.077	0.068	6.32
92	2	3.85	3.61	1.82	0.106	5.60	3.50	0.032	2.11	0.084	54.30	0.72	0.40	0.139	0.016	5.20
93	3	3.81	3.68	2.22	0.109	6.30	3.50	0.038	2.11	0.076	70.35	0.24	0.52	0.180	0.007	5.48
94	4	3.80	3.67	1.95	0.115	5.60	4.20	0.068	1.67	0.118	50.29	0.88	0.32	0.129	0.033	5.68
95	5	3.93	3.75	1.55	0.098	7.00	4.20	0.099	3.58	0.122	66.33	0.60	0.60	0.170	0.016	5.10
96	6	5.18	4.92	3.23	0.165	19.60	8.40	0.069	52.85	0.078	319.09	3.84	3.60	0.816	0.051	10.32
97	7	3.81	3.70	2.22	0.115	7.00	4.20	0.050	3.22	0.096	42.26	1.08	0.40	0.108	1.121	10.26
98	8	4.32	4.05	1.21	0.070	7.00	4.20	0.034	15.18	0.058	12.26	0.56	0.64	0.108	0.068	4.48
99	9	4.21	3.93	1.82	0.095	7.00	4.20	0.059	6.06	0.094	122.50	0.88	0.60	0.313	0.086	4.64
100	10	4.15	3.98	1.88	0.115	5.60	3.50	0.080	3.58	0.094	70.35	0.92	0.76	0.180	0.068	5.48
101	11	3.88	3.78	2.89	0.148	7.70	4.90	0.063	2.56	0.094	58.31	0.44	0.40	0.149	0.033	5.16
102	12	4.06	3.83	4.24	0.207	5.60	4.20	0.087	5.55	0.108	78.37	1.20	1.40	0.200	0.051	12.50
103	13	4.10	3.85	3.30	0.171	11.20	2.60	0.106	3.88	0.108	130.53	0.92	1.28	0.334	0.068	12.90
104	14	3.80	3.72	1.82	0.098	8.40	4.20	0.033	1.91	0.082	54.30	0.76	0.68	0.139	0.051	4.78
105	15	3.71	3.02	3.83	0.188	11.90	5.60	0.064	2.86	0.152	178.67	0.12	1.00	0.457	0.086	12.22

Source: Environmental Research Institute Chulalongkorn University (ERIC), 2009. Data obtained from soil sampling locations of initial site selection.

Figure 5.5 Soil Sampling Locations at Hat Gniun Area, Bolikhan District, Bolikhamxay Province. Conducted in December 2007



(2) Soil Properties for Agriculture of the Area on the Right Bank of the Re-regulation Dam and Upstream Area of the Dam Site

Additional surveys of the soils in the proposed resettlement area on the right bank of the re-regulation dam (HY P01 ~ HY P06) were conducted and samples collected in July 2011 for evaluation of soil fertility. Soils of the existing agricultural lands of the affected persons' villages of Ban Sopyouak (SG-1) and Ban Namyouak (SG-2) were also collected for comparison, to determine if the lands in the proposed resettlement area is of similar quality.

The field survey and soil physico-chemical analysis data of the resettlement site on the right bank of the re-regulation dam found that most areas are extremely acid to very strongly acidic (soil pH 4.0 ~ 4.6). Organic matter and total nitrogen were found at low to medium levels. The soil contained low available phosphorus and very low to medium exchangeable potassium. The majority of soil types are Sandy Loam (SL) or Loam (L) texture, so they should not pose a problem for agricultural production. Soil characteristics are shown in ***Table 5.5*** and ***Table 5.6***, while ***Figure 5.6*** and ***Figure 5.7*** show the location of the samples.

Soil Profile HY P01:

This soil profile has a medium organic matter (%OM) content of 2.02% in topsoil layer, medium % base saturation (42.72%), very low exchangeable potassium (0.05 Exch-k meq/100g soil), low % total phosphorous content (0.04%), soil reaction is extremely acidic with pH value equals to 4.4, and moderate cation exchange capacity (5.32 CECt cmol/kg). Corresponds to soil texture (SL) that have clay content of 13.4%, field water stored in this soil profile is assumed adequate for rice growing due to soil having moderate downward water movement (the estimated downward water movement rate (percolation) ranges for sandy loam soil (SL) were from 0.8-6.5 mm/day, while for sandy soils they ranges from 3.4-9.2 mm/day). Considering chemical and physical properties, this soil profile is rated as marginal to moderately suitable for rice cultivation. Exchangeable potassium and soil pH make this soil generally less suited to cultivation and limit its use if without soil improvement application. Special attention should be paid to improve soil acidity; farm manure and organic fertilizer together with liming application is recommended. The yield under indigenous soil nutrient supply simulated by the Crop yield model (AEZ) is around 1,180 kg/ha.

Soil Profile HY P02:

This soil profile has a medium topsoil OM content (2.23%), low % base saturation (10.58%BS) and % total phosphorous (0.04%), very low exchangeable potassium (0.07 K_2O meq/100g soils), and medium cation exchange capacity (11.58 CECt cmol/kg). Soil reaction is classified as extremely acidic with pH value of 4.2. Soil has loam texture (L) with clay content in top soil layer (15.24%) and downward water movement rate of around 1.1 mm/day. Considering physical and chemical properties, this soil is rated as marginally to moderately suitable for rice cultivation due to low indigenous soil potassium supply and high acidity. To ensure rice crop production, an appropriate management on improving soil fertility and acid soil are needed. Farm manure and organic fertilizer together with liming application is recommended. Simulated yield under indigenous soil nutrient supply is about 1,200 kg/ha.

Soil Profile HY P03:

This soil profile has similar soil physical and chemical properties as HY P02. Medium OM content (2.59%) in topsoil layer, medium rate of cation exchange capacity (6.88 CECt cmol/kg), low level of % base saturation (17.76 %BS) and total phosphorous content (0.03%), very low exchangeable potassium (0.05 K_2O meq/100g soils). Soil reaction is also extremely acidic with pH value of less than 4.4. This soil shows sandy loam texture which is characteristic of a soil that has moderate water holding capacity and moderate percolation rate of 1.5 mm day^{-1}. When all limiting factors are combined, this soil is considered as marginally to moderately suitable for rice cultivation, with yield estimates around 1,073 kg ha^{-1} under native soil fertility conditions. Farm manure and organic fertilizer together with liming application is also recommended.

Soil Profile HY P04:

This soil profile is considered as marginally to moderate suitable for rice cultivation on account of low native soil fertility on soil organic matter content (1.8%OM), low % base saturation (24.28%) and low P-total (0.03%), although cation exchange capacity and exchangeable potassium are rated as medium, with the values of 6.38 CECt cmol/kg and 0.09 K_2O meq/100g soils, respectively. Soil reaction is also classified as extremely acidic, with pH value equal to 4.45. These soils are limited in use for rice cultivation due to low soil fertility and strongly acidic soil; farm yard manure and organic fertilizer together with liming is advisable in order to improve both soil chemical and physical properties and maintain soil fertility.

Soil Profile HY P05:

This soil profile has moderate to high potential for rice cultivation due to soil having no limitation in crop requirements on % base saturation (70.25%) and exchangeable potassium (0.23 ExchK meq/100g soil), soil organic matter (2.77%OM) as well as cation exchange capacity (7.28 CECt cmol/kg), which are classified as high for %BS and medium rate for ExchK, OM and CECt. Although this soil requires minor input, the improvement of soil fertility, particularly indigenous phosphorous supplies from soils and soil acidity, is needed due to both elements being considered limiting factors affecting rice crop production for this soil. The yield in response to indigenous nutrient supplies estimated exceeding 1,300 kg.

Soil Profile HY P06:

This soil profile is comparatively a better soil than the other soil profiles, and is associated with high value of soil pH (4.56), moderate in the percentage of base saturation (46.82%BS), total phosphorous (0.06%), cation exchange capacity (10.28 CECt cmol/kg) and soil organic matter (2.41%), even though exchangeable potassium (0.07 K_2O meq/100g soils) is low. This soil shows high clay content which is characteristic of a soil that has a high water holding capacity, and poor or imperfect drained due to low downward water movement (0.7 mm day^{-1}). Based on chemical and physical properties, this soil is considered as moderately to highly suitable for rice cultivation, with yield estimated of around 1.6 t ha^{-1} under native soil fertility conditions.

Soil Profile SG-1:

This soil profile has no limitation for crop requirement on soil organic matter content (15.82%) and cation exchange capacity (15.04 CECt cmol/kg), which are classified as very high and high, respectively; moderate total phosphorous content (0.54%), low % base saturation (14.10%), and very low exchangeable potassium (0.02 ExchK meq/100 g soil). Soil has high clay content (23.96%) which is characterized as high field water stored due to low downward water movement (estimated percolation is 0.6 mm/day). This soil shows extreme acidity, which requires a major input of liming. Additionally, improvement of soil fertility, particularly potassium supplies, from chemical fertilizer are needed due to both elements being considered as limiting factors affecting rice crop production for this soil. The yield in response to indigenous nutrient supplies estimated exceeding 1,600 kg/ha.

Soil Profile NG-1:

This soil profile has similar soil physical and chemical properties as soil profile mentioned above (SG-1) with organic matter content of 10.99% and cation exchange capacity of 36.86 CECt cmol/kg in topsoil layer, which are classified as very high for both elements. Soil has moderate total phosphorous content (0.58%), but very low % base saturation (3.91%) and very low exchangeable potassium (0.01 ExchK meq/100g soil). Soil reaction is also an extremely acidic, with pH value of less than 4.14. This soil show sandy loam texture, which is characteristic of a soil that has moderate water holding capacity due to moderate percolation rate of 1.0 mm day^{-1}. When all limiting factors are combined, this soil is considered as moderately to highly suitable for rice cultivation, with yield estimates around 1,664 kg ha^{-1} under native soil fertility conditions.

Table 5.5 Soil Texture of Proposed Area on the Right Bank of Re-Regulation Dam, Ban Sopyouak and Ban Namyouak, in July 2011

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Nam Ngiep 1 Soil Results (24 samples)

N/N	No.Lab.	Profile	Layer	Date	Soil paricle zise(hydrometer)			Texture
					Sand %	clay %	silt %	class
1	3178	Hy P01	0-15	19-07-11	61.48	13.24	25.28	SL
2	3179	Hy P01	15-46	19-07-11	57.48	15.24	27.28	SL
3	3180	Hy P01	46-77	19-07-11	59.48	17.24	23.28	SL
4	3181	Hy P01	77-110	19-07-11	55.48	17.24	27.28	SL
5	3182	Hy P02	0-14	19-07-11	51.48	15.24	33.28	L
6	3183	Hy P02	14-41	19-07-11	53.48	17.24	29.28	SL
7	3184	Hy P02	41-68	19-07-11	51.48	19.24	29.28	L
8	3185	Hy P02	68-110	19-07-11	49.48	21.24	29.28	L
9	3186	Hy P03	0-16	19-07-11	53.48	11.24	35.28	SL
10	3187	Hy P03	16-52	19-07-11	49.48	19.24	31.28	L
11	3188	Hy P03	52-73	19-07-11	47.48	21.24	31.28	L
12	3189	Hy P03	73-120	19-07-11	45.48	23.24	31.28	L
13	3190	Hy P04	0-16	19-07-11	51.48	15.24	33.28	L
14	3191	Hy P04	16-57	19-07-11	49.48	17.24	33.28	L
15	3192	Hy P04	57-83	19-07-11	43.48	23.24	33.28	L
16	3193	Hy P04	83-120	19-07-11	45.48	25.24	29.28	L
17	3194	Hy P05	0-14	19-07-11	47.48	11.24	41.28	L
18	3195	Hy P05	14-49	19-07-11	43.48	21.24	35.28	L
19	3196	Hy P05	49-74	19-07-11	49.48	25.24	25.28	SCL
20	3197	Hy P05	74-110	19-07-11	39.48	27.24	33.28	CL
21	3198	Hy P06	0-15	20-07-11	41.48	21.24	37.28	L
22	3199	Hy P06	15-66	20-07-11	35.48	23.24	41.28	L
23	3200	Hy P06	66-87	20-07-11	37.48	25.24	37.28	L
24	3201	Hy P06	87-120	20-07-11	33.48	27.24	39.28	CL

Director of Agriculture and Forestry Land Use Research Center Director of Soil Analysis Unit

N/N	No.Lab.	Profile	Layer	Date	Soil paricle zise(hydrometer)			Texture
					Sand %	clay %	silt %	class
1	3308	SG-1	0-10	26-07-11	52.76	23.96	23.28	SCL
2	3309	SG-1	30-40	26-07-11	66.76	21.96	11.28	SCL
3	3310	SG-1	60-70	26-07-11	44.76	35.96	19.28	CL
4	3311	SG-1	80-90	26-07-11	60.76	27.96	11.28	SCL
5	3312	NG-1	0-10	26-07-11	72.76	15.96	11.28	SL
6	3313	NG-1	30-40	26-07-11	48.76	29.96	21.28	SCL
7	3314	NG-1	60-70	26-07-11	64.76	27.96	7.28	SCL
8	3315	NG-1	80-90	26-07-11	46.76	33.96	19.28	SCL

Director of Agriculture and Forestry Land Use Research Center **Director of Soil Analysis Unit**

Table 5.6 Chemical Soil Properties of Proposed Area on the Right Bank of Re-regulation Dam, Ban Sopyouak and Ban Namyouak, in July 2011

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Vientiane. Date ..../........../........

Nam Ngiep 1 Soil Results (24 samples)

N/N	No Lab.	Profile	Layer	Date	pH		OM	NH_4^+	NO_3^-	P_2O_5	CEC	Exchangeable cation(meq/100g)				BS
					H_2O	KCl	%	ppm	ppm	%	cmol/kg	Ca^{+2}	Mg^{+2}	K^+	Na^+	%
1	3178	Hy P01	0-15	19-07-11	4.4	3.83	2.02	17.50	7.00	0.04	5.32	1.12	0.92	0.05	0.18	42.72
2	3179	Hy P01	15-46	19-07-11	4.03	3.7	1.29	14.00	5.60	0.03	9.58	0.12	0.68	0.02	0.17	10.27
3	3180	Hy P01	46-77	19-07-11	4.26	3.79	1.05	17.50	10.50	0.02	9.48	0.28	0.84	0.02	0.29	15.03
4	3181	Hy P01	77-110	19-07-11	4.3	3.78	0.75	14.00	7.00	0.02	7.28	0.28	0.76	0.01	0.29	18.33
5	3182	Hy P02	0-14	19-07-11	4.2	3.69	2.23	16.10	7.70	0.04	11.58	0.16	0.76	0.07	0.24	10.58
6	3183	Hy P02	14-41	19-07-11	4.12	3.8	1.68	17.50	10.50	0.03	14.08	0.12	0.52	0.04	0.24	6.49
7	3184	Hy P02	41-68	19-07-11	4.16	3.83	1.14	21.00	12.60	0.03	13.68	0.16	0.56	0.04	0.22	7.14
8	3185	Hy P02	68-110	19-07-11	4.3	3.88	1.31	16.80	7.00	0.03	9.88	1.52	3.48	0.22	0.22	55.02
9	3186	Hy P03	0-16	19-07-11	4.29	3.75	2.59	14.00	7.00	0.03	6.88	0.2	0.72	0.05	0.25	17.76
10	3187	Hy P03	16-52	19-07-11	4.31	3.85	1.43	14.00	6.30	0.03	4.38	0.04	1.16	0.02	0.27	33.97
11	3188	Hy P03	52-73	19-07-11	4.35	3.89	1.05	18.20	8.40	0.03	7.78	0.08	2.8	0.02	0.15	39.15
12	3189	Hy P03	73-120	19-07-11	4.42	3.89	1.12	21.00	10.50	0.03	6.78	0.12	0.76	0.02	0.20	16.20
13	3190	Hy P04	0-16	19-07-11	4.45	3.76	1.80	10.50	7.00	0.03	6.38	0.36	0.88	0.09	0.22	24.28
14	3191	Hy P04	16-57	19-07-11	4.35	3.83	1.66	10.50	6.30	0.03	5.98	0.16	1.36	0.04	0.15	28.55
15	3192	Hy P04	57-83	19-07-11	4.44	3.88	1.30	10.50	4.90	0.02	5.38	0.2	1.04	0.06	0.15	26.92
16	3193	Hy P04	83-120	19-07-11	4.6	3.89	1.00	14.00	7.00	0.02	6.18	0.12	1.16	0.06	0.15	24.08
17	3194	Hy P05	0-14	19-07-11	4.43	3.99	2.77	17.50	7.00	0.04	7.28	1.12	3.6	0.23	0.17	70.25
18	3195	Hy P05	14-49	19-07-11	4.43	3.82	1.43	14.00	5.60	0.03	3.72	0.32	1.48	0.19	0.15	57.38
19	3196	Hy P05	49-74	19-07-11	4.43	3.8	1.02	15.40	6.30	0.03	12.38	0.44	2.36	0.07	0.13	24.24
20	3197	Hy P05	74-110	19-07-11	4.56	3.82	1.08	21.00	10.50	0.03	6.3	0.56	1.24	0.06	0.22	32.98
21	3198	Hy P06	0-15	20-07-11	4.56	3.74	2.41	22.40	11.90	0.06	10.28	1.2	3.36	0.07	0.18	46.82
22	3199	Hy P06	15-66	20-07-11	4.43	3.78	2.06	10.50	7.00	0.05	10.18	0.28	1.8	0.04	0.25	23.29
23	3200	Hy P06	66-87	20-07-11	4.39	3.83	1.59	11.90	5.60	0.04	9.72	0.16	1.52	0.04	0.29	20.64
24	3201	Hy P06	87-120	20-07-11	4.38	3.86	1.51	10.50	7.00	0.05	7.98	0.04	1.52	0.05	0.29	23.77

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Director of Soil Analysis Unit

Lao People's Democratic Republic

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Vientiane. Date ..../............/.........

Nam Ngiep 1 Soil Results (8 samples)

N/N	No.Lab.	Profile	Layer	Date	pH		OM	NH_4^+	NO_3^-	P_2O_5	CEC	Exchangeable cation(meq/100g)				BS
					H_2O	KCl	%	mg/kg	mg/kg	%	cmol/kg	Ca^{+2}	Mg^{+2}	K^+	Na^+	%
1	3308	SG-1	0-10	26-07-11	4.4	4.04	15.82	14.00	5.60	0.054	15.04	1.36	0.64	0.02	0.10	14.10
2	3309	SG-1	30-40	26-07-11	4.38	3.99	8.75	15.40	7.00	0.065	3.12	0.96	0.84	0.01	0.12	61.81
3	3310	SG-1	60-70	26-07-11	4.34	4.09	3.75	10.50	3.50	0.059	6.52	0.36	0.84	0.03	0.07	19.87
4	3311	SG-1	80-90	26-07-11	4.09	3.98	4.96	11.90	4.90	0.063	2.80	0.76	0.64	0.02	0.09	53.69
5	3312	NG-1	0-10	26-07-11	4.14	3.99	10.99	17.50	10.50	0.058	36.86	0.76	0.64	0.01	0.03	3.91
6	3313	NG-1	30-40	26-07-11	4.2	4.06	9.96	20.30	11.20	0.063	15.32	0.36	1.24	0.03	0.09	11.18
7	3314	NG-1	60-70	26-07-11	4.14	4.03	5.39	14.00	5.60	0.064	23.80	0.56	0.64	0.02	0.01	5.18
8	3315	NG-1	80-90	26-07-11	4.39	4.12	5.82	10.50	3.50	0.069	22.16	0.36	0.64	0.03	0.07	4.95

Director of Agriculture and Forestry Land Use Research Center

Director of Soil Analysis Unit

Figure 5.6 Soil Sampling Locations at Proposed Area on the Right Bank of Re-Regulation Dam during the Final Resettlement Site Selection

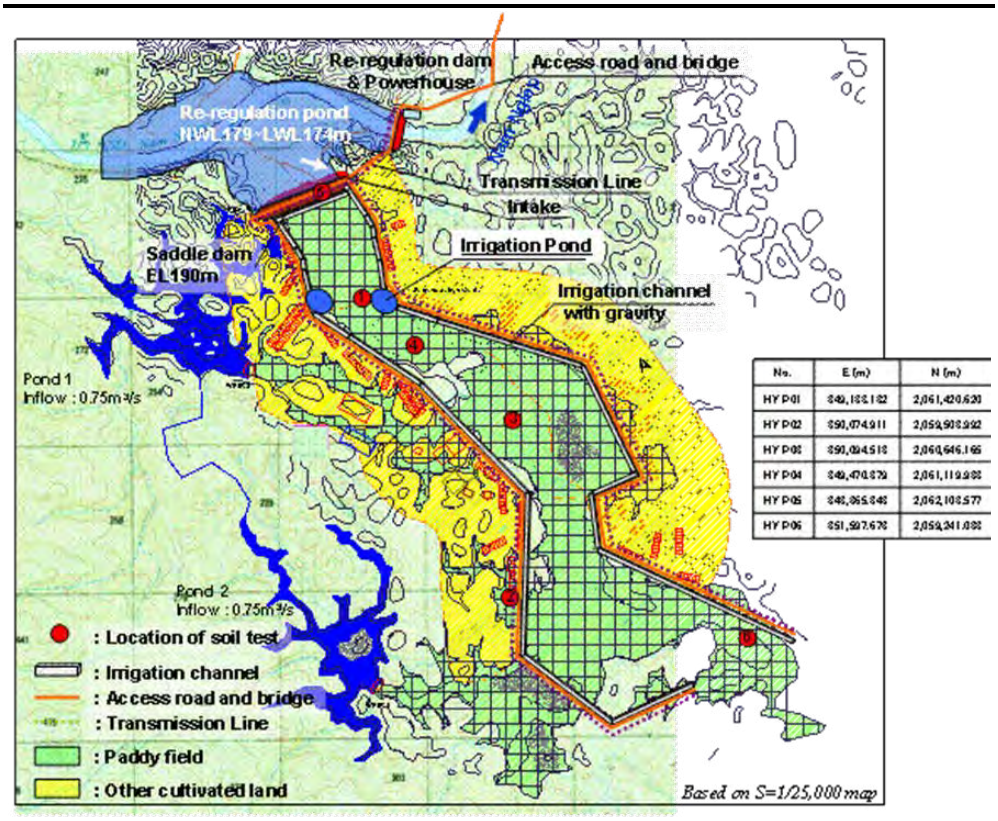
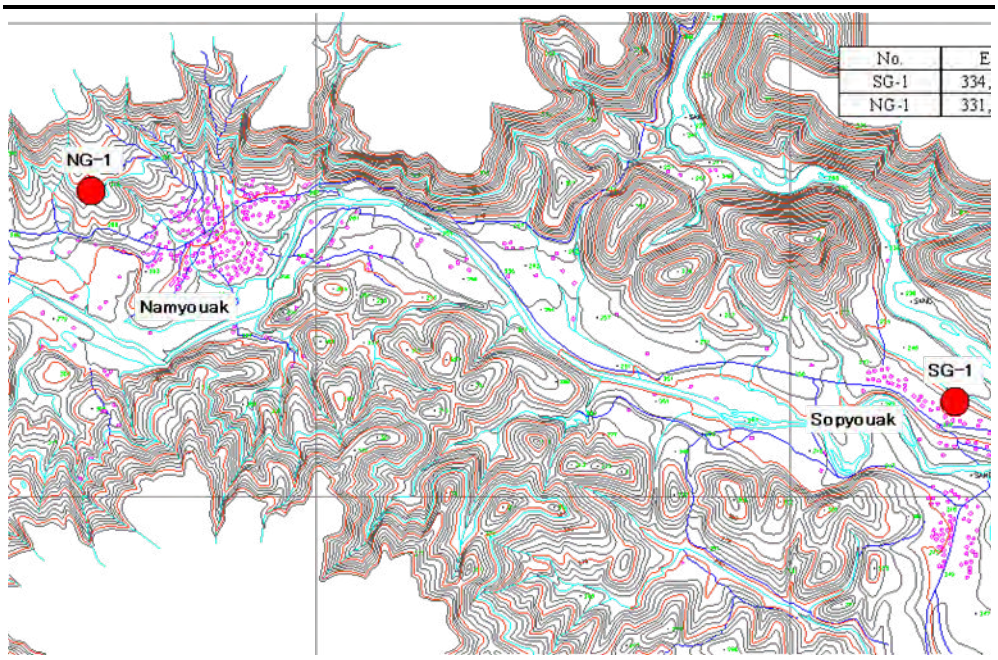


Figure 5.7 Soil Sampling Locations of Ban Sopyouak and Ban Namyouak



5.1.5 *Erosion and Sedimentation*

5.1.5.1 *Soil Erodibility and Texture*

As noted in the section above on soil properties, the soils around the proposed reservoir are susceptible to wind and water erosion. Given the need to control sedimentation, further analysis of potential soil erodibility was taken.

Soil in the Nam Ngiep watershed area, according to the survey by Soil Survey and Land Classification Centre in 1994, is classified into two major soil types:

- STP steep slope complex where the topography is very steep, the slope is more than 55%, and the soil is relatively fragile and easy to erode.
- Humid ACRISOLS: consists of fertile organic matter, A Umbric or A mollic layers present, soil in 0-75 cm in depth is Loam (LL) and Clayed loam (CL), slope ranges from moderately steep 16-30% to steep of 30 to 55% (***Table 5.7*** and ***Table 5.8***).

Table 5.7 Soil Erodibility for Humic ACRISOLS

Soil Texture (T)	Soil Depth (D)	Slope (S)	Erodibility (E)	Soil Fertility (F)
LL (Loam)	> 100 cm	0-25%		75-100%
SL (Sandy loam)	75-100 cm	2-8%		50-75%
CL (Clay loam)	50-75 cm	8-16%	E	25-50%
LC (Light clay)				
HC (Heavy clay)	<25 cm	30-55%	EEE	
LS (Loamy sand)		> 55%		
SA (Sand)				

Note: EEE: very serious potential erodibility

Table 5.8 Soil Texture

SOIL TEXTURE	AREA	
	ha	%
CL (Clay loam)	269,972	59.00
HC (Heavy clay)	39,904	8.72
LL (Loam)	25,784	5.63
LS (Loamy sand)	214	0.05
SL (Sandy loam)	121,729	26.60
TOTAL	457,603	100.00

Figure 5.8 shows a soil texture map of the Nam Ngiep watershed. The figure shows that the reservoir area of the Project is classified in two soil textures: Sandy Loam (SL) and Clay Loam (CL). A comparison of Soil Erodibility for Humic ACRISOLS identified that the slope of SL and CL are 2-8% and 8-16% respectively, and ***Table 5.7*** shows that only the CL soil type is likely to have potential erodibility, according to Soil Survey and Land Classification Centre in 1994. Additionally, the slope map of Nam Ngiep watershed in ***Figure 5.9*** shows that the Project is located South of Nam Ngiep watershed, which consists of gentler slopes near the Mekong River, compared to the North and Northeast areas of watershed which contain steep slopes.

Figure 5.8 Soil Texture Map of the Nam Ngiep Watershed

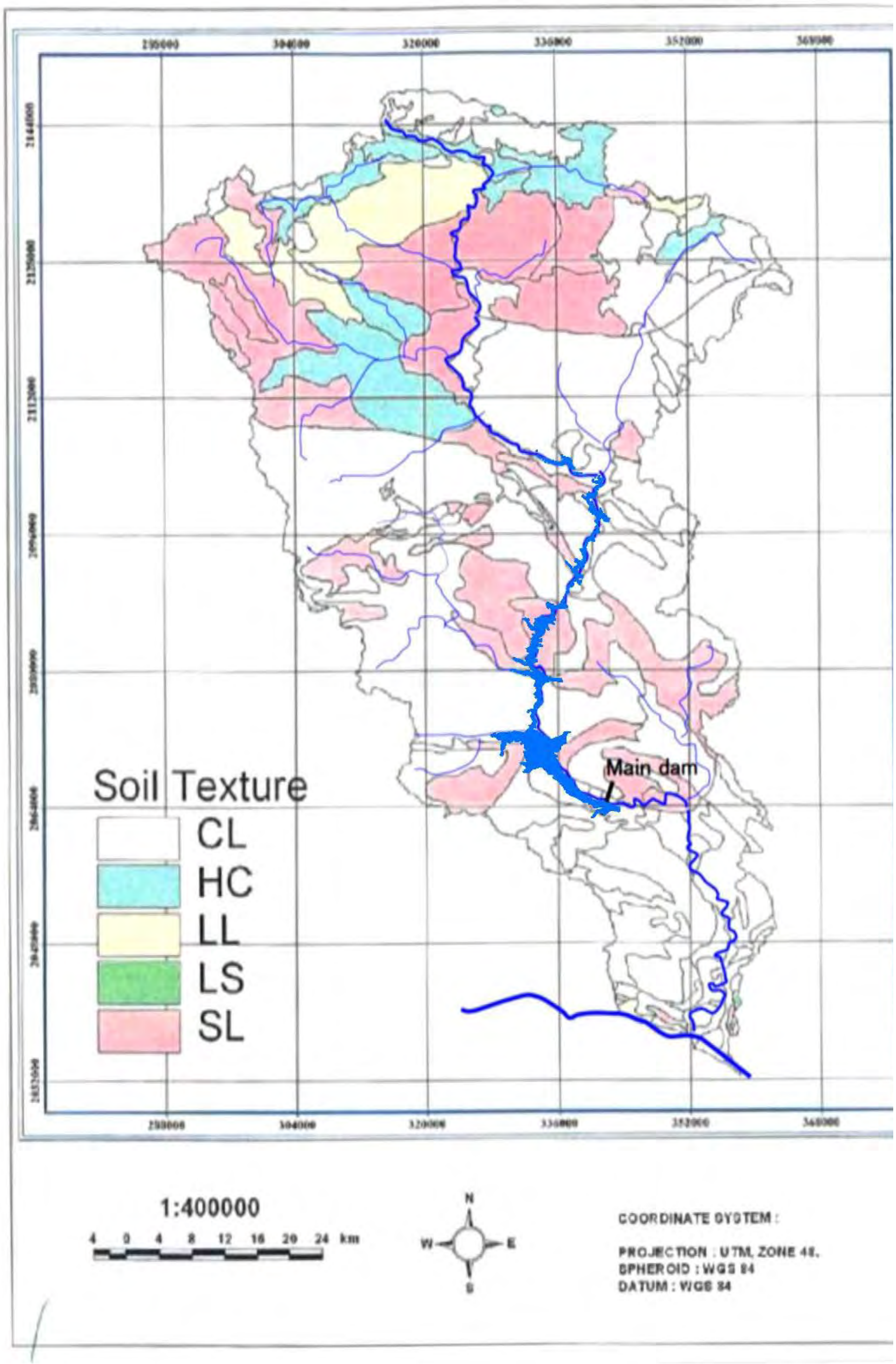
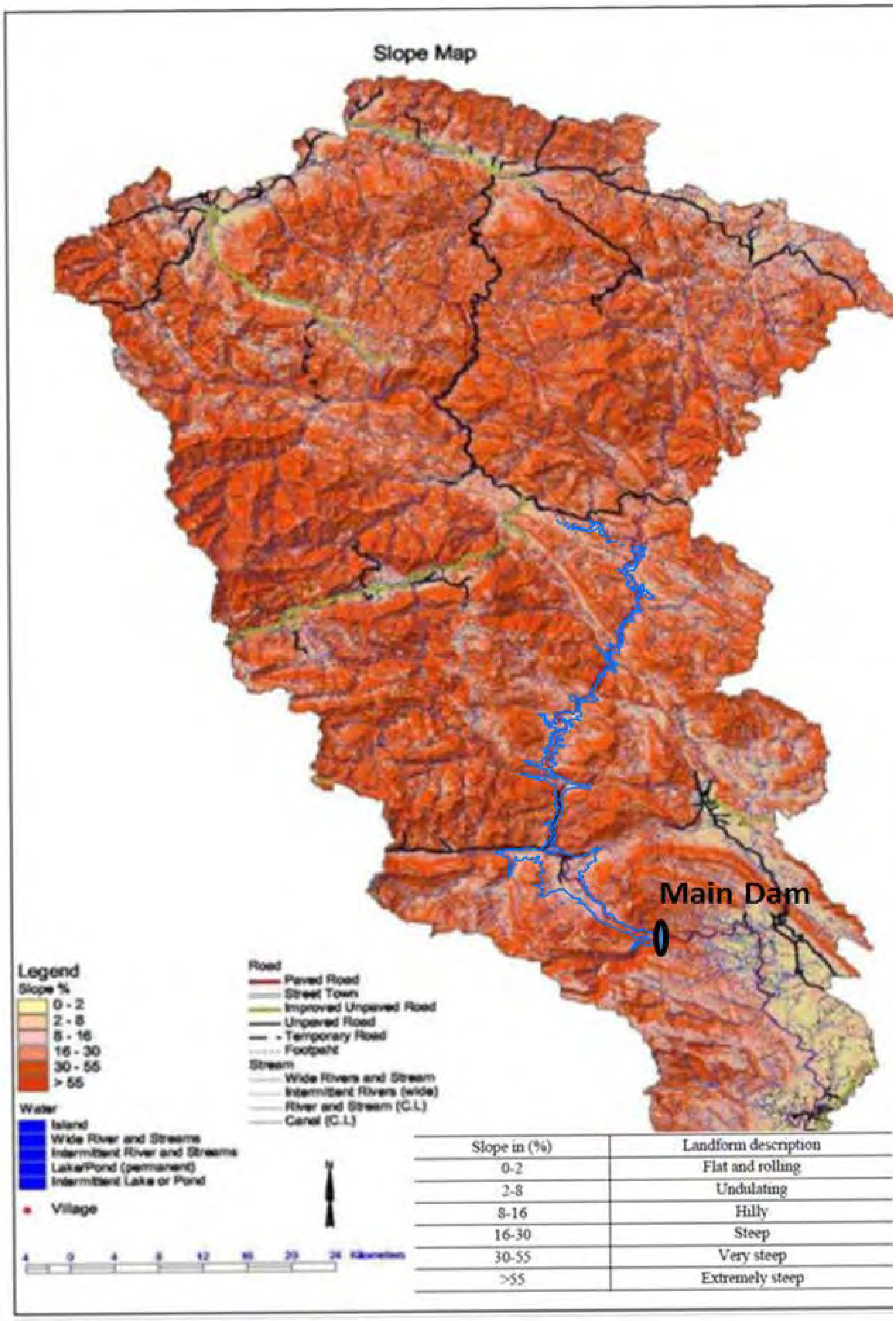


Figure 5.9 Slope Classification Map of the Nam Ngiep Watershed



Slope in (%)	Landform description
0-2	Flat and rolling
2-8	Undulating
8-16	Hilly
16-30	Steep
30-55	Very steep
>55	Extremely steep

5.1.5.2 *Erosion and Sedimentation in the Nam Ngiep Watershed*

The Western and Northern edges of the basin form a vast cirque with very steep sides due to headward erosion, while only outliners remain of the eastern rim which separates this basin from that of the Nam Sane River. The maximum altitude of the ridge separating the two basins is 2,819 m, in the middle of the western edge of the Nam Ngiep catchment area.

The study on erosion and sedimentation from river basins is important for many reasons. Sediment deposits in a reservoir reduce its capacity and power generation. Use of forestland, logging in particular, has often been a cause for concern, because it reduces forest cover and so increases erosion and sedimentation. This not only affects the quality of water but also alters stream behavior, water released from catchments, and makes flooding and droughts more extreme. Logging operations over large tracts of land have often been described as one of the major causes for altering the complicated hydrological processes of hydropower projects.

Suspended sediment sampling was carried out as part of the baseline data collection.

Methodology for Suspended Sediment Sampling

Suspended sediment sampling was carried out at water sampling stations at Ban Hat Gniun in the Project area.

Analysis of Suspended Sediment and Filtrate Separation

To determine the inorganic sediment concentrations, use of glass fiber filters might not be suitable. The filter is not combustible at 550ºC, but loses its form at higher temperatures. The Whatman 542, Whatman cellulose nitrate, were used at the temperature required to remove organic matter from suspended sediment.

To obtain a good record of sediment data normally requires adequate stream water sampling at various stages of the stream flow. However, the frequency of sampling is sometimes constrained by the time taken for the water samples to be analyzed in the laboratory. The laboratory apparatus used for the gravimetric analysis were as follows (and noted in ***Table 5.9***):

- Whatman 542;
- Porcelain crucibles of 50 ml capacities;
- Measuring cylinder 500 ml;
- Stainless steel forceps;
- Desiccators;
- Drying Oven (operation at 105 ºC);
- Muffle furnace Type ELF 10/14;
- Conical flasks;
- Electronic Balance (AND ER-180A), an electrical weighing balance that measures to the nearest 0.0001g.

Table 5.9 Laboratory Procedure for Suspended Sediment and Filter Separation

Step	Procedure
1	Each porcelain crucible (p.c) was washed thoroughly then placed in the muffle furnace for 2 hours. It was cooled in a desiccator for 30 minutes before being weighed to the nearest 0.0001 g.
2	Whatman 542 filters were placed in individually weighed p.c before oven dried for 2 hours at 105°C, then placed in desiccator for 30 minutes before its weight was measured.
3	About 100 ml of the filtrate was saved and stored in a vial tube, preserved with 1 ml of concentrated nitric acid and kept in a refrigerator for chemical analysis.
4	The filter with the residue from (3) was then placed in the oven for 24 hours at 105°C. This was then desiccated for 30 minutes before weighing was carried out to determine the suspended sediment concentrations. The amount of suspended sediment in milligrams per liter (mg/l) was determined as: Suspended solids (mg/l) = $\frac{A_1\text{-}B}{V} \times 10^6$ Where; A_1 is the weight of residue on filter paper + p.c (g) B is the weight of filter paper + p.c (g) V is the volume of water sample (ml)
5	The residue on the filter paper was then ashes, heated at 550°C for two hours in a muffle furnace (CARBOLITE Furnaces Type ELF 10/14) to remove organic matter for the determination of suspended mineral sediment. The amount of suspended sediment in milligrams per liter (mg/l) was determined as: Suspended sediment (mg/l) = $\frac{A_2\text{-}A_1}{V} \times 10^6$ Where; A_2 is the weight of ignited residue + p.c (g) A_1 is the weight of residue on filter paper + p.c (g) V is the volume of water sample (ml)

Source: Inthavy, 2005

Results

Based on the above methodology, suspended sediment concentrations in milligram per liter (mg/l) are summarized in ***Table 5.10*** for the dry season and ***Table 5.11*** for the rainy season. The volume of water sampled at Ban Hat Gniun for gravimetric analysis was 1,000 ml.

Table 5.10 Results of Erosion and Sedimentation Monitoring during Dry Season 2010

Station No.	Date	Depth (m)	Volume (ml)	Suspended Sediment (mg/l)
Stations at Ban Hat Gniun	1 Oct 2010	-	1,000	42.5
	14 Oct 2010	1.17	1,000	32.1
	30 Oct 2010	0.97	1,000	12.9
	14 Nov 2010	0.85	1,000	5.2
	30 Nov 2010	0.76	1,000	10.9
	14 Dec 2010	0.74	1,000	9.5

Preliminary assessment found suspended sediment concentration highest during the rainy season, ranging from 14.10 mg/l to 532.60 mg/l at Ban Hat Gniun, with the water level at about 1-3m. During the dry season, the maximum suspended sediment concentration was 42.50 mg/l at Ban Hat Gniun and the minimum was 5.20 mg/l. It is a common phenomenon in the tropics that storms cause high intensity of sedimentation, but are short lived and localized in nature. Storms of small and moderate nature are responsible for transporting suspended sediment from one reach to another in stages as they progress downstream.

Table 5.11 Results of Erosion and Sedimentation Monitoring during Rainy Season 2010

Station No.	Date	Depth (m)	Volume (ml)	Suspended Sediment (mg/l)
Stations at Ban Hat Gniun	30 Apr 2010	-	1,000	14.1
	29 May 2010	-	1,000	103.5
	30 Jun 2010	-	1,000	221.1
	31 Jul 2010	1.82	1,000	532.6
	28 Aug 2010	2.44	1,000	323.5
	29 Aug 2010	2.68	1,000	182.5
	30 Aug 2010	2.62	1,000	114.9
	31 Aug 2010	3.06	1,000	522.7
	1 Sep 2010	3.02	1,000	237.3
	5 Sep 2010	2.86	1,000	374.4
	14 Sep 2010	2.97	1,000	179.6
	16 Sep 2010	3.31	1,000	204.3
	20 Sep 2010	2.25	1,000	67.1
	27 Sep 2010	1.76	1,000	71.6

5.1.5.3 Sediment Load and Yield

In order to estimate the overall sediment transport of the Project watershed, it was necessary to compute the suspended sediment load, which constitutes an important component of watershed sediment output. Because of the considerable gaps in the sediment sample record, the sediment rating curve method is the most suitable procedure. In the absence of sedimentation survey information for the Nam Ngiep River, reservoir sedimentation is estimated based on the suspended sediment concentration and discharge at a lognormal distribution.

The following formula is obtained from the relationship between discharge and suspended sediment.

$$Qs = 7.063\times10^{-8}\times Q^{2.155}$$

where Qs: Suspended Sediment (m^3/s)

Q: Discharge (m^3/s)

Annual sediment yield at the dam site is estimated by the following equation, where bed load, which is equivalent to 20 % in weight of suspended load, was added to the suspended load:

$$Vy = Vy_s + Vy_b$$

$$Vy_S = R \times \frac{1}{\gamma} \times \frac{1}{(1-n_s)}, \quad Vy_b = R \times 0.2 \times \frac{1}{\gamma} \times \frac{1}{(1-n_b)}$$

R= Suspended load curve × D_h

where V_y: Annual sediment yield (m^3/yr)

Vy_S, Vy_b: Sediment yield of suspended load, bed load (m^3/yr)

R: Sediment weight (kg)

γ: Specific gravity (2,650 kg/m^3)

n_s, n_b: Void content; Suspended load: 0.7, Bed load: 0.4

D_h: Discharge of duration curve (sec)

Based on the above equation to estimate suspended sediment, the results of annual sediment yield produced from the Nam Ngiep watershed is 178 ton/km^2/year. ***Table 5.12*** provides a comparison of this estimated annual sediment yield to that of other major watersheds in Lao PDR.

Table 5.12 Comparison of Annual Sediment Yields Estimates at Major Hydropower Project Sites in Lao PDR

	Catchment area (km^2)	Sediment yield (ton/km^2/year)	Remarks
Houay Ho	223	404	Hedroconsul 1993
Xe Set	325	431	Norconsult 1985
Xe Don	4,090	193	Nippon Koeo & Sogreah 1991
Nam Leuk	274	347	Beca Worley & Lahmeyer 1993
Nam Song	1,303	277	Beca Worley & Lahmeyer 1993
Nam Tha-1	7,630	137	Acres, RSW. Hydro Quebec 1997
Xe Katam	290	300	JICA 1992
Nam Tha-1	7,630	137	Acres,RSW,Hydro Quebec 1997
Nam Ngum-1	8,460	140	NN3 Report ADB
Nam Ngiep Watershed	3,700	178	Observed SS (2010 KANSAI)

Source: Technical Report, 2011

5.1.6 *Surface Water and Groundwater Quality*

A World Bank[3] environmental monitoring report for Lao PDR found that the major source for urban water supply is surface water, while groundwater is the main source of water for rural communities in lowland areas. For upland communities, water is supplied by gravity-flow systems, mostly originating from streams or springs.

3 World Bank. 2006. Lao PDR Environmental Monitoring Report.

5.1.6.1 Surface Water Quality

In 1998, the water quality of rivers within the Lao PDR was generally considered to be Class 2 or Class 3, depending on human use and activities in catchment of water courses. The level of oxygen was high, while the nutrient concentration was low[4]. However, water quality was found to be deteriorating. In urban areas, pollutants from roads, commercial and industrial areas, and private properties were found to wash into drains and watercourses. Open dumps of garbage, dust, dirt, oil and grease, rubber, tires, metal, glass and plastic in public areas and private properties were commonly found, as seen in ***Figure 5.10***.

Figure 5.10 Open Dump of Solid Waste in a City

Residential development and agriculture cultivation have contributed to sediment and nutrient loads in the rivers. Urban drainage, such as industrial discharges and septic tank seepage, also worsened water quality. To determine the quality of water supply in the Project area, the existing lifestyle of villagers and their practices relating to the Nam Ngiep River was investigated.

The Nam Ngiep River originates in the mountainous areas of Xieng Khouang, and runs through the mountains down to the lowlands and into the Mekong River in Bolikhamxay province. Density of villages in the upstream is low. Many more villages are found in the lowland plains of Pakxan district near the Mekong River. The villagers along the Nam Ngiep River use the river for personal transportation, to transport their agricultural produce, and for washing, bathing and to dump their wastes.

4 ADB. 1998. Water Sector Study.

A number of these activities along the river can affect water quality, with several sources of water pollutants observed.

Upstream reaches of the river remain relatively undisturbed (***Figure 5.11*** to ***Figure 5.13***), though the relatively few people living there practiced shifting cultivation and grew industrial trees. Even with such low population, the agricultural practices and the residential activities could directly pollute the Nam Ngiep River. This is especially true farther downstream, particularly in the relatively densely populated plains of Pakxan (***Figure 5.14***). Garbage was found to be openly dumped and scattered around the residential area. The garbage was mostly organic and plastic. After degradation of the organic matter, plastic bags remained scattered throughout the villages. Animals such as water buffaloes, cows, and fowl were kept in the house areas (***Figure 5.15***). Their waste can mix with runoff and flow through the riverbank down to the river.

Figure 5.11 Three-Canopy Forest Located near the Proposed Dam Site

Figure 5.12 Stake Marking the Dam Site

Figure 5.13 Forest at the Proposed Dam Site

Figure 5.14 Disturbed Forest from Grazing near Ban Xomxeun

Figure 5.15 Residential Areas Divided for Activities such as Washing, Waste Dumping and Animal Feeding

Water Quality Sampling Survey

After observing activities that could cause pollutants to be transported into the river, ten locations were determined for surface water sampling, to cover four zones, as follows:

- Zone 1 Upstream area: ST1 Ban Xiengkhong and ST2 Ban Phonngeng
- Zone 2 Reservoir area: ST3 Ban Pou, ST4 Ban Hoaypamom, ST5 Ban Sopphouan, ST6 Ban Sopyouak and ST7 Hatsakhua
- Zone 3 Construction area: ST8 Ban Hat Gniun
- Zone 4 Downstream area: ST9 Ban Xomxeun and ST10 Nam Ngeip bridge

Locations of the water sampling stations are shown in ***Table 5.13***, and photos of the sampling locations are presented in ***Figure 5.16***. Seven of these stations are situated inside the controlled watershed (Nos. 1 to 7) and the other three stations are situated downstream from the Dam site (Nos. 8 to 10).

The water samples were collected manually at the water sampling stations on two occasions: once during the rainy season, on a stormy day, and once during the dry season. These samples can be considered representative for the distinct wet and dry seasons.

The water quality at these sites is shown in ***Table 5.14.***

Table 5.13   Location of Water Sampling Stations by their Coordinates

Station No.	Coordinate	
	N	E
Stations Situated Upstream of Dam Site		
1. Ban Xiengkhong	19°06′01.80′′	103°20′51.30′′
2. Ban Phon Gneng	19°02′25.67′′	103°23′40.14′′
3. Ban Pou	19°01′04.58′′	103°27′25.53′′
4. Ban Houypamom	18°47′04.53′′	103°26′08.67′′
5. Ban Sopphouan	18°46′53.60′′	103°25′56.82′′
6. Ban Sopyouak	18°42′52.61′′	103°26′01.74′′
7. Hat sakhua	18°41′11.22′′	103°27′03.87′′
Stations Situated Downstream of Dam Site		
8. Ban Hat Gniun	18°39′15.25′′	103°35′22.44′′
9. Ban Xomxuen	18°30′17.54′′	103°39′31.81′′
10. Nam Ngiep Bridge	18°25′03.77′′	103°36′11.30′′

Figure 5.16   Ten Locations of Surface Water Sampled in April 2007

Station 1: Ban Xiengkhong

Station 2: Ban Phonngeng

Station 3: Ban Pou

Station 4: Ban Houypamom

Station 5: Ban Sopphouan

Station 6: Ban Namyouak


Station 7: Hatsakhua


Station 8: Hat Gniun


Station 9: Ban Xomxeun


Station 10: Nam Ngiep Bridge

Table 5.14Results of Surface Water Quality Sampled from the Nam Ngiep River in April and October

Parameters	Unit	St 1		St 2		St 3		St 4		St 5		St 6		St 7		St 8		St 9		St 10	
		April	Oct.	April	Oct.	April	Oct.	April	Oct.	April	Oct.	April	Oct.	April	Oct.	April	Oct.	April	Oct.	April	Oct.
Temperature	°C	26.4	24.2	28.8	24.5	28.5	24.5	27.0	28.5	27.6	29.9	25.9	31.1	26.3	27.4	29.5	25.3	28.2	27.9	27.7	26.5
pH	-	8.06	6.87	8.17	7.16	8.20	7.24	7.03	7.85	7.21	7.78	7.35	8.13	7.25	7.79	7.09	7.09	8.18	7.34	7.58	7.17
Alkalinity	meq/L	NA	0.14	NA	0.23	NA	NA	0.28	NA	0.26	NA	0.21	NA	0.29	NA	0.26	0.14	NA	0.29	NA	0.27
DO	mg/L	7.80	6.90	8.00	7.12	8.10	7.30	6.87	7.80	7.11	6.60	8.10	7.20	7.20	6.40	7.21	7.23	7.60	7.47	7.20	6.97
BOD_5	mg/L	2.6	1.1	3.0	0.9	2.8	3.4	1.3	2.4	1.3	2.1	1.2	2.5	1.1	2.1	1.4	1.2	2.6	1.1	3.3	1.1
Oil and Grease	mg/L	NA	<0.01	NA	<0.01	NA	NA	<0.01	NA	<0.01	NA	<0.01	NA	<0.01	NA	<0.01	<0.01	NA	<0.01	NA	<0.01
Turbidity	FTU	24.7	13.3	31.4	12.4	31.4	57.2	19.4	59.1	12.0	12.9	18.2	21.1	16.9	9.1	17.9	16.2	47.9	15.7	32.9	17.3
Suspended solids	mg/L	100.0	21.6	78.0	19.2	94.0	246.0	18.7	69.0	19.0	72.0	23.8	74.0	21.5	80.0	21.4	22.1	112.0	17.9	72.0	21.2
TDS	mg/L	100.0	18.2	110.0	17.4	90.0	70.0	33.9	110.0	37.8	110.0	22.4	50.0	29.6	30.0	33.1	19.7	100.0	21.2	93.0	31.6
Hardness	mg/L	124.0	71.5	90.0	66.2	136.0	140.0	77.4	78.0	69.3	100.0	83.2	130.0	86.4	140.0	78.0	73.0	184.0	84.0	118.0	76.0
Conductivity	µS/cm	92.4	47.7	94.4	49.8	104.8	56.60	58.00	89.40	49.80	147.00	56.88	85.10	61.04	82.40	60.56	48.9	88.5	72.0	94.5	74.1
Phosphate-P	mg/L	0.05	0.21	0.98	0.31	0.03	0.11	0.21	0.20	0.18	0.20	0.25	0.09	0.38	0.19	0.48	0.10	0.14	0.20	0.16	0.12
Total P	mg/L	0.35	0.09	0.31	0.06	0.11	0.34	0.07	0.36	0.06	0.29	0.09	0.33	0.09	0.29	0.11	0.04	0.27	0.09	0.32	0.04
Ammonium-N	mg/L	0.01	0.02	0.01	0.02	0.01	0.01	0.02	0.01	0.05	0.01	0.04	0.01	0.04	0.01	0.05	0.02	0.01	0.04	ND	0.04
Nitrate-N	mg/L	0.16	0.12	0.23	0.15	0.18	0.26	0.12	0.27	0.14	0.34	0.14	0.29	0.16	0.20	0.14	0.21	0.17	0.10	0.20	0.09
Total N	mg/L	NA	0.05	NA	0.06	NA	NA	0.02	NA	0.05	NA	0.05	NA	0.07	NA	0.07	0.05	NA	0.07	NA	0.03
Total coliform	MPN/100	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Fecal coliform	MPN/100	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Cadmium, Cd	mg/L	0.01	<0.001	0.03	<0.001	<0.001	<0.001	<0.001	0.02	<0.001	0.01	<0.001	0.01	<0.001	<0.001	<0.001	<0.001	0.06	<0.001	0.05	<0.001
Mercury, Hg	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Copper, Cu	mg/L	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Lead, Pb	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.16	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Zinc, Zn	mg/L	0.03	<0.02	0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	0.02	<0.02	<0.02	<0.02
Arsenic, As	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001

Note: NA = Not available

The quality of water sources can be affected by residential and agricultural activities. Therefore, the water samples were collected at various locations along the river to cover all types of existing land uses, including natural areas, agriculture lands, residential areas, and other types of discharges that can lead to a deterioration in water quality. The water parameters found in this sampling survey can provide a baseline for water quality, before further impacts caused by project activities during construction and operation.

Parameters of interest included physical and chemical water qualities (temperature, pH, alkaline, conductivity, salinity, hardness, turbidity, suspended solid and total dissolved solid), biological water qualities (DO, BOD_5, PO_4^{3-}, P, N, NO_3^-, NH_3, oil and grease), bacteriological water quality (total coliform and fecal coliform) and trace elements (As, Cd, Cu, Fe, Hg, Mn, Ni, Pb and Zn). Rains started around the end of March, so the river turned to a brown color in April, the early rainy period when the first sample was taken. The dry season had already started when the second sample was taken in October.

The sampling survey revealed that natural water temperatures ranged between 24°C to 31°C in April and 24°C to 30°C in October. The range of temperature was similar to the water temperature of Nam Thurn on the Nakai Plateau. The environmental assessment and management plan of Nam Theun 2 Hydroelectric Project reported that the temperature was about 17°C to 22°C in December to February and 20°C to 28°C in March and even reached 31°C in April.

As a result of geological properties, the water samples were found to be slightly basic. Other physical properties such as conductivity, salinity and hardness were found to be at levels showing good clean freshwater. Turbidity value was low in the dry season, but became higher in rainy season. The higher value could be the result of suspended sediments, which were obviously higher in the rainy season. Average concentration of suspended sediments were about 83 ppm in April and 17 ppm in October.

DO concentrations in the Nam Ngiep river were found to be high, with a range of >7 to 10. However water quality data corresponding to nutrient concentrations showed that nitrate concentration in April was higher than in October. The increase of nitrates during the rainy season might be caused by nitrate-polluted runoff discharged from residential communities and from animal farms along the riverside. The runoff could flush animal and human wastes, which accumulated on the land during the dry season, into the river during the early rainy season.

Since data of total coliform and fecal coliform was not available, no microbiological parameters were measured for the water samples. The WHO/UNICEF Joint Monitoring Programme in its Country, Regional and

Global Estimate on Water and Sanitation gave an estimate for water and health in Lao PDR in 2002 that only 24% of households used latrines, and of those, only a few households had a pit or water-seal toilets. Lands with animal herds and fowl might contribute further to those contaminants, especially high levels of coliform, a parameter indicating poor sanitation of communities.

Because Lao PDR does not yet have its own water quality standards, the quality of surface water was evaluated using the classification of the Surface Water Standards (***Table 2.4***) of Thailand and of the Surface Water Quality Guidelines and Standards by International Organizations and Countries (***Table 2.5***).

In general, the water quality of sae3mples collected in October was classified as Class 2 according to the Thai Surface Water Standards. This is considered very clean fresh surface water resources that can be used for consumption with simple water treatment before use. It was also classified as being appropriate for aquatic organisms for conservation, fisheries and recreation. However, the quality in April fell to Class 3 according to the Thai standards, which is medium clean fresh surface water resources that can be used for agriculture but that needs to pass through water treatment before being used for consumption. BOD_5 increase can be caused by the nutrients flushed from the agricultural lands and residential areas into the river during the start of the rainy season.

5.1.6.2 Groundwater Quality

Although there is a well at Ban Hat Gniun, the villagers do not use it for drinking water purposes, and it was found that they occasionally dump trash into the well. Spring water from a gravity-flow system built under Action Contre la Faim (ACF), and the Nam Ngiep River, are the main water sources that supply water to the village. Residents of Ban Xomxeun, however, do use water from a well and also from the river. The well at Ban Xomxeun was about 12 m deep (***Figure 5.17***, ***Figure 5.18***). ***Table 5.15*** shows the results for groundwater quality at Ban Xomxeun.

Figure 5.17 Groundwater Sampling at Ban Xomxeun

Figure 5.18 The Well at Ban Hat Gniun

Figure 5.19 Spring Water Gravity Flow System in Ban Hat Gniun

Table 5.15 Ground Water Quality of Ban Xomxeun Collected on 17 October 2007

Parameters	Unit	Xomxeun	STD value	
			Suitable allowance	Maximum allowable
Temperature	°C	31	-	-
pH	units	5.98	7.0-8.5	6.5-9.2
Alkalinity	meq/L	0.34	-	-
DO	mg/L	6.90	-	-
BOD_5	mg/L	1.20	-	-
Oil and Grease	mg/L	<0.01	-	-
Suspended solids	mg/L	21.8	-	-
TDS	mg/L	17.6	≤ 600	1,200
Hardness	mg/L	79	≤ 300	500
Conductivity	µS/cm	37	-	-
Phosphate-P	mg/L	0.88	-	-
Total P	mg/L	0.22	-	-
Ammonium-N	mg/L	0.16	-	-
Nitrate-N	mg/L	0.22	≤ 45	45
Total N	mg/L	0.10	-	-
Coliform	MPN/100	NA	< 2.2	-
E. coli	MPN/100	NA	None	-
Cadmium, Cd	mg/L	<0.001	None	0.01
Mercury, Hg	mg/L	<0.001	None	0.001
Copper, Cu	mg/L	0.10	≤ 1.0	1.5
Iron, Fe	mg/L	0.23	≤ 0.5	1.0

Parameters	Unit	Xomxeun	STD value	
			Suitable allowance	Maximum allowable
Manganese, Mn	mg/L	0.10	≤ 0.3	0.5
Nickel, Ni	mg/L	<0.10	-	-
Lead, Pb	mg/L	<0.01	None	0.05
Zinc, Zn	mg/L	<0.02	≤ 5.0	15.0
Arsenic, As	mg/L	<0.001	None	0.05

Note: NA = Not Available , - = Not indicated

The WHO/UNICEF Joint Monitoring Programme in 2002 reported around 60% of communities used dug wells (also called boreholes) as their water source and they often suffered from outbreaks of diarrhoeal disease, indicating that the source of the disease likely originated from the dug wells. Data of coliform in the sample at Ban Xomxeun were not available, so the other water quality parameters were assessed. Water quality of the sample collected from the well was good according to the Groundwater Quality Standard of Thailand. However, the water was slightly acidic. Assuming the presence of waterborne disease carried in the wellwater, as found in the WHO/UNICEF Joint Monitoring Programme, it is recommended that the wellwater should be boiled before drinking.

5.1.7 *Mineral Resources*

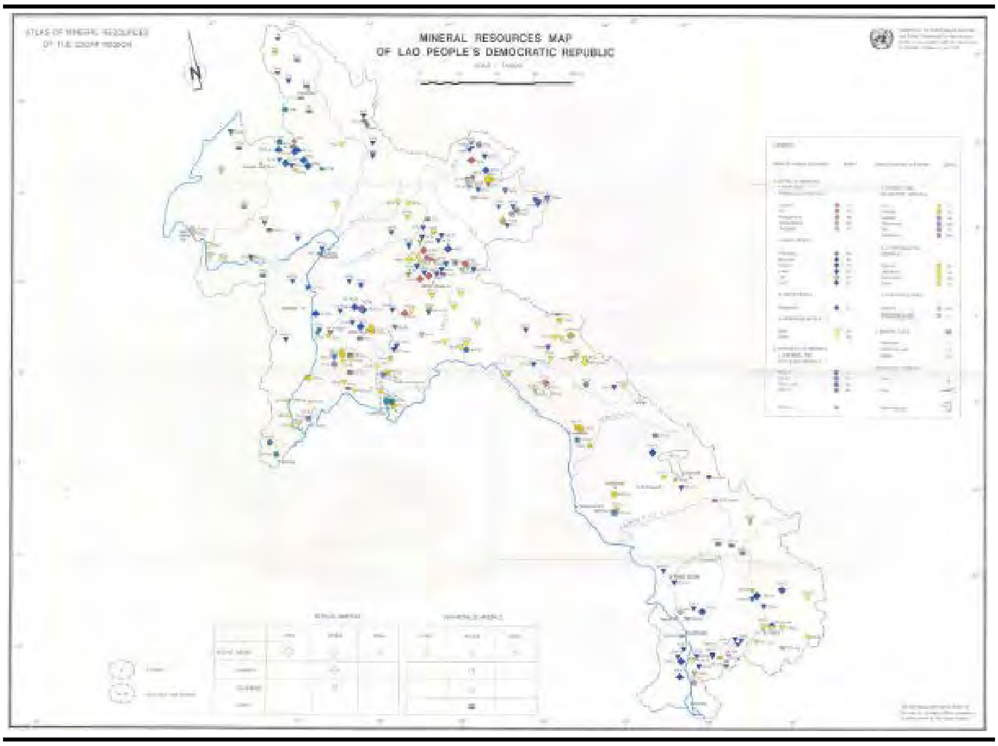
Mineral resources in the Project area were classified according to the 5 zones indicated in *Chapter 1*. In particular, the opportunity loss of mineral exploitation was considered, i.e. if valuable mineral resources were to be inundated by the reservoir. At the same time, the presence of any mineral mines around the Project reservoir was assessed for potential water and land contamination of the Project zones.

Geological surveys around the reservoir area (Zone 2) and construction area (Zone 3) show that the geologic setting has very low potential for mineral deposits in these areas.

According to the information obtained from the Department of Geology and Mines at Provincial and District levels, the Project area had not been explored in detail by the Lao government for possible mineral resources. From interviews with Vientiane and Bolikhamxay government officers, confirmation from villagers, and further confirmation from Lao mining officials, it is almost certain that no valuable mineral resources would be lost due to the Project.

As for potential water contamination from existing mineral resources and mines, the chances of contamination from mines is extremely small since the closest mines are located quite far (approximately 100 km) from the Project reservoir.

Figure 5.20 Mineral Resource Map of Lao PDR



Only medium occurrence of metallic and non-metallic mineral reserves was found in Xieng Khouang, Vientiane, and Bolikhamxay Provinces. Gold is the major valuable metallic mineral found in Hom District, however, the two gold mines under operation are located very far from the dam sites and are not located in the catchment of Nam Ngiep River. Other minerals, including zinc, copper, silver and rock salts are scattered within those provinces, but they are also located far from the reservoir area (Zone 2) and construction zone (Zone 3). One site was found to be a potential source of copper according to a geological study conducted by Lao-Fuda Co., Ltd in March 2007, but this site, which is located in Houixiat Village, Hom District, Vientiane Province, is also far from the Project and so should not have any impact on the Project.

Furthermore, according to confirmation from local provincial governmental authorities, the map of mining concession area of Ministry of Energy and Mines, Department of Mines, Lao PDR (July 2013) found that the Project is not located in a valuable minerals area.

Most potential mining sites and existing mining near the Project are located more than 100 km away. Only a few mining operations exist within 100 km of the Project, at Vientiane, Khammouane and Xaisomboun Provinces, as shown in ***Figure 5.21*** and ***Figure 5.22***

Figure 5.23 to ***Figure 5.25*** show the pre-existing mining project in Xieng Khouang and Bolikhamxay Provinces.

Figure 5.21 Map of Mining Concession Area (Ministry of Energy and Mines, Department of Mines, Lao PDR; July 2013)

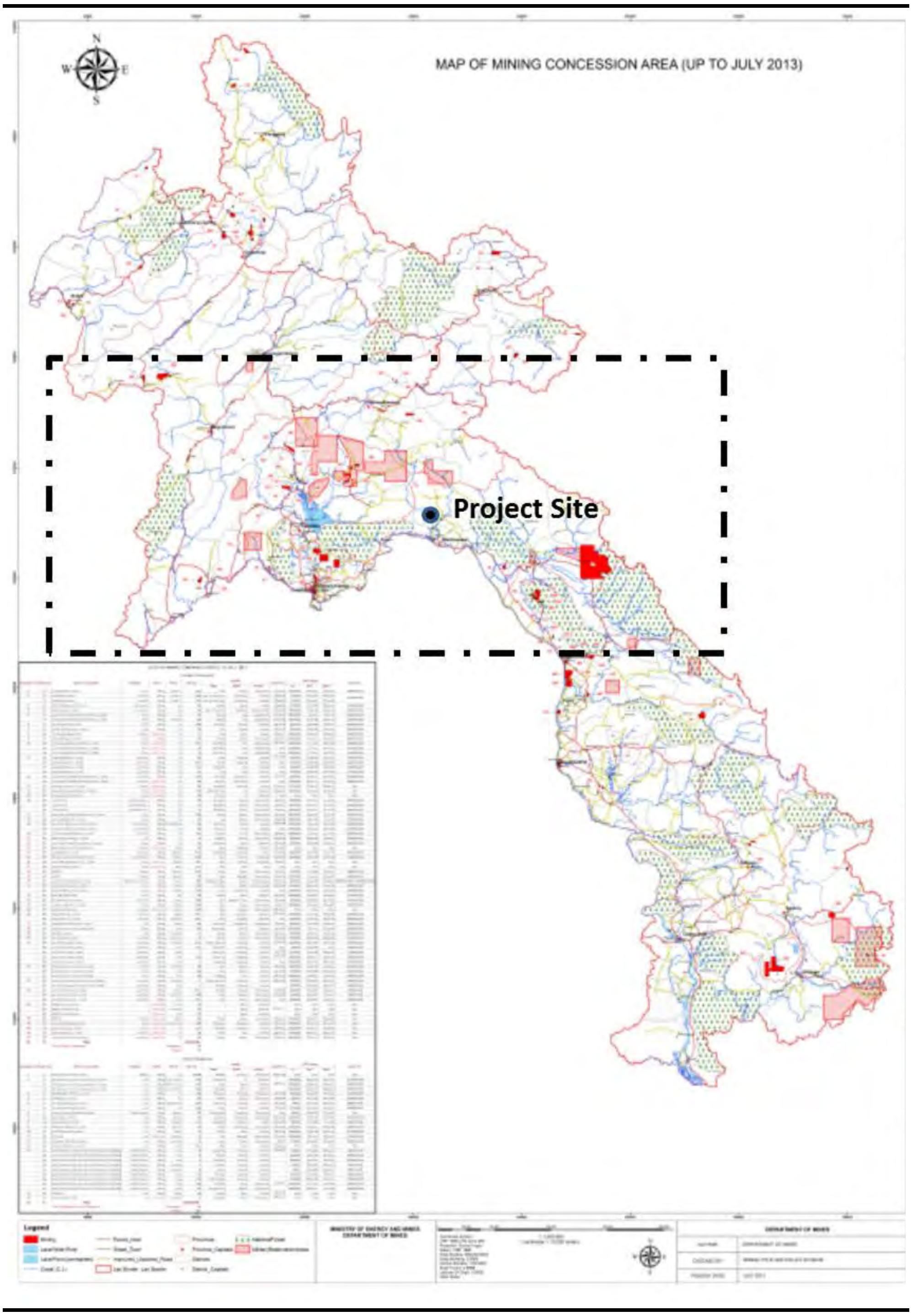


Figure 5.22 Mining Sites in 100 Kilometres Radius of the Project

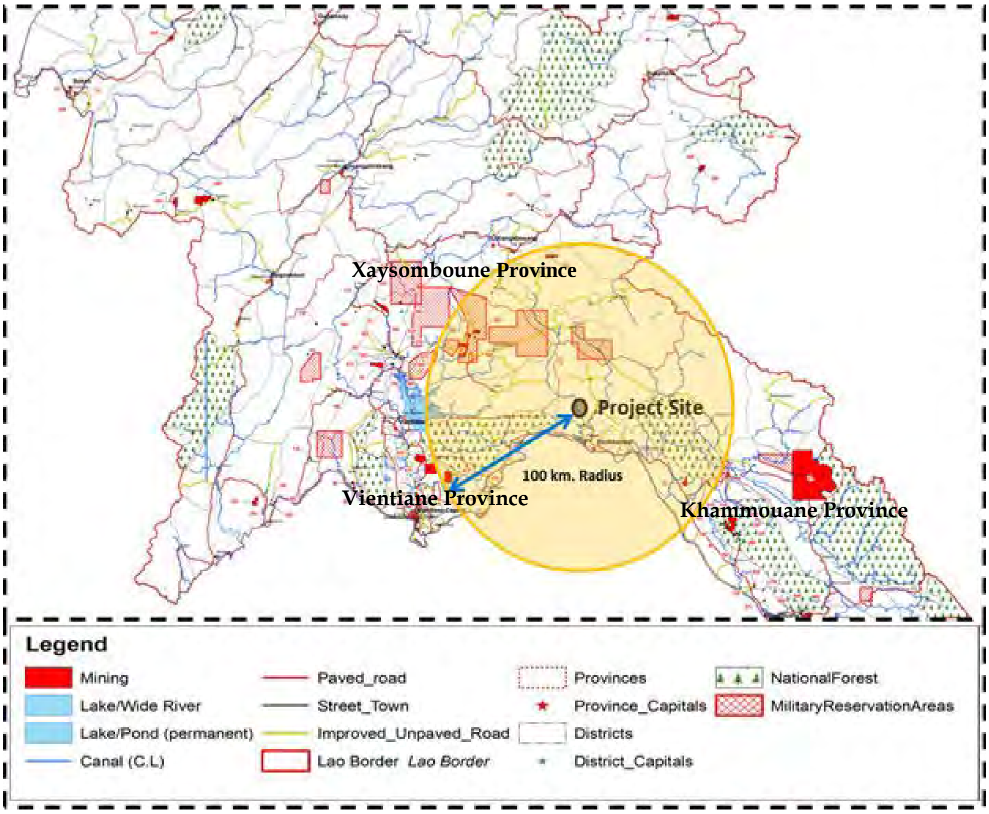
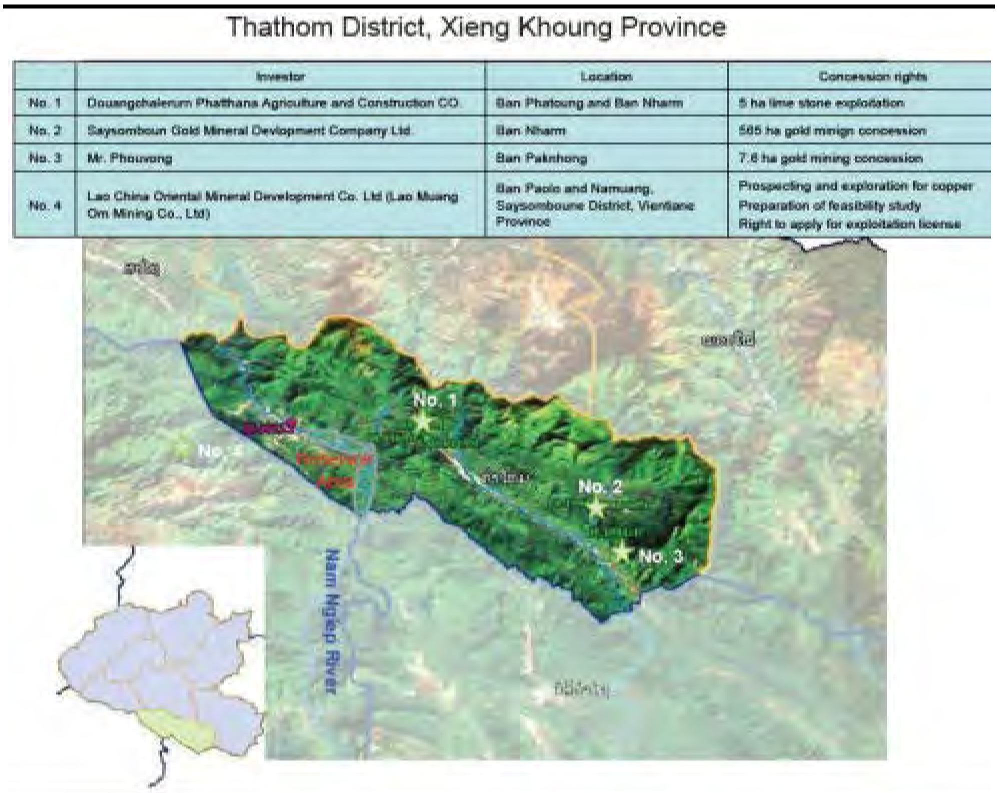


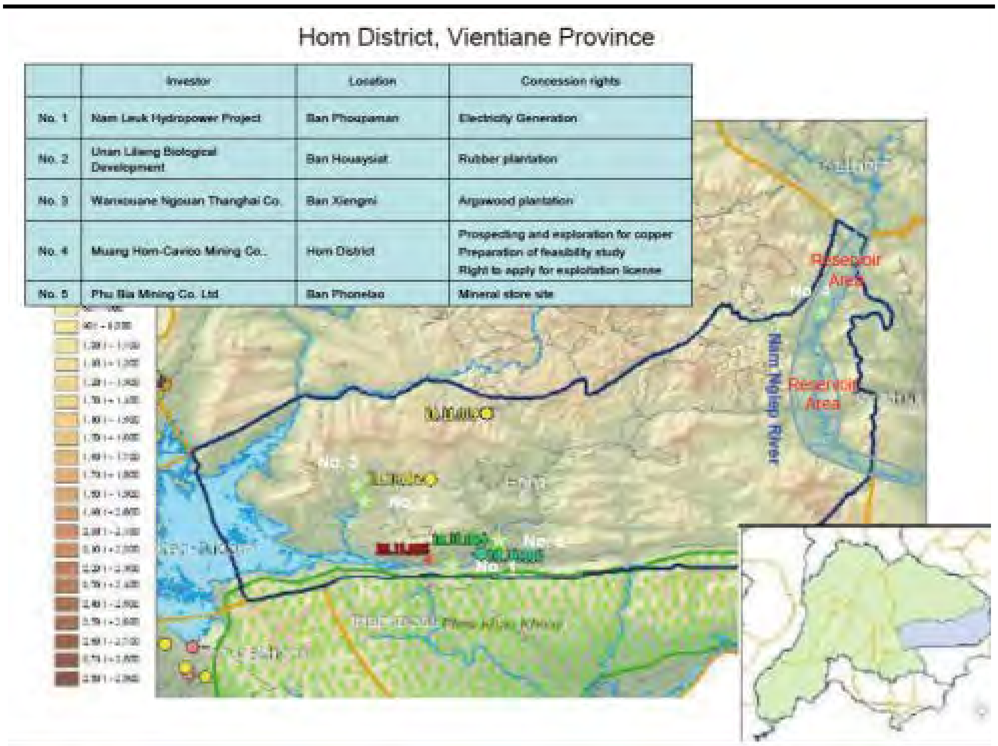
Figure 5.23 Pre-Existing Mining Projects in Thathom District, Xieng Khouang Province



Thathom District, Xieng Khoung Province

	Investor	Location	Concession rights
No. 1	Douangchalerum Phatthana Agriculture and Construction CO.	Ban Phatoung and Ban Nharn	5 ha lime stone exploitation
No. 2	Saysomboun Gold Mineral Devlopment Company Ltd.	Ban Nham	585 ha gold minign concession
No. 3	Mr. Phouvong	Ban Paknhong	7.6 ha gold mining concession
No. 4	Lao China Oriental Mineral Development Co. Ltd (Lao Muang Om Mining Co., Ltd)	Ban Paolo and Namuang, Saysomboune District, Vientiane Province	Prospecting and exploration for copper Preparation of feasibility study Right to apply for exploitation license

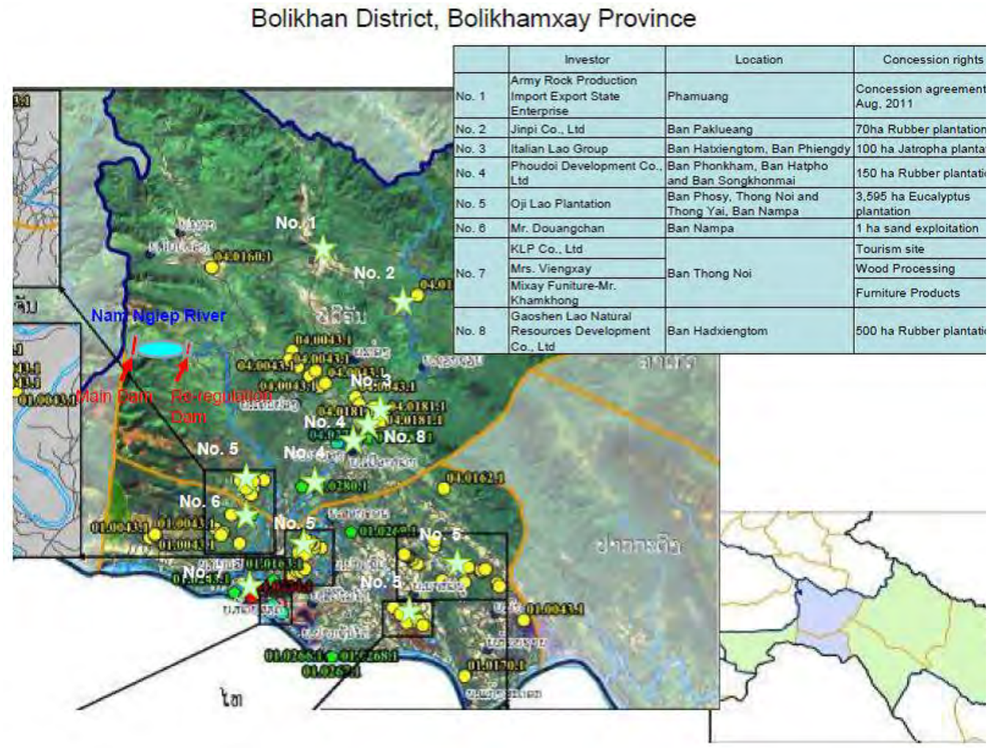
Figure 5.24 Pre-Existing mining Projects in Hom District, Vientiane Province



Hom District, Vientiane Province

	Investor	Location	Concession rights
No. 1	Nam Leuk Hydropower Project	Ban Phoupaman	Electricity Generation
No. 2	Unan Liliang Biological Development	Ban Houaysiat	Rubber plantation
No. 3	Wanxouane Ngouan Thanghai Co.	Ban Xiengni	Argawood plantation
No. 4	Muang Hom-Cavico Mining Co.	Hom District	Prospecting and exploration for copper Preparation of feasibility study Right to apply for exploitation license
No. 5	Phu Bia Mining Co. Ltd	Ban Phonelao	Mineral store site

Figure 5.25 Pre-Existing Mining Projects in Bolikhan District, Bolikhamxay Province



5.1.8 Noise and Vibration

Any undesirable sounds are usually called noise. This is especially true for loud or irritating sounds. Sound is measured by its frequency as the number of vibrations per second in units of Hertz (Hz). Humans are capable of hearing sounds between 20 Hz and 20,000 Hz. Frequency is also related to pitch, with the higher pitches having higher frequencies. Sound intensity is measured in decibels (dB), which is a measure on a log scale of perceived change in loudness. If the sound level increases by 10 dB, the normal ear perceives it as doubling in loudness, while a drop of 10 dB is a helving in loudness. Annoyance can be evaluated by differences in background levels and additional sound sources.

The actual background noise and vibrations were unable to be measured for this Project. Despite official letters of application for a permit to measure existing noise and vibration levels around the dam site and sensitive areas having been submitted since October 2007 to three organizations that could authorize the measurements, no approval was granted by any of the organizations. The measurements could not proceed and plans to carry them out were finally cancelled in January 2008.

Because of this, references to other projects and activities similar to the NNP1 Project were compared and applied to the noise and vibration assessment. In particular, the background sound level of the Hutgyi Hydropower Project in Kayin state, in the south of Myanmar, was selected.

Some of the staff conducting the field studies for the NNP1 Project also worked on the field research for the ESIA of the Hutgyi Hydropower Project. They found that the two sites have many similarities in noise and vibration sources and impacts. Variables that were considered for comparison were similarities of local agricultural activities of sensitive communities, of other land uses that could contribute to noises and vibrations, and other noise and vibration sources.

5.1.8.1 Sensitive Receptors

Field surveys were conducted for identification of sensitive areas. Villages that are located near the construction route or access road include Ban Hat Gniun, Ban Nonsomboun and Ban Hatsaykham. Only Ban Hat Gnuin, a village located about 3 km from the construction site (***Figure 4.2***), was considered close enough to the dam site to be affected by noises and vibrations during construction or operation.

Sensitive receptors in the village included houses (***Figure 5.21***), a school (***Figure 5.27***School at Ban Hat Gniun

) and a temple (

***Figure* 5.28**). There were 395 residents in Hat Gniun and 86 students attending the Hat Gniun Completed Primary School. On religious days, most villagers congregate at the Hat Gniun Temple for religious observances and to offer food to the monks. Noise and vibration annoyance in this community must be considered and controlled at acceptable levels so as not to disturb the lives of the residents and students.

Figure 5.26 Houses at Ban Hat Gnuin

Figure 5.27 School at Ban Hat Gniun

Figure 5.28 Temple at Ban Hat Gnuin

5.1.8.2 *Noise and Vibration Sources*

The village area is generally quiet. However, some agricultural activities produce sounds that interfere with activities of nearby people. This sound could become a disturbing noise, especially in the evening and during normal sleeping hours. The main noise source of the village is the hand tractor, a popular form of local transport. It has two wheels, and is operated with the driver walking behind to steer. It is used to plough rice fields, and also to pull a cart to transport items, including agricultural products such as bagged rice and bamboo, materials for house construction, and people (***Figure 5.29***). The acoustic environment normally consists of natural sounds, such as wind blowing through trees, birds, and pets.

Figure 5.29 Two-Wheel Tractor Pulling a Cart

5.1.8.3 *Background Sound Level*

The Ministry of Agriculture Food and Rural Affairs of the Government of Ontario provided common sound levels for various equipment, including agricultural activities (***Table 5.16***). Most of the common sounds listed are found in everyday life (whisper, leaves, conversation and traffic). Others, such as agricultural machinery and chain saws, would be similar, whether in a temperate climate with large scale commercial agriculture, as in Canada, or tropical small scale farms as in Lao PDR.

Background sound and vibration levels in rural areas were also reviewed. The background sound levels of the Hutgyi Hydropower Project were reviewed because of the many similarities with the areas near NNP1 with regard to noise and vibration sources and their impacts. For example, its location is in a remote and mountainous area similar to Nam Ngiep 1. Equipment and techniques of construction were generally similar, and community sizes near the dam site also small.

Table 5.16 Decibel Levels of Common Sounds

dB	Sound
0	Acute threshold of hearing
15	Average threshold of hearing
20	Soft whisper
30	Leaves rustling
40	Rural ambient background
65	Normal conversation
69	In bin grain dryers and aeration fans
80	Heavy traffic
90	Grain dryers
100	Tractor under load
110	Chain saws

Source: Ministry of Agriculture Food and Rural Affairs, Government of Ontario Last Modified: August 9, 2008. http://www.omafra.gov.on.ca Retrieved on August 9, 2008.

Preliminary sound measurements of Hutgyi Hydropower Project were carried out in April 2007 by measuring equivalent sound level at 1 hour (Leq 1 h). Sound level was about 60 dB(A) in the small towns, with occasional vehicular noise as the loudest noise sources.

The sound level was even lower in rural areas where the major noise sources usually came from natural sounds such as wind and birds. Noise sources at Ban Hat Gnuin were mostly the two-wheel tractor and the natural acoustic environment, so sound levels would likely be between 40 to 60 dB.

Figure 5.30 Ban Hat Gniun

5.1.9 *Air Quality*

Air quality in the Project area is still considered to be of generally good quality.

The relationship between environment and the development is one of the most important issues at present. Many developmental activities, including construction of hydropower plants, transmission lines, and related facilities, cause degradation to many aspects of the environment, including the hydrosphere (water), lithosphere (soil) and atmosphere (air), and even the biosphere through pollution and disturbance. In order to recognize the adverse effects of air pollutants, accurate scientific data is essential. Quantitative characterization of air quality is a prerequisite to understanding the existing conditions and the potential air pollution around the Project site. This can help to determine the extent to which pollution control is required, and how much the atmosphere might be able to act as a natural sink for gaseous pollutants.

The exact baseline air quality of the Project site could not be measured, because there is no permanent air quality monitoring station in the Project area, and permission was not granted to conduct site specific monitoring during the period of field assessment. However, because of the lack of major pollutants in the Project area, air quality is expected to be good: there are no industrial pollution sources in the vicinity, and transportation density is still quite low.

The Lao PDR has not adopted its own ambient air standards, so generally accepted international standards are used instead. "The Lao PDR Environment Monitor 2005" of the World Bank showed that overall air quality is currently at acceptable levels in both urban and rural areas in Lao PDR. It is therefore quite reasonable to expect that the air quality in the Project area falls well within the standards presented in ***Table 5.17***.

Table 5.17 Ambient Air Standards Applied to the NNP1 Project

(Unit: mg/m^3)

Parameter	Average Time					Method of Measurement
	1 hr Av	8 hr Av	24 hr Av	1 Month Av	1 Year Av	
Carbon monoxide (CO)	30	10				Non dispersive infrared analyzer method
Nitrogen dioxide (NO_2)	0.30					Chemi-luminescence method using ozone or Colorimetry employing Saltzman reagent
Sulfur dioxide (SO_2)	0.50		0.30		0.10	Ultraviolet Fluorescence or Conductometric method
Particulate (TSP)			0.33		0.10	Gravimetric High Volume or Weight concentration measuring methods
Ozone (O_3)	0.20					Chemi-luminescence or Absorption spectrophotometry using a neutral potassium iodide solution
Lead				0.5-1.0		Atomic Adsorption Spectrometer

Parameter	Average Time					Method of Measurement
	1 hr Av	8 hr Av	24 hr Av	1 Month Av	1 Year Av	
Dust			0.12		0.05	Gravimetric High Volume

Sources:

1. WHO, 1987. 'WHO Ambient Air Quality Guideline', URL: http://w3.whosea.org/techinfo/air.htm ,(21/6/06)
2. Pollution Control Department (PCD), Ministry of Natural Resource and Environment, 1995. 'Air Quality and Noise Standards', URL: http://www.pcd.go.th/info_serv/en_reg_std_airsnd.html, (18/6/06)
3. Ministry of Environment, Government of Japan, 1973. 'Environmental Quality Standards in Japan: Air Quality', URL: http://www.env.go.jp/en/air/aq/aq.html (18/7/06)

5.1.10 *Potential Contaminated Sites*

Aside from solid waste and wastewater from human activity in the villages in the area, there do not appear to be any pre-existing activities or conditions that would lead to contamination of the Project sites. A number of project related activities, especially during construction, do have considerable potential to cause contamination. The location of these sites has been determined and the potential contamination threats considered.

Potential contaminated sites were examined to determine their existing, baseline conditions so that any mitigation measures would assure that those conditions would be maintained. The potential contamination sites were considered for both hazardous and non-hazardous sources. For hazardous sources, data on the presence of hazardous industries on or near the dam site and the Nam Ngiep basin were considered. In addition, the possible sites of contamination were determined by reviewing plans of transport, storage, and use of hazardous substances during project construction and operations. For non-hazardous contamination, similar assessment was made of existing sources of waste, and potential contamination sites were determined based on plans for construction and operation.

The hazardous site investigation was also taken to identify potential contaminated activities within the area that could affect the Project, whether existing or past contamination within the river basin. The study concluded that, while there were potential mineral resources in the region (see Mineral Resources), these were not located in the Nam Ngiep River basin. Thus, there were no contaminated sites from minerals or mineral extraction that could cause hazardous contamination in the Project area. There are also no industrial activities within or immediately adjacent to the Nam Ngiep River basin, so industrial activity would also not be a source of hazardous contamination at present.

Potential contaminated sites would be solely the result of various activities relating to hazardous material transport, storage, and use during construction and operation of the NNP1 dam. The chemicals that must be used for the Project during construction and operation were reviewed to predict potential site contamination. The Project materials that would be stored in the construction site and could cause hazardous contamination to the environment were determined to be explosive materials, fuel (diesel, LPG), lubricant oils, pesticides and paints. The activities that involve hazardous materials are: chemical use and storage, drum reconditioning or recycling, electric transformers, explosive use and storage, landfills, pest control, use of petroleum product and oil storage, and scrap yards. Hazardous materials used for the RCC were also considered. During the operation phase, pesticides and fertilizers may be used for landscaping in the Project area, along roadsides, near offices and parking areas.

Non-hazardous substances that could contaminate the Project site would be from the generation of solid waste and wastewater during construction. Human waste and wastewater from the workers could also be a source of land and water contamination. It is estimated that 1,000 to 1,800 persons will work for the Project daily for six years; thus creating solid waste of about 800 kg to 1,500 kg/day. Seepage from the landfill for this waste would be another potential source of pollution and therefore potential contaminated sites. Turbidity and hardness caused by runoff from the quarry site near the riverbank are also potential problems. The contractor camp yard, the disposal site for solid waste, the stockpile, the potential quarry site near the river, and other sites where project activities will be carried out that could run the risks of contamination are shown ***Figure 4.2***.

5.1.11 Hydrology and Hydrogeology

A dam will necessarily change the hydrology of a river. However, measures can be taken to minimize any adverse impacts from changes caused by the dam.

5.1.11.1 Nam Ngiep Basin

Nam Ngiep basin has a catchment area of about 4,533 sq.km., and is divided into 33 sub-basins. Most of the sub-basins are rather small, and only 3 sub-basins have a catchment area of more than 10% of the total catchment area (***Figure 5.31*** and ***Table 5.18***).

Based on the information of the sub-basin area, the isohyte generated from average annual rainfall from the existing stations in and nearby the basin, and the runoff coefficient analyzed at the main dam site of 0.676, the annual flow and the specific yield in each sub basin are calculated as shown in ***Table 5.18***. On average, the upper part of the basin (sub-basin no. 1-16) contributes less flow than the lower part (sub-basin no. 17-33) due to the spatial variation of the rainfall.

Figure 5.31 Nam Ngiep Sub-Basins and Boundaries

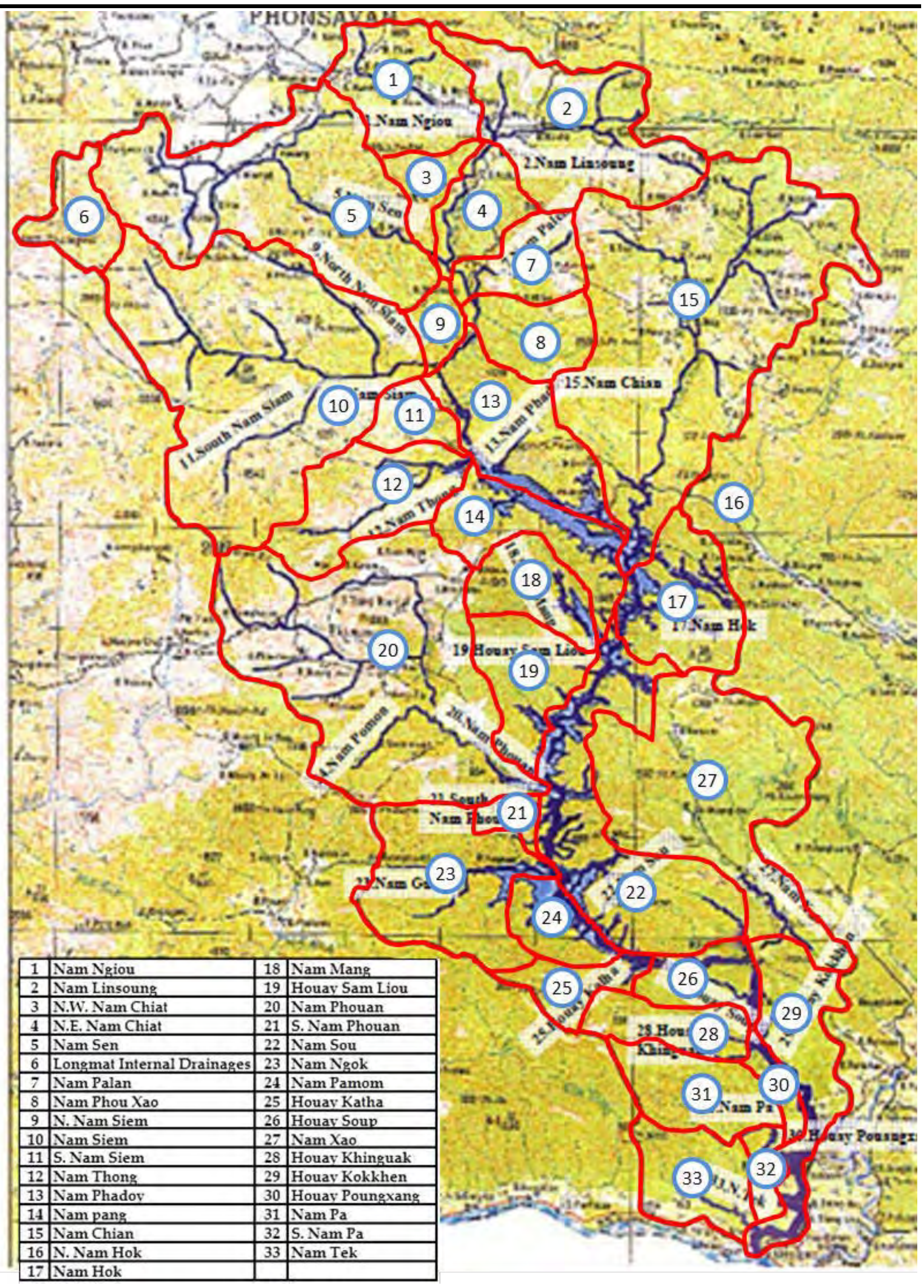


Table 5.18 Nam Ngiep Sub-Basins and Annual Runoff

No	Sub-basin	Basin Area		Annual Runoff	Specific Yield	Flow Contribution
		sq.km.	%	mcm	cms/100sq.km	%
1	Nam Ngiou	134	3.0	128.6	3.04	2.2
2	Nam Linsoung	196	4.3	191.9	3.10	3.3
3	N.W. Nam Chiat	29	0.6	28.9	3.16	0.5
4	N.E. Nam Chiat	92	2.0	91.8	3.16	1.6
5	Nam Sen	256	5.7	255.3	3.16	4.4
6	Longmat Internal Drainages	63	1.4	63.5	3.20	1.1
7	Nam Palan	66	1.5	65.8	3.16	1.2
8	Nam Phou Xao	66	1.5	75.8	3.64	1.3
9	N. Nam Siem	34	0.8	38.2	3.56	0.7
10	Nam Siem	528	11.7	620.0	3.72	10.8
11	S. Nam Siem	34	0.8	40.7	3.80	0.7
12	Nam Thong	169	3.7	206.4	3.87	3.6
13	Nam Phadoy	129	2.9	154.4	3.80	2.7
14	Nam pang	124	2.7	155.4	3.97	2.7
15	Nam Chian	519	11.5	673.3	4.11	11.7
16	N. Nam Hok	24	0.5	33.5	4.43	0.6
17	Nam Hok	127	2.8	174.8	4.36	3.0
18	Nam Mang	72	1.6	99.5	4.38	1.7
19	Houay Sam Liou	121	2.7	169.0	4.43	2.9
20	Nam Phouan	459	10.1	638.2	4.41	11.1
21	S. Nam Phouan	28	0.6	39.1	4.43	0.7
22	Nam Sou	214	4.7	308.0	4.56	5.4
23	Nam Ngok	202	4.5	282.1	4.43	4.9
24	Nam Pamom	45	1.0	62.8	4.43	1.1
25	Houay Katha	47	1.0	65.6	4.43	1.1
26	Houay Soup	57	1.3	81.9	4.56	1.4
27	Nam Xao	313	6.9	457.8	4.64	8.0
28	Houay Khinguak	67	1.5	93.6	4.43	1.6
29	Houay Kokkhen	126	2.8	182.6	4.60	3.2
30	Houay Poungxang	24	0.5	33.5	4.43	0.6
31	Nam Pa	78	1.7	108.9	4.43	1.9
32	S. Nam Pa	26	0.6	36.3	4.43	0.6
33	Nam Tek	64	1.4	89.4	4.43	1.6
	Nam Ngiep	4,533	100.0	5,746.6	4.02	100.0

As the number of divided sub-basins is redundant, and many of them have very small catchment areas, the Lao PDR's Department of Water Resources responsible for river planning and management has re-organized the division of sub-basins, which would reduce the number of sub-basins in Nam Ngiep to 15, although this change has not yet been officially released.

5.1.11.2 *Geography along the Nam Ngiep River*

For most of its 160 km length, the Nam Ngiep flows through mountainous regions in a south to southeastern direction. After a turn to the east, it passes through a narrow gorge of some 7 km between Mt. Huasua (elevation 1,538m) to the northeast and Mt. Katha (elevation 2,071 m to the southwest). The mouth of the gorge lies 7.7 km west-southwest of the main settlement of Ban Hat Gniun. From there the river runs through hilly terrain to the Mekong River.

About 2.9 km from the end of the gorge, the Nam Katha joins the Nam Ngiep. This last segment of the gorge has a river gradient as steep as 1/100. The planned dam site is located in this segment of the gorge, about 1.2 km downstream from the confluence of the Nam Katha River. The entire basin for the dam has an area of about 3,700 km^2.

5.1.11.3 *Hydrological Analysis*

Hydrological data were compiled from records of gauging stations within and in the peripheral of the planned basin. The locations of these stations are shown in ***Figure 5.1***.

Rainfall, water level and discharge records are shown in ***Table 5.19***. Other meteorological data such as air temperature, relative humidity, barometric pressure, solar radiation, sunshine hours, evaporation and wind velocity were obtained from related areas.

(1) Rainfall records

Rainfall records were obtained from September 1998 to December 2000 at an automatic rainfall recorder installed at Ban Thaviang.

(2) Water level records

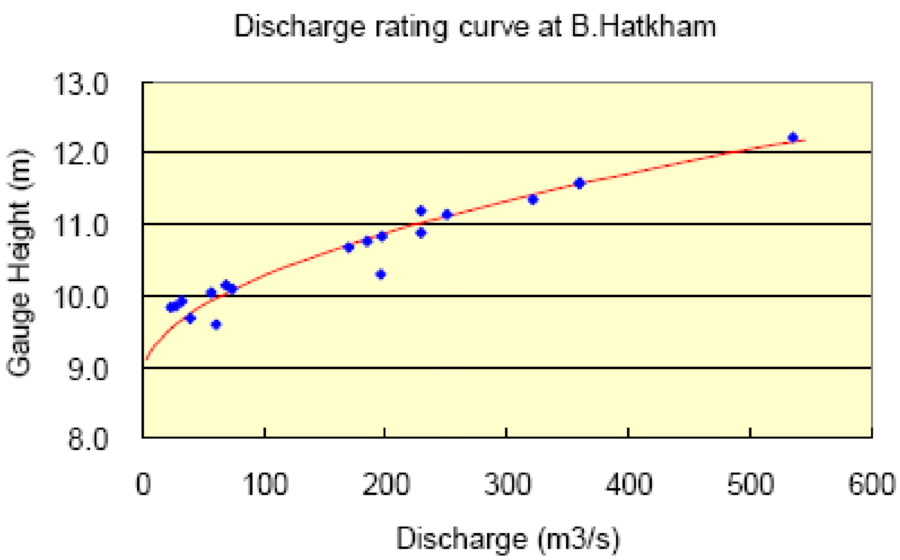
Water level records were obtained from September 1998 to December 2000, at a staff gauge for water level measurement installed at Ban Hatkham (a sub-village of Ban Hat Gniun). Discharge measurements were taken at the same location until March 2000. Discharge rating curve is shown in ***Figure 5.32***.

Table 5.19 *Basic Hydrological Data*

Gauging Station		Data	Elevation (m)	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	00	01	02
Rainfall																																			
R1	B.Nakham (B.Pakthouei)	Day	159m																				●	●	●		●	●	●	●	●	●	●	●	●
R2	Paksane	Day	155m	●	●	●	●	Δ	Δ	●	●	●	●			Δ				●	●	●	●	●		●	●				●	●	●	●	●
R3	Muong Mai	Day	158m								●	●						Δ			Δ	●	●	●	●	●	●	●	●	●	●	●	●	●	●
R4	Muong Kao (Borikhane)	Day	158m								●	Δ									●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
R5	M.Khoun (B.Thoum)	Day	1,110m																										●	●	●	●	●		
R6	XiengKhouang	Day	1,050m																	●	●	●	●	●	●		●	●	●	●	●	●	●	●	●
R7	M.Phaxay (B.Hokai)	Day	1,100m																										●	●	●	●	●		
R8	B.Naluang	Day	460m																	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
R9	Hounyleuk (Tadleuk)	Day	220m																									●	●	●	Δ	●	●		
R10	B.Thabok	Day	160m																			●	●	●	●	●	●	●							
R11	Vientiane	Day	170m	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●		●	●	●	●	●	●	●	●	●
R12	Vangviang	Day	215m				●	Δ	Δ		●	Δ	●	●	●		●			●	Δ	●	●	●	●	●	●	●	●	●	●	●	●	●	●
R13	Muong Mork	Day	900m																										●	●	●	●	●		
R14	B.Thaviang	Hour	370m																												Δ	●	●		
Discharge/River water level																																			
	B. Hajyun	Day	-																												Δ	●	●		
	Muong Mai	Day	153m																			●	●	●	●	●	●	●	●	Δ	Δ	●	●	●	●
River water level																																			
	Paksane	Day	142m																			Δ	●	●	●	●	●	●	●	●	Δ	●	Δ	●	●

Note: •: Fully available, Δ : Partly available

Figure 5.32 *Discharge Rating Curve*



(3) Hydrological study

The data collected from September 1998 to December 2000 were used for the hydrological study. However, hourly water level data were not available for flood analysis. The flood water level and the tail water level at the dam site were determined by using 1/10,000 topographical maps derived from aerial photos.

Water level measurement was carried out using an automatic water level recorder (pressure type) and periodic discharge measurement at Ban Hat Gniun, as well as rainfall measurement at Ban Thaviang since June 2007.

5.1.11.4 *Low Flow Analysis*

Hydrological records of the Nam Ngiep River basin have not been well maintained. The estimate of mean basin rainfall was assessed from the rainfall data available for areas within and outside of the basin. The mean basin rainfall and discharge were inputs for the Tank Model method to estimate the mean annual discharge. These records were not collected for a sufficiently long period for accurate analysis. Thus rainfall data from peripheral areas was also applied using the Thiessen method to obtain the mean basin rainfall. Missing data during the measurement period is derived by using correlations. The assumed mean basin rainfall is shown in ***Table 5.20***.

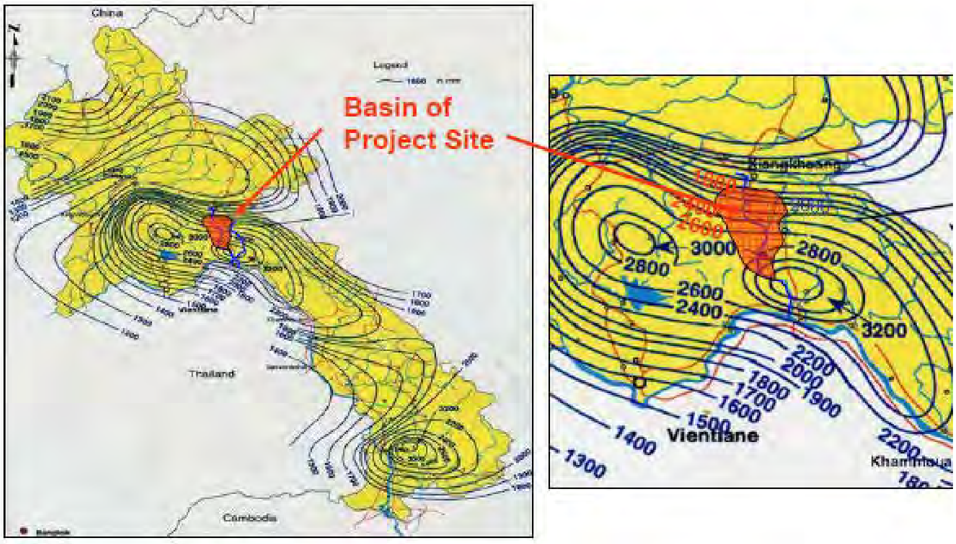
Table 5.20 Assumed Mean Basin Rainfall (1971-2000)

(mm)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1971	0	65	56	120	280	432	551	302	164	39	0	10	2,019
1972	0	2	27	120	192	395	316	350	75	107	16	2	1,603
1973	0	0	16	25	244	278	277	484	296	13	0	0	1,634
1974	3	11	13	111	195	216	403	471	152	49	16	0	1,642
1975	23	12	27	27	304	421	189	340	285	119	3	0	1,752
1976	0	54	4	53	210	230	385	427	250	170	0	0	1,783
1977	6	0	12	72	122	269	402	242	194	9	6	8	1,.42
1978	10	12	39	122	38	518	400	31	3360	87	5	0	1,904
1979	1	29	10	51	404	253	324	189	146	26	0	0	1,433
1980	0	7	29	67	236	415	433	367	256	39	0	0	1,849
1981	0	0	5	119	214	292	519	346	221	196	0	0	1,913
1982	2	0	72	134	240	304	363	540	508	42	21	0	2,226
1983	0	63	52	141	185	263	363	500	226	131	45	0	1,999
1984	26	33	10	100	191	301	351	356	222	74	24	0	1,688
1985	0	2	6	129	508	363	404	276	182	35	0	22	1,928
1986	0	31	42	158	133	333	250	332	228	67	25	0	1,601
1987	0	11	10	47	167	357	397	556	189	192	7	0	1,932
1988	85	0	120	123	215	460	523	285	320	128	5	5	2,270
1989	12	0	120	145	189	435	382	313	229	117	0	0	1,942
1990	4	36	66	99	173	644	717	305	267	311	30	0	2,653
1991	2	0	33	115	164	359	379	438	233	30	6	4	1,762
1992	35	28	1	41	127	315	354	263	140	26	0	36	1,365
1993	0	5	35	94	262	448	464	337	198	15	0	3	1,863
1994	9	32	106	118	171	401	413	330	219	115	38	9	1,960
1995	1	0	8	94	222	398	567	552	119	54	14	0	2,029
1996	0	8	41	107	251	337	451	555	215	29	84	3	2,080
1997	9	4	85	220	250	302	485	416	243	94	4	0	2,111
1998	0	11	17	86	231	295	364	282	156	45	9	8	1,503
1999	7	3	60	119	521	426	320	537	293	125	26	8	2,445
2000	4	46	7	178	296	359	293	382	312	93	2	0	1,972
Av.	8	17	38	104	231	361	402	380	230	86	13	4	1,873

The mean rainfall of the basin of 1,870 mm/year was selected after considering the Isohyetal Map (***Figure** 5.33*). The mean rainfall of Nam Ngiep River basin is considerably less than the annual rainfall of Pakxan (3,000 mm). The tropical low pressure systems that develop in the China Sea and move along the Mekong Valley are blocked by high mountains and steep cliffs in the northwest, causing many of the storms to stall there until the low pressure dissipates.

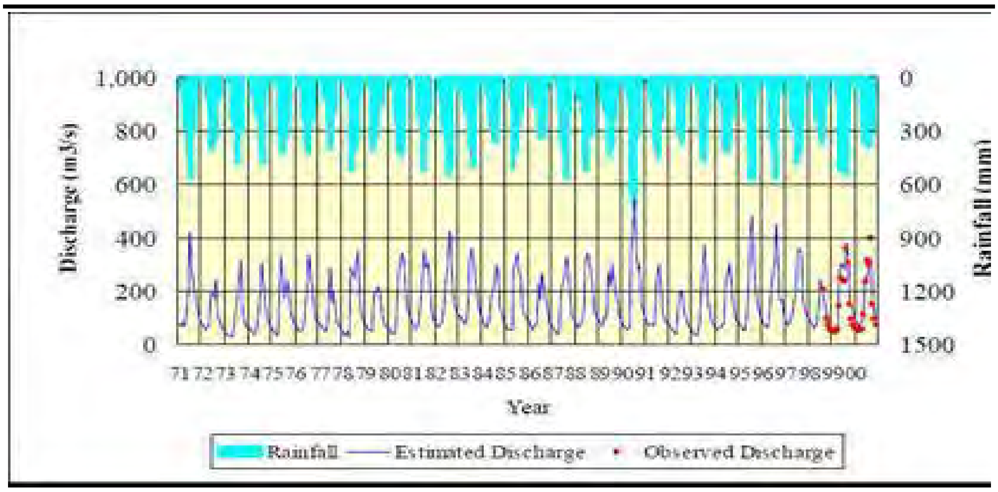
Figure 5.33 ***Isohyetal Map***



Source: Ministry of Mines and Energy, Lao PDR

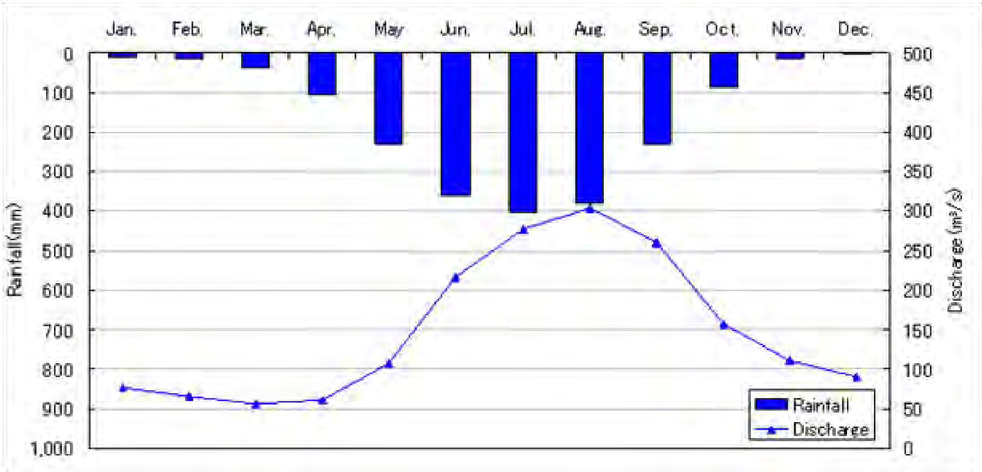
Based on the 14-year actual measurement of discharge at the Moung Mai station and the measured discharge at Ban Hat Gniun (September 1998-December 2002), the difference between measured discharge and calculated discharge was minimized through trial-and-error method. The result of the dam site low flow analysis by Tank Model method showed the annual average discharge (1971 to 2000) of 148.4 m^3/s ***(Figure 5.34).*** The model was calibrated and verified.

Figure 5.34 ***Result of low Flow Analysis by Tank Model Method***

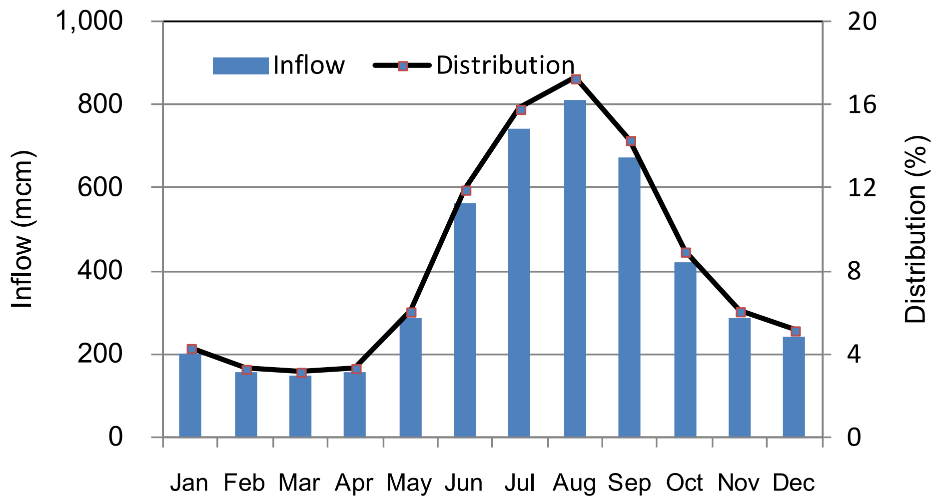


Based on the mathematical model (Tank Model), the long-term inflow at the main dam site is estimated as tabulated in ***Table 5.21*** and ***Figure 5.35.*** The average inflow is about 148.4 m^3/s, with an annual runoff of around 4,680 mcm. The seasonal distribution (***Figure 5.36*** Seasonal Charge of Inflow at Nam Ngiep Dam Site

) is quite different, with 74% of total runoff in the wet season (May-October) and 26% in the dry season (November-April). The highest monthly runoff occurs in August, with an average value of 813 mcm, and the lowest in March, with average 150 mcm. Due to the significant difference in runoff quantity between wet and dry seasons, one can expect that the extreme events of flood and draught might occur if no mitigation measures are provided.



(a) Flow Rate



(b) Runoff

Figure 5.37 shows the duration curve of the inflow at the main dam site, with the flow at probability of being equalled or exceeded. Based on the minimum flow of 26.4 m^3/s, it is equivalent to 99.58% probability.

Table 5.21 Estimated Monthly and Annual Mean Inflow at Nam Ngiep Dam Site (m^3/s)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ave
1971	76.2	67.6	83.4	65.4	119.1	233.8	418.9	275.0	226.9	136.4	108.7	90.7	158.5
1972	75.1	62.7	52.6	64.1	71.3	198.2	178.5	242.5	106.7	86.8	66.0	54.4	104.9
1973	45.1	37.8	31.6	26.4	66.0	119.3	158.8	247.9	313.1	117.3	89.0	74.1	110.5
1974	61.5	51.6	43.1	38.6	55.3	116.1	196.7	303.1	224.8	101.4	83.4	69.3	112.1
1975	57.9	48.2	40.3	35.3	127.4	333.6	173.6	220.3	242.8	177.3	103.3	85.9	137.2
1976	71.3	73.4	50.6	47.3	77.0	154.4	202.4	335.3	253.8	210.1	116.2	94.7	140.5
1977	78.6	65.8	55.2	47.4	48.1	103.5	288.2	159.5	196.4	85.2	70.9	59.1	104.8
1978	49.0	41.3	35.1	51.5	28.7	287.3	248.1	312.0	349.8	154.3	108.1	89.9	146.2
1979	74.6	63.5	52.6	48.4	185.6	191.0	217.7	217.9	167.0	98.1	79.3	66.0	121.8
1980	54.8	45.9	39.6	36.8	99.7	252.6	299.8	341.7	318.1	144.8	116.9	97.3	154.0
1981	80.7	67.6	56.6	67.2	102.4	186.1	348.7	288.9	306.2	224.9	121.7	101.3	162.7
1982	84.1	70.4	64.5	85.2	128.3	234.9	276.8	427.9	409.6	244.6	151.0	124.8	191.8
1983	103.5	102.5	85.1	76.0	100.1	149.2	319.3	359.6	303.9	203.8	141.9	109.5	171.2
1984	94.1	79.1	64.1	63.7	99.4	176.9	232.1	293.4	281.1	140.4	109.6	90.6	143.7
1985	74.8	62.6	52.5	57.5	277.3	307.5	341.7	268.4	256.7	144.7	116.5	99.1	171.6
1986	80.7	68.0	56.8	71.6	78.9	225.2	163.6	262.5	219.2	137.3	96.5	79.3	128.3
1987	65.8	55.2	46.2	38.9	56.7	205.1	260.7	327.7	308.1	193.0	111.8	92.7	146.8
1988	95.6	72.0	62.8	85.7	131.5	307.7	345.1	316.4	263.6	213.9	128.1	106.7	177.4
1989	88.5	74.0	70.8	106.8	104.2	272.7	222.1	296.7	241.8	166.9	111.6	92.9	154.1
1990	77.1	64.9	57.7	52.8	68.9	346.3	546.7	331.5	281.8	301.0	149.1	122.7	200.0
1991	101.9	85.3	71.7	79.7	72.3	160.4	257.0	297.5	218.7	126.3	96.4	80.3	137.3
1992	71.6	58.1	47.6	40.9	37.5	153.6	195.4	194.1	120.1	80.9	66.2	61.2	93.9
1993	46.4	38.9	32.6	31.4	81.5	209.6	370.2	266.4	157.2	121.5	91.0	75.8	126.9
1994	63.3	56.2	61.1	70.0	80.0	244.2	259.3	303.9	250.4	167.9	119.3	96.2	147.7
1995	79.8	66.8	55.9	56.8	111.9	206.9	399.0	483.0	300.4	159.3	128.7	106.6	179.6
1996	88.5	73.8	63.7	61.3	116.4	223.4	306.5	454.4	303.3	164.5	165.3	114.5	178.0
1997	95.2	79.5	72.5	122.4	157.6	181.9	349.5	361.4	341.0	180.7	136.0	113.2	182.6
1998	93.9	78.7	65.9	60.1	84.6	152.9	243.2	213.4	178.1	98.9	81.5	67.9	118.3
1999	56.3	47.1	42.0	48.0	262.9	304.6	282.4	381.2	335.1	184.6	136.4	113.1	182.8
2000	93.9	81.6	66.0	95.6	175.8	258.4	228.2	319.0	318.7	153.9	116.5	96.7	167.0
Ave	76.0	64.7	56.0	61.1	106.9	216.6	277.7	303.4	259.8	157.4	110.6	90.9	148.4
Max	103.5	102.5	85.1	122.4	277.3	346.3	546.7	483.0	409.6	301.0	165.3	124.8	255.6
Min	45.1	37.8	31.6	26.4	28.7	103.5	158.8	159.5	106.7	80.9	66.0	54.4	74.9

Figure 5.35 Basin Annual Mean Rainfall and Discharge (Inflow) at Nam Ngiep Dam Site

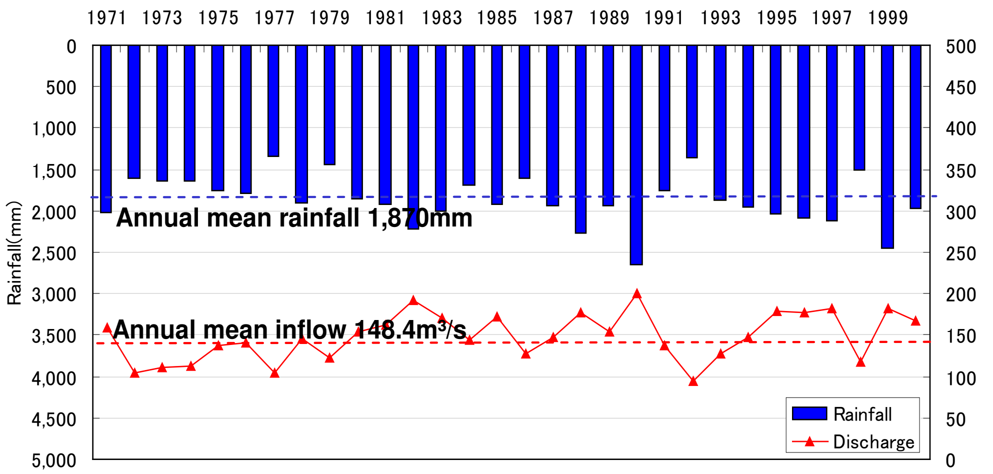
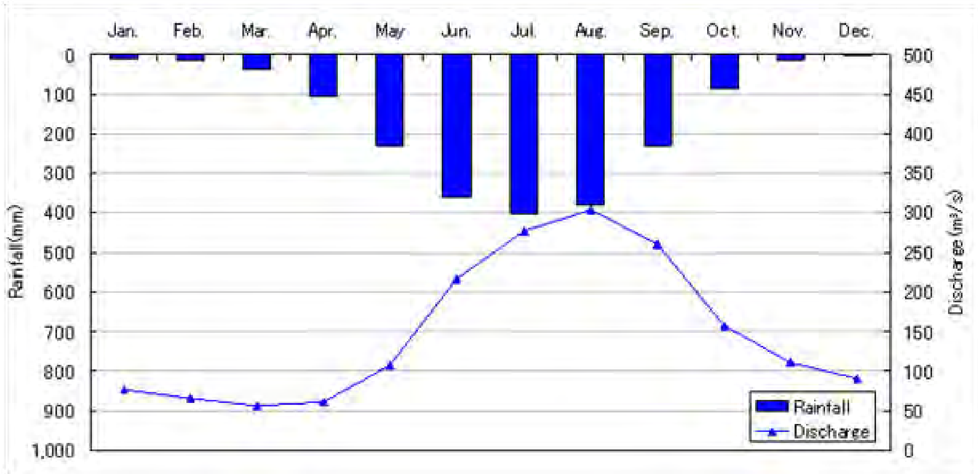
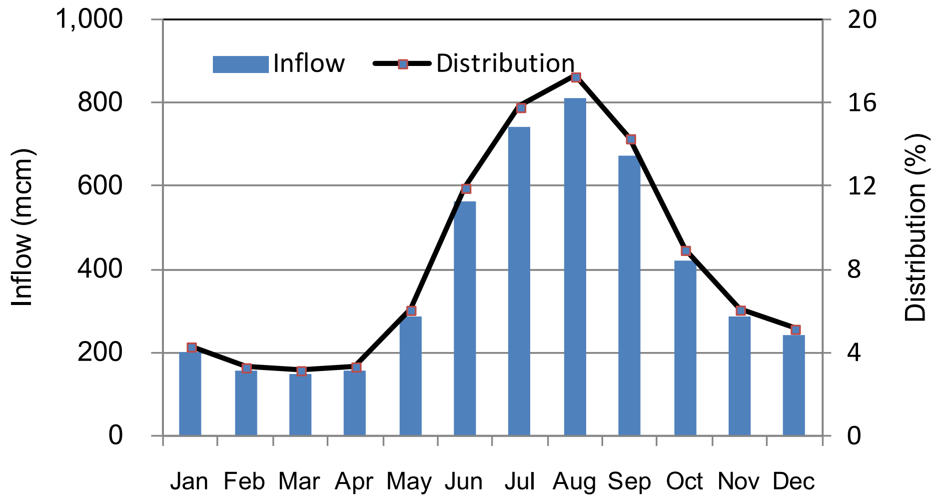


Figure 5.36 Seasonal Charge of Inflow at Nam Ngiep Dam Site

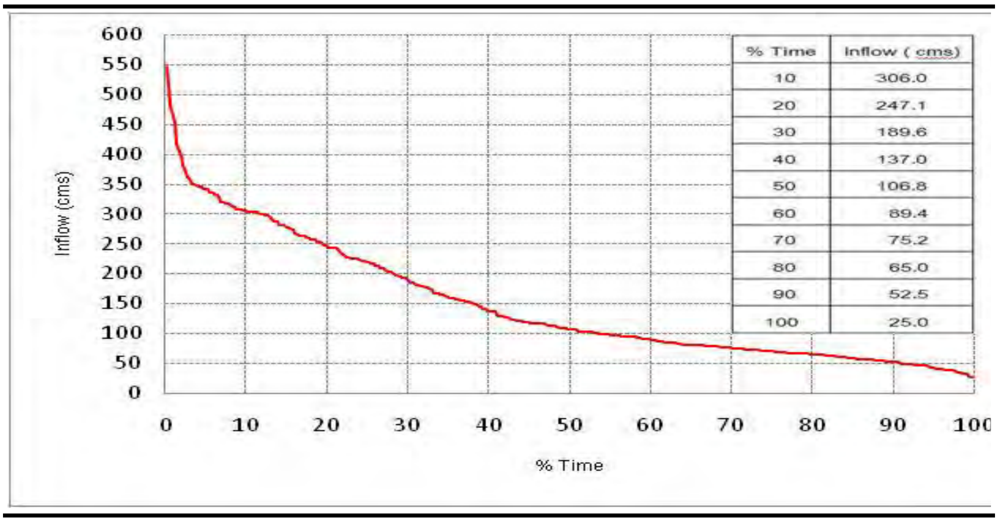


(a) Flow Rate



(b) Runoff

Figure 5.37 Flow Duration Curve at Nam Ngiep Dam



The annual average discharge (148.4 m^3/s) was compared with other projects located in the middle of Laos (the Nam Theum River basin) and in the northwest (the Nam Ngum River basin) to confirm values of runoff coefficient and the specific yield (***Table 5.22***).

Table 5.22 Comparison of Hydrological Characteristics with other Projects in North and Middle of Laos

Project	Source	Year	Catchment Area km^2	Annual average rainfall mm/year	Annual average discharge m^3/s	Specific yield $m^3/s/100\ km^2$	Runoff coefficient
Nam Ngiep 1	KANSAI Update F/S	2007	3,700	1,874	148.4	4.01	0.67
	Feasibility Study on the NAM NGIEP 1 Project (Phase II) Final Report: volume1 Main Report (JICA)	2002	3,700	1,874	147.2	3.98	0.67
Nam Ngum 2	Hydropower Development Strategy for LAO Draft Final Report (LAHMEYER)	2000	5,640	2,166	200.6	3.56	0.52
Nam Ngum 3			3,873	2,166	106.2	2.74	0.40
Nam Ngum 5			483	1,944	22.7	4.70	0.76
Nam Theun 3			2,338	-	110.00	4.70	-
Nam Theun 2	Water Management Plan for the NAM THEUN Final Report (NORPLAN	1997	4,013	2,250	233.0	5.81	0.81

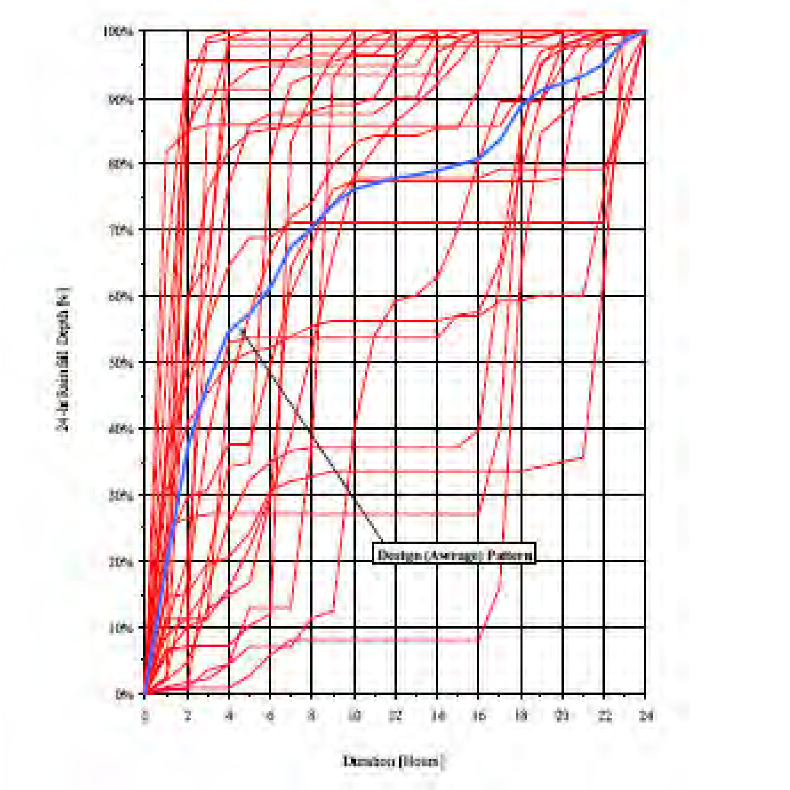
Project	Source	Year	Catchment Area km²	Annual average rainfall mm/year	Annual average discharge m³/s	Specific yield m³/s/100 km²	Runoff coefficient
	A.S.)						
Nam Ngum 1	Nam Ngum5 Hydropower	1997	8,460	-	308.0	3.64	-
Nam Ngum 5	Project Feasibility Study (LAHMEYER)		483	2,200	22.8	4.72	0.68
Nam Ngum 1	NAM NGUM 1 Hydropower	1995	8,460	2,250	301.2	3.56	0.50
Nam Ngum 2	Station extension		5,750	1,950	163.0	2.83	0.46
Nam Ngum 3	Feasibility and Engineering study Mid-term Report (LAHMEYER)		3,810	1,600	74.1	1.94	0.38

5.1.11.5 *Flood Analysis*

The hourly rainfall data for the Nam Ngiep basin was collected by the automatic rainfall recorder installed at Ban Thaviang, near the center of the basin (September 1998 - December 2000).

To estimate the hourly rainfall hydrograph under torrential rain conditions, 24-hour rainfall of 50 mm and more was selected from the hourly rainfall data observed at Ban Thaviang, and a pattern of typical rainfall of the Nam Ngiep basin was determined (***Figure 5.38).***

Figure 5.38 Accumulated Hourly Rainfall Curves



(1) Base Flow

Using the 13-year discharge data of Muong Mai station, the base flow at Muong Mai station was estimated at 400 m^3/s, and the base flow at the dam site was estimated at 350 m^3/s, by multiplying the ratio of the basin.

(2) Runoff Coefficient

Typical hydrographs were selected from the 13-year discharge data of Muong Mai station. By cutting off the base flow from the hydrographs, the effective rainfall was obtained, and a runoff coefficient was estimated.

(3) Unit Hydrograph

Hourly discharge data are necessary for preparing a unit hydrograph, but such data are not available for the Project area. Hence the dimensionless unit hydrograph quoted by the US Soil Conservation Service was used as a unit hydrograph.

(4) Probable Flood Discharge Estimation

Probable flood discharge estimation was made using two methods. The first was an estimation using annual maximum daily discharge data of Muong Mai station and frequency curve. The flood time peak discharge at Muong Mai site was converted from annual maximum daily discharge by multiplying with the correction coefficient (1.2). Log Peason Type-III was selected as the most suitable frequency curve.

The second method was an estimation of probable rainfall from the annual maximum daily rainfall (1971−2000) of the mean basin rainfall using a frequency curve.

(5) Flood Analysis Result

It is likely that actual discharge measurement at Moung Mai station was more reliable than the rainfall data estimated by the Thiessen method. Thus, 5,210 m^3/s of probable flood discharge in 1,000 years was adopted for designing the dam (***Table 5.23***).

Table 5.23 Flood Analysis Result

Probable year	Probable flood discharge (m^3/s)
10,000	7,920
1,000	5,210
500	4,560
200	3,800
100	3,290
50	2,840
30	2,530
20	2,300
10	1,930
5	1,590
2	1,150
1.01	680

5.1.11.6 Human Use Values of Nam Ngiep River

Like most tropical monsoon communities, the life of the people living along the Nam Ngiep River and its tributaries changes with the seasonal rains and the water levels. In a 16 year study of annual maximum and minimum discharge of the Nam Ngiep River, conducted from 1987 to 2002, average annual maximum flow was 1,046.76 m^3/s, while the average annual minimum flow as 29.72 m^3/s. Based on discussions with local residents, similar extremes in flow are found at all the communities, with at least some water available even in drier years.

Nam Ngiep River is utilized for various types of activities, other than fishery and navigation, by villages along the river. The river water is used for essential activities such as drinking, house consumption, bathing and washing.

Water sources of villages nearby the project, in addition to Nam Ngiep River, include groundwater wells. The villages relevant to the Project areas have their own water supply facility (see ***Table 5.24***). All villages in the affected area of the Project, from Zone 1 upstream to Zone 4 downstream, obtain their drinking water from gravity flow water systems, with the water obtained from springs or other sources with all-year flows, or from wells, with the Nam Ngiep and tributaries as a supplemental source of domestic water.

For most of its course, the Nam Ngiep passes through valleys with steep embankments. Even farther downstream, where the topography is less mountainous, the river flows through a valley between higher hills. Nearly all the agricultural fields are on lands well above the river. The main agriculture production – lowland rice, upland crops, and tree crops – depends upon rainfall rather than river water. A few areas are irrigated, but these use water from streams flowing down toward the Nam Ngiep from the mountains. Farmers use river water only for scattered small plots near the embankments. These are mostly vegetable plots, and they are planted when the waters are high and more accessible, just after the rice harvest in October or November.

The most important source of fish for the people in these communities is the Nam Ngiep River. Tributaries to the Nam Ngiep, as well as fish ponds, are also of some importance. For those communities farthest downstream, near the mouth of the river, the Mekong River is another important source of fish, whether caught by the households themselves or purchased from the market.

During the wet season, villagers will often navigate the river with long-tail boats. In the dry season, when the flow is much lower, villagers tend to use boats with oars, so as to better navigate the rocky outcrops and other hazards in the low-lying waters. The preferred method of fishing is with cast-net, and less so with fishhooks and with baskets.

Table 5.24 Infrastructure of Villages in the Project Area

Village	Infrastructure Service				Social Welfare						Private and Public Organiza-tion
	Electri-city	Water Supply	Road	Market	1° school	2° school	Health center	Temple	Ceme-tery	Grocery	
Zone 1-Upstream Area											
Thaviengxay	✓	✓	✓	✓	✓	-	N/A	-	✓	✓	-
Phonngeng	✓	✓	✓	✓	✓	-	N/A	-	✓	✓	-
Nasong	✓	✓	✓	-	✓	-	N/A	-	✓	✓	-
Viengthong	✓	✓	✓	-	✓	-	N/A	-	✓	✓	-
Nasay	-	✓	✓	-	✓	-	N/A	-	✓	✓	-
Xiengkhong	✓	✓	✓	-	✓	-	N/A	-	✓	✓	-
Nahong	✓	✓	✓	-	✓	-	N/A	-	✓	✓	-
Phonhom	✓	✓	✓	-	✓	-	N/A	-	✓	✓	-
Zone 2-Reservoir Area											
Zone 2UR											
Pou	-	✓	✓	-	✓	N/A	N/A	N/A	✓	✓	✓
Piengta	-	✓	✓	-	✓	-	N/A	N/A	✓	✓	✓
Hatsamkhone	-	✓	✓	-	✓	N/A	N/A	N/A	✓	✓	✓
Zone 2LR											
Houaypamom	-	✓	✓	-	-	-	-	-	✓	✓	-
Sopphouan	-	✓	✓	-	✓	-	-	-	✓	✓	-
Sopyouak	-	✓	✓	-	✓	-	✓	-	✓	✓	-
Namyouak	-	✓	✓	-	✓	✓	-	-	✓	✓	-
Zone 3-Construction Area											
Hatsaykham	-	✓	✓	-	-	-	-	-	✓	✓	✓
Zone 4-Downstream Area											
Nampa	-	✓	✓	N/A	✓	N/A	-	-	✓	✓	N/A
Xomxuen	✓	✓	✓	N/A	✓	N/A	-	✓	✓	✓	N/A
Houykhoun	✓	✓	✓	N/A	✓	N/A	✓	✓	✓	✓	N/A
Thong Noi	✓	✓	✓	N/A	✓	N/A	✓	✓	✓	✓	N/A
Thong Yai	✓	✓	✓	N/A	-	N/A	-	✓	✓	✓	N/A
Sanaxay	✓	✓	✓	N/A	✓	N/A	-	-	✓	✓	N/A
Phonsy	✓	✓	✓	N/A	✓	N/A	-	-	✓	✓	N/A
Pak Ngiep	✓	✓	✓	N/A	-	N/A	-	✓	✓	✓	N/A
Sanoudom	✓	✓	✓	N/A	✓	N/A	-	✓	✓	✓	N/A
Zone 5-Resettlement Area											
Hat Gniun	-	✓	✓	-	✓	-	-	-	✓	✓	✓
Thahuea	✓	✓	✓	N/A	✓	N/A	-	✓	✓	✓	N/A

Table 5.25   Other Activities Related to the Nam Ngiep River

Village		XomXuen	HuayKhoun	Hat Guiun	HatSayKham	ThaHue	ThongNoy	ThongYai	NamPa	XaNaXay	NamNgiep	PhoneSy	SaenOuDom
Total		1196	2191	610	217	273	849	529	521	1185	955	753	NA
M		597	1108	323	105	152	433	279	270	599	484	373	NA
FM		599	1083	287	112	121	416	250	251	586	471	380	NA
Laundry	description	some HH	NA	NA	for HH consu	NA	villager using	NA	NA	general using	NA	HH consump	NA
	number of occupation	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	annual income (kip)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	operation period (year-year)	NA	NA	NA	NA	NA	1937-2012	NA	NA	NA	NA	1964-2012	NA
Bathing	description	some person	go to upland ,g	NA	NA	NA	villager using	NA	people go to t	take shower	take shower	HH consump	NA
	number of occupation	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	annual income (kip)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	operation period (year-year)	NA	NA	NA	NA	NA	1937-2012	NA	until 2012	NA	until 2012	NA	NA
Power generati	description	NA	NA	use genarator	NA	NA	NA	NA	NA	NA	NA	NA	NA
	number of occupation	NA	NA	20	NA	NA	NA	NA	NA	NA	NA	NA	NA
	annual income (kip)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	operation period (year-year)	NA	NA	6	NA	NA	NA	NA	NA	NA	NA	NA	NA
Extracting sand	description	NA	By use Excav	NA	excavate san	NA	NA	NA	By use Excav	NA	Excavate san	NA	NA
	number of occupation	NA	1	NA	NA	NA	NA	NA	1	NA	NA	NA	NA
	annual income (kip)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	operation period (year-year)	NA	2010	NA	NA	NA	NA	NA	1992-1993;19	NA	NA	NA	NA
Mining	description	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	number of occupation	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	annual income (kip)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	operation period (year-year)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Drinking	supplied HH or area(ha)	221	NA	NA	30	NA	NA	NA	58	NA	NA	NA	NA
	quantity of water supply(m3/day)	based on usin	NA	NA	100	NA	20	NA	10	NA	NA	150	NA
	water supply period(days/year)	365	NA	NA	180	NA	NA	NA	180	NA	NA	NA	NA
	charge (kip)	NA	NA	NA	NA	NA	4000	NA	NA	NA	NA	NA	NA
	method of intake	carry,pump	NA	NA	carry	NA	pump	NA	carry	NA	NA	pump	NA
	operation period (year-year)	until 2000	NA	NA	1994-2012	NA	1937-2012	NA	until 2008	NA	NA	2002-2012	NA
HH consuming	supplied HH or area(ha)	221	NA	NA	30	NA	NA	NA	97	unit 1,2,3 of v	100	NA	NA
	quantity of water supply(m3/day)	based on usin	NA	NA	200	NA	4000	NA	200	NA	200	200	NA
	water supply period(days/year)	365	NA	NA	180	NA	NA	NA	365	NA	365	NA	NA
	chage (kip)	NA	NA	NA	NA	NA	NA	NA	NA	NA	20,000	NA	NA
	method of intake	carry,pump	NA	Carry	carry	NA	pump	NA	pump	pump	pump	NA	NA
	operation period (year-year)	until 2000	NA	NA	1994-2012	NA	1937-2012	NA	until 2012	NA	until 2012	NA	NA
Irrigation	supplied HH or area(ha)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	pumping for	NA
	quantity of water supply(m3/day)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	water supply period(days/year)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	chage (kip)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	60,000/day	NA
	method of intake	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	operation period (year-year)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Fishery	apporving organization	Luxembourg	NA	NA	word vision	NA	NA	NA	Luxembourg	NA	WWF;MoAF	NA	NA
	period of right(year)	3	NA	NA	2007-2012	NA	NA	NA	2008-2012	NA	2001	NA	NA
	approved date	NA	NA	NA	10/05/2007	NA	NA	NA	2008	NA	2011	NA	NA
	expense of right (kip)	NA	NA	NA	800,000	NA	NA	NA	900,000	NA	NA	NA	NA
Irrigation water	apporving organization	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	period of right(year)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	approved date	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	expense of right (kip)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

5.1.11.7 *Hydrogeology*

Based on the geological information and boring holes (depth <=150 m) at the main dam site and its appurtenance structures, it was found that the areas are composed of sandstone, mudstone and conglomerate. Generally, the groundwater obtained from these types of rocks is from the crack areas, and their yield are very limited, at about 1-5 cu.m/hr. With a Lugeon Test at a depth more than 20-30 m, the hydraulic conductivity of most of the soil was found to be low.

5.2 BIOLOGICAL ENVIRONMENT

The terrestrial biodiversity values have been described using a combination of desktop based information sources (for example literature, databases, and species profiles), field collected data (2007 and 2013 studies) and geospatial analysis. The following reports have been provided in full as *Appendices*:

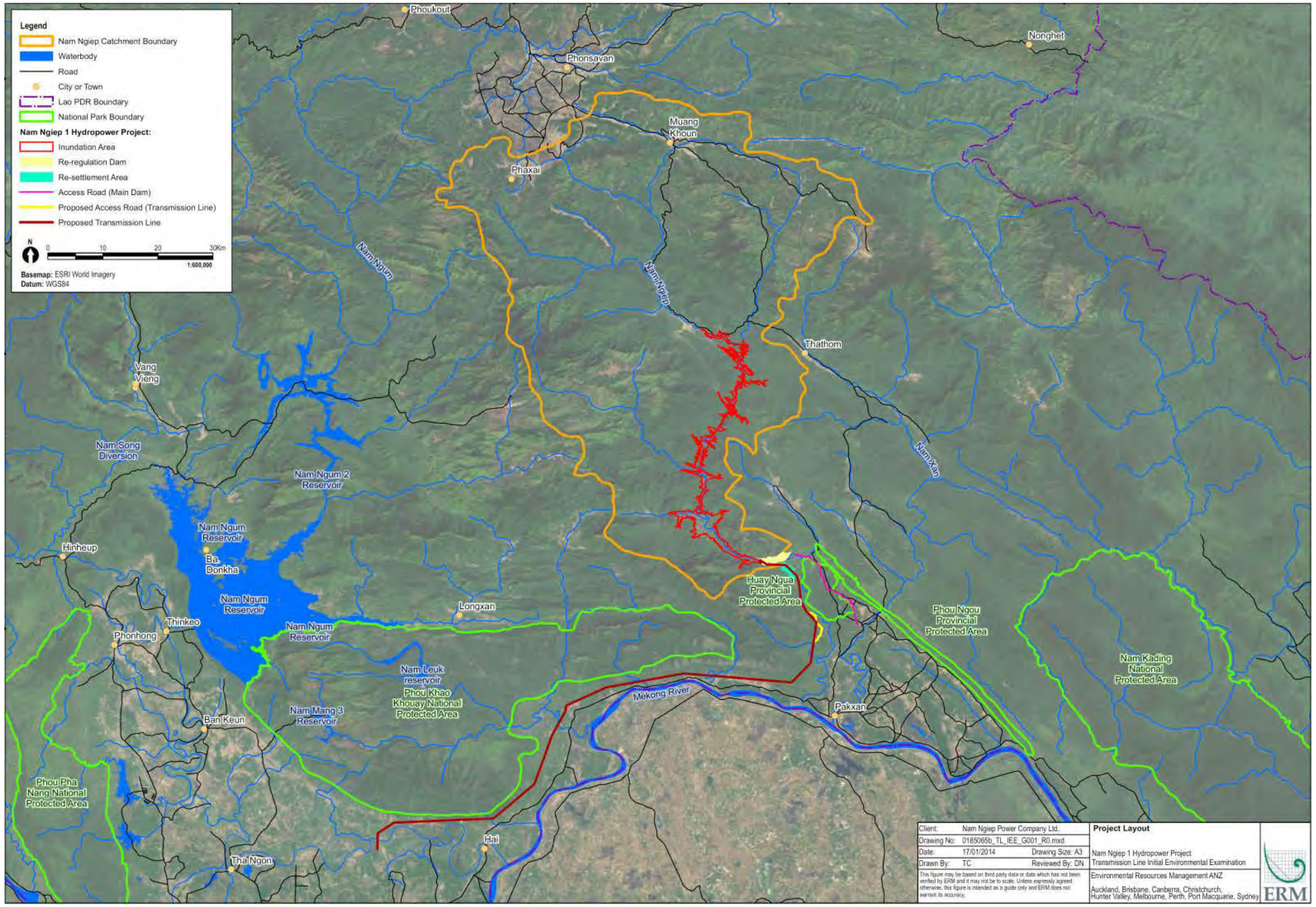
- ERM (2014a) Nam Ngiep 1 Hydropower Project - Baseline Biodiversity Assessment Report (*Appendix A*);
- ERM (2014b) NNP1 Transmission Line from the Main Dam to Vientiane Initial Environment Examination (*Appendix F*); and
- ERM (2014c) NNP1 Access Road from Ban Nomsomboun to the Main Dam Environment Assessment (*Appendix E*).

The description of the biological environment focuses on developing an understanding of the biodiversity directly and indirectly relevant to the Project and its activities. For the purposes of this assessment, the following terminology applies:

- Study area – the area encompassing all areas assessed for biodiversity values. This includes the Project are and candidate offset sites (***Figure 5.39***).
- Project area (the focus of this impact assessment) – the area potentially directly and indirectly affected by the Project. This includes the footprint of disturbance of the various components and surrounds. The Project footprint is approximately 8359 ha.
- Candidate offset sites – the areas investigated to provide potential offset sites. This included consideration of the biodiversity values at four locations the Upper Nam Ngiep River, Nam Xan River, Huay Ngua Provincial Protected Area and the Phou Khao Khoay (PKK) National Protected Area (NPA).

The overall Study area consists of two adjacent catchments in Lao PDR. The Nam Ngiep and Nam Xan catchments which are in the Bolikhamxay Province, 145 kilometres (km) northeast from Vientiane or 50 km north from Pakxan District.

Figure 5.39 Biodiversity Study Area



The sub-catchment of Nam Ngiep River where the Project area is located is approximately 340,000 ha in size. The inundation area proposed for this Project will consist of two reservoirs; the main reservoir (main dam) being 6700 ha in size; and a smaller subsidiary reservoir (re-regulation dam) being 130 ha in size. The total length of the proposed inundation area from Ban Piengta to the proposed main dam is around 73 km and from main dam to the proposed re-regulating dam is around 5 km.

The Nam Xan catchment is 21,000 ha in size. The study area encompasses a 140 km reach of the Nam Xan River and the surrounding forested areas and villages. A detailed description of all Project components is provided in *Chapter 4*.

5.2.1 *Baseline Survey Effort and Timing*

The NNP1 Project Environmental Impact Assessment (EIA) document was completed in 2012, which included an ecological investigation undertaken by the ERIC. The investigation included studies on the biological environment of the Project area covering terrestrial ecology and wildlife, forest and vegetation cover, aquatic biota and wetlands.

ERIC surveyed the Project area in March and October 2007 in order to identify threatened species occurring in or near the Project area, and whether the Project has potential to impact their habitats. The assessments were carried out through visual inspections, interviews with villagers on wildlife conditions and utilisation of secondary data sources. Results of the surveys indicated that current clearing and general habitat disturbance has resulted in many species not occurring in the Project area.

In order to supplement the available information, field investigations were undertaken in March and July 2013 by the Thailand Institute of Scientific and Technological Research (TISTR) to collect data representative of wet and dry season biodiversity conditions. The surveys incorporated detailed assessments that included forest and vegetation cover survey and assessment, wildlife survey and assessment, and aquatic ecology survey and assessment. These updated surveys form the basis of this assessment and are reported itn the Nam Ngiep 1 Hydropower Project - Baseline Biodiversity Assessment Report as provided in *Appendix A*.

Field reconnaissance were also undertaken along the access road route in 2013 by the National University of Laos as reported in NNP1 Access Road from Ban Nomsomboun to the Main Dam Initial Environment Examination. The Lao PDR Department of Forest Resource Management (DFRM) undertook a flora survey to record tree species adjacent to the existing road between Ban Nonsomboun and Ban Hat Gniun in August

2013 and results were provided to ERM Siam. This assessment was completed independent of the NNP1 assessment.

These sources provide description of vegetation communities and habitats, and species that may occur in the Project area. A summary of the survey methods, including the key literature references, is provided in ***Table 5.26.***

Table 5.26 Summary of Survey Methods and Information Sources

Researcher	Date	Location	Study Topic
Terrestrial			
Dr Phaivanh Phiapalath	November 2013	Main dam inundation area	• Targeted IUCN listed primate species survey and critical habitat assessment
Pheng Phengsintham[5]	November 2013	Access Road Project Area	• Habitat classification (natural/modified) • Tree species identification • Study area included: o Full length of: Ban Nonsomboun to Ban Hat Gniun; JICA Road; T9; T10 and T11; and T12. o Portions of T7 and T8. The complete area surveyed, and locations of sample plots, are shown in the Access Road EA (ERM 2014c) (*Appendix E*).
TISTR	March and July 2013	Resettlement site Huay Ngua PPA	• Targeted searches of fauna or signs of fauna (tracks, scats etc) in areas of preferred habitat • Spotlighting • Mist-net capture of birds • Trapping of small mammals • Interview of local residents • Sampling plots for flora species diversity
ERIC	October and March 2007	NNP1 Project area (from the dam site north)	• Interview of local residents • Targeted searches of fauna or signs of fauna (tracks, scats etc) in areas of preferred habitat • Assessment of flora diversity, density, and biomass of large trees.
DFRM	2013	Ban Nonsomboun to Ban Hat Gniun road corridor	• Survey to record tree species in vegetation proposed to be cleared to widen the existing road.
PAFO	Date unknown	Huay Ngua PPA	• Interview of local residents • Camera trapping
GIS	various	Regional scale	• Land cover mapping • Rapid Eye imagery and NDVI processing
Aquatic			
ERIC	October and March	Ten stations including	• Fish sampling using a seine net

5 Local botanist and lecturer of the National University of Laos.

Researcher	Date	Location	Study Topic
	2007	stations at Hatsaykham, Hat Gniun and Xomxeun.	• Plankton sampling • Benthic sampling
PAFO	Date unknown	Huay Ngua PPA	• Interview of local residents • Camera trapping

Note: PAFO – Provincial Agriculture and Forestry Office (Bolikhamxay)
Source: Access Road EA (ERM 2014c)

The data collated for the purposes of this report can be categorised into two types:

Direct: Species recorded during biodiversity field surveys undertaken during 2007 and 2013 are considered direct counts. In general the location and details of this data has been recorded and a higher level or certainty can be inferred.

Indirect: Species reported from village surveys or within reports (secondary data) using a more regional study area are considered indirect records. These data sources provide a valuable understanding of the biodiversity of the locality and region however should be afforded further analysis or applicability considered. Data obtained from village surveys can contain errors in some instances, especially when considering identification of species with more challenging diagnostic features.

The reliability of the records has been considered throughout the report and the data category of species records is denoted.

5.2.2 *Regional Biodiversity Values*

The proposed Project is located in central Lao PDR within the Mekong River basin in the Luang Prabang Montane Rainforest Ecoregion (IM0121), as defined by the Worldwide Fund for Nature (WWF) (WWF, 2003a).

Terrestrial ecoregions are natural ecological communities with shared species, dynamics and environmental conditions and offer a useful way of understanding the biodiversity within an area (ADB & UNEP, 2004). The Luang Prabang Montane Rainforests ecoregion comprises areas largely above 800 m in north-central Lao PDR and is globally recognised for its diversity in bird species (some 540 different species of birds have been recorded) despite more than 70 per cent of the original forest cover being lost as a result of shifting cultivation. The remaining forests contain a rich mix of tree and non-timber species including hardwoods, conifers, rhododendron, ferns, orchids and lichens (WWF, 2003b). No endemic species have been recorded in this ecoregion but this is thought to be due to the lack of biological surveys rather than a true lack of endemics.

The ecoregion is characterised by a variety of forest associations including montane hardwoods, mixed conifer-hardwood forests, open montane forests, and open conifer forests (Wikramanayake et al., 2002). These forests have been subject to heavy logging pressure and much of the forest cover of central Lao PDR is subject to existing forestry operations, or occurs within approved forest leases. Humid evergreen forest occurs at lower elevations around 800 m with *Dipterocarpus turbinatus* and *Toxicodendron succedanea* as the dominant over storey species. The low stature of trees in this community and open understory with an abundance of broad-leaved monocots and grasses suggest severe past impacts from burning and clearance (Wikramanayake et al., 2002). Slash and burn agriculture is a land use that is still practiced widely in central Lao PDR, including the Project area (ERM, 2013b).

Large tracts of remnant and intact forest are reported to occur in less accessible parts of the ecoregion housing several large mammals such as Northern White-cheeked Gibbon (*Nomascus leucogenys*), Tiger (*Panthera tigris corbetti*), Asian Elephant (*Elephas maximus*) and Asiatic Black Bears (*Ursus thibetanus*); all of which are considered to be under continued threat due to habitat loss and hunting/ poaching (WWF, 2003b).

The ecoregion, and the biodiversity housed within it, continues to be threatened by intensive land use pressures, such as cultivation, agriculture, mining and hydropower. As of 2004, the remaining forest cover in Lao PDR was considered to be approximately 41.5 per cent, which is a significantly less than the 1940 estimation of approximately 70 per cent (World Bank, 2005).

These pressures are coupled with use by local communities pose additional threats to the biodiversity values of the area. This includes hunting of small mammals and firewood collection in nearby forests and fishing in local waterways. Much of what is caught and/ or collected is consumed locally (i.e. within household) rather than sold at market.

The existing road from Ban Nonsomboun to Ban Hat Gniun traverses the Huay Ngua Power Purchase Agreement (PPA) and will be upgraded as part of this project. The PPA was established in 2010 and is located to the east of the Nam Ngiep River between Borikham and Hat Kham. It is an important part of a wildlife corridor between PKK and along the Nam Ngiep River. The area is considered significant for aquatic and terrestrial wildlife habitat (Provincial Conservation Division, 2010) as well as providing a research site of Province Agriculture and Forestry School. The Huay Ngua PPA currently does not have any formal management arrangements in place to facilitate its management. A management committee under Central, Provisional or District levels of government has not been established. A Management Plan for the Huay Ngua PPA has been prepared but it has not been implemented as no funding currently exists to pay for the management actions it contains. The priority actions to manage the Huay Ngua PPA included in the plan are related to:

- raising community awareness to increase participation in sustainable uses;
- improving community livelihoods in and around the Huay Ngua PPA to assist in management of natural resources;
- law enforcement and patrolling;
- biodiversity research and monitoring; and
- development of ecotourism opportunities.

The forest and wildlife is considered a high value resource with increasing demand in Lao PDR and neighbouring countries. The Huay Ngua PPA is abundant in these resources. Some fauna species have been impacted by hunting and trapping for local and regional market and there is harvesting for rosewood and agar wood (*Aguilaria cassna*) (Provincial Conservation Division, 2010).

The Phou Khao Khoay NPA is a protected are near Vientiane that encompasses a range of landscapes from sandstone cliffs and river gorges to rugged mountain slopes. The area is dominated by natural habitat and a number of IUCN Red List species are considered to occur in the area. The Project Area does not intersect this national protected area rather traverses the foothills that are associated with the region.

Both of these conservation significant areas (Huay Ngua PPA and Phou Khao Khoay NPA) are considered as candidate offset sites for the project as outlined within the separate Biodiversity Offset Assessment (ERM 2014d).

5.2.3 *Forests and Vegetation Cover*

The Project will cover parts of three provinces, and so will affect forest and other vegetative cover in those areas. The largest area will be affected by the reservoir, most of which is located in Hom district, Vientiane Province and Bolikhan district, Bolikhamxay Province.

5.2.3.1 *Land Cover*

The Lao landscape has historically been dominated by dense forest and, despite more recent clearance, retains significantly more forest coverage than neighbouring countries Thailand, Vietnam and China (Yunnan Province) (Duckworth et al., 1999). The original forests of the Northern-

Central Highlands, where the Project is located, were predominantly dry evergreen and mixed deciduous forests. However, shifting cultivation has removed much of the original forest and large areas of grassland, bamboo and other secondary vegetation are now present. Non-timber forest products (NTFPs) such as leaves, shoots, flowers, fruits and bark are used extensively by the Lao people and are of great importance both as a food source and also medicinally and culturally.

Using land cover mapping (DFRM, 2010), natural and modified habitats, in accordance with IFC definition, can be identified within the Project Area (refer to ***Table 5.27*** and ***Figure 5.40***).

As detailed in Baseline Biodiversity Assessment Report (ERM 2014a; refer to *Appendix A*), the vegetation within the Project Area is dominated by forest (natural habitat) and fallow land vegetation (modified habitat). The deciduous forest land cover dominates the Project Area, representing approximately 35 per cent of the footprint. Young and old fallow land is also highly represented with 16 and 21 per cent respectively.

Within the main dam, approximately 50 per cent of the area is mapped as natural habitat with deciduous forest the dominant land cover type. Patches of natural habitat are dispersed throughout the main dam inundation area though it is the narrower stretches of the inundation area where the majority of the deciduous forest and evergreen forest is mapped. The fallow lands and rice paddy areas dominate the lower third of the inundation area, in particular in large patches where the dam inundation will be its widest at Vang Naxay and Na Nhao.

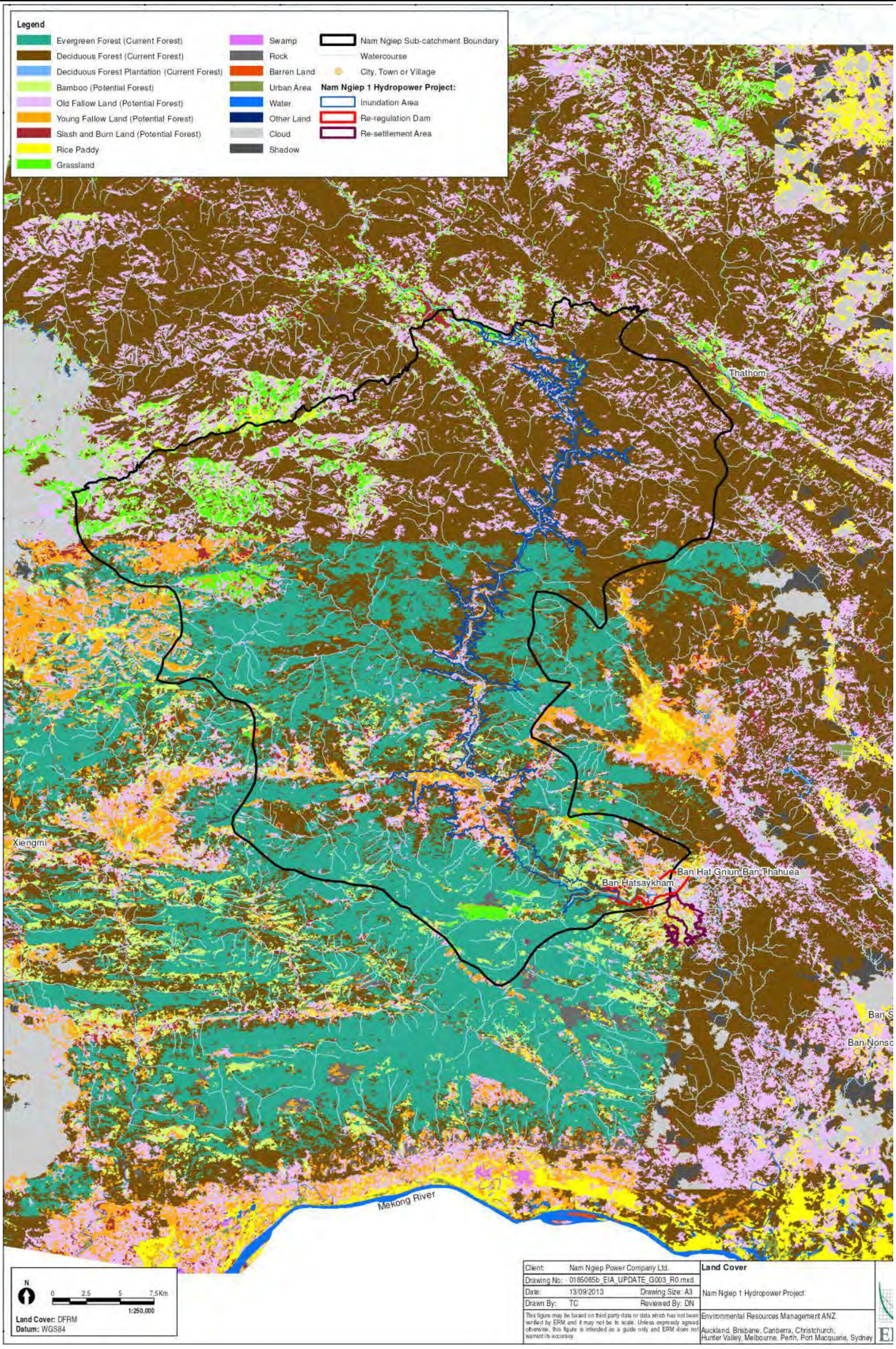
Within the re-regulation dam area, approximately 40 per cent is mapped as natural habitat with high proportions of deciduous forest and bamboo, mainly located on the southern bank of the Nam Ngiep River. These land cover types are located in the upper re-regulation dam area as the lower reach is dominated by fallows lands.

The resettlement site is mapped with approximately 40 per cent natural habitat which is primarily bamboo and a small area of deciduous forest. The bamboo is distributed throughout the fallow lands, though the deciduous forest is generally restricted to the edges of the proposed resettlement area.

The access road mapping identifies the dominant landcover types to be deciduous forest, with smaller portions of old fallow land. Approximately 60 per cent is mapped as natural habitat which is primarily deciduous forest and a small area of bamboo.

The transmission line mapping identifies the dominant landcover types to be deciduous forest and old fallow land, with smaller portions of young fallow land and rice paddies. Approximately 40 per cent is mapped as natural habitat which is primarily deciduous forest and a small area of bamboo. The land cover types mapped are based on a 35 m wide ROW.

Figure 5.40 Land Cover within the Project Area



(a)

Figure 5.40 Land Cover within the Project Area (continue)

(b)

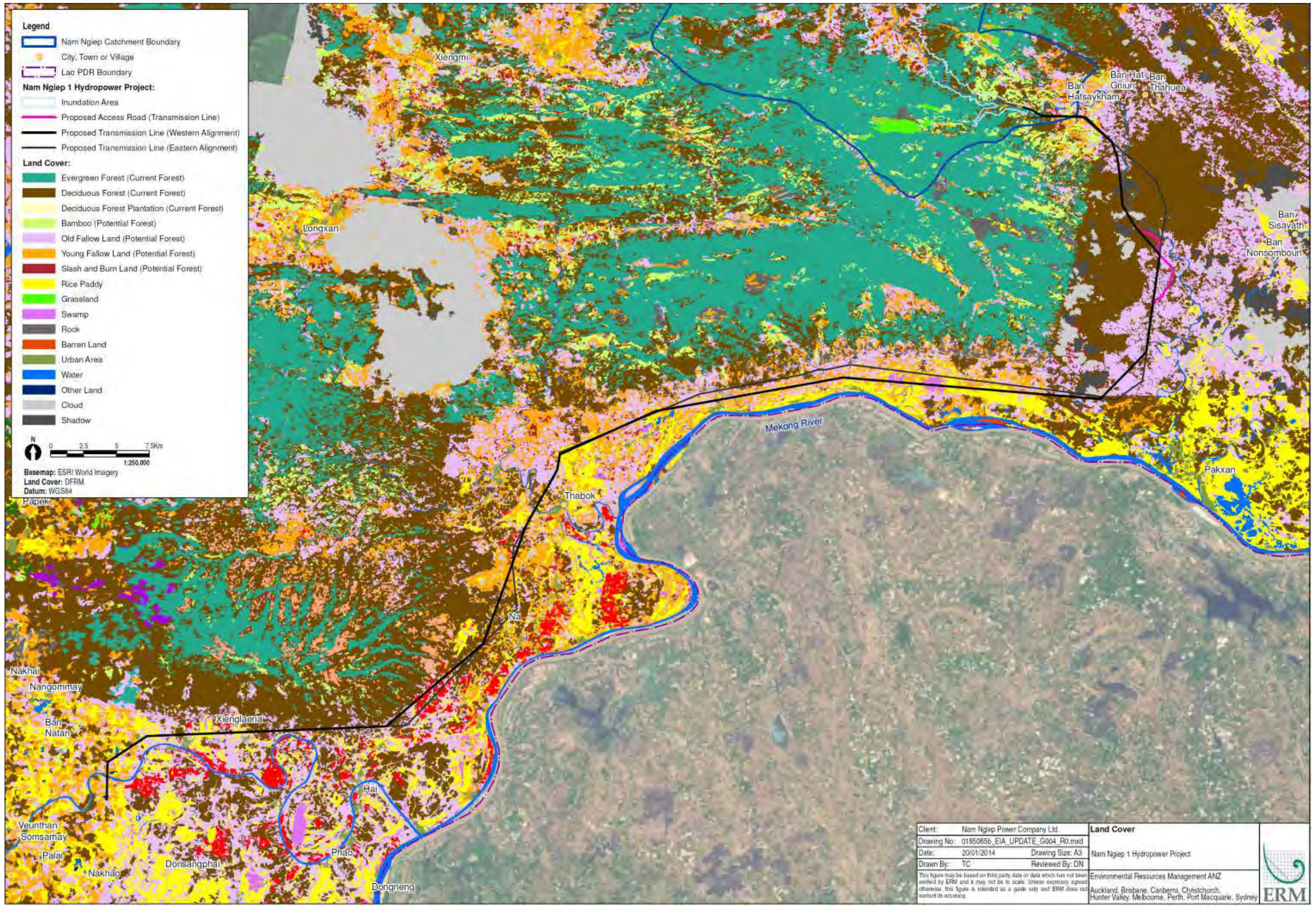
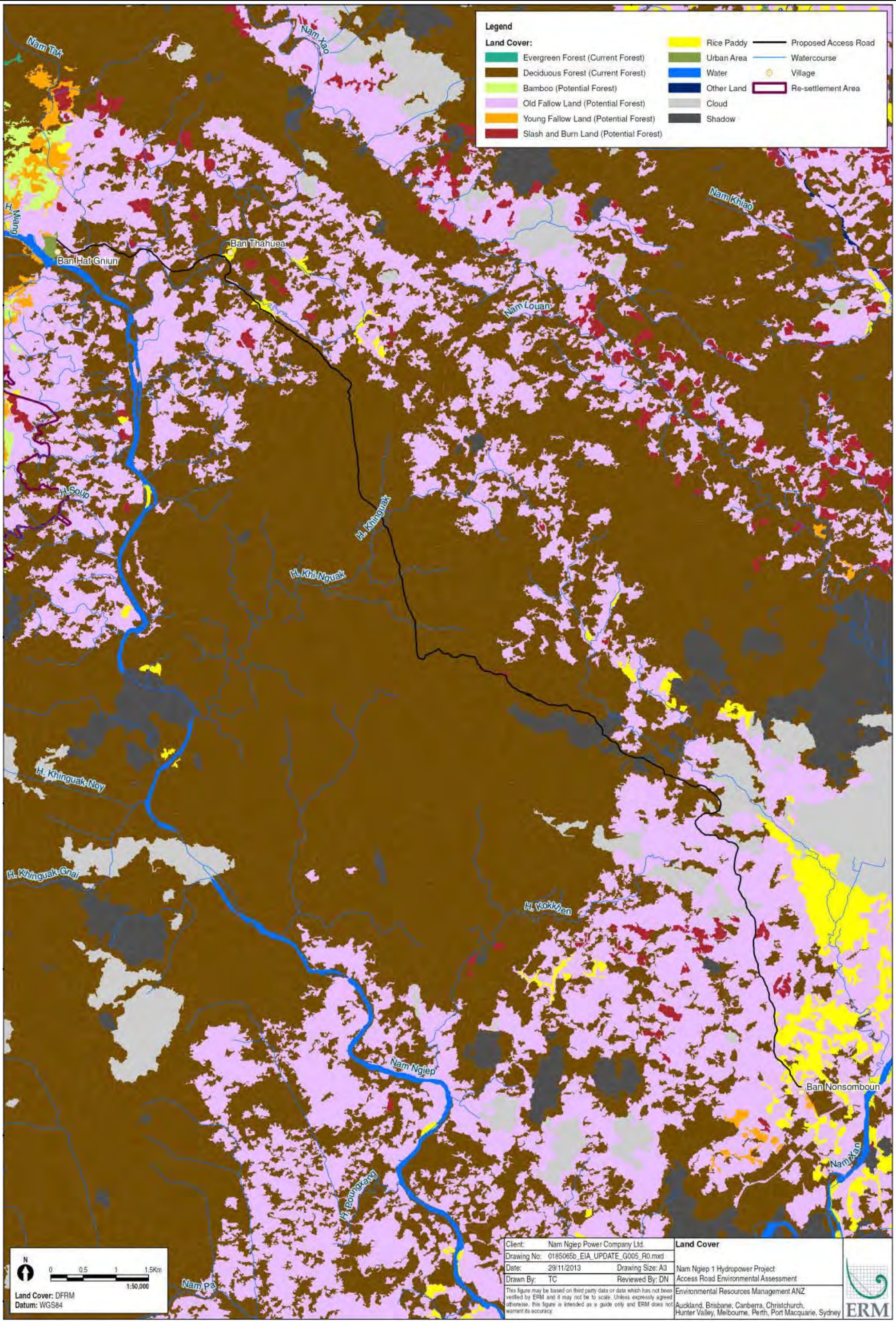


Figure 5.40 Land Cover within the Project Area (continue)



(c)

Table 5.27 Landcover within the Project Areas

Land Cover	IFC Habitat Class	Description	Area (ha)					Total (ha)	% of Total
			Main dam	Re-regulation dam	Resettlement	Access Road*	Transmission Line#		
Natural Habitat								117411	
Deciduous Forest (DF)	N	Deciduous forest occurs when deciduous tree species represent more than 50% of the stand. The forest storeys are not as dense as those of evergreen type. Deciduous Forest includes both upper and lower deciduous forest types and this definition is based on relative altitude, forest occurring above 200 m is classified as Upper Mixed deciduous Forest and deciduous forest occurring at an altitude 200 m and below is classified as Lower Deciduous Forest.	2690	131	56	19	122	3018	35%
Evergreen Forest (EF)	N	Area dominated by trees where 75% or more of the tree species maintain their leaves all year. Canopy is never without green foliage.	488	24	0	2	1	515	6%
Bamboo (B)	N	Bamboo area where the over storey has a crown cover less than 5%.	236	127	132	7	6	508	6%
Scrub, Heath (SR)	N	This is an area covered with scrub and stunted trees. The soil is shallow and rocky.	0	0	0	0	2	2	<1%
Swamp (SW)	N	Areas where the soil is saturated with water. The soil may basically be fertile but the lack of oxygen limits its agricultue or forest capacity. The swamp could have high ecological or environmental value and the flora and fauna may be rich.	0	0	0	0	7	7	<1%
Modified Habitat								100249	
Agriculture Plantation (AP)			0	0	0	0	7	7	<1%

Land Cover	IFC Habitat Class	Description	Area (ha)					Total (ha)	% of Total
			Main dam	Re-regulation dam	Resettlement	Access Road*	Transmission Line#		
Old fallow land (OFL)	M	Land that has been ploughed and tilled and left un-seeded during a growing season.	1321	194	163	12	124	1814	21%
Young fallow land (YFL)	M	Land that has been recently ploughed and tilled and left un-seeded during a growing season.	1036	143	82	5	68	1334	16%
Rice paddy (RP)	M	Areas permanently being used for rice cultivation.	107	5	15	1	53	181	2%
Slash and burn (SB)	M	Slash-and-burn is a description of land that has been subjected to an agricultural technique which involves cutting and burning of forests or woodlands to create fields.	328	27	19	1	4	379	5%
Grassland	M	Unfertile or degraded land on which no trees or shrubs grow. It might be an area that is too dry for tree growth that has been covered by grasses. It could also be an area that has originally been covered by trees, but has been heavily disturbed by cutting and fire and gradually depleted.	108	0	0	0	0	108	1%
Urban Area	M	Urban Areas include all areas being used for permanent settlements such as villages, towns, public gardens etc. It also includes roads having a width of more than 5 m and areas under electric high power lines.	38	3	0	<1	0	0	<1%
Unclassified								83924	

Land Cover	IFC Habitat Class	Description	Area (ha)					Total (ha)	% of Total
			Main dam	Re-regulation dam	Resettlement	Access Road*	Transmission Line#		
Water	-	The land cover class Water includes rivers, water reservoirs (i.e. ponds and dams for irrigation and hydro power) and lakes. Water reservoirs and lakes with an area of 0.5 ha and rivers should be at least 10m wide to be classified as Water.	368	42	0	<1	3	3	5%
Shadow	-	Shadow indicates limitations in the dataset from shadows and cloud contained in the aerial imagery.	16	0	0	1	<1	18	<1%
Cloud	-	Cloud indicates limitations in the dataset from shadows and cloud contained in the aerial imagery.	4	0	0	<1	4	9	<1%
Other	-		0	0	0	0	<1	1	<1%
Rock	-	Unfertile or seriously degraded land on shallow soil and rocky areas on which neither trees nor grasses can grow.	1	0	0	0	<1	2	<1%
		Total	6741	696	467	51	404	8359	

Note: *Access Road calculations based on 9.5 m wide road corridor.
#Transmission line calculations are based on an 125km long, 35m wide ROW

5.2.3.2 *Vegetation Condition*

The NDVI features recorded in Rapideye Imagery provides an index of vegetation density and condition at the time of image capture. It indicates the photosynthetic capacity of the land surface cover and has been used to refine the vegetation type extents into an additional level of detail. The NDVI across the Project Area is shown in ***Figure 5.41*** and the area of each classification is detailed within ***Table 5.28***.

Table 5.28 Vegetation Condition in the Project Area

Forest type	Impacted (- to 0)	Low (0 - 0.4)	Moderate (0.4 - 0.6)	High (0.6 - 0.8)
Main Dam (inundation area)(ha)				
Deciduous Forest	31	154	1091	1445
Evergreen Forest	20	38	266	184
Old Fallow Land	10	93	573	644
Young Fallow Land	19	217	549	250
Bamboo	5	21	67	147
Slash and Burn	10	171	96	51
Rice Paddy	5	72	27	2
Water	237	80	39	12
Grassland	8	34	51	16
Urban Area	1	31	6	0
Rock	1	0	0	0
Cloud	2	1	0	1
Shadow	8	5	2	0
Total (ha)	357	917	2767	2752
% of Total	5%	13%	41%	41%
Re-regulation Dam (ha)				
Deciduous Forest	1	10	75	47
Evergreen Forest	2	5	16	4
Old Fallow Land	2	30	139	24
Young Fallow Land	1	14	101	27
Bamboo	0	11	59	57
Slash and Burn	0	7	15	4
Rice Paddy	0	4	1	0
Water	32	7	2	0
Urban Area	0	3	0	0
Total (ha)	38	91	408	163
% of Total	5%	13%	58%	23%
Resettlement Site (ha)				
Deciduous Forest	0	8	39	10
Old Fallow Land	0	37	106	20
Young Fallow Land	0	25	48	10
Bamboo	0	19	77	36
Slash and Burn	0	5	12	2
Rice Paddy	0	7	7	1
Total (ha)	0	101	289	79
% of Total	0%	22%	62%	17%
Access Road Network				
Ban Nonsomboun – Ban Hat Gniun	<1	11	6	<1
JICA Road	<1	2	4	<1
Permanent Roads Ban Hat	<1	1	6	3

Forest type	Impacted (- to 0)	Low (0 - 0.4)	Moderate (0.4 - 0.6)	High (0.6 - 0.8)
Gniun				
Temp Roads Ban Hat Gniun	<1	2	8	5
Total (ha)	<1	16	24	14
% of Total	<1%	33%	50%	17%
Transmission Line				
Transmission Line	7	159	212	25
% of Total	2%	40%	52%	6%

Over 80 per cent of the Project Area is classified as moderate or high NDVI. Only 5 per cent of the Project Area is classified as impacted NDVI.

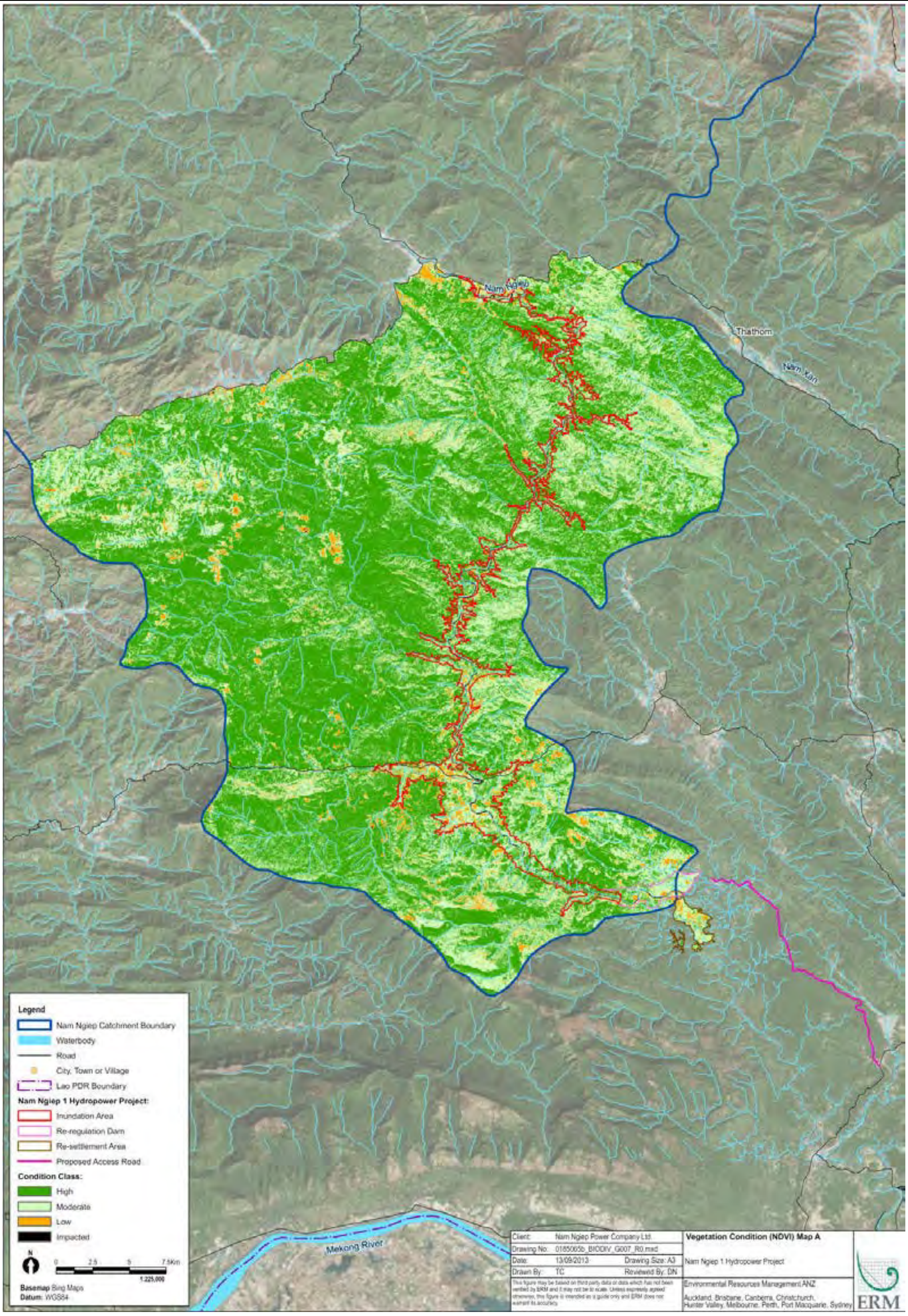
5.2.3.3 *Forestry Classification Mapping*

Forestry classification mapping identifies both protection forest and production forest across the Project Area. ***Figure 5.42*** depicts the extent of protected and production forest within the Project Area and shows that greater than half of the Project Area is mapped as National Protected Forest. Protection forest is described as:

'forest and forest land classified for the protection of watershed areas and the prevention of soil erosion. It also includes areas of forest land significant for national security, areas for protection against natural disaster and protection of the environment and other areas.'

The protection forest extends from the resettlement site up the catchment of the Nam Ngiep River. The upper area of the main dam inundation area is mapped as production forest. Production Forests are natural forests and planted forests classified for the utilization purposes of areas for production, and wood and forest product businesses to satisfy the requirements of national socio-economic development and people's living. Production forests are primarily managed for the production of timber resources. The Forestry Law provides the basis for the management of production and conservation forests in Lao PDR outside of the protected area system. It enables the possible reclassification of production forests to protection forests to enable long-term conservation of potential biodiversity offset areas.

Figure 5.41 Vegetation Condition within the Project Area



(a)

Figure 5.41 Vegetation Condition within the Project Area (continue)

(b)

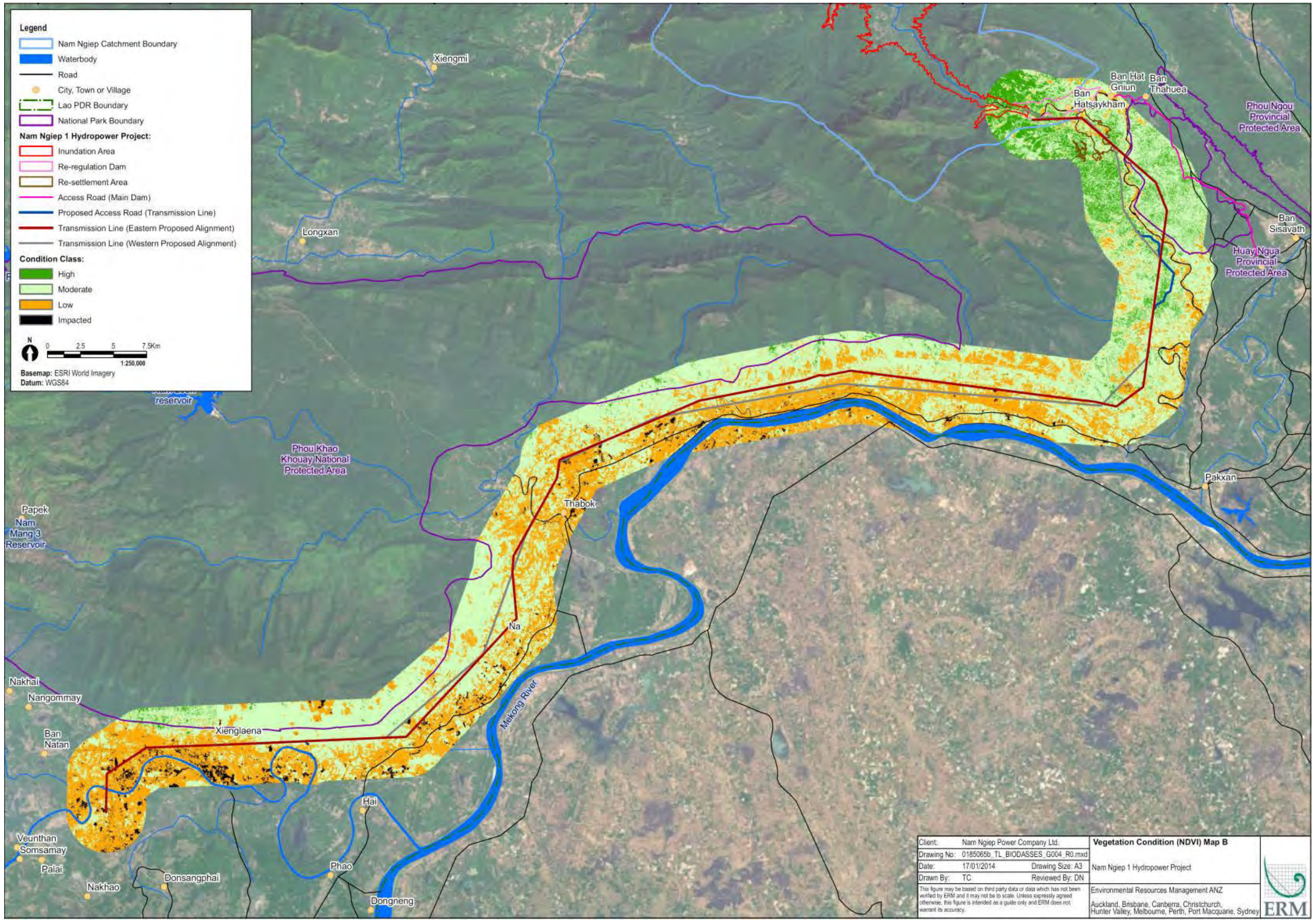
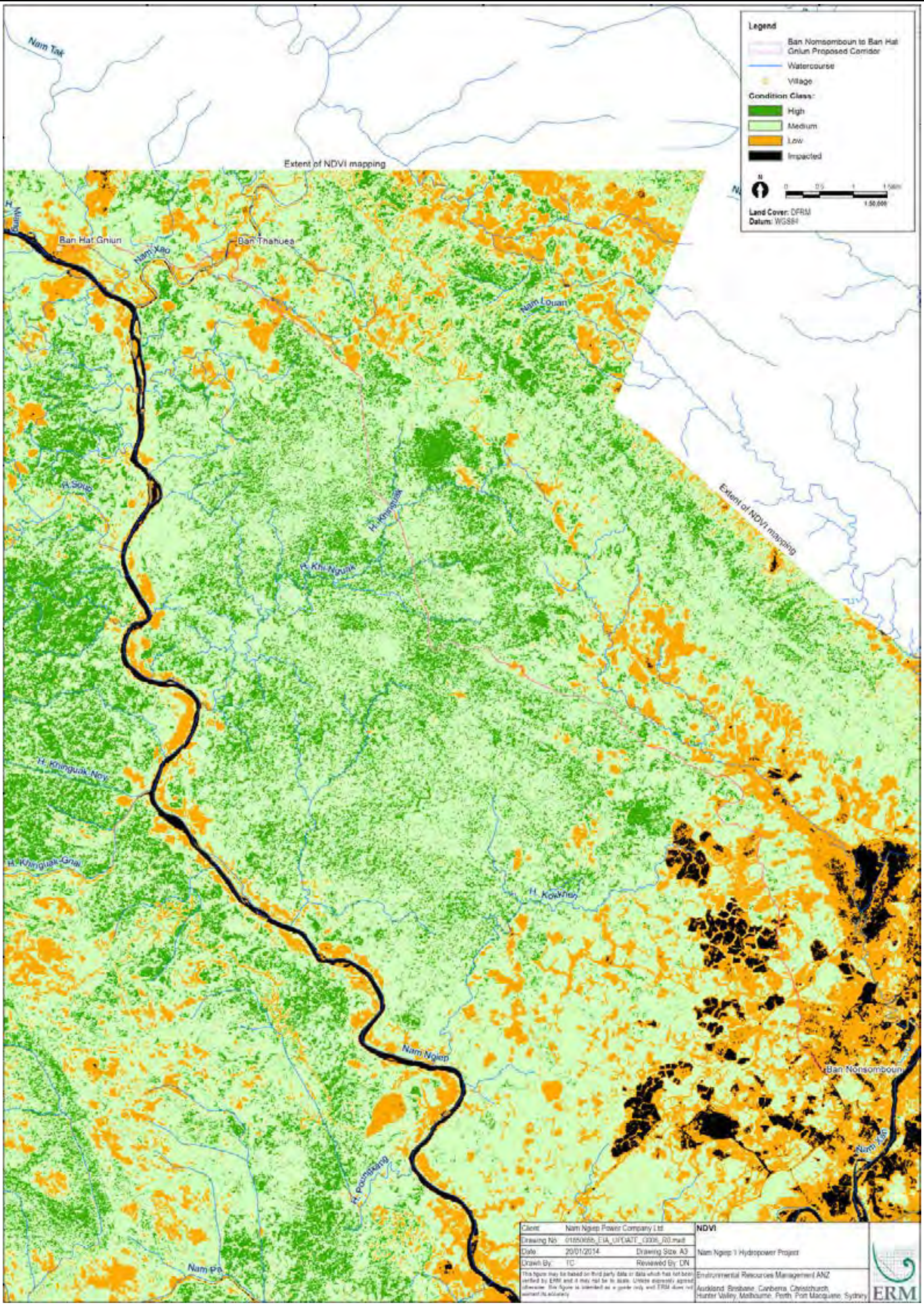
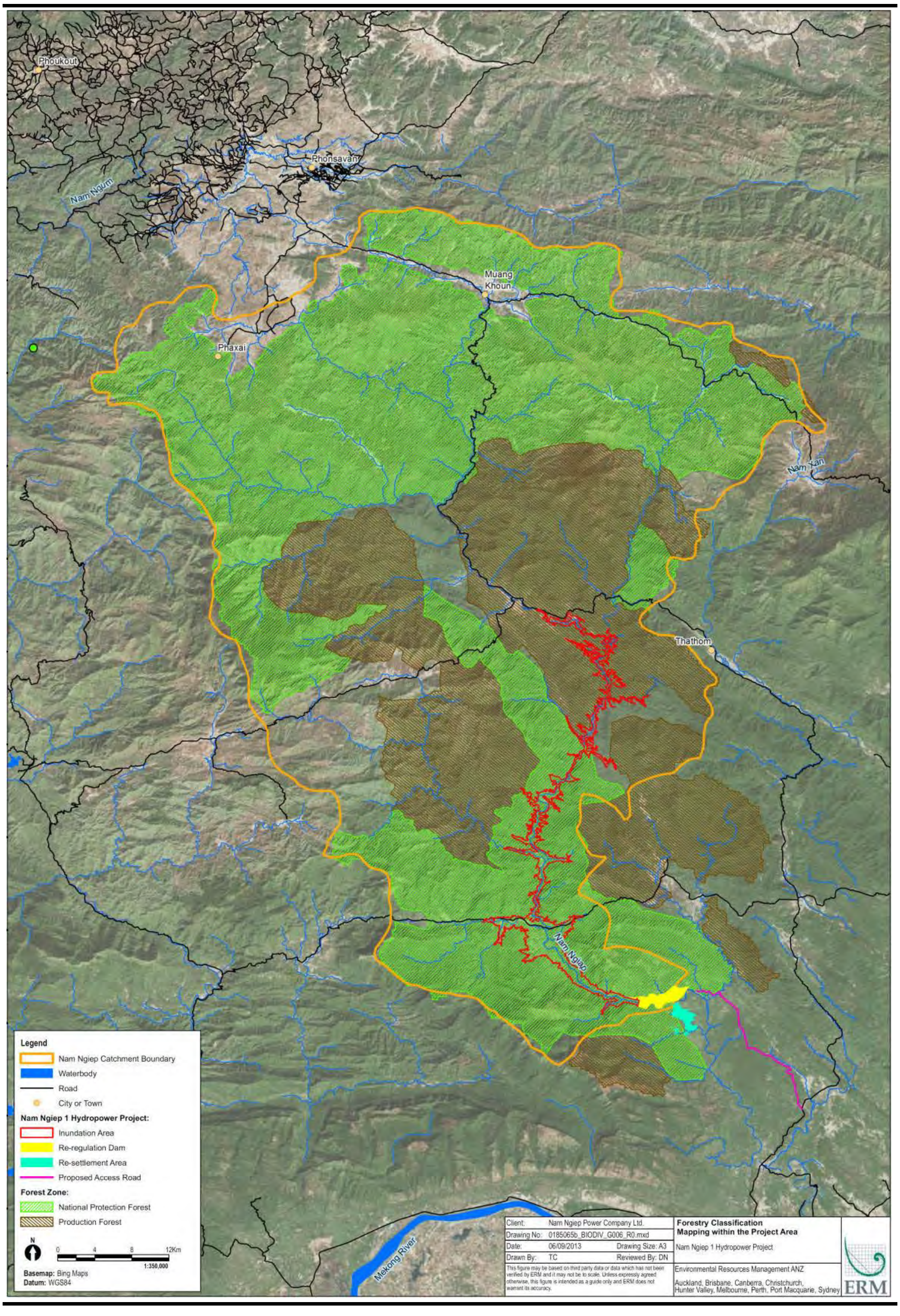


Figure 5.41 Vegetation Condition within the Project Area (continue)



(c)

Figure 5.42 Forestry Classification Mapping within the Project Area



5.2.3.4 *National Biodiversity Conservation Areas (NBCAs) and Protected Areas*

National Biodiversity Conservation Areas were established in 1993 under Prime Ministerial Decree No. 164/1993. At first 18 NBCAs were established, covering approximately 10% of the land area of the country. Another two were added in 1995-1996 plus two corridor areas, bringing the total area covered by NBCAs to 3.4 million hectares or 14.3% of the country's total area. In addition, provinces and districts have designated their own conservation areas and protection forests bringing the overall national protected area to 5.34 million hectares or 22.6% of the total land area (see ***Table 5.29***).

Table 5.29 Summary of Production, Biodiversity Conservation & Protection Forests in the Entire Country

Forest Categories	No. of areas	Total area (Ha)	% to national land area	Remarks
Production Forests	53	3,600,000	15.2	37 areas have been officially established by PM Decrees, while the rest is planned and ongoing
National Protection Forests	69	6,800,000	28.72	Planned and under study (some of these have been established in the provincial and district levels
NBCAs and 2 Corridors	20+2	3,390,766	14.32	Officially established (by PM Decree 164/PM)
Provincial Conservation Forests	57	931,969	3.94	Established by Provincial governors
District Conservation Forests	144	503,733	2.12	Established by District governors
TOTAL	345	15,226,468	64.3	

Source: Forestry Strategy to the Year 2020 of the Lao PDR and DOF's 5 Years Plan (MAF, DOF, July 2005).

The Ministry of Agriculture and Forestry (MAF) has overall responsibility for management of all categories of forests including NBCAs. Responsibility is delegated to the Department of Forestry (DOF), with the Forest Resource Conservation Division (FRCD) as a technical unit. Under the DOF (FRCD), local responsibilities lie with the Provincial Agriculture and Forestry Offices (PAFO) and the District Agriculture and Forestry Extension Offices (DAFEO), who manage the conservation forests, aquatic animals and wildlife within their jurisdiction.

Two of the 20 NBCAs, Phou Khao Khoay and Nam Ka Ding, are in Vientiane and Bolikhamxay Provinces, outside of the Project Area. The Project does not pose any direct threat to any NBCA.

The Project Area does contain some important forests, including village conservation forests and special spirit pool forests at Namyouak, Sopyouak and Sopphouan Villages, Hom District and at Hatsaykham Village, Bolikhan District (***Table 5.30***). These are generally located on steep terrains and lands inaccessible to humans, allowing the vegetation to remain relatively intact and keeping the areas as viable sites for a number of native flora and fauna species. These forests are located at elevations above the flood level of the reservoir.

Table 5.30 Summary of Village Conservation and Protection Forests within the Proposed Project Area

No	Forest Categories	Forest Types	Forest Conditions	Area (ha)	Village/District
1	MD Forest	Conservation	Still abundant	202	B.Namyouak, Hom District
2	MD Forest	Protection	Still in good conditions	89	B.Namyouak, Hom District
3	MD Forest	Conservation	Still abundant	22	B.Sopphouan, Hom District
4	MD Forest	Conservation and spirit lake inside forest	Still abundant	22	B.Sopyouak, Hom District
5	MD Forest	Conservation	Still in good conditions	-	B.Hatsaykham, Bolikhan District

Source: Discussions with village leaders

The area is under pressure from logging and hunting and from continuing patterns of shifting cultivation. In the more remote and steep areas there are also patches of pristine forest, especially in Mixed Deciduous Forest. These are located, however, outside of the immediate Project and reservoir area, in places difficult to access by boat or by foot (more than a day's walk from settlements). Because of the relatively difficult access, there is also less hunting pressure in these areas.

None of the Project components are proposed within conservation forest or protected areas.

5.2.4 *Flora Species*

Thirty-five sample plots were assessed in the main dam area during the 2007 survey by ERIC with an additional 113 survey plots assessed across the main dam, re-regulation dam and resettlement area during the 2013 TISTR survey.

The 2013 field surveys conducted in the Study area identified that most vascular plants in the survey areas were common or abundant throughout the sites sampled. A number of threatened plant species, as listed under the IUCN were recorded during the surveys and these are discussed in *Section 5.2.4.1* below.

The primary vegetation types at each of the components of the Project is summarised in *Table 5.31* based on the 2013 TISTR survey results.

A full species list is provided in *Appendix A.*

Table 5.31 Primary Forest Type at Project Area

Survey Location	Forest Type Description
Main Dam Site	**Mixed deciduous forest** located in the steep valley. Nearby the forest is mixed with some species of dry evergreen forest. Canopy cover is approximately 60-70%. Top canopy height is 20-40 m.
Resettlement Site	**Secondary growth of mixed deciduous forest**. Canopy cover is approximately 40%. The average height of the upper canopy is approximately 15 m.
Re-regulation Dam Site	**Lower mixed deciduous forest** and **mixed deciduous forest** on one river bank. Canopy cover is approximately 50-60%. Top canopy height is 10 m. On other river bank is Eucalyptus plantation. Canopy height is 15 m under which is densely covered by seedlings of the original mixed deciduous forest type.
Lower Nam Ngiep	Dominated by **disturbed mixed deciduous forest**. Canopy cover is approximately 60-70%. Top canopy height is 20-30 m.
Access Road (Huay Ngua PPA)	Dominated by **mixed deciduous forest** with some areas of **mixed evergreen forest and secondary growth of mixed deciduous forest**. Canopy cover is approximately 60-70%.
Transmission Line	**Secondary growth of mixed deciduous forest** with canopy cover of 40%. Forest condition and species diversity is similar to the Resettlement site. The average height of the upper canopy is approximately 15 m.

For the forest types the forest canopies are divided in 3 classes. The dominant species for each survey locations are summarised in ***Table 5.32***.

Table 5.32 Dominant Flora Species in Project Area

Canopy class	Dominant species
Main Dam Site Mixed Deciduous Forest	
Top canopy (20-35m)	*Pometia pinnata, Duabanga grandiflora, Lagerstroemia calyculata, Toona ciliata, Pterospermum diversifolium.*
Middle canopy (10-15m)	*Nephelium hypoleucum, Mitrephora tomentosa, Baccaurea ramiflora, Saracia indica, Arenga weaterhoutii.*
Lower canopy (<10m)	saplings and seedling of the higher canopies
Resettlement Site Secondary Growth of Mixed Deciduous Forest	
Top canopy (~15m)	*Talipariti macrophyllum, Peltophorum dasyrachis, Macaanga denticulata, Lepisanthes rubiginosa, Cratoxylum formosum, Aporosa villosa, Chaetocarpus castanocarpus, Maesa ramentacea, Irvingia malayana, Lagerstoemia calyculata.*
Lower canopy (<10m)	Densely covered by seedlings of original forest type, shrubs, climbers and herbs such as *Cleistanthus papyraceus, Ardisia helferiana, Chionanthus velutinus, Connarus semidecandrus, and Amomum biflorum*. The typical species of bamboo found in the area is *Gigantochloa albociliata*.
Re-regulation Dam Lower Mixed Deciduous Forest	
Top canopy (~10m)	*Macaanga denticulata, Maesa ramentacea, Milletia acutiflora, Lagerstoemia calyculata*. The common species of bamboo found in the area, which are *Gigantochloa albociliata, Pseudostachyum polymorphum, Bambusa bambos.*
Lower Nam Ngiep Disturbed Mixed Deciduous Forest	
Top canopy (20-30m)	*Gironniera nervosa, Ficus racemosa, Xanthophyllum lanceatum*. In a particular area, a cemetery forest, contains a very large tree, and dominated with *Lagerstroemia calyculata*. The forest is highly respected by local people, and very well preserved.
Middle canopy (10-18m)	*Callicarpa arborea, Litsea glutinosa, Crudia chrysantha, Cratoxylum formosum.*
Lower canopy (<10m)	Saplings and seedling of the trees in the higher such as *Trewia nudiflora, Baccaurea ramiflora, Pseuduvaria rugosa, Mallotus philippinensis.*
Access Road (Huay Ngua PPA) Mixed Deciduous Forest	
Top canopy (20-35m)	*Anisoptera costata, Lagerstroemia calyculata, Shorea roxburghii, Irvingia malayana, Alstonia glaucescens, Schima wallichii, Vitex pinnata, Stereospermum fimbriatum*
Middle canopy (10-20m)	*Acronychia pedunculata, Peltophorum dasyrachis, Nauclea orientalis, Microcos tomentosa, Mallotus paniculatus, Gonocaryum lobbianum, Cratoxylum formosum*
Lower canopy (<10m)	*Croton cascarillicdes, Breynia glauca, Ardisia helferiana, Glycosmis pentaphylla, Melicope pteleifolia, Allophylus cobbe, Salacia chinensis*
Transmission Line Secondary Growth of Mixed Deciduous Forest	
Top canopy (~15m)	*Talipariti macrophyllum, Peltophorum dasyrachis, Macaanga denticulata, Lepisanthes rubiginosa, Cratoxylum formosum, Aporosa villosa, Chaetocarpus castanocarpus, Maesa ramentacea, Irvingia malayana, Lagerstoemia calyculata.*
Lower canopy	Densely covered by seedlings of original forest type, shrubs, climber and herbs such as *Cleistanthus papyraceus, Ardisia helferiana, Chionanthus velutinus, Connarus semidecandrus, and Amomum biflorum*. The typical species of bamboo found in the area is *Gigantochloa albociliata*.

5.2.4.1 *IUCN Listed Species*

A total of thirteen species of plants listed as critically endangered, endangered or vulnerable under the IUCN Red List were recorded within the Project Area during 2007 ERIC and/or 2013 TISTR surveys. These include one species listed as critically endangered, seven as endangered and five as vulnerable (***Table** 5.33*).

Table 5.33 IUCN Listed Flora Species recorded in the Project Area

Scientific Names	Main Dam	Resettle-ment Site	Re-regula-tion Dam	Lower Nam Ngiep	Access Road	Transmis-sion Line	IUCN Status
Afzelia xylocarpa	✓	✓	✓	✓	✓	x	EN
Anisoptera costata					✓	x	EN
Aquilaria crassna*							CR
Cycas pectinata					✓	x	VU
Dalbergia cochinchinensis	✓				✓	x	VU
Dalbergia oliveri	✓	✓	✓		✓	x	EN
Dipterocarpus alatus	✓			✓	✓	x	EN
Dipterocarpus turbinatus	✓		✓		✓	x	CR
Hopea ferrea	✓	✓				✓	EN
Hopea odorata	✓	✓	✓	✓	✓	x	VU
Shorea roxburghii	✓	✓		✓	✓	x	EN
Syzygium vestitum				✓	✓	x	VU
Ternstroemia wallichiana	✓				✓	x	VU
Vatica cinerea					✓		EN

Note: IUCN Status: CR – Critically Endangered; EN – Endangered; VU – Vulnerable
✓ = Direct record; x = Indirect record
*Species included at request

All of these threatened species have been considered as candidates for determination of critical habitat (refer to *Section 5.2.11*). This determination is then used in the assessment of potential impacts and the determination of management and mitigation measures (refer to *Section 6.2.2* and *Section 6.3.2*).

Mai Yang Khao (*Dipterocarpus turbinatus*) and Mai Bak (*Anisoptera costata*), are economic trees and can be used for house construction (Phengsintham 2013). The field survey of the access road identified 159 *Dipterocarpus turbinatus* stems and 254 *Anisoptera costata* stems in the proposed road and surrounds (DFRM, 2013). The more detailed survey by NUL of the defined proposed road alignment confirmed 29 stems to be disturbed.

5.2.5 *Other Plants and Non-Timber Forest Products (NTFPS)*

Other plants and NTFPs were also noted and collected during field surveys. Forest products especially NTFPs play a important role in the rural economy, as they provide: 1) animal protein (from wild meat, fish, frogs, shrimp, soft-shelled turtles, crabs and molluscs), 2) calories, vitamins and dietary fiber (from mushrooms, bamboo shoots, honey, wild fruits and vegetables), 3) materials for house construction and handicraft production (bamboo, rattan, pandanus, bloom-grass, paper mulberry), 4) traditional medicines and 5) cash income (from the sale of NTFP species). However, most villagers within the project area collect NTFP mostly for food and household use, and not for sale, because the area is distant from the town and market.

The main NTFPs found in the Project Area are:

Bamboos and Bamboo Shoots: Four species of bamboo found in the Project area, mostly in Mixed Deciduous and Unstocked Forests, are used by local residents. May Lay (Gigantochloa albociliata Munro Kurz) provides bamboo shoots that are an important food source in the rainy season (June to September). May Hia (Dendrocalamus longispathus Kurz), May Xang (Dendrocalamus *membranaceus Munro), and* May Xort *(Oxytenanthera parvifolia Br.)* are used as temporary housing material, material for fencing, and to make looms for weaving. They are distributed along the streams and up to the hills, widespread throughout the study area. The distribution of these species is shown in ***Table 5.35***.

Table 5.34 ***Average Number of Bamboo Trees and Clumps per Hectare***

No	Species		Average No. of Clumps per Hectare	Average No. of Tree per Clump	Average No. of Trees per Hectare
	Lao Name	**Scientific Name**			
Dry Evergreen Forest (DE)					
1	May Hia	*Dendrocalamus longispathus Kurz*	6.5	27	175.5
2	May Xang	*Dendrocalamus membranaceus Munro*	7.2	23	165.6
3	May Xort	*Oxytenanthera parvifolia Br.*	8.4	31	260.4
4	May Lay	*Gigantochloa albociliata Munro Kurz*	5.8	24	139.2
	Sum Average for all species		**27.9**		**740.7**
Mixed Deciduous (MD) Forest					
1	May Hia	*Dendrocalamus longispathus Kurz*	12.4	32	396.8
2	May Xang	*Dendrocalamus membranaceus Munro*	11.8	28	330.4
3	May Xort	*Oxytenanthera parvifolia Br.*	10.6	35	371.0
4	May Lay	*Gigantochloa albociliata Munro Kurz*	8.7	28	243.6
	Sum Average for all species		**43.5**		**1,342**
Unstocked Forest					
1	May Hia	*Dendrocalamus longispathus Kurz*	23.2	38	881.6
2	May Xang	*Dendrocalamus membranaceus Munro*	19.3	35	675.5
3	May Xort	*Oxytenanthera parvifolia Br.*	18.8	42	789.6
4	May Lay	*Gigantochloa albociliata Munro Kurz*	11.4	29	330.6

No	Species		Average No. of Clumps per Hectare	Average No. of Tree per Clump	Average No. of Trees per Hectare
	Lao Name	Scientific Name			
	Sum Average for all apecies Forest		72.7		2,677

Rattans (*Palmae sp.*): Most Rattans (*Palmae sp.*) are found in Mixed Deciduous forest, though some can also be found in evergreen and unstocked forests, especially in the rainy season and the early dry season. Five main species that are harvested both for local use and for sale are Nhot-Nhe (*Calamus sp., C. tenuis Roxburgh*), Nhot-Boun (*Daemonorops schmidtii*), Nhot-San (Rhapia species generally), Nhot-Wai (*Calamus sp.*) and Nhot Tao (*Wallichia gracilis Beccari*). The local price is 10,000-20,000 kip/kg.

Mushrooms: Mushrooms grow well in Unstocked and Mixed Deciduous Forests in the early rainy season. Villagers reported the main mushroom species they collected for food were: Het Puak (*Termitomycetes* species, *Agaricus integer Loureiro*), Het Pheung (*Boletus* sp.), Het Hu Nou (*Auricularia polytricha-Montagne-Saccardo*), Het Khao (*Lentinus* sp.), Het La Ngok (*Auricularia* sp.), Het Bot (*Lentinus kurzianus Curr*., *L. praerigidus*), and Het Khon Kong (*Hiatula sp., Lepiota sp.*).

Agarwood, or Ket-Sana (*Aquilaria crassna*), known locally as **May Por Heuang**, has long been an important plant for international trade. Perfumed essential oils can be extracted from the wood of the plants that have been infected with a particular parasitic mold. Due to its value, it has become very rare, and no price is reported locally due to the lack of trade of this resource. Only young trees still remain in nearby forests. While these trees are too young for harvesting, their potentially high value in the future and the risk of local extinction suggest the need for management of this species.

Aside from the main NTFPs described above, other species that are important for local villagers' livelihood were also found within the Project area, such as wild vegetables, wild fruits and wild groundnuts, and some resins. Table 5-32 presents the main species of NTFPs found within the Project Area.

Table 5.35 Main Species of Plants and NTFPs Found within the Project Area

No	Dry Evergreen and Mixed Deciduous Forest		Unstocked Forest	
	Lao Name	Scientific Name	Lao Name	Scientific Name
1	Mak Neng (Cardamom)	*Amomum Xanthioides Wallich*	Mak Deua	*Ficus species generally*
2	Wan Lai	*Neolourya pierrei Rod*	Khi Lek Paa	*Cassia javanica L.subsp*
3	Kam Langseuakhong	*Ziziphus attopoensis Pierre*	Laou	*Erianthus arundinaceus(Retzius)*
			(Bloom grass)	
4	Kha Khom	*Alpinia Malaccensis*	Man Paa (Groundnut)	*Adinandra laotica Gagnepain*
5	Nhot Khon Khen		Man Koy	*Discorea hippida*

No	Dry Evergreen and Mixed Deciduous Forest		Unstocked Forest	
	Lao Name	Scientific Name	Lao Name	Scientific Name
			(Groundnut)	*Dennstedt*
6	Tao	*Wallichia gracilis Baccari*	Mak Neng (Cardamom)	*Amomum Xanthioides Wallich*
7	Boun (Rattan)	*Calumus sp*	Khaa	*Alpinia Malaccensis*
8	Mak Khi Mou		Tao	*Wallichia gracilis Baccari*
9	Wai (Rattan)	*Rattans generally*	Kheua Wai Din	*Combretum decandrum Roxburgh*
10	Wai Thun (Rattan)	*Calamus sp*	Wai Thun (Rattan)	*Calamus sp*
11	Wai Noy (Rattan)		Wai Noy (Rattan)	
12	Nam Han		Por	*Sterculia species generally*
13	Kheua Wai Din	*Combretum decandrum Roxburgh*	Boun (Rattan)	*Calumus sp*
14	Kor Pang		Wai Lai (Rattan)	*Neolourya pierrei Rod*
15	Ka Pouk		Mak Maou	*Antidesma bunius sprengel*
16	Phak Wan	*Melientha Suavis Pierre*	Mak Huat	*Lepisanthes rubiginosa (Roxburgh) Leenh*
17	Dok Pheung		Kheua Hang Kuang	*Ancistrocladus tectorius (Loureiro)Merrill*
18	Phak Ii Leud	*Piper albospicum DC,P.lotot C.*	Koud Paa	*Cythea spinulosa wall*
19	Khem (Bloom grass)		Ya Nang	*Limacia traindia Mers*
20	Het Khao (Mushroom)	*Lentinus.sp*	Phak Wan	*Melientha Suavis Pierre*
21	Het Tan (Mushroom)	*Auricularia sp*	Het Khao (Mushroom)	*Lentinus.sp*
22	Het Bot (Mushroom)	*Lentinus kurzianus curr*	Het Ka Tan(Mushroom)	*Auricularia sp*
23	Het Ka Dang (Mushroom)		Het Bot (Mushroom)	*Lentinus kurzianus curr*
24	Het Man (Mushroom)		Dok Ka Chieo	*Curcuma singularis Gagnepain*
25	Phak Kud Paa	*Cythea spinulosa wall*	Het Puak (Mushroom)	*Temitomycetes species,Agaricus*
26	Ya Nang	*Limacia traindia Mers*	Het Puak Kay Noy (Mushroom)	
27	Dok Ka Chieo	*Curcuma singularis Gagnepain*	Wai (Rattan)	*Rattans generally*
28	Palm		Man Paa (Groundnut)	
29	Kheua Haem (Beberin)	*Coscinium fenestratum(Gaertner)*	Palm	
30	Kheua Kadongtipok		Phak Ii Leud	*Piper albospicum DC,P.lotot C.*
31	Teuy	*Pandanus species generally*	Mak Nat Paa	*Ananas comosus(L) Merrill*
32	Kheua Makkhibe	*Murraya Koenigii(L) Sprengel*	Kuay Paa	*Musa acuminata colla,M paradisiaca L*
33	Mak Khi Ma	*Aerva Sanguinolenta(L) Blume*	San	*Rhapis species generally*
34	San	*Rhapis species generally*		

Note: Some NTFPs were collected during the field survey and some were identified in interviews with villagers (in particular those are seasonal and were not present during the field survey).

5.2.6 *Terrestrial Ecology/ Wildlife*

The definition of wildlife used for the purpose of this study consists of 4 groups of animals: mammals, birds, reptiles, and amphibians. Forests are the dominant habitat of wildlife in Lao PDR. Lao PDR is still rich in wildlife, when compared with many other countries, including its immediate neighbors. According to the UNDP, at least 166 species of reptile and amphibian, 700 bird species, and 100 mammal species are found in Lao PDR;[1] but with rather extensive forest degradation and destruction in recent decades, much of the wildlife can now be found mainly in the designated National Biodiversity Conservation Areas (NBCAs).

The richness of Lao PDR's wildlife has less to do with conservation efforts than with the country's low population density and consequent remaining extensive forest cover. Although there is still considerable hunting in the country (most villagers depend on hunting for part of their diet), the relative abundance of forest habitat and, in some cases, its considerable distance from human settlements and inaccessibility have provided some protection for the country's wildlife. However, human population and development pressures are increasing, especially since 1990, and consequently the wildlife population has declined dramatically throughout the country.

Most of the Project components are located on the lower slopes of mountains or in the valleys. Although these used to be among the most important wildlife habitats, human activities have forced the wildlife into the higher and less accessible slopes, so that the proposed Project activities are now located well below their remaining habitats. However, local residents also reported that some of the wildlife will come down to the river at night, then return to the comparative safety of the higher elevations during the day.

Wildlife conditions were surveyed and assessed by visual inspection and interviews with villagers on wildlife conditions in and around their village areas, as well as secondary data and information gathered from previous assessments and from authorities who work with wildlife, forests, and related activities to establish a baseline information on the distribution of wildlife and wildlife habitats to determine likely impacts of the Project on such fauna and to assess how any such impacts might be mitigated through appropriate interventions. The main dam area was surveyed for fauna during the 2007 survey by ERIC with additional data collected in 2013 by

6 UNDP, "Agrobiodiversity, Mainstreaming Biodiversity in Lao PDR's Agricultural and Land Management Policies, Plans and Programmes," Fact Sheet 04/2009 ABD April 2009.

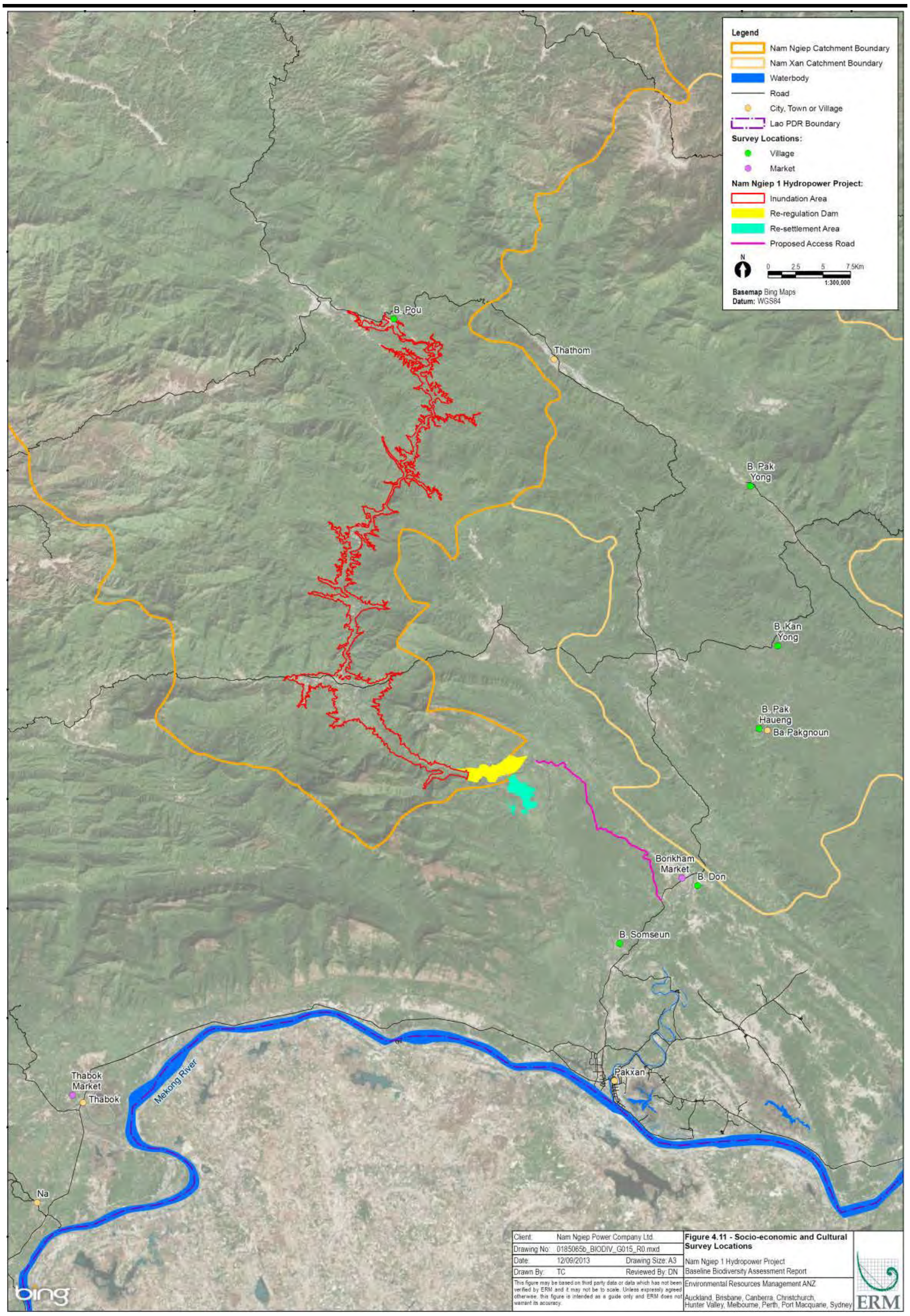
TISTR. The field survey was conducted in both wet and dry seasons to collect primary field data concerning all wildlife species including mammals, reptiles, amphibians and birds. Survey coverage is shown in ***Figure 5.43.***

The diversity of fauna in the main dam inundation area (upper Nam Ngiep) was high in comparison to other areas sampled in 2013 by TISTR. Habitats varied in condition with human disturbance evident in areas downstream of the main dam. The habitat and species detected at each of the main surveyed areas are summarised in ***Table 5.36***.

Table 5.36 Fauna Habitat in the Surveyed Areas

Survey Location	Forest Type Description
Main Dam Site	The upper area of the Nam Ngiep River is dominated by primary forest. Site surveys detected (through interviews with villagers or direct observation) at least 46 mammals species, 50 bird species, 28 reptiles species and 10 amphibian species.
Lower Nam Ngiep	This area is mostly disturbed and dominated by agricultural landuse. There is high human activity in this area. Site surveys detected (through interviews with villagers or direct observation) at least 12 mammals species, 27 birds species, 21 reptiles species and 7 amphibian species.
Access Road	The access passes through the Huay Ngua PPA in the Bolikhamxay Province and traverses nearby the Phou Khao Khoay National Protected Area (NPA). The Huay Ngua PPA is an important part of a wildlife corridor between PKK and along the Nam Ngiep River. This area is mostly disturbed and dominated by deciduous forest with smaller proportions of old fallow land.
Resettlement Site	The resettlement area is mostly and heavily disturbed as a result of slash and burn activities. There is evidence of some regeneration and secondary growth. Site surveys detected (through interviews with villagers or direct observation) at least 9 mammals species, 24 birds species, 19 reptiles species and 8 amphibian species.
Transmission Line	The 125 km transmission line passes through the Huay Ngua PPA in the Bolikhamxay Province, crosses the Nam Ngiep River and traverses nearby the Phou Khao Khoay National Protected Area (NPA). The Huay Ngua PPA is an important part of a wildlife corridor between PKK and along the Nam Ngiep River. This area is dominated by deciduous forest with smaller proportions of old fallow land.

Figure 5.43 Biodiversity Survey Coverage



A full species list of fauna species recorded within the Project Area is provided in the Baseline Biodiversity Report (*Appendix A*) and the results are summarized below in terms of threatenend and protected species and biodiversity.

5.2.6.1 IUCN Listed Species

The fauna species have been categorised by the IUCN (2012) and a number listed on the IUCN Red List have been recorded within the Project area. The 2013 (TISTR) surveys recorded one species, the Northern white-cheeked gibbon listed as critically endangered within the Project area at the main dam area. A number of other species were reported through indirect records. Species listed as critically endangered or endangered are considered candidates for critical habitat and these species records have been investigated further in *Section 5.2.11*.

Overall, the direct and indirect records identified:

- Twenty-one mammal species (1 critically endangered, 7 endangered, 13 vulnerable);
- Five bird species (1 critically endangered, 2 endangered, 2 vulnerable);
- Nine reptile species (2 endangered, 7 vulnerable);
- No amphibian species.

Table 5.37 summarises the species recorded. Of particular note is the Northern White-cheeked Gibbon which was indirectly recorded (via vocalization) within the main dam site during the March 2013 survey period. The species is listed as Critically Endangered on the IUCN Red List as the species has declined by at least 80% over the past 45 years (three generations) due primarily to hunting and habitat loss. It also has an elevated protection status nationally and is listed as Restricted in the Regulation of the Ministry of Agriculture and Forestry No. 0360/MAF. This species is critically endangered, found only in Lao PDR, China and Vietnam. Lao PDR holds nearly all of the world's remaining wild Northern White-cheeked Gibbons and may hold all the viable populations.

Targeted primate survey undertaken in November 2013 by Dr Phaivanh Phiapalath of the IUCN SSC/Primate Specialist Group reported two records (vocalisations) of gibbons in the uphill mountain area outside the inundation area. Phiapalath (2013) notes that although gibbons are present in the Project Area, their habitats are not located within the identified inundation area. The survey also confirmed the presence of the Phayre's Leaf Monkey, Sambar Deer, Stump-tailed Macaque and Northern Pig-tailed Macaque.

Table 5.37 Restricted and IUCN Species reported within the Project Area

Common Name	Scientific Name	No. 060/MAF Status	IUCN Status	Main Dam (Upper Nam Ngiep)	Re-settlement Site	Re-regulation Dam	Lower Nam Ngiep	Access Road	Transmission Line
Mammals									
Asian small-clawed otter	Aonyx cinera	R	VU	x					x
Binturong	Arctictis binturong		VU	x					
Gaur	Bos gaurus		VU	x		x			x
Golden jackal	Canis aureus	R	LC	x					
Southwest China serow	Capricornis milneedwardsii	R	NT	✓					
Asian wild dog, dhole	Cuon alpinus	R	EN	x					x
Asian elephant	Elephas maximus		EN	x		X			x
Malayan Sun bear	Helarctos malayanus	R	VU	x		x		x	x
Smooth-coasted otter	Lutrogale perspicillata	R	VU	x					
Stump-tailed macaque	Macaca arctoides		VU	✓					
Northern pig-tailed macaque	Macaca leonina		VU	x					x
Sunda pangolin	Manis javanica		EN	✓	x				x
Clouded leopard	Neofelis nebulosa		VU			x			x
Northern white-cheeked gibbon	Nomascus leucogenys	R	CR	✓					x
Bengal slow loris	Nycticebus bengalensis	R	VU	x					x
Pygmy slow loris	Nycticebus pygmaeus	R	VU	x					
Tiger	Panthera tigris		EN	x					

Common Name	Scientific Name	No. 060/MAF Status	IUCN Status	Main Dam (Upper Nam Ngiep)	Re-settlement Site	Re-regulation Dam	Lower Nam Ngiep	Access Road	Transmission Line
Leopard	Panthera pardus	R	NT	x		x		x	x
Tiger	Panthera tigris	R	EN	x					
Asiatic golden cat	Pardofelis temminckii	R	NT	x		x		x	x
Leopard cat	Prionailurus bengalensis	R	LC	x					
Fishing cat	Prionailurus viverrinus		EN	x		x		x	x
Red-shanked douc langur	Pygathrix nemaeus		EN						
Sambar deer	Rusa unicolor	R	VU	✓		x		x	x
Phayre's leaf monkey	Trachypithecus phayrei		EN	✓					x
Himalayan black bear	Ursus thibetanus	R	VU	x		x		x	x
Large spotted civet	Viverra megaspila		VU			x		x	x
Reptiles									
Southeast Asian softshell turtle	Amyda cartilaginea		VU	x			x		x
Reticulated python	Broghammerus reticulatus	R		✓	x	x	x	x	x
Snail-eating turtle	Malayemys subtrijuga		VU	x					x
Impressed tortoise	Manouria impressa		VU			x		x	x
Indo-Chinese spitting cobra	Naja siamensis		VU	x			x		x
King cobra	Ophiophagus hannah	R	VU	x			x		
Big-headed turtle	Platysternon	R	EN	x		x		x	x

Common Name	Scientific Name	No. 060/MAF Status	IUCN Status	Main Dam (Upper Nam Ngiep)	Re-settlement Site	Re-regulation Dam	Lower Nam Ngiep	Access Road	Transmission Line
	megacephalum								
Siamese temple turtle	Siebenrockiella crassicollis		VU	x					
Birds									
Rufous-necked hornbill	Aceros nipalensis		VU						x
Imperial eagle	Aquila heliaca		VU			x		x	x
Greater hornbill	Buceros bicornis	R	NT			x		x	
White winged duck	Cairina scutulata		EN			x		x	x
Greater coucal	Centropus sinensis	R	LC	✓	✓	✓	✓	✓	✓
White backed vulture	Gyps bengalensis		CR						
Siamese fireback	Lophura diardi	R	LC			x		x	x
Silver pheasant	Lophura nycthemera	R	LC	✓		x		x	x
Green peafowl	Pavo muticus		EN			x		x	x
Grey peacock-pheasant	Polyplectron bicalcaratum	R	LC			x		x	x
Red-breasted parakeet	Psittacula alexandri	R	LC			✓		✓	✓

Note: IUCN Status: CR – Critically Endangered; EN – Endangered; VU – Vulnerable; NT – Near Threatened; LC – Least Concernx
✓ = Direct record; x = Indirect recor d

5.2.6.2 *Restricted Species*

Species listed as Restricted under the Regulation of the Ministry of Agriculture and Forestry No. 0360/MAF includes wild animals and fish which are rare, endangered, high conservation value, and special significance to the economy and national environment.

The Regulation of the Ministry of Agriculture and Forestry No. 0360/MAF identifies wildlife into two categories, restricted species (List I), and protected species (List II). Restricted species are wild species which are rare, endangered, high conservation value and species significance to the economy/society and national environment in Lao. Activities relating to this group require permission from the Lao Ministry of Agriculture and Forestry.

A number of these species were recorded during field surveys in the Project area undertaken by ERIC (2007) and TISTR (2013). Species listed as Restricted are considered candidates for critical habitat (Section *5.2.11*).

The recent surveys (TISTR 2013) in main dam site (upper Nam Ngiep), lower Nam Ngiep, resettlement site and access road detected the following terrestrial species listed as restricted in the Regulation of the Ministry of Agriculture and Forestry No. 0360/MAF:

- fifteen mammal species;
- six bird species;
- three reptiles; and
- no amphibians.

Table 5.37 summarises the species recorded.

5.2.7 *Aquatic Biodiversity Values*

The proposed Project lies on the Nam Ngiep River which flows in a south-southeast direction through a mountainous region to the gorge at Hat Gniun village where the topography changes to a hilly landscape before entering the Mekong River at Pakxon. The gorge is the location for the proposed dam construction.

The flow regime of an aquatic ecosystem plays a role in the health and productivity of the system and for some species, flows can trigger movement during some periods. The Nam Ngiep River has a catchment area of 370,000 ha with the river approximately 160 km in length (Kansai 2012). Flows of the river are influenced by the monsoon dominated weather which divides the year into clearly defined wet and dry periods. Peak discharges (200-325 m3/s) occur between June and September with lowest discharge volumes (50-75 m3/s) in February to April.

In the Project area, a variety of aquatic habitats are represented, with characteristics generally dependent on the location in the catchment. Upstream of the main dam site is a mountainous terrain with some intermittent narrow plains which are inhabited. High mountains can be found on both sides of the Nam Ngiep, sources of tributaries to the Nam Ngiep, providing continuous supplies of large amounts of water throughout the year. Elevated water levels during the rainy season may cause rocky and sandy banks in the river, as well as invisible rapids. Downstream of the main dam site and a re-regulation dam divide the downstream into two parts, one between the two dams and the other downstream of the re-regulation dam. Between the main dam and the re-regulation dam, the terrain on both sides of the river widens and consequently forms flatter plains. Downstream of the re-regulation dam, the terrain downstream of the re-regulation dam is predominately flat and tilts gradually towards the Mekong River. In this area, the Nam Ngiep runs parallel to the Nam Xan before it merges with the Mekong at Pakxan.

Portions of the proposed transmission line route, which extends from the Ngiep River Powerhouse to the Nabong substation, cross major rivers and streams. These waterways include the Nam Ngiep, Nam Xan, Nam Ngum, Nam Mang, Nam Jing, and Nam Lo. These rivers and streams are tributaries for the Mekong River.

5.2.8 *Aquatic Habitats*

Aquatic riverine and tributary habitats were assessed during TISTR 2012 site surveys. Seasonal variation was observed in terms of water depth, clarity, flow and wetted width. Habitat characteristics recorded are summarised in ***Table 5.38.***

In general, river habitats were fast flowing with greater water depth and flows during the wet season. Dry season river habitats exhibited riffle zones which were flooded during the wet season. The river bed was generally dominated by sand and gravel. Villagers use the river environment for fishing and other activities and cattle were observed in the waterbody.

Tributary habitats were surveyed in the Upper Nam Ngiep River and Resettlement Area (as well as Huay Ngua PPA). These habitats were generally shallower and slower flowing than riverine habitats with some areas drying to isolated pools in the dry season.

Table 5.38 Aquatic Ecology Sampling Area Habitat Characteristics

Main Dam Site (Upper Nam Ngiep)

Dry Season	Wet Season
	

- main river and tributary habitats
- in tributary areas, the watercourse is dried to small pools in the dry season
- the main river current flows rapidly in the wet and dry season
- river depth in dry season 1-3m, wet season 3-5m
- river bed is sand and gravel with some boulders
- aquatic plants present sparsely
- water level is high during the wet season flooding all banks and vegetation
- riparian zone is mainly original forest with agriculture close to communities
- water is clear with greenish brown colour in the dry season, turbid and reddish brown in the wet season
- surrounding landuse is agriculture and communities
- Villagers use waterbody for fishing, cattle swim

Lower Nam Ngiep	
Dry Season	Wet Season
	

- main river habitat
- river depth in dry season 2-3 m (shallower in riffle zone where water flows fastest), wet season 4-5m depth
- width of the river is approximately 50-100 m in dry season, 100-150 during wet season
- river bed is sand and small gravel
- aquatic plants present sparsely on the river bank in the dry season
- water is turbid and reddish brown in wet season
- riparian zone is mainly covered by big trees and bamboos
- upper zone has communities where people and cattle share the river in terms of swimming and washing. People always fishing

Resettlement Area	
Dry Season	Wet Season
	

- tributary habitat
- water is approximately 1m depth in the dry season and 5m wetted width
- bed is clay
- no aquatic plants
- riparian zone is covered by big trees left after shifting and burning
- landuses around the creek are agricultural areas, and secondary growth

5.2.9 *Aquatic Biota*

5.2.9.1 *Fish*

The fish community of the Mekong River is one of the largest in the world with most of the production based on migratory river species (Poulsen et al., 2004). Fish migration is an important component for many fish species life cycle. In the Mekong, fish migration can be generally described in terms of (EIA citing Poulsen et al., 2004):

- annual movement between inundated floodplains (where most fish production originates) and dry season refuges;

- movement into spawning areas within the river system (usually upstream) from dry season refuges, generally upon start of flooding; and
- passive migration of fish fry downstream from spawning areas.

During the 2007 survey of the main dam site, 42 species were detected. The species detected included relatively similar proportion of surface feeder, column feeder and bottom feeder species. The survey within the main dam area during 2013 detected 75 species.

The EIA noted that the fish community detected in 2007 contains species common to the Mekong tributaries and was dominated by Cyprinidae species. Cyprinidae family species were reported to adapt to different environmental in various sections of the river, and this family was also the dominant group detected during 2013 survey. The EIA assessment also noted that of the larger species detected many are migratory species of the lower Mekong basin that move upstream during the wet season spawning activities (EIA citing Poulsen et.al. 2004). These larger species, such as mud carp (*Cirrhinus molitorella*) and Asian red tailed catfish (*Hemibagrus wyckioides*) were detected in 2007 and 2013 surveys. The surveys noted a number of juvenile individuals of the migratory species suggesting that the Nam Ngiep River plays a role in providing habitat for the reproductive cycle (EIA citing Lowe-McConnell 1995).

A full species list is provided in the Biodiversity Baseline Assessment Report. An additional field survey is planned to support the data collected and assist in the determination of critical habitat for fish species. The results of this study will be used to update this report and the impact assessment.

An additional field survey is scheduled to support the data collected and assist in the determination of critical habitat for fish species. The results of this study will be used to update this report and the impact assessment.

5.2.9.2 Other Biota

Benthic fauna and plankton samples were collected from the Project area with species richness varying at each sampling site. No specific trends in richness across sampling areas were identified. Complete results are provided in the Baseline Biodiversity Report.

5.2.9.3 Threatened Fish Species

Aquatic surveys across the Project area detected nine species listed as critically endangered, endangered or vulnerable on the IUCN Red List (summarised in ***Table 5.39).*** Species listed as critically endangered or endangered are considered candidates for critical habitat and these species records have been queried further in *Section 5.2.11* Species listed a Restricted under the Regulation of the Ministry of Agriculture and Forestry No. 0360/MAF are also considered candidates for critical habitat and as such Wallago leeri has also been included as a candidate species. This species has been indirectly recorded within the Project Area.

Table 5.39 IUCN Listed Fish Species Reported within the Project Area

Family/Common Name	Scientific Name	2012 EIS		TISTR Survey				IUCN Status
		Inside Project area	Outside Project area	Upper Nam Ngiep	Lower Nam Ngiep	Huay Ngua	Resettlement Site	
Giant barb	Catlocarpio siamensis					x		CR
Leaping barb	Laubuca caeruleostigmata			13				EN
Striped catfish	Pangasianodon hypothalamus					x		EN
Yellow tail brook barb	Poropuntius deauratus			139	22	13	21	EN
Thicklipped barb	Probarbus labeamajor					x		EN
Mrigal carp	Cirrhinus cirrhosus				2			VU
Common carp	Cyprinus carpio							VU
Bandan sharp-mouth barb	Scaphognathops bandanensis					3		VU
Jaguar loach	Yasuhikotakia splendida				1	4		VU

Note: IUCN Status: CR – Critically Endangered; EN – Endangered; VU – Vulnerable; NT –Near Threatened; LC – Least Concern
counts = Direct record; x = Indirect record;
blue x = noted within Huay Ngua PPA Area Management Plan

5.2.10 *Wetlands*

A wide range of inland wetland habitats are found in Laos PDR. The Mekong River and its tributaries, paddy fields, small ponds, swamps, and flooded forests are among them. These habitats provide a fundamental source of food for local people as well as shelters for wildlife species such as native catfish and large waterbirds (Giant ibis and Sarus crane). Although the Lao PDR has not yet ratified the Ramsar Convention on Wetlands for the protection of wetlands of international importance, as of March 2009, it does recognize the importance of wetlands. Therefore, any significant adverse impact on wetland habitat caused by this Project should be identified. In addition, the rehabilitation and restoration of any damaged wetland ecosystem should be promoted.

According to the survey results and the analysis of forest and vegetation cover and land use maps conducted by the Forest Inventory and Planning Division, Department of Forestry (2002), only 97 ha (0.97 km^2) or about 0.02 % of the watershed are swampy. However, most of this is already disturbed by the expansion of residential and agricultural areas, so they have lost their ecological function as a wetland. They are not Ramsar sites and they have no potential in their disturbed states to become Ramsar sites.

5.2.11 Priority Biodiversity Values

IFC PS6 provides guidance on the identification of habitat values of an area through the definition of modified and natural habitats, as well as critical habitats. These categories provide a mechanism to rank areas of importance across the site. Similarly, species categorised as critically endangered, endangered and vulnerable are considered to be at a heightened risk of extinction and are awarded an elevated level of consideration under the IFC Performance Standards.

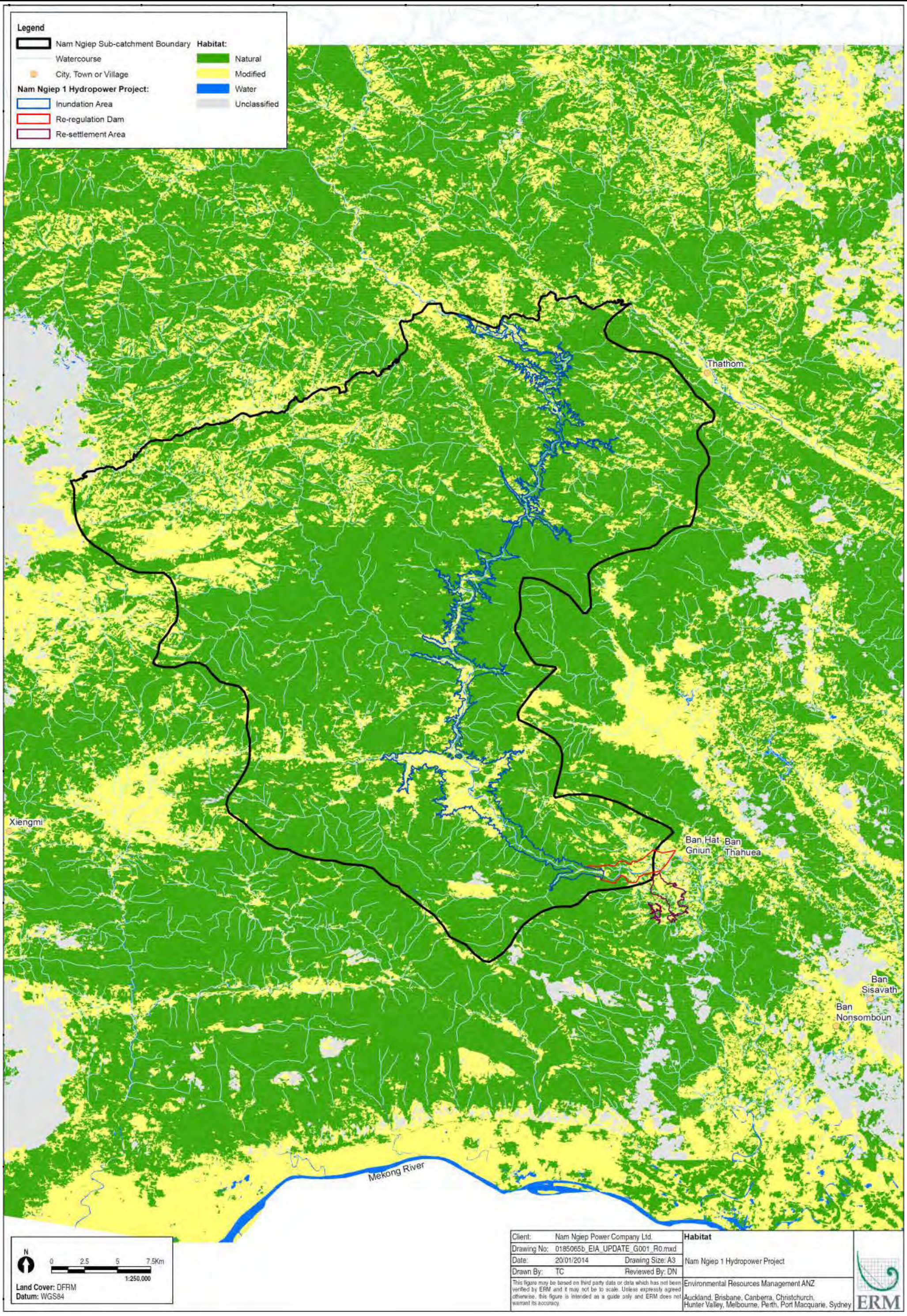
IFC PS6 identifies that the relative importance with respect to conserving a biodiversity value can be determined by its status in terms of irreplaceability in the landscape and vulnerability in being able to persist. These factors have been included in the presentation of species specific information for the purposes of critical habitat determination. Irreplaceability refers to the number of spatial options remaining where conservation of a value can occur. Vulnerability is a temporal limitation whereby threats to a value in a location increase the exposure to conservation risk.

5.2.11.1 Modified Habitat

Modified habitat is altered natural habitat, often formed by the removal of native species for harvesting, land conversion and/or introduction of alien flora and fauna species (ADB, 2012).

Land cover mapping for the Project Area identified a number of vegetated cover classes. The old fallow land, young fallow land, rice paddy, slash and urban classes are considered to be modified habitats. ***Figure 5.44*** shows the distribution of these modified land uses within the Project Area.

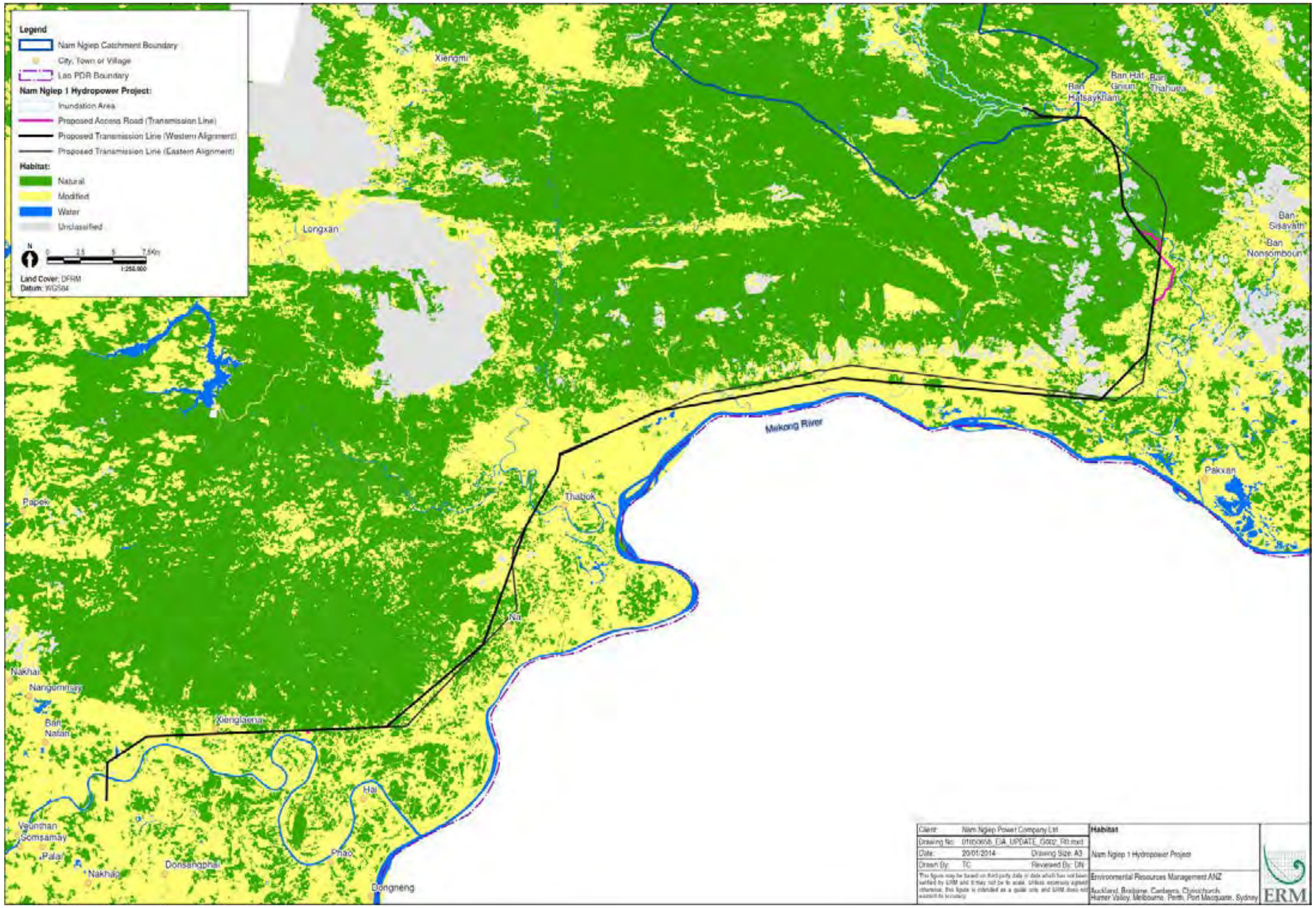
Figure 5.44 Distribution of Modified Landuses within the Project Area



(a)

Figure 5.44 Distribution of Modified Landuses within the Project Area (continue)

(b)



5.2.11.2 *Natural Habitat*

Natural habitat is an environment where the biological communities are largely formed by native plant and animal species and where human activity has not modified the areas primary ecological functions (ADB, 2012).

Land cover mapping for the Project Area identified a number of vegetation cover classes. The deciduous forest, evergreen forest and bamboo are considered to be natural habitats for the purposes of this assessment. ***Figure 5.44*** shows the distribution of the natural habitat land uses within the Project Area.

5.2.11.3 *Critical Habitat*

One of the key provisions of IFC PS 6 is the identification of 'Critical Habitat'. IFC PS6 defines critical habitats as areas with high biodiversity value, including (but not limited to) habitat of significant importance to critically endangered and/or endangered species. For this Project, threatened species with potential to occur have been considered as candidates for determination of critical habitat.

Specifically, critical habitat criteria form the basis of the determination (IFC PS6 Guidance Note). The criteria include:

- Criterion 1: Critically endangered and or endangered species (Tier 1 and Tier 2 sub-criteria for habitat for these species). Tier 1 sub-criteria relate to a proportion of the population and known and regular occurrences. Tier 2 sub-criteria relate to nationally/regionally important concentrations;

- Criterion 2: Endemic and/or restricted-range species (Tier 1 and Tier 2 sub-criteria for habitat for these species). Tier 1 and 2 sub-criteria relate to the proportion of the global population;

- Criterion 3: Migratory and/or congregatory species (Tier 1 and Tier 2 sub-criteria for habitat for these species). Tier 1 and 2 sub-criteria relate to the proportion of the global population;

- Criterion 4: Highly threatened and/or unique ecosystems;

- Criterion 5: Key evolutionary processes.

Assessment of the Project area has not identified any highly threatened and/or unique ecosystems, or key evolutionary processes. As such the assessment focusses on the relevance of Criterion 1-3. Each of the candidate species has been assessed for the critical habitat determination criteria 1-3 using the literature and field survey data collected in the Project area.

A summary of the analysis is provided below. The species screened against the determination criteria and quantitative thresholds include IUCN listed species, species listed as Restricted in the Regulation of the Ministry of Agriculture and Forestry No. 0360/MAF and species considered to be migratory. Refer to *Appendix A* for full assessment details and copies of species specialist reports.

Table 5.40 Summary of Critical Habitat Assessment

Species	Habitat Requirements	Criteria	Record		Likely Critical Habitat	Comment
			Direct	In-direct		
Flora						
Afzelia xylocarpa	This tree is reported to grow in dense forest habitats and in transitional areas between evergreen and dry open dipterocarp forest. Altitude range of 100-650m in areas with uniform rainfall.	1	✓		No	Given the distribution of known records it is considered unlikely that the Project area sustains >10 per cent of the global population (Tier 1), or, habitat of significant important or containing nationally important concentrations (Tier 2). Measures such as planting and management of harvesting threats locally will assist in managing the local population of the species.
Anisoptera costata	It is reported to grow in semi-evergreen dipterocarp, evergreen and humid lowland forest	1	✓		NA	The species is not native to Lao PDR and as such is not considered a priority biodiversity value. The species is not a candidate for critical habitat within the Project area.
Dalbergia oliveri	It is reported to be scattered among dense evergreen and semi-deciduous forest of up to 1200 m elevation.	1	✓		NA	The species is not native to Lao PDR and as such is not considered a priority biodiversity value. The species is not a candidate for critical habitat within the Project area.
Dipterocarpus alatus	In Indo-China and Thailand the species occurs gregariously along river banks, and in the Philippines it is found in mixed dipterocarp forest. It is a tropical tree of dense evergreen and mixed dense forest.	1	✓		NA	The species is not native to Lao PDR and as such is not considered a priority biodiversity value. The species is not a candidate for critical habitat within the Project area.

Species	Habitat Requirements	Criteria	Record		Likely Critical Habitat	Comment
			Direct	In-direct		
Dipterocarpus turbinatus	The species is found in mixed deciduous, evergreen and semi-evergreen forests. It is reported to often occur in wet dense forest.	1	✓		No	Given the distribution of known records it is considered unlikely that the Project area sustains >10 per cent of the global population (Tier 1), or, habitat of significant important or containing nationally important concentrations (Tier 2). Measures such as planting and management of harvesting threats locally will assist in managing the local population of the species.
Hopea ferrea		1	✓		NA	The species is not native to Lao PDR and as such is not considered a priority biodiversity value. The species is not a candidate for critical habitat within the Project area.
Shorea roxburghii White meranti	The species is considered unusual for its adaptation to withstand adverse climatic conditions and soil types. It occurs in dry evergreen or deciduous forest and bamboo forest, often on sandy soils.	1	✓		No	Given the distribution of known records it is considered unlikely that the Project area sustains >10 per cent of the global population (Tier 1), or, habitat of significant important or containing nationally important concentrations (Tier 2). Measures such as planting and management of harvesting threats locally will assist in managing the local population of the species.
Vatica cinerea	This small species is reported to flourish in exposed areas, occurring on rocky, dry land and in bamboo forest.	1	✓		NA	The species is not native to Lao PDR and as such is not considered a priority biodiversity value. The species is not a candidate for critical habitat within the Project area.
Mammals						

Species	Habitat Requirements	Criteria	Record		Likely Critical Habitat	Comment
			Direct	In-direct		
Aonyx cinerea Asian small-clawed otter	Habitat use apparently varies across its wide range. Original habitat use in lao PDR is unknown; recent hunting is likely to have removed it from accessible and even some remote areas. Asian small-clawed otters have a high climatic and trophic adaptability in south and south-east Asian tropics, occurring from coastal wetlands up to mountain streams.	1		✓	No	The general patterns in northern southeast Asia suggest it is unlikely that hunting will not have reduced this species to very low numbers in the Project Area. There is no situational reason to expect an anomalously high survival in the Project area (which could potentially now qualify as critical habitat), but this cannot be excluded. The key threats relate to hunting and degradation of aquatic environments and although current information does not confirm critical habitat, the precautionary approach should be considered and the threats to the species should be managed throughout the Project construction and operation and within any Biodiversity Offset Design.
Canis aureus Golden jackal	All records in Lao PDR and surrounding areas come from deciduous dipterocarp forest and other open, deciduous forests, and also, in areas where hunting is relatively low, cleared evergreen areas. There are no records from interior evergreen forest. As such, the species is highly restricted in Lao PDR, because most suitable habitats are too heavily hunted for it to survive.	1		✓	No	Numbers in the Project Area are likely insignificant given the much larger, and growing populations in Thailand and probably Cambodia. Although numbers in Lao PDR are now probably small, there is no reason to indicate the Project Area has any particular role for conserving the species compared with the many other landscapes of similar habitat in the country. As such the Project Area is considered unlikely to be critical habitat for the species.

Species	Habitat Requirements	Criteria	Record		Likely Critical Habitat	Comment
			Direct	In-direct		
Capricornis milneedwardsii Southwest China serow	Accounts from throughout the species range report the species inhabits rugged steep hills and rocky places, especially limestone regions up to 4,500 m. However, the species is also routinely recorded (by camera-trapping) in hill and mountain forest areas with gentler terrain.	1		✓	No	Serows plausibly remain widespread and locally common in the Project Area, but this is equally true of much of hilly north and central Lao PDR. The Project area is only a small proportion of the nation's total such habitat and as such would not be expected to constitute critical habitat.
Cuon alpinus Asian Wild Dog/Dhole	The species is found in a wide variety of vegetation types including primary, secondary and degraded tropical dry and moist deciduous forest, evergreen and semi-evergreen forests, dry thorn forests, grassland scrub forest mosaics and alpine steppe. Habitat selection factors include the availability of medium to large ungulate prey, water, presence of other large carnivores, suitability of breeding sites and human population levels.	1		✓	No	Dholes plausibly remain widespread and perhaps even locally common in the Project area; but this is equally true of much of hilly north and central Lao PDR. The Project area is only a small proportion of the nation's total such habitat and as such would not be expected to constitute critical habitat.
Elephus maximus Asian elephant	The species is found in many habitat types up to atleast 1200 m, remaining widely distributed in forested, hilly areas. The species is a generalist occurring in grassland, evergreen forest, semi-evergreen forest, moist deciduous forest, dry deciduous forest, dry thorn forest, scrublands and cultivated and secondary forests.	1		✓	No	The location of the indirect records is mainly to the east of the Project area and to the north, outside the Project area. Similarly there are a number of locations noted for the species other countries. As such, the Project area is not considered likely to be part of one of 10 or fewer habitat areas or required to sustain greater than 10 per cent of the global population (C1 Tier 1). The Project area is not a known important area in Lao PDR for the species however suitable habitat exists.

Species	Habitat Requirements	Criteria	Record		Likely Critical Habitat	Comment
			Direct	In-direct		
Helarctos malayanus Sun bear	Sun bears rely on tropical forest habitat and in mainland south-east Asia inhabit seasonal ecosystems with a long dry season (3–7 months), during which rainfall is 1,000m.	1		✓	No	Sun Bears plausibly occur in the Project Area; but this is equally true of much of Lao PDR. The Project Area is only a small proportion of the nation's total such habitat and as such would not be expected to constitute critical habitat
Lutrogale perspicillata Smooth-coated otter	Habitat use may vary across its wide range, but in general it seems mostly to occur in areas of gentle terrain, in both flowing and standing wetlands.	1		✓	No	The general patterns in northern southeast Asia suggest it is likely that hunting will have reduced this species to very low numbers in the Project area. There is no situational reason to expect an anomalously high survival in the Project area (which could potentially now qualify as critical habitat), and the record is a weak indication of the species, but this cannot be excluded. The key threats relate to hunting and degradation of aquatic environments and although current information does not confirm critical habitat, the precautionary approach should be considered and the threats to the species should be managed throughout the Project construction and operation and within any Biodiversity Offset Design.

Species	Habitat Requirements	Criteria	Record		Likely Critical Habitat	Comment
			Direct	In-direct		
Manis javanica Sunda pangolin	Found in primary and secondary forest as well as cultivated areas, gardens and plantations. The species inhabits hollows for sleeping and den sites and as such primary forest might occupy more individuals because they contain higher numbers of older, larger trees with suitable hollows. The species is largely nocturnal and solitary, feeding on ants and termites. Home range size has been estimated at 6.97 ha.	1		✓	No	There is some uncertainty associated with the indirect data sources for the species as there can be confusion between Manis javanica and other pangolin species. The key threat to the species is hunting and although current information does not confirm critical habitat, the precautionary approach should be considered and the threats to the species should be managed throughout the Project construction and operation and within any Biodiversity Offset Design.
Nomascus leucogenys Northern white-cheeked gibbon	The species is strictly arboreal though there is very little behavioural ecology information, including home range extent. Habitat includes tall primary and heavily degraded evergreen and semi-evergreen forest. The diet is dominated by fruits and some small amounts of leaves and insects.	1	✓		No	Key habitat areas for the species are reported by Dr Phaivanh Phiapalath at Phou Thin, Phouru Pha Noy, Phou Pha hua and Phou Sam Liem. These locations are outside the Project area though must be considered for indirect impact. As such the Project area is not considered to be critical habitat however threat management should be considered.
Nycticebus bengalensis Bengal slow loris	The species is arboreal and nocturnal, and inhabits tropical evergreen rainforest, semi-evergreen forest, and moist deciduous forest	1		✓	No	This loris plausibly remains widespread and common in the Project area, but this is equally true of much of Lao PDR. The Project area is only a small proportion of the nation's total such habitat and as such would not be expected to constitute critical habitat.

Species	Habitat Requirements	Criteria	Record		Likely Critical Habitat	Comment
			Direct	In-direct		
Nyctocebus pygmeaeus Pygmy slow loris	This species has been sighted in a wide variety of habitats, including primary evergreen and semi-evergreen forest, forest on limestone, secondary and highly degraded habitats, and bamboo thickets. It seems to be more common below 600 m.	1		✓	No	This loris plausibly remains widespread and common in the Project area, but this is equally true of much of Lao PDR. The Project area is only a small proportion of the nation's total such habitat and as such would not be expected to constitute critical habitat.
Panthera pardus Leopard	In south-east Asia, the species is found in all forest types, from tropical rainforest to the temperate deciduous and alpine coniferous (up to 5,200 m in the Himalaya), and also in dry scrub and grasslands .	1		✓	No	Given the large range of the species, certainty of records and secondary information from local village representatives it is unlikely that the Project area and immediate surrounds supports greater than 10 per cent of the global population or habitat of significant importance. The key threat to the species is hunting and although current information does not confirm critical habitat and there is uncertainty of the relevance of the villege interview data, the precautionary approach should be considered and the threats to the species should be managed throughout the Project construction and operation and within any Biodiversity Offset Design.

Species	Habitat Requirements	Criteria	Record		Likely Critical Habitat	Comment
			Direct	In-direct		
Panthera tigris Tiger	The availability of sufficient prey base or large ungulates is a major habitat requirement for the species. It is estimated a tiger needs to kill 50 large prey animals per year. The species is generally solitary. Home range is dependent on prey availability but can be up to 10,000 ha.	1		✓	No	Given the large range of the species, certainty of records and secondary information from local village representatives it is unlikely that the Project area and immediate surrounds supports greater than 10 per cent of the global population or habitat of significant importance. The key threat to the species is hunting and although current information does not confirm critical habitat and there is uncertainty of the relevance of the villege interview data, the precautionary approach should be considered and the threats to the species should be managed throughout the Project construction and operation and within any Biodiversity Offset Design.
Pardofelis temminckii Asiatic golden cat	The species is primarily found in forest habitats ranging from tropical and subtropical evergreen to mixed and dry deciduous forest; it is evidently very tolerant of degradation and perhaps, where not hunted, of fragmentation.	1		✓	No	This cat plausibly persists, perhaps widely, in the Project Area, but this is equally true of much of Lao PDR. The Project Area is only a small proportion of the nation's total such habitat and as such would not be expected to constitute critical habitat.

Species	Habitat Requirements	Criteria	Record		Likely Critical Habitat	Comment
			Direct	In-direct		
Prionailurus bengalensis Leopard cat	The species is found widely in forest habitats (ranging from tropical and subtropical evergreen to mixed and dry deciduous forest) and is highly tolerant of deforestation provided some dense low-level cover remains, being common, for example, in various plantations, and even persisting in peri urban Bangkok and Hanoi, far from any forest..	1		✓	No	Leopard cat plausibly remains widespread and perhaps locally common in the Project area; but this is equally true of much of Lao PDR. The Project area is only a small proportion of the nation's total such habitat and as such would not be expected to constitute critical habitat.
Prionailurus viverrinus Fishing cat	The species is thought to feed mainly on fish but also small rodents, reptiles and amphibians. Home ranges reported in Nepal ranged between 400 and 1600 ha.	1		✓	No	There is no reason to think that Fishing cat inhabits the Project area, but equally it cannot be excluded that it does so. However, the Project area's habitat is not distinct in any way from typical Lao hill-country, and so there is no reason to conclude that the Project area could be considered critical habitat for the species. This assessment remains particularly provisional given the uncertainty surrounding the species's distribution and habitat use in inland SE Asia.
Pygathrix nemaeus Red shanked douc langur	The species is found in primary and secondary evergreen and semi-evergreen broadleaf forest. It is mainly folivorous.	1		✓	No	The Project area is outside the range of the species and targeted primate survey in 2013 did not detect the species.

Species	Habitat Requirements	Criteria	Record		Likely Critical Habitat	Comment
			Direct	In-direct		
Rusa unicolor Sambar	Habitat is reported as wooded areas, more commonly in broken areas amid semi-evergreen forest but also open deciduous forest and unbroken evergreen forest.	1		✓	No	If the reports that Sambar is locally common in the Project Area are accurate, the area may be important habitat on a national scale. There are large remaining populations in some other countries. As such the Project area is not considered to be critical habitat for the species however measures should be employed to understand the importance of the population on a national level.
Trachypithecus phayrei Phayre's leaf monkey	The species inhabits primary and secondary evergreen and semi-evergreen forest, mixed moist deciduous forest as well as bamboo areas, light woodlands and near tea plantations. In Lao it seems to be particularly occurring in edge and degraded areas.	1	✓	✓	No	This species is probably among the mammal species for which the Project Area provides a significant contribution to national conservation prospects. However, even at the national level it is implausible that the Project Area supports close to 10% of the population, given that it comprises far less than 10% of the species's presumed present area of occupancy in today's Lao PDR. As such the Project Area is not considered to be critical habitat for the species. Key habitat areas for the species are reported by Dr Phaivanh Phiapalath at Phou Thin, Phouru Pha Noy, Phou Pha hua and Phou Sam Liem. These locations are outside the Project area though must be considered for indirect impact.
Ursus thibetanus Himalayan black bear	The species occupies a variety of forested habitats in Lao PDR, including highly degraded landscapes.	1		✓	No	The Project Area's habitat is not distinct in any way from typical Lao hill-country, and so there is no reason to conclude that the Project Area could be considered critical habitat for the species.

Species	Habitat Requirements	Criteria	Record		Likely Critical Habitat	Comment
			Direct	In-direct		
Birds						
Aceros undulates Wreathed hornbill	The species is report to occur in evergreen forest from lowlands to at least 1300m. Range extends into deciduous forest to visit fruit trees	1		r	No	Wreathed hornbill plausibly still occurs in the Project Area but probably only in low numbers. Its status is similar across large parts of Lao PDR. The Project area is small in proportion to the nation's total suitable habitat and as such is most unlikely to constitute critical habitat.
Buceros bircornis Great hornbill	This species frequents evergreen, semi-evergreen and mixed deciduous forests, ranging out into open deciduous areas to visit fruit trees and ascending slopes to at least 1,560 m. The species is perhaps most common in unlogged forest.	1		✓	No	Great hornbill plausibly still occurs in the Project Area but probably only in low numbers. Its status is similar across large parts of Lao PDR. The Project area is small in proportion to the nation's total suitable habitat and as such is most unlikely to constitute critical habitat..
Cairina scutulata White winged duck	The species occur in stagnant or slow-flowing wetlands (natural and artificial) within or adjacent to evergreen, deciduous or swamp forest. Individuals roost and nest in the tree hollows. The species is secretive and forages at night on seeds, aquatic plants, grain, rise, small fish and invertebrates.	1		✓	NA	White winged duck might possibly still occur in the Project Area but at best only in very low numbers. Despite major loss of habitat in the last half century, tracts similar in extent and condition to the Project Area remain in many parts of Lao PDR. The Project Area is only a small proportion of the national's total suitable habitat and as such it is unlikely to constitute critical habitat.
Centropus sinensis Greater coucal	Habitat is noted to be forest edge, scrub, tall secondary growth and grassland including ponds and villages.	1	✓		No	Greater coucal is probably abundant over the deforested and degraded parts of the Project Area. This is so across Lao PDR however the Project Area constitutes an insignificant proportion of the nation's total suitable habitat and as such does not constitute critical habitat.

Species	Habitat Requirements	Criteria	Record		Likely Critical Habitat	Comment
			Direct	In-direct		
Gyps bengalensis White backed vulture	The species occurs mainly in plains and less commonly in hilly regions. It is known to utilise light woodland, villages, cities and open areas. The species is thought to forage over a vast range, primarily on carrion.	1		✓	No	Given the ease of finding this species when present and the high levels of survey in the general region of Lao PDR within which lies the Project Area, there is no chance that the interview reports collected in fact refer to a resident population of this or any other vulture. The Project Area does not constitute critical habitat.
Lophura diardi Siamese fireback	The species occurs in evergreen, semi-evergreen and bamboo forest, secondary growth and scrub, often near roads and tracks through the forest, chiefly in the plains and foothills to 500 m, but occasionally much higher.	1		✓	No	Siamese fireback is very likely to occur, perhaps widely, in the Project Area. Nonetheless, the Project Area constitutes an insignificant proportion of suitable habitat across Lao PDR, so does not constitute critical habitat.
Lophura nycthemera Silver pheasant	Occurs in hill and montane forest (mainly evergreen) and tall secondary growth. Generally found between 500m and 2020m although occasionally down to 200m.	1		✓	No	Silver Pheasant is very likely to occur, perhaps widely and commonly, in the Project Area. Nonetheless, the Project area constitutes an insignificant proportion of suitable habitat across Lao PDR, so does not constitute critical habitat. This remains so even if one treats the various morphologically distinctive races as separate conservation units.

Species	Habitat Requirements	Criteria	Record		Likely Critical Habitat	Comment
			Direct	In-direct		
Pavo muticus Green peafowl	The main threat to the species in Lao PDR is hunting, including egg collection. Habitat modification and fragmentation may locally compound the problem. These threats have led to widespread extirpation across Lao PDR and adjacent countries.	1		✓	No	Assuming that the interview reports are in error, there is no reason to consider that the Project area constitutes critical habitat. However, the rather anomalous survival of the small population around Ban Nakhaty, Phou Khao Khoay NPA, emphasises the possibility that other remnants may also survive, and it cannot be excluded that the Project Area might support one. Such a population could be significant at the national level.
Polyplectron bicalcaratum Grey peacock pheasant	Occurs in evergreen forest from lowlands to 1850 m. The species is reported to be tolerant to degradation of forest.	1		✓	No	Grey Peacock Pheasant is very likely to occur, perhaps widely and commonly, in the Project Area. Nonetheless, the Project Area constitutes an insignificant proportion of suitable habitat across Lao PDR, so does not constitute critical habitat.
Psittacula alexandri Red-breasted parakeet	In Lao the species occurs in deciduous forests and adjacent secondary growth, mostly below 400m.	1		✓	No	Accepting the likelihood of this species's occurrence in the Project Area, it is however unlikely, that in the context of the much larger numbers remaining in parts of Central and South Lao PDR, that the Project area could comprise critical habitat.

Species	Habitat Requirements	Criteria	Record		Likely Critical Habitat	Comment
			Direct	In-direct		
Anhinga melanogaster Darter	In Lao PDR a wide variety of waterbodies, from forest streams to large ope reservoirs, is used. This is typical of the species elsewhere in its range. The species is probably independent of forests.	1		✓	No	Darters in Lao PDR's forest rivers are presently widely scattered in small numbers. The Project area would support only a small proportion of the number visiting Lao PDR presently, which are moreover, mobile (much suitable habitat remains unoccupied); and in any case the reservoir might actually improve Darter habitat in the Project Area. Thus, the Project area does not comprise critical habitat.
Ichthyophaga humilis Lesser fish eagle	Rivers with good fringing forest.	1		✓	No	With no information on the status in the Project area no firm decision can be made. Numbers, if any, in the Project area are probably too few for the area to constitute critical habitat; but if there are surprisingly large numbers there, then it possible would be critical habitat.
Reptiles						
Broghammerus reticulatus Reticulated python	expected to occur in most forest types though it is also documented to inhabit humid forests and is typically found in riparian areas	1		✓	No	Given that the Lao PDR population is not considered to be of global significance and that is it widespread it is unlikely that the Project area sustains greater than 10 per cent of the global population or is one of 10 discrete management sites globally for the species (C1 Tier 1). The baseline information does not provide an indication that the habitat is of significant importance, or that records are part of an important concentration (C1 Tier 2).

Species	Habitat Requirements	Criteria	Record		Likely Critical Habitat	Comment
			Direct	In-direct		
Indotestudo elongate Elongated tortoise	A damp forest species although is also found in dry habitats. The species diet consist of fruits, leafy greens, worms, slugs and carrion.	1		r	No	Given that the Lao PDR population is not considered to be of global significance and that is it widespread it is unlikely that the Project area sustains greater than 10 per cent of the global population or is one of 10 discrete management sites globally for the species (C1 Tier 1). The baseline information does not provide an indication that the habitat is of significant importance, or that records are part of an important concentration (C1 Tier 2).
Ophiophagus hannah King cobra	Found in most forest types, including bamboo.			✓	No	Given that the Lao PDR population is not considered to be of global significance and that its haitat is widespread it is unlikely that the Project area sustains greater than 10 per cent of the global population or is one of 10 discrete management sites globally for the species (C1 Tier 1). The baseline information does not provide an indication that the habitat is of significant importance, or that records are part of an important concentration (C1 Tier 2).
Platysternon megacephalum Big-headed turtle	The species inhabits fast flowing, cool, rocky mountain brooks and streams, usually narrower than 1 m and less than 10 cm deep.	1		✓	No	The Project area contains small perennial streams and a number of larger watercourse crossings however due to the design of the crossing infrastructure to maintain flows and manage stability of the sediment the Project area of influence are of limited size. As such the Project area is considered unlikely to be critical habitat for the species.
Fish						

Species	Habitat Requirements	Criteria	Record		Likely Critical Habitat	Comment
			Direct	In-direct		
Catlocarpio siamensis Giant barb	The species inhabits floodplain and main river habitats feeding on algae, phytoplankton, vegetation and small fish. Spawning areas are unknown and little is known about spawning behaviour.	1,3		✓	Pending	If the species is present downstream of the reservoir, the modification of the topography of its habitat and alteration of the flow pattern (especially disruption of daily and annual cycle) are expected to have an impact of the spawning sites and the reproduction of the species. Given the declining global population and the fragmentation of its distribution range, any spawning site would be a critical habitat.
Laubuca caeruleostigmata Leaping barb			✓		Pending	
Pangasianodon hypophthalmus Striped catfish	It inhabits main channels and floodplains, moving off-channel for feeding and nursing. The species feeds mainly on algae, plants, zooplankton, insects, fruits, crustaceans and fish.	1,3		✓	Pending	In the event there is spawning area downstream of the dam, the area may be considered critical habitat. Further targeted village interviews are scheduled to identify the locations where the species has been noted in the Nam Ngiep and neighbouring catchments.
Poropuntius deauratius Yellow tail brook barb	Species habitat is listed as coastal river drainages in Central Viet Nam (Hukstorf and Freyof, 2011) and it is considered that the survey record is a misidentification.	1	✓		Pending	Species profile and specialist input (pers. comm. Dr Maurice Kottelat 11/11/2013) suggest that the species record is a misidentification and as such further confirmation on the record is currently being sought in order to identify critical habitat status.

Species	Habitat Requirements	Criteria	Record		Likely Critical Habitat	Comment
			Direct	In-direct		
Probarbus labeamajor Thicklipped barb	The species inhabits the deep, slow reaches of the main channel of large rivers with a sand or gravel substrate and abundant mollusc population.	1,2		✓	No	Specialist input (Dr Maurice Kottelat pers comm 11/11/2013) indicated that the species is not known to occur in the Project area part of the catchment and the record would require verification. Should the record be correct, the habitat in the lower reaches of the Nam Ngiep River may be susceptible to indirect impacts from the propose dam, however the area is unlikely to represent >10% of the habitat within the Mekong. The Project Area is not considered to be critical habitat for the species.
Yasuhikotakia splendida Jaguar loach	Species habitat is listed as rocky rapids in large streams and rivers. The distribution of the species is reported from the Sekong River, Mekong (as Savannakhet) and the Mun River, Thailand.	2	✓		Pending	Specialist input (Dr Maurice Kottelat pers comm 11/11/2013) indicated, consistent with other sources, the species is only known from the Xekong drainage in southern Lao and may be a mis-identification. If an accurate species identification the Nam Ngiep should be considered critical habitat and as such verification of the record would be required. Photographic record of the survey captures are currently being confirmed and the individuals may be Y. lecontei or Y. caudipunctata which are listed as least concern on the IUCN Red List.

Species	Habitat Requirements	Criteria	Record		Likely Critical Habitat	Comment
			Direct	In-direct		
Wallago leeri	The species is noted to occur in large streams and rivers with juveniles found in the mouth of small streams connected to larger rivers.	2		✓	Pending	Species profile information suggests that the species would utilise main or larger river areas and smaller streams for juveniles.
Migratory fish species		3	✓		Pending	For a number of the species identified by the baseline study the Project area is not within the distribution of the species and as such the Project area is unlikely to provide critical habitat characteristics. For other species aquatic habitats up-and downstream of the access road crossings may play a role in migration pathways and as such crossing structure design has considered the requirement for adequate bridge length and allowance to maintain water flow.

Note: r = species included at request

Source: Baseline Biodiversity Assessment (ERM, 2014a)

5.2.12 *Conservation Significant Values Summary*

The outcomes of the assessment and specialist consultation did not identify any areas of critical habitat for terrestrial flora or fauna species. Ongoing assessment is currently underway to clarify the values of the Project area and the potentially impacted downstream area for fish species, including migratory species.

While no areas of critical habitat have been idenitified within the Project Area, an assessment of potential impacts and the application of mitigation measures with specific reference to biodiversity values, including priority habitat values have been considered in *Section 6.2.2* and *Section 6.3.2*.

6 ENVIRONMENTAL IMPACTS AND MITIGATION MEASURES

6.1 INTRODUCTION

This chapter identifies and assesses impacts from the Project that are likely to affect the environment, and provides recommendations for mitigation measures to minimize impacts. Impacts are assessed over the following phases of the Project:

(i) Pre-construction and construction of Project facilities (total 6 years, 1 for preconstruction and 5 for construction)
(ii) The initial inundation period (including the time when the reservoir is first filled, 1 – 3 years), and
(iii) Operation of the two reservoirs and power plants (up to 27 years)

The environmental impacts are analyzed for two major aspects, (1) the physical environment and (2) the biological environment.

Assessment of impacts due to the access road is discussed separately in NNP1 Access Road from Ban Nonsomboun to the Main Dam Environmental Assessment", 2014 (*Appendix E*). However, some of the main environmental issues concerning the access road are also briefly covered in this chapter.

As discussed in *Chapter 4*, the major works of the Nam Ngiep 1 Hydropower Project are:

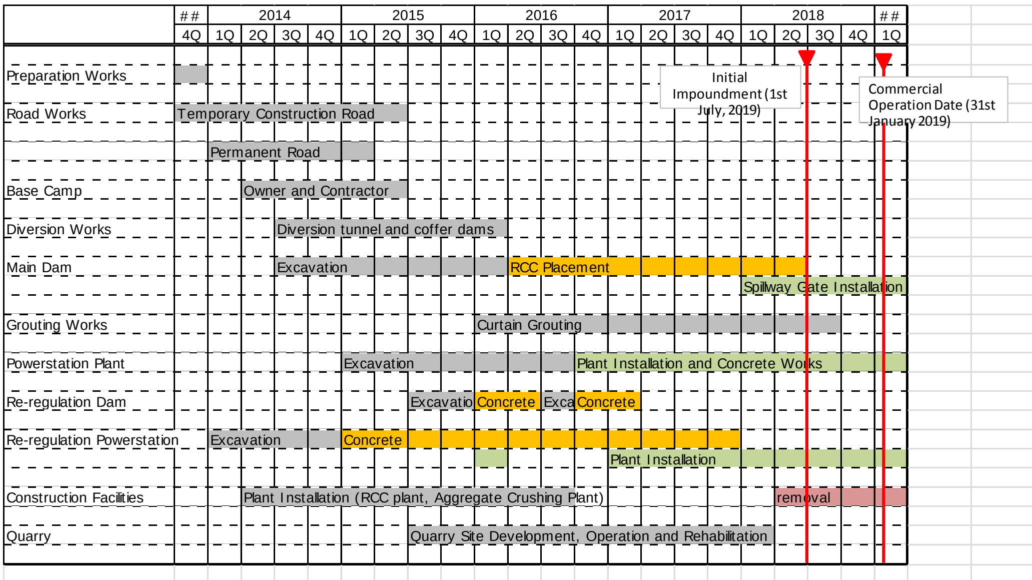
1) Road Works (Access Road, Permanent Road, Temporary Road)
2) Temporary Facilities (Aggregate Production Plant, Concrete Batching Plant, Concrete Delivery System, Concrete Placing System, Tower Crain, Water Supply, Power Receiving System, Communication, Lighting System, Accommodation, etc.)
3) Main Dam
    - Diversion and cofferdams (during construction)
    - Foundation excavation
    - Concrete placing
    - Grouting works
    - Spillway
    - Main Powerhouse
    - Transformer and Switchyard
4) Re-regulation Dam Construction
    - Diversion and cofferdams (during construction)
    - Foundation excavation
    - Concrete placing
    - Grouting works
    - Saddle dams

- Re-regulation Powerhouse
- Transformer and Switchyard

5) Other
   - Spoil Disposal Area
   - Quarry Site
   - Transmission Line
   - Administration office (NNP1PC's Base Camp)

These Project components are planned to be completed over a total of 64 months, as shown in ***Table 6.1***.

Table 6.1 ***Tentative Schedule of Construction Activities***



The main construction activities will commence after the access roads have been completed and the contractor's facilities have been prepared. This is expected to take about 19 months. Construction will commence with the excavation of the diversion tunnel, which will then be followed by other activities until the powerhouse and dam are completed. During this time, the reservoir and resettlement programs will also be completed. Construction will conclude with the filling of the reservoir and the commissioning of the structure, which is scheduled to commence at the end of Year 6 of the construction phase. The principal construction activities associated with these components are described in *Chapter 4*.

6.2 *ANTICIPATED IMPACTS DURING PRE-CONSTRUCTION AND CONSTRUCTION PHASES*

6.2.1 *Summary of Construction Activities and Potential Impacts*

6.2.1.1 *Diversion of Water around Cofferdams*

The main construction activities on the dam foundation can only start after the river has been diverted through diversion tunnels, and the river has been excluded from the site by upstream and downstream cofferdams constructed above and below the proposed dam site. There are likely to be temporary fluctuations in the flow regime in the river while this is going on, as well as a release of sediment associated with the diversion tunnel construction.

6.2.1.2 *Movement of Materials and Equipment to Site*

There will be considerable movement of materials, such as cement, fuel, construction materials, construction waste, equipment and machinery, along roads to the dam site and within the construction area. Residents living alongside access roads may experience impacts from increased traffic resulting in noise, dust, vibration and reduced safety.

6.2.1.3 *De-mining*

The area around the dam site, quarries, access roads and transmission lines are located within known UXO-contaminated sites. De-mining activities will need to be performed according to established criteria before construction activities start. De-mining will also be required at the resettlement sites. Inappropriate removal of UXO could result in injuries or fatalities.

6.2.1.4 *Earth Moving*

This is a major activity associated with the dam, and is required for building internal and external access roads, preparing sites for construction camps, dam foundation, opening quarries and for landscaping after completion of the dam site. Risks and potential impacts involved include: increased erosion of exposed surfaces, increase sediment loads in drainage lines, release of chemical contaminants into water, and emissions of dust and noise.

6.2.1.5 *Spoil Disposal*

Proper design should maximize the re-use of spoil from excavation activities for road and foundation preparation. Surplus spoil will need to be safely disposed of to avoid erosion and destabilization of the spoil disposal area, which could lead to sedimentation of water courses and release of chemicals in runoff.

6.2.1.6 Quarrying

Quarries will need to be opened to provide rock fill for the dam, and as a source of aggregate for concrete and road surface materials. This will involve removing overburden, including topsoil which should be stockpiled for later use, blasting, rock crushing and sorting. Potential impacts on people and wildlife arise from the noise and vibration from hammers, blasting and dust. There is also a risk of release of sediment and chemicals into watercourse from washing activities.

6.2.1.7 Vehicle and Machinery Maintenance

There will be several hundred vehicles and machines, operating in and around the construction sites, requiring regular maintenance. This will produce quantities of used oil, parts etc. which will need to be disposed of safely and securely to prevent environmental damage.

6.2.1.8 Materials Storage

Some construction materials can be dangerous e.g. inflammable, toxic or explosive. Hazardous materials will need to be properly identified, stored and handled to minimize risks of accidents and environmental pollution.

6.2.1.9 Waste Management – Worker Camps

There will be several thousand workers at the site at any one time who will require accommodation, recreation, washing, sanitation and cooking facilities. Worker camps will produce solid and liquid wastes, which will require treatment and safe disposal to prevent soil and water pollution.

6.2.1.10 Worker Health and Worker's Impacts on Wildlife

Programs will be required to raise awareness of workers to minimize conflicts with local communities and issues of occupational and sexually transmitted diseases, including HIV/AIDS. Workers will also need to be aware of the prohibition of hunting and entry into the NPA and PPA, as well as excessive use of scarce natural resources and hunting and trade in wildlife.

6.2.1.11 Reservoir Clearance

The vegetation in the reservoir area will need to be cleared in order to minimize the development of anoxic conditions due to breakdown of the organic matter after flooding, which could impact water quality downstream. If vegetation is burned for disposal, this can cause air pollution. During filling, vegetation residues that float to the surface will need to be cleared to prevent clogging the dam intake structure.

6.2.1.12 *Impoundment*

After the removal of the vegetation and resettlement of people from within the reservoir, the dam will be closed and the reservoir will commence filling by closing the diversion tunnel. Management of the downstream river flows will be a key task at this stage.

6.2.1.13 *Decommissioning of Construction Facilities*

On completion of construction, the construction facilities, quarries, stores, equipment and machinery, and worker camps will need to be safely and securely removed, and the areas stabilized to minimize risks of release of toxic or polluting materials to the environment. All disturbed sites which are no longer being used will need to be rehabilitated and re-vegetated.

6.2.2 *Construction Impacts on Physical Environment*

6.2.2.1 *Topography*

To assess the potential impacts to topography, available topographic maps for the Project area of 1:250000, 1:50000 and 1:2000 scale were examined. Additionally, more accurate information was obtained from visits to the proposed dam sites, as well as other secondary documents.

During pre-construction and construction phases, the topography will necessarily change with the modification of the landscape during construction of the dam and other civil works and the construction of access routes.

No mitigation measures are required that relate solely to changes in topography. Possible impacts that are related to changes in topography, such as erosion or sedimentation, are considered separately.

6.2.2.2 *Meteorology*

The potential impact of the Project on climate is not expected to be significant (see *Section 6.2.2.7* and *6.3.1.6*). Climate, however, can have considerable impact on the construction and operation of the Project.

The number of available and effective meteorology stations, the monitored parameters, and the period of monitoring will limit the precision of weather forecasts. Standardization of available records from peripheral stations, and the use of Thiessen and Isohyetal methods, were the most practical means for obtaining meteorological data for the Project hydrological study. However, they may not be appropriate for certain activities or purposes, such as the scheduling of the clearing plan. Therefore, more local monitoring of meteorological and climate data should be carried out during pre-construction, construction and operation, so that work plans can be adjusted to fit the meteorological conditions.

Meteorological conditions will affect several Project activities. Site cutting and clearing will not be possible during the rainy season, and cut and fill work will also be limited by the rains.

Mitigation measures may be needed during construction to control the dispersion of dust created by clearing lands at the construction sites. If the clearing of the reservoir area is done in part by burning, meteorological conditions also need to be taken into account (***Figure 6.1***). Both rains and wind would have potential effects on clearing.

Figure 6.1 Wet Weather Affecting the Clearing Process

Available periods to transport heavy machinery and to work at the construction site during pre-construction and construction phases will be limited by heavy rain.

Local winds will distribute dust from the construction site. After vegetative covering has been removed at the construction sites, the large bare areas will cause increased dust, which will be dispersed downwind.

6.2.2.3 Geology, Landforms and Seismology

Most of the geological information available for review for the Project was at the regional scale. Some of the major geological impacts, such as seismic events, can also be assessed at this scale. Some geological ground surveys were conducted around the construction sites by Kansai Electric Power Co., Inc in 2009. The data obtained from these surveys was used for Project design and can also be used to assess the potential impact of geological patterns on riverbank erosion, landslides, and ground leakages of the reservoir.

Based on regional geology of the Project area and local geological data from the Technical Report (Kansai Electric Power Co., Inc, 2011), the potential for earthquake in the Project area is determined to be low.

Landslides and rock movements are possible during construction. The potential for such movements is influenced by the Late Palaeozoic granites found intruded into Palaeozoic formations, which were found to be highly fractured and deeply weathered in the middle part of the reservoir area, and by young unconsolidated sediments found along the river and riverside.

The fractures and deep weathering patterns may partly impact the construction process and dam designs. For instance, they can affect the stability of excavations and engineered structures. Landslides and rock movement may occur, particularly along steep slopes around the construction site. This is the most crucial geological impact that needs to be prevented or mitigated.

To prevent these possible impacts, the following mitigation measures are recommended:

- The data obtained from the geological tests around the Zone 2, Zone 3 and some locations of Zone 4 (Downstream) should be used for detailed Project design and to prepare a safety plan during Project construction.
- Detailed testing should be carried out to ascertain appropriate geological properties. Ground geophysical survey and drilling exploration along the dam axis must be carried out in more detail to avoid large fractures that could lead to water leakage and dam deterioration.
- Any landslides and rock movements around the site should be investigated during construction.
- Grouting is recommended as reported in the Technical Reports (Kansai Electric Power Co., Inc, 2011).

Dams Safety Review Panel (DSRP) has an agreement between ADB and the Project. The scope of the Dam Safety Review Panel reflects all aspects of dam safety in terms of flood hydrology, seismology, engineering geology, rock mechanics/underground excavations, sedimentology, dam design, hydraulic design, planning and design of dams and hydropower facilities, construction of dams and hydropower facilities, concrete technology, specifications and manufacturers' proposals.

The DSRP will also review the various detailed plans required to be prepared in accordance with the plan for construction supervision and quality assurance, the instrumentation plan, the operation and maintenance plan, and an emergency preparedness plan.

6.2.2.4 Erosion and Sedimentation

Most erosion from construction occurs due to the removal of protective ground cover and vegetation by activities that require land clearing. It is anticipated that, until the ground is stabilized through natural or artificial means, the Project will result in increased sediment yields through greater erosion and subsequent sediment discharge. This has frequently been observed on other projects, whereby after the vegetation has been removed and catchment areas have been converted to other land uses (Brooks 1993), increased sediment discharges and associated adverse effects result and can persist for some time.

The proposed Project will involve the construction of a variety of associated major facilities, including power plant facilities, as well as support infrastructure such as roads, bridges, and transmission lines. Consequently, the potential for adverse impacts from erosion is considered to be significant, and careful implementation of sediment control measures will be required. As some of the details on the locations of the workers' camp, landfill, and quarry are all still tentative, it is not possible to precisely estimate the potential erosion and sediment discharge from these works.

If suitable mitigation measures are implemented, such erosion impacts due to construction would likely be significantly reduced and controlled. Consequently, it is essential that appropriate mitigation measures be implemented, with best management practices followed. Whenever feasible, construction, particularly land clearing activities, should be conducted during dry periods to help minimize erosion impacts. Moreover, care needs to be taken during road construction and excavation works at the dam site.

In the general Project area, Erosion and Sediment Control Design Plans should be prepared prior to the commencement of works. These should contain:

- Conceptual design of erosion and sediment controls to be implemented on-site in accordance with the requirements of this Project.
- Water quality monitoring in accordance with the requirements of a water quality monitoring plan.
- All vegetation on the slope above full supply level (FSL) shall be retained to protect the slope areas.

Erosion and sediment control plans will be included in the site-specific plans prepared for each construction site. The erosion and sediment works will be implemented prior to the commencement of any construction works on the site.

Erosion and sedimentation should be controlled during the construction phase of the power plant. Wherever possible, land clearing and vegetation removal should be conducted with as small footprint as possible to ensure as much of the original ground cover is maintained in its existing condition.

Suitable measures to control sedimentation and erosion resulting directly or indirectly from the Project include the following practices:

- Soil erosion and sediment control practices should be installed prior to any major soil disturbance.
- All areas disturbed by construction activities will be, as far as reasonably possible, landscaped to reflect natural contours and restore suitable drainage paths.
- Soil and spoil removed during the construction process will be stockpiled separately and stabilization measures implemented. The stockpiles will be constructed with smooth slopes and free draining patterns. Topsoil stockpiles will be deep ripped to provide for moisture retention and regrowth. Appropriate measures will be installed in between the stream and the stockpile to control runoff where necessary.
- Stockpiles will not be located on drainage lines, in floodway zones, or in other areas important for the conveyance of floodwaters during major floods.
- Potential problems with erosion along the base of waste or soil surplus piles must be considered in planning the location of such sites.
- Waste or surplus materials shall not be placed in areas subject to potential flooding and inundation, or in manmade or natural watercourses.

In terms of erosion control, the major effort at construction sites for the Project will focus on the management of erosion of excavated surfaces, especially during the wet season when the volume of runoff is expected to be high. A Site Management Plan which includes a sub-plan for Erosion and Sediment Control will be prepared by the Head Contractor for use at all the construction sites. It will include environmental management and pollution control techniques for all areas of activity, including drainage measures for underground works. It will also include a Water Quality Monitoring Plan. The Plan will meet the appropriate standards, and include development of drainage works, sediment traps, diversions, culverts and other structures designed to treat water to an acceptable quality before discharge into natural and/or constructed watercourses.

The Erosion and Sediment Control Plan will be prepared for use at all construction sites as part of the site management plan for construction. It will include environmental management and pollution control techniques for all drainage measures, as follows:

- Water management plans to meet the appropriate standards, including development of drainage works, sediment traps, diversions, culverts and other structures designed to treat water to an acceptable quality before discharge into natural and constructed watercourses. These structures will be constructed prior to commencement of earthworks if necessary. Regular inspection and maintenance will be conducted to monitor their efficiency. The volume of turbid water will be kept to the minimum and the discharge regulated. Turbid water from the construction areas will be directed to the sediment settling areas.

- Sedimentation controls will be implemented in the form of sedimentation basins, silt trap fences, or similar measures where appropriate, depending upon the size of the catchment area, and other physical and environmental constraints.

The following measures are also recommended to control erosion:

- Soil erosion and sediment control practices will be installed prior to any major soil disturbance, or in their proper sequence.
- Soil and spoil removed during the construction process will be stockpiled separately and stabilization measures implemented.

6.2.2.5 *Reservoir and River Water Quality*

Assessment of impacts to water quality is considered with reference to the standards reviewed in *Section 2.1.6* and water quality models developed by NEWJEC, an international engineering firm based in Japan (*Appendix G2*).

Due to the varying impacts from different activities, the impact assessment considers three main phases: (1) pre-construction and construction (total 6 years, 1 for preconstruction and 5 for construction), (2) the initial inundation period (including the time when the reservoir is first filled), and (3) long-term operations.

During the construction phase, treated wastewater, with BOD_5 of less than 20 mg/L, will be discharged to the Nam Ngiep River from the on-site wastewater treatment facility, or from a settling pond. During the period with the maximum expected number of workers (1,800 workers), the quantity of wastewater generated by the Project is estimated to be a total of 90,000 L/day or 1.0×10^{-3} m^3/s[1] (assuming 50 L/day/person). Given the average annual flow of 148.4 m^3/s of the Nam Ngiep River, the release of treated water with low BOD at the rate of 1.0×10^{-3} m^3/s will not have a significant impact on water quality.

It is more likely that changes to water quality could occur from construction and clearance activities. If these are not carefully monitored and controlled, a number of parameters could be affected, among them water temperature, nutrient load, turbidity, suspended solids and concentration of dissolved elements. Of particular concern is the increase in sediment load downstream caused by construction activities, such as cutting into the hillsides to build the new access road, which could lead to more sediment and landslides during the cut and fill works.

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1. Average wastewater 140 L/day/person were designed for the rural areas in Mahasarakham Province, Thailand. The average water use of rural Thai people was 45 liters/person/day. (www.spo.moph.go.th/). Water use of Nam Ngum 2 Hydroelectric Power Project was designed at 50-60 L/person/day.

Figure 6.2 Water Drainage Channel Provided along an Elevated Unpaved Road

Figure 6.3 Large Sediment Load due to Unpaved Road

The area to be cleared for construction has been estimated to cover about 1,431 km^2 or 189.7 ha. This is based on estimates from spaces provided for the construction activities such as opened diversion channel, longitudinal cofferdam, foundation excavation, etc., as shown in ***Table 6.2***.

Table 6.2 The Estimated Clearing Area from Construction Activities

Composition of Construction	Area (ha)
Main dam	25.9
Re-regulation dam	14.3
Access road	
• Ban Nonsomboun to Ban Hat Guiun (21 km length, .5-10 m. Width)	42.0
• Ban Hat Guiun to Dam Site (11.2 km length, 6.6 m Avg. width)	18.6
Approximate right of way 5 m. of each side of route	
Quarry site	46
Office	10.2
Spoil disposal area	32.7
Total	**189.7**

Note: The above number is to be revised later by NNP1PC due to detailed design.

The annual sediment yield of NNP1 is estimated at about 178 tons/km^2/year. During the wet season, the suspended solids could rise up to about 200 mg/L, with a much lower rate of about 20 mg/L in the dry season. The erosion rate would likely be very high on uncovered lands developed for agriculture. Within the areas to be inundated, logging and land clearing must be carried out. During this logging and clearing period, the top soil could be eroded by rains, and high sediment concentrations in the river could affect downstream water quality.

The bare topsoil and excavated debris rocks caused by the construction activities at the construction site would also contribute to high sediment levels downstream. Uncovered soil will be a major source of sediment through runoff. Soil erosion and subsequent downstream sedimentation during the rainy season could occur during the five to six years of the construction period.

The main materials used for construction could also be a potential source of water contamination. Specifications and/or labeling of the materials should indicate which substances would be potential contaminants, such as heavy metals. Some metal elements could leach from components used as construction materials, or from the geochemistry of foundation rocks where anaerobic reaction occurs.

Based on the geological characteristics at the main dam site (sandstone, mudstone and conglomerate) and the mountainous topography, the leakage of the impoundment water is expected to be very limited. The siltation in the reservoir would also enhance the blockage of the leakage. Therefore, the underground water is not expected to be significantly impacted from the reservoir development in terms of quantity. No hazardous minerals are found in the area, so the underground water quality is also not expected to be significantly impacted.

The primary potential cause of deterioration on downstream water quality requiring mitigation measures is surface water runoff from the erosion of the soil surface. Although the impact of wastewater from the worker camp sites is predicted to be insignificant, proper measures still need to be taken to minimize that impact. Water quality monitoring will begin as soon as possible after the Environment and Social Management and Monitoring Unit (ESMMU) is formed and technical assistance for the Project begins.

Details of mitigation measures are suggested as follows:

1) Settling ponds for sediment settling and for nutrient treatment.

Sediment settling tests should be conducted to determine the settling pond retention time to meet the natural concentration of that area. Settling ponds are suggested, where space is available, to trap sediments and other water pollutants from either runoff or direct discharge.

Properly designed settling ponds retain water long enough for coarse suspended solids to settle. Water discharge from the settling ponds will have reduced concentrations of suspended solids, total nitrogen, total phosphorus, and biochemical oxygen demand, compared with the influent water. The ponds also provide the opportunity for pH adjustment. The wastewater discharge from the worker camps should be trapped in a separate pond, since the time for nutrient degradation is longer. Shapes and sizes of the ponds can be flexible depending on the topographical structure. The end of pipe where the treated water is released can be near the river. However, direct discharge into natural receiving water is not recommended as a best management practice, and discharged water should be monitored to determine the quality of the treated wastewater before it is released into the river.

2) Hygiene training for workers

Workers at the construction sites should be educated on the impact of sediment and other water pollutants to local people living downstream. The management should be conducted with at least two levels of command and control, and a voluntary reward-based approach introduced. Workers should be educated on the proper use of sanitary toilets, and open defecation should be prohibited.

Referring to OSHA 29 CFR 1910.141(c)(1)(i), it is recommended that toilet facilities shall be provided in all places of employment, and the number of facilities to be provided for each gender shall be based on the number of employees, as shown in ***Table 6.3***.

Table 6.3 Guideline for Provision of Toilet Facilities in Construction Area

Number of employees	Minimum number of water closets[1]
1 to 15	1
16 to 35	2
36 to 55	3
56 to 80	4
81 to 110	5
111 to 150	6
Over 150	1[2]

1 Where toilet facilities will not be used by women, urinals may be provided instead of water closets, except that the number of water closets in such cases shall not be reduced to less than 2/3 of the minimum specified.

2 additional fixture for each additional 40 employees

Source: U.S. Department of Labor Occupational Safety and Health Administration

Period of Practices

The settling ponds should be provided when and where cut-and-fill operations are conducted, and where bare areas occur during the construction period.

6.2.2.6 Noise and Vibration

Assessment of noise and vibration impacts is made only for the Project construction phase; the impacts during normal operation of the dam are expected to be negligible. The impacts due to noise and vibration levels are dependent on the sources of noise and vibration, distance between sensitive receptors and those sources, exposure time and differences between day/night times.

The sensitive receptors of the Project would primarily be humans and animals located in and around Ban Hat Gniun, which is located next to the proposed new access road and is near the re-regulation dam.

Potential noise and vibration impacts from the Project on sensitive receptors during the construction activities, and recommended mitigation measures, are assessed as follows:

(1) Noise

During the construction phase, activities that may cause noise impacts to the surrounding area include cutting and land excavation, and movement of equipment and materials for construction. Using measurements of the noise level of construction equipment by the Federal Transit Administration (FTA), and typical usage factors, equivalent hourly sound levels were calculated for each construction activity. Pile driving sound levels of 90 dBA and 84 dBA were obtained at 100 feet (30.48 m) and 200 feet (60.96 m), respectively.

Construction Noise

Potential noise impacts associated with grading and construction have been assessed using the methodology developed by FTA (Federal Transit Administration, 1995). ***Table 6.4*** is a summary of typical noise levels generated from construction equipment (in terms of Leq) (Federal Transit Administration, 1995). Generally, construction equipment can be operated intermittently or fairly continuously, with multiple pieces of equipment operating concurrently. Typically, construction-site noise levels are about 80-90 dBA, measured 50 feet (15.24 m) from the activity. Ban Hat Gniun lies about 3 km, or nearly 9,900 feet, from the construction site, so the noise level would be less than 50 dBA.

Table 6.4 Typical Noise Levels Generated from Construction Equipment

Type of Equipment	Maximum Level (dBA at 50 feet)
Grader	85
Scrapers	89
Bulldozers	85
Heavy Trucks	88
Backhoe	80
Pneumatic Tools	85
Concrete Pump	82

Source: Federal Transit Administration, 1995

To assess a typical reasonably foreseeable construction noise condition, a scenario in which a grader (85 dBA) and a scraper (89 dBA) operate concurrently and continuously in the same area has been assessed. The combined sound level of these two pieces of equipment would be approximately 90 dBA at a distance of 50 feet (15.24 m) from the construction site.

Considering a worst case scenario, where all construction equipment operates concurrently and continuously in the same area (whereas several activities might be operated at the same time) the combined sound level of all equipment would be approximately 94.2 dBA at a distance of 50 feet (15.24 m) from the construction site. The nearest community, Ban Hat Gniun lies about 3 km, or nearly 9,900 feet, from the construction site. At this distance, the noise level would be approximately 48.3 dBA.

Distance attenuation, molecular absorption, and anomalous excess attenuation were taken into account in the calculation. Given that some houses are quite dispersed in the village, the closest residences could be as near as about 1,200 feet (365 m) from active construction sites. At this distance, the combined sound level of all of equipment would be approximately 66.6 dBA.

Table 6.5 indicates construction-period noise levels at various distances based on a source level of 90 dBA (measured at 50 feet). The closest residences could be as near as about 1,200 feet (365 m) from active construction sites. The results in the table indicate that the typical reasonable foreseeable construction noise would be approximately 60 dBA at the closest residences. If short–term sound–level measurements at residential locations in the Project area indicated that existing ambient sound levels are in the range of 40 to 45 dBA, the construction noise will have a potential to be no more than 15 dBA above the existing ambient sound level for the closest houses. Noise levels will be negligible for most of the community, which lies nearly 10,000 feet (3,048 m) from the nearest construction site.

Table 6.5 Estimated Grading–Related Construction Noise in the Project Area

Distance Attenuation*	
Distance to Receptor (feet)	**Sound Level at Receptor (dBA)**
50	90
100	84
200	78
400	71
600	67
800	65
1,200	60
1,500	58
2,000	55
2,500	52
3,000	49
4,000	45
5,280	41
7,500	34

*Based on the following assumptions:

Basic sound level drop-off rate:	6.0	dB per doubling of distance
Molecular absorption coefficient:	0.7	dB per 1,000 feet
Analogous excess attenuation:	1.0	dB per 1,000 feet
Reference sound level:	90	dBA
Distance for reference sound level:	50	Feet

The report of the World Health Organization on "Guidelines for Community Noise" establishes health-based guideline values of noise exposure, for which no adverse effects of community noise exposure on human health would be expected. The guidelines provide guidance on various levels of risk on public health. This concept allows countries to adopt their own level of noise control, according to affordability and technical feasibility versus public health risks. It is also recommended that community noise exposure should be managed through the use of environmental health impact analyses. ***Table 6.6*** shows guideline values for community noise in specific environments.

Table 6.6 Guideline Values for Community Noise in Specific Environments

Specific environment	Critical health effect(s)	LAeq [dB(A)]	Time base [hours]	LAmax , fast [dB]
Outdoor living area	Serious annoyance, daytime and evening	55	16	-
	Moderate annoyance, daytime and evening	50	16	-
Dwelling, indoors	Speech intelligibility and moderate annoyance, daytime and evening	35	16	
Inside bedrooms	Sleep disturbance, night-time	30	8	45
Outside bedrooms	Sleep disturbance, window open (outdoor values)	45	8	60
School class rooms and pre-schools, indoors	Speech intelligibility, disturbance of information extraction, message communication	35	during class	-
Pre-school bedrooms, indoors	Sleep disturbance	30	sleeping-time	45
School, playground outdoor	Annoyance (external source)	55	during play	-
Hospital, ward rooms, indoors	Sleep disturbance, night-time	30	8	40
	Sleep disturbance, daytime and evenings	30	16	-
Hospitals, treatment rooms, indoors	Interference with rest and recovery	#1		
Industrial, commercial shopping and traffic areas, indoors and outdoors	Hearing impairment	70	24	110
Ceremonies, festivals and entertainment events	Hearing impairment (patrons:<5 times/year)	100	4	110
Public addresses, indoors and outdoors	Hearing impairment	85	1	110
Music through headphones/earphones	Hearing impairment (free-field value)	85 #4	1	110
Impulse sounds from toys, fireworks and firearms	Hearing impairment (adults)	-	-	140 #2
	Hearing impairment (children)	-	-	120 #2
Outdoors in parkland and conservation areas	Disruption of tranquility	#3		

#1 :as low as possible;
#2 :peak sound pressure (not LAmax, fast), measured 100 mm from the ear;
#3 :existing quiet outdoor areas should be preserved and the ratio of intruding noise to natural background sound should be kept low;
#4 :under headphones, adapted to free-field values

Source: World Health Organization, 1999

Construction noise impacts may occur throughout the construction phase. The Project will involve the use of many different types of equipment and activities. Large machinery, such as generators, will be transported to the dam sites by trucks.

Noise from Transportation

Many of the raw materials for construction will be transported from the Thai border by trucks along the newly constructed access road. The noise impacts from this transportation will be low, because there are few residential areas along the new road. However, vehicles will pass very near (within 50 meters) to Ban Hat Gniun. The loudest vehicles expected to pass within the vicinity of the village on the roads are heavy trucks. Heavy trucks are expected to emit a noise level of 88 dB(A) at 50 feet (15 meters) from the source, as shown in ***Table 6.4.*** Although this level of noise is capable of producing "hearing impairment" (World Health Organization, 1999), that is only the case for continuous, extended exposure of an hour or more, as shown in ***Table 6.6***. The noise from passing vehicles along the road will be intermittent and of very short duration. Additionally, the estimated noise levels present an absolute worst-case condition: the surrounding trees and other vegetation and the topography are expected to lead to substantial absorption and rapid attenuation of noise.

Mitigation Measures

Since there are no residential communities currently in the immediate vicinity of the Project site, the primary noise impact would be on the workers and on some communities that have been proposed to be resettled by the riverside.

Recommended mitigation measures for noise impacts from the Project are as follows:

- Appropriate and sufficient Personal Protective Equipment (PPE) for noise protection shall be provided to all workers.
- All noise generating construction equipment shall have sound-control devices (e.g., exhaust mufflers) that are no less effective than the sound control devices that are provided on the equipment when new.
- Construction activities that may generate harmful noise should be limited to only day time, e.g. 6 am – 7 pm, in order to minimize community disturbance.
- A blasting report shall contain complete details of the blasting schedule and procedures. People shall be warned in advance and trespassing to the blasting area shall be strictly prohibited.
- For mitigation of transport noise, construction activities that may generate harmful noise should be limited only in day time, e.g. 6 am – 7 pm, in order to minimize community disturbance. It will also be ensured that properly working mufflers are in use for all diesel/gas

driven machinery and that all machinery and vehicles are properly maintained and serviced as per the manufacturer's maintenance schedule.

- Noise barriers will be installed at the construction camp and near villages along access roads if noise levels are found to exceed standards during monitoring.

(2) Vibration

Vibration levels of different construction activities were also calculated to assess the impact of vibration from the Project. Using reference source vibration levels and typical usage factors, peak particle velocities (PPV) were calculated for each type of construction activity. The vibration records from explosions collected at the Mae-Moh Coal Mine, Lumpang Province, Thailand show the relative peak particle velocity compared with distance from explosive source and size explosive mass, as shown in ***Table 6.7***.

Table 6.7 Peak Particle Velocities (PPV) from Explosion at Mae-Moh Coal Mine, Lampang Province, Thailand

Distance from source	Explosive mass	Vibration level	
(m)	(kg/d)	PPV (mm/s)	Freq (Hz)
640	20	0.90	39
613	20	0.63	30
690	20	0.79	43
677	20	0.73	21
653	20	0.59	57
4,302	165	<0.50	0
1,559	25	<0.50	0
1,440	50	<0.50	0
1,502	25	<0.50	0
1,547	25	<0.50	0
668	20	0.62	32
597	20	0.52	27
631	20	0.67	47
4,506	187	<0.50	0
1,434	25	<0.50	0
N\R	N\R	N\R	N\R
4,302	165	<0.50	0
604	20	0.63	34
1,574	25	<0.50	0
1,547	25	<0.50	0
1,404	25	<0.50	0
5,291	200	<0.50	0
1,547	25	<0.50	0
4,269	100	<0.50	0
4,302	165	<0.50	0
4,269	100	<0.50	0
622	20	0.63	27
659	20	0.76	37
670	20	0.71	37
662	20	0.68	43
668	20	0.54	37
685	20	0.54	34

Distance from source	Explosive mass	Vibration level	
(m)	(kg/d)	PPV (mm/s)	Freq (Hz)
1,252	55	<.50	0
5,193	187	<0.50	0
661	20	0.94	21
4,317	25	<0.50	0
1,547	25	<0.50	0
1,549	25	<0.50	0
N\R	N\R	N\R	N\R
5,282	225	<0.50	0
4,277	25	<0.50	0
671	20	0.56	47
5,205	50	<0.50	0
1,872	25	<0.50	0
1,872	25	<0.50	0
617	20	<0.50	0
4,292	125	<0.50	0
N\R	N\R	N\R	N\R
N\R	N\R	N\R	N\R
603	20	<0.50	0
617	20	<0.50	0
1,882	25	<0.50	0
5,159	187	<0.50	0
1,237	20	<0.50	0
1,404	25	<0.50	0
4,463	125	<0.50	0
1,452	25	<0.50	0
572	20	<0.50	0
575	20	<0.50	0

Source: The Situation Analysis of Noise and Vibration Problem and Attitude of Residents of Mae Moh District, Lampang Province, 2004

Vibration produced by grading activities, using the method recommended by the FTA (Federal Transit Administration, 1995), considers a reference vibration amplitude (PPV ref) for a large bulldozer as 0.089 in/s at 25 feet distance, and assumes it would attenuate over distance according to the following equation:

$$PPV = PPV_{ref} \text{ X } (25/\text{distance})^{1.5}$$

Using the above equation and recommended reference amplitude, the estimated vibration amplitudes at various distances were calculated, and are summarized in ***Table 6.8.***

Table 6.8 ***Estimation of Vibration Amplitude Released from Large Bulldozer***

Distance (feet)	PPV (in/s)
25	0.08900
50	0.03100
100	0.01100
200	0.00390
500	0.00100
1,000	0.00035
1,200	0.00027
2,000	0.00012

Blasting is required for the excavation of dam foundation and diversion tunnel. Noise and vibration generated by blasting is a complex function of the charge size, charge depth, hole size, the degree of confinement, initiation methods, spatial distribution of charges, and other factors. This information is not currently available for the Project. To provide a general indication of the potential for an air blast and vibration impacts from blasting, data obtained from the blasting assessment for a mining project in northern California are presented in ***Table 6.9*** (Jones & Stokes 1999). Specifically, the data showed the estimated air blast and ground-vibration values as a function of distance, based on a 293-pound charge under average normal confinement.

Table 6.9 ***Estimated Air Blast and Ground-Vibration Levels Blast***

Distance (feet)	Peak Particle Velocity under Average Normal Confinement (in/s)	Probable Peak Air Overpressure (dB)
250	1.400	130
500	0.460	123
750	0.240	119
1,000	0.150	116
1,250	0.110	114
1,500	0.080	112
1,850	0.057	110
2,000	0.050	109
2,250	0.042	108
3,450	0.021	103
4,400	0.014	101
5,150	0.011	99
6,200	0.008	97
7,200	0.009	96

Source: Jones & Stokes, 1999

Based on these results, the air blast could exceed the 130 dB USBM standard at a location within about 250 feet (76.2 m) from a blast.

The contractor shall retain a qualified blasting specialist to develop a site-specific blasting program report to assess, control, and monitor air blasts and ground vibrations from blasting. This shall include, at a minimum, the following measures:

- The contractor shall use current state-of-the-art technology to assure that blast-related vibrations at offsite residential and other occupied structures are as low as possible, consistent with blasting safety. In no instance shall blast vibration, measured on the ground adjacent to a residential or other occupied structure, be allowed to exceed the frequency-dependent limits specified in the Alternative Blasting Level Criteria contained in USBM Report of Investigations 8507.
- The Project contractor shall use current state-of-the-art technology to keep air blasts at offsite residential and other occupied structures as low as possible. In no instance shall air blast, measured at a residence or other occupied structure, be allowed to exceed the 0.013-psi (133 dB) limit recommended in USBM Report of Investigations 8485.
- The contractor shall monitor and record air blast and vibration for blasts within 1,000 feet (330 m) of worker camps and other occupied structures to verify that measured levels are within the recommended limits at those locations. If blasting is found to exceed specified levels, controlled blasting or alternative blasting or excavation methods shall be employed that result in the specified levels not being exceeded.
- Air blast and vibration monitoring shall be made at the nearest offsite residential or other occupied structure. If vibration levels are expected to be lower than those triggering the seismograph at that location, or if permission cannot be obtained to record at that location, recording shall be accomplished at some closer site in line with the structure. Specific locations and distances where air blast and vibration are measured shall be documented in detail along with measured air blast and vibration amplitudes.

6.2.2.7 Air Quality

At the construction site, particles and fugitive dust from the construction activities, the emissions from on-road vehicles associated with the construction site and on-site machinery (off-road emissions) may impact air quality. In addition to the land clearing and surface excavation activities, construction of water conveyance systems, tunnels, and distribution systems also represent potential sources of air emissions from point sources. Increased traffic on unsealed gravel road surfaces will contribute to air pollution by the generation and release of fugitive dust. All of these activities can lead to potential impacts on the air quality at the Project site. However, these can be limited through good construction management practices. In addition, only minor impacts are expected from upgrading and construction of new roads, including other infrastructure construction.

(1) Dust Emissions

There are many dust and emission sources in the construction sites that can release a range of particles, including dust (all particulate matter up to 75 µm in diameter) and PM_{10} (airborne particles with an aerodynamic diameter of 10 microns or less).

PM10 is comprised of coarse particles (2.5 - 10 µm in diameter, which are primarily from non-combustion sources) and fine particles (<2.5 µm in diameter, which includes combustion processes or the chemical reaction of primary emissions of gases).

Dust particles can cause eye, nose and throat irritation, and lead to deposition on object surfaces, while the PM_{10} can have greater effect to human health, such as causing breathing and respiratory problems. PM_{10} can be carried by wind to humans who live and work in the area surrounding and near the site. Emissions of particles and dust from construction activities can also affect indoor air quality in the neighboring areas.

Flora and fauna can also suffer adverse impacts from PM_{10} particles and dust. It is thus important to consider the impact of dust on sensitive sites, such as special areas of conservation, protection areas, and non-statutory wildlife sites in the vicinity of the construction site.

Three principles: prevention, suppression and containment, are adopted to control the creation of dust and other emissions, and to decrease airborne hazards to health. The impacts on air quality caused by the Project construction activities will likely be temporary and controllable.

The contractor should implement an emission and dust control plan within their environmental protection and mitigation framework. The emission and dust control plan should include methods for dust suppression resulting from quarry sites, crushing and batching plans, including road construction, embankment and channel construction, haulage of materials and construction of work camps. Methods for dust suppression should be employed as necessary, including supplying water to control dust resulting from construction activities. The following measures should be used:

1) Site planning

- Planned site-layout machinery and dust causing activities should be located away from sensitive receptors.
- Choose an appropriate location of stockpiles to place, taking into consideration the wind direction. Blasting activities nearby the village or work camps will be carried out during the daytime only.

2) Construction traffic

- All vehicles should switch off engines when stopped, and should not leave the vehicle idling.
- All vehicles should be washed or cleaned before leaving the site.
- Loads entering and leaving the site should be covered if they are expected to contribute to dust emissions.
- Construction equipment emissions as a result of diesel fuel combustion are expected to be relatively minor and localized. However, combustion engines should be inspected on a regular basis and adjusted as required to minimize pollution levels.
- In the event that combustion engines are used underground, suitable ventilation measures must be provided to avoid air pollution and health/safety issues. Additional ventilation may also be needed to limit the exposure of workers to toxic gases released from excavated rock in underground work.
- Sprinkle water on unpaved roads to reduce incidence of dust in the air and around the affected villages at least 2 times in the dry season, and frequency will be increased depending on inspector's observations/monitoring for adequate dust suppression.

3) Demolition works

- Use water as needed to suppress dust dispersion by winds.
- Cutting equipment should use water as suppressant or other practical ventilation systems.
- Securely cover skips and minimize drop heights.

4) Site activities

- Minimize dust generating activities.
- Use water as suppressant where applicable.
- Keep stockpiles only as required, and cover when possible.

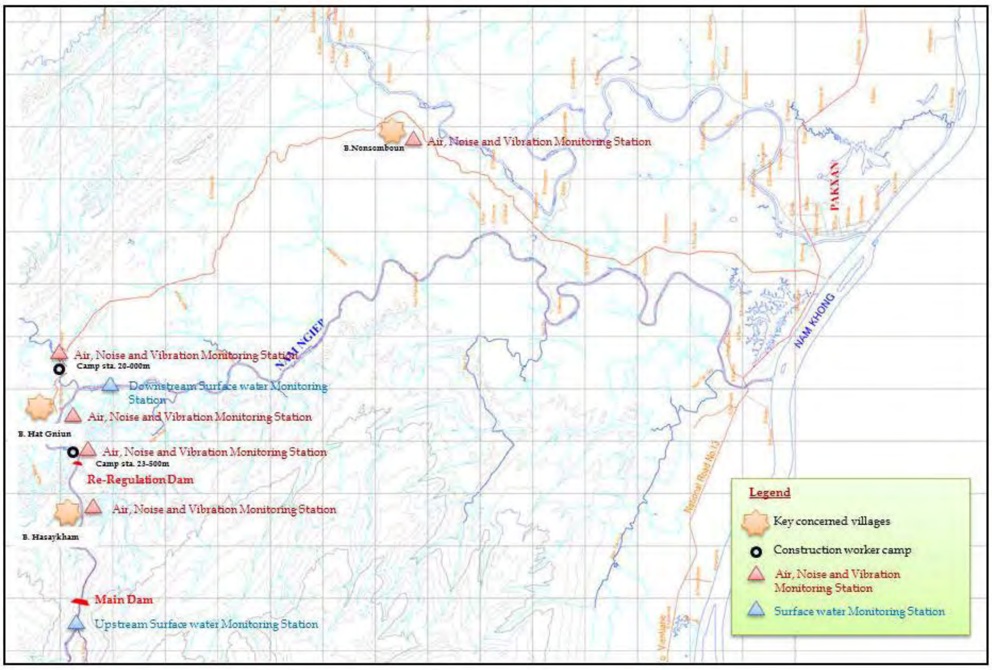
In addition, an air monitoring program in the area of construction activities that generate dust will be routinely conducted, and sampling locations and parameters specified in applicable standards will be identified specifically in the Site-Specific Environmental Management Plan. Parameters should include, at a minimum, those contained within the Lao National Environmental Standard for ambient air quality standard, which are:

  - Carbon monoxide
  - Nitrogen dioxide
  - Sulphur dioxide
  - Total Suspended Particulate
  - PM_{10}
  - Ozone
  - Lead

Along the construction route, the villages that are located near the construction route or access road are Ban Nonsomboun, Ban Hat Gniun and Ban Hatsaykham. These three villages are also identified as sensitive receptors that may be affected by the air and noise impacts during the construction phase.

Additional mitigation measures and monitoring locations of sensitive receptors were proposed in the ESMMP-CP for the access road of the Project, as shown in ***Figure 6.4.***

Figure 6.4 ***Air, Noise and Vibration Monitoring Locations along the Access Road***



In addition, the ESMMP-CP and its Sub-Plans shall be proposed as guidelines for equivalent measures that would be implemented for safety precautions during construction, and for minimizing the environmental impact of the Project. These plans provide details in terms of the mitigation measures to be implemented, including those related to traffic and road impacts from access road.

(2) Greenhouse Gas Emissions

The use of approximately 27 million liters of fuel and 60,000 MWh of electric power during construction of the Project will generate approximately 65,610 ton CO_2 and 42,000 ton CO_2 respectively, for a total of approximately 108,000 ton CO_2 during 64 months of the Project construction period, or 18,500 ton CO_2 per year. This is approximately 1% of Lao PDR's annual GHG emissions, which were 1,810,000 ton CO_2 in 2009[1].

1. http://data.un.org/CountryProfile.aspx?crName=Lao%20People's%20Democratic%20Republic

6.2.2.8 *Potential Contaminated Sites*

Assessment of impacts related to potential contaminated sites during the construction phase, and recommended mitigation measures, are described as follows:

(1) Chemical Use and Storage

Some of the Project construction materials that are classified as hazardous include explosive materials, fuel (diesel, LPG), lubricant oils, pesticides and paints. The improper transport, storage, use, and disposal of these materials could cause spills, leakage, fire, and site contamination. Besides hazardous materials, leachates from solid waste landfill and wastewater from campsites could pollute the river and soils by increasing nutrient loads, heavy metals, and pathogens.

Activities that may cause contamination are chemical storage, drum reconditioning or recycling, electric transformers, explosive product and storage, landfill, pest control, petroleum product and oil storage, and scrap yards. The hazardous chemicals from these activities may leak into the environment during construction. In addition, the hazardous materials may pollute the areas near the temporary stockpiles and spill on the area along the access roads during transport.

The receptors of contaminants are likely to be the workers who are involved in chemical use, transport and storage, aquatic flora and fauna in the Project area, and the local residents of Ban Hat Gniun, some 3 km from the nearest main construction site. Since the functional units during construction are Projected to be close to the river, the risk enhanced by high slope surfaces would be increased. The cut-and-fill technique that is planned for application for the high slope can only retain the contamination. Stringent management of hazardous materials to prevent spills must be applied to the construction sites.

(2) Quarry Site and Waste Disposal

The proposed quarry site and the solid waste landfill near the river will require careful operation and must follow best practices. They can be sources of water contaminants, which would be carried by runoff during heavy rain.

Recommended mitigation measures to minimize potential contamination are provided as follows:

1) Use of construction chemicals

- All chemicals and waste that are considered as potentially hazardous materials will be registered in order to track the type, quantities stored, quantities used or generated. Movements from storage and to waste disposal sites will be recorded. Emergency response procedures will be developed and displayed at each construction site. Safety procedures applicable to the handling and use of hazardous materials will be established and become a part of the training program for workers.

- Hazardous materials should only be handled by trained personnel.
- General waste generated from employees and in the construction site will need to be cleared regularly. Cleaning should be daily for the worker camps and office. Waste collection should be done periodically for construction sites, with the frequency depending on actual construction activities. The waste could be stored in a temporary storage container and transported out of the office or the camp. Wastewater treatment systems are proposed for the wastewater released from the construction sites. The system should be able to treat water contaminants such as human waste and suspended solids.

2) Spillage prevention

- Vehicles carrying hazardous materials must be covered during transport. Vehicles carrying pesticides and fertilizers for landscaping must be covered on the route between the storage warehouse and the landscape site.
- Chemicals must be sealed well before use.
- All workers responsible for handling hazardous waste will receive appropriate training in accordance with general good practices recommendations and emergency response procedures.

3) Storage of hazardous materials

- A hazardous waste storage area will be prepared.
- All workers will be informed of the stringent controls.
- Warning signs and rules must be located in appropriate places, such as the entrance to the storage warehouse, the office, and other places where these materials might be used or where workers will congregate.

4) Leachate of quarry site and landfill

Appropriate measures to prevent the contaminated runoff from discharging to the river should be taken.

6.2.2.9 Hydrology

The duration of Project construction will be about 64 months, or 5 years and 4 months. The duration of water impoundment, to reach the operational reservoir level, will be one rainy season, or one year. During the pre-construction and construction period, there will be several activities that must be completed before initial impoundment can begin.

A diversion tunnel with 10 m inner diameter, 660 m of length is proposed to be constructed on the left bank to avoid the folding zone in the middle of the right bank. Duration of service of the diversion tunnel will be 3 years, and there is no plan for other uses of the tunnel. A flood discharge of 1.5 year probability (1,000 m^3/s) was proposed to be used for design purposes for the diversion tunnel.

During construction, there will need to be regular analysis of the actual conditions and in particular the actual hydrological phenomena, because the available hydrological information at present is very limited. This makes any assessment to evaluate or simulate hydrological impacts difficult. The proposed construction schedule is also a draft plan, and there is uncertainty in its applicability, especially since flood events can interrupt the construction schedule. Prediction of these flood events is also difficult because of the lack of long-term hydrological data in the Project area and vicinity. Extreme events, such as rapid surface floods from the highland, could cause some damage to the construction process and equipment.

Cofferdams will bank up the river with a design flood discharge of 1,000 m^3/s, and the upstream cofferdam will be set at the downstream side of the river diversion outlet to prevent river flow into the construction site of the dam body.

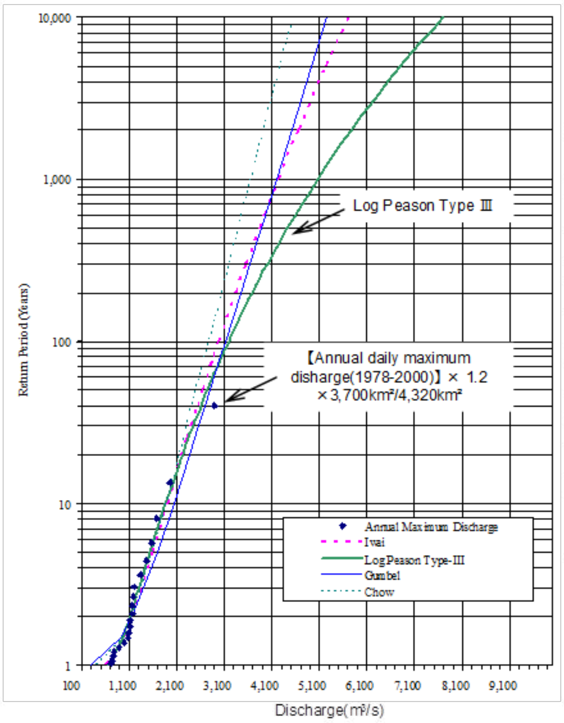
At the dam construction site, there is a proper procedure in place to handle flooding during the construction period. The diversion tunnel would handle flooding only during the first wet season after RCC placement (approximately 6 months). During this period, floods higher than 1.5-year return period (1,000 m^3/s) would be allowed to overtop the main dam. No damage is expected to occur to upstream or downstream areas, as both coffer dam and main dam are designed to withstand the overflow conditions. Therefore, construction materials would not be a potential cause of flood damages downstream of the construction site. At the upstream area, there will be no people living in the area lower than the elevation of normal water level (EL.320 m). However, a warning system must be provided to alert all workers and machinery to move to a safe place during potential overflow conditions.

After the 2nd wet season of RCC placement, the dam and its storage, together with the diversion tunnel, can handle a 50-year return period flood (2,840 m^3/s).

The flood analysis and frequency distribution curve are shown in ***Figure 6.5*** .

Figure 6.5 The Flood Analysis and Frequency Distribution Curve

Flood analysis - Frequency distribution curve -



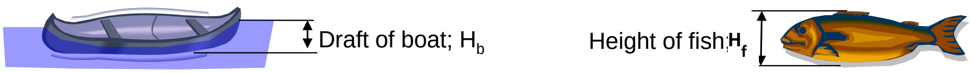
Return Period (year)	Flood Discharge (m³/s)	Method
1.01	680	Statistical analysis
1.5	1,000	
2	1,150	
5	1,590	
10	1,930	
20	2,300	
30	2,530	
50	2,840	
100	3,290	
200	3,800	
500	4,560	
1,000	5,210	
PMF	8,050	Unit hydrograph metl (Modified Snyder equation applied)

It should be noted that minimum flows to mitigate environmental impacts along the Nam Ngiep River downstream from the construction site are not applicable to the Pakxan area at the mouth of the river 40 km from the site. This is because the Pakxan area is affected more by fluctuations or influences from the Mekong River than from the Nam Ngiep River.

6.2.2.10 *Riparian Release and Environmental Flows*

During reservoir impoundment, upstream inflow has to be collected in the reservoir to meet water storage requirements before hydropower operations can commence. However, there is still a need to maintain minimum flow downstream to mitigate environmental impacts as far as practical. Although water can be discharged from the riparian release conduit when water in the reservoir is at an elevation of 245 m, water cannot be discharged from the main dam immediately after the closure of the diversion conduit inside the main dam, because the reservoir will not yet be up to the sill elevation of the bottom outlet. Instead, during this period, water will be released downstream from the re-regulation reservoir, which stores natural inflow from its side catchment (25 sq.km). Within 2 weeks, the reservoir water level at the main dam will reach the sill elevation of the bottom outlet, and the flow can be released downstream. The released flow from the re-regulation dam will gradually be increased from 5.5 m³/s (the minimum required riparian released in accordance with concession agreement) to 27 m³/s after starting impoundment of the main dam (***Figure 6.6*** and ***Figure*** 6.7).This will help control the ecological system of the Nam Ngiep River and the uses of the river by local residents downstream from the dam site.

Required minimum water depth for navigation and fish has been considered. A villager at B. Hat Gniun stated that the minimum required water depth for navigation is 0.5 m (Hb) and suggested that the required water depth for fish is usually double the height of the fish. A depth of 0.5 m enables boat navigation and appears to be sufficient for the ecology of most fish. Required minimum water depth for navigation and fish are 0.5 m.



As a result of assessment for environmental flow and discussions with related authorities, the required environmental flow and water depth has been determined as shown in ***Table 6.10***, which can be found in *Concession Agreement Annex C: Environmental and Social Obligation* between the GOL and NNP1PC. The compliance status with the below threshold will be adequately monitored during impoundment.

Table 6.10 Flow Requirement in Annex C of Concession Agreement During Impoundment

River reach	Absolute Minimum Flow	Water depth (measured at a fixed point immediately downstream of the re-regulation dam)
Downstream of the re-regulation dam	Min 5.5 m^3/s at all times in the dry season and in the rainy season	0.5 m

Figure 6.6 Discharge Scheme during Initial Impounding

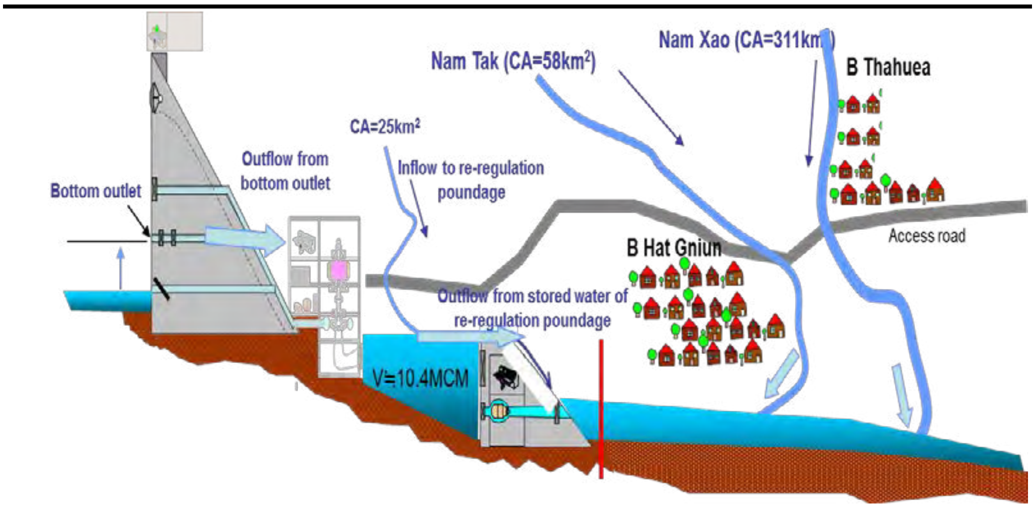
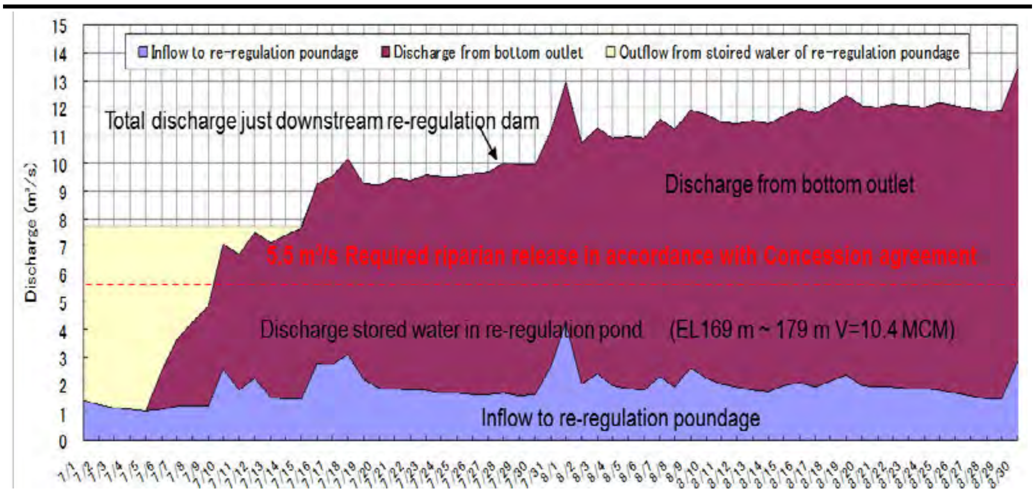


Figure 6.7 Riparian Release Flow during Construction (Average Flow of Year 1994)



Recommended mitigation measures to minimize the impacts on hydrology from the Project are as follows:

- During construction, flow in the river must not be significantly changed because there is no interruption in the flow. The suitable period for construction is during low flow season.
- The possibility of flash floods during the rainy season should be included in safety plans for the construction sites. Construction materials for both the diversion channel and the dam structure must be carefully stored during the potential flooding season. To avoid any loose construction materials getting carried in the flood waters, appropriate mitigation measures must be taken.
- Water levels at major locations/communities, especially downstream from proposed dam site to Pakxan should be monitored continuously. This data must be analyzed periodically for electricity production.
- During dam construction and water storage in the reservoir, the developer must resettle all households in the flooded area and must compensate them according to national regulations and international standards.
- During construction, public consultation with local residents both upstream and downstream from the dam site must be conducted frequently, so the local residents understand what is occurring during construction and what to expect during operation.
- Training should be given to local residents in downstream communities to help them prepare for emergency situations. This training should include such preparations as how to evacuate in case of extreme floods and other potential situations, no matter how unlikely they may be.
- During construction, the minimum downstream flow rate released from the re-regulation dam will be 5.5 m^3/s, and the minimum downstream water depth will be maintained at 0.5 m.

6.2.2.11 *Environmentally Responsible Procurement Plan*

An Environmentally Responsible Procurement Plan will be implemented for the Project. The Plan will seek to purchase goods and services that are aligned with the objectives of environmental sustainability.

Departments within the Project are to purchase goods and services that have reduced impacts on the environment compared with competing products and services that achieve the same function and value-for-money outcomes.

All purchasing of the Project is required to consider environmental impacts and opportunities, during the procurement process until the end of the Project or lifetime of goods.

6.2.3 *Construction Impacts on Biological Environment*

6.2.3.1 *Approach to Assessment of Impacts*

In accordance with the ADB sourcebook (Section V) the objectives of biodiversity impact assessment are to identify and quantify the potential project impacts; design measures to avoid, minimise or mitigate potential adverse impacts; and identify likely residual impacts. To achieve this; a five step process was undertaken. This included:

- **Screening** to determine the biodiversity features that require studying;
- **Scoping** to determine which direct and indirect biological impacts are likely to be significant in order to determine the focus issues of the impact assessment (*Chapter 5.2*);
- **Baseline Studies** to define the values of the habitats that will be affected on the Project area and in the area of influence (*Section 5.2* and *Appendix A*);
- **Impact Analysis** to assess impacts identified during scoping and baseline studies to determine the significance of the impacts (*Section* 6.2.3 and *6.3.2*);
- **Mitigation Measures** are developed to avoid or reduce adverse impacts to biodiversity with a priority given to impacts on features with significant biodiversity values (*Section* 6.2.3 and *6.3.2*); and
- **Biodiversity Offsets** are determined to compensate for unavoidable residual harm caused to biodiversity (*Section 6.3.2*).

The vegetation within the Project area and surrounds is described in terms of modified and natural habitats in accordance with the ADB sourcebook and IFC PS6. The Baseline Biodiversity Assessment Report (*Appendix A*) also presents information specific to IUCN Red List critically endangered and endangered species that are known or may occur within the Project area such that a determination of critical habitat status was developed.

The main activities associated with the construction of the Project that relate to potential impacts to biodiversity include:

- UXO clearance for any footprint;
- Land clearing for road construction, workers camps and offices, resettlement area, the main and re-regulation dams and power plants, quarry, batching plant, crushing plant, bitumen plant and concrete plant, spoil and borrow area, and transmission line;
- Excavation including blasting and land levelling required for infrastructure footprints;
- Transport of materials along existing and new transport corridors and transmission line;
- Operation of large machinery;
- In-stream construction activities for waterway crossings;
- Interruption of river and tributary flows for infrastructure construction and filling of the reservoir;
- Storage of hazardous materials and refuelling;
- Tunnelling; and
- Operation of accommodation camps during the construction period.

Table 6.11 summarises the nature of impacts to biodiversity values related to these activities. These terms are used in the scoping of project impacts on biodiversity values and relate to the identified threats from the activities.

Table 6.11 Nature of Impacts on Biodiversity Values

Term	Description
Direct Impacts	Means direct physical displacement or impact from the Project on a species' habitat or lifecycle.
Indirect Impacts	Means a secondary impact resulting from a direct impact from the Project on a species' habitat or lifecycle.
Spatial Impacts	Means impacts on species' habitats or lifecycle including: isolation of populations or individuals; impacts on species endemism; impacts on the heterogeneity of species; environmental gradients; edaphic interfaces (derived from soil toils); connectivity between habitats and climate change adaptation importance.
Temporal Impacts	Means: • Temporary Impact means a reversible impact on a species' habitat or lifecycle; and • Permanent Impact means an irreversible impact on a species' habitat or lifecycle.
Cumulative Impacts	Means the impacts from the total of all impacts on a species' habitat or lifecycle.

The Project impacts identified have been assessed for their significance against each potentially occurring habitat and species according to these criteria provided in ***Table 6.12*** and ***Table 6.13***.

Table 6.12 Habitat Impact Assessment – Significance Criteria

Habitat Sensitivity/Value		Magnitude of Effect			
		Negligible	**Small**	**Medium**	**Large**
Low	Habitats with no or local designation/recognition; habitats of significance for species of Least Concern; habitats which are common and widespread within the region.	Negligible	Negligible	Minor	Moderate
Medium	Habitats within nationally designated or recognised areas; habitats of significant importance to globally Vulnerable, Near Threatened or Data Deficient species; habitats of significant importance for nationally restricted range species; habitats supporting nationally significant concentrations of migratory species and/or congregatory species; nationally threatened or unique ecosystems.	Negligible	Minor	Moderate	Major
High	Habitats within internationally designated or recognised areas; habitats of importance to globally Critically Endangered or Endangered species; habitats of importance to endemic and/or globally restricted-range species; habitats supporting globally significant concentrations of migratory species and/ or congregatory species; highly threatened and/or unique ecosystems, areas associated with key evolutionary species (In accordance with IFC Critical Habitat Criteria)	Negligible	Moderate	Major	Critical

Magnitude of Effect Definition

Negligible	*Effect is within the normal range of variation*
Small	*Affects a small area of habitat, but without the loss of viability/function of the habitat*
Medium	*Affects a sufficient proportion of the habitat that the viability/function of part of the habitat or the entire habitat is reduced, but does not threaten the long-term viability of the habitat or species dependent on it.*
Large	*Affects the entire habitat or a significant proportion of the habitat to the extent that the viability/function of the entire habitat is reduced and the long-term viability of the habitat and the species dependent on it are threatened.*

Table 6.13 Assessment of Risks to Species – Significance Criteria

Species Sensitivity/Value		**Magnitude of Effect**			
		Negligible	**Small**	**Medium**	**Large**
Low	Species which are included on the IUCN Red List of Threatened Species as Least Concern (LC) (IUCN 2011).	Not significant	Not significant	Minor	Moderate
Medium	Species included on the IUCN Red List of Threatened Species as Vulnerable (VU), Near Threatened (NT) or Data Deficient (DD) (IUCN 2011). Species protected under national legislation. Nationally restricted range species. Nationally important number of migratory or congregatory species.	Not significant	Minor	Moderate	Major
High	Species included on the IUCN Red List of Threatened Species as Critically Endangered (CR) or Endangered (EN) (IUCN 2011). Species having a globally Restricted Range (i.e. plants endemic to a site or found globally at fewer than 10 sites, fauna having a distribution range (or globally breeding range for bird species) less than 50,000 km^2. Internationally important numbers of migratory or congregatory species. Key evolutionary species.	Not significant	Moderate	Major	Critical
Magnitude of Effect Definition					
Negligible	*Effect is within the normal range of variation.*				
Small	*Affects a small proportion of a population, but does not substantially affect other species dependent on it, or the populations of the species itself*				
Medium	*Affects a sufficient proportion of a species population that it may bring about a substantial change in abundance and /or reduction in distribution over one or more generations, but does not threaten the long term viability of that population or any population dependent on it.*				
Large	*Affects an entire population or species at sufficient scale to cause a substantial decline in abundance and/or change in distribution beyond with natural recruitment (reproduction, immigration from unaffected areas) may not return that population or species, or any population or species dependent upon it, to its former level within several generations, or when there is no possibility of recovery.*				

6.2.3.2 *Impacts to Biodiversity Values*

Table 6.14 summarises the threats to biodiversity values related to the activities during construction. These threats to biodiversity are derived from IFC 6 and relate to the activities that are likely to occur during Project construction. ***Table 6.15*** provides an assessment of significance for the natural and modified habitats within the Project area, while ***Table 6.16*** provides the assessment of significance for the identified biodiversity conservation values within the Project area.

Table 6.14 Threats to Biodiversity Values during Construction

Term	Description
Permanent Loss	Permanent loss of habitat or species due to permanent or temporary site activities for the Project
Disturbance and displacement	Disturbance to, or displacement/exclusion of a species from foraging habitat due to construction activities, de-commissioning activities, and operational and maintenance activities.
Barrier creation	Creation of barriers to the movements of animals, especially fish, but also mammals, reptiles and amphibians and invertebrates and plants with limited powers of dispersal.
Fragmentation	Fragmentation of habitat, or permanent /temporary severance of wildlife corridors between isolated habitats of importance for biodiversity.
Edge Effects	Disturbance or damage to adjacent habitat and species caused by movement of vehicles and personnel, potential mobilisation of sediment, artificial lighting, dust, spillage of fuels and chemicals, emissions and noise, and subsidence.
Alteration of Flow Regime	Effects on upstream and downstream habitats caused by alterations to natural flow regime.
Light Impacts	Effects on species caused by permanent alterations in night time light conditions;
Alien Species	Introduction or spreading of alien species during the construction works.
Creation of new habitats	Creation of new habitats and introduction of species as a result of reinstatement works, habitat enhancement proposals and landscaping.
Pollution	Contamination of the environment that has a direct or indirect impact on a species either through exposure to harmful substances.
Mortality	Mortality of individual fauna species as a result of vehicle or machinery strike or falling debris during clearing activities.

Table 6.15 Assessment of Impacts to Habitats during Construction

Impact	Description	Comment	Sensitivity	Magnitude	Significance
Temporary loss of habitat	Temporary disturbance of terrestrial and aquatic habitat in areas required to facilitate construction. Temporary disturbance will mainly be associated with access roads to construction areas, laydown areas and construction camps as well as waterway crossings and in-stream infrastructure construction (bridges).	Construction activities will require clearing of natural and modified vegetation to facilitate the construction process which will remove habitat. The habitats are common and widespread within the region (low sensitivity) and the loss will be limited to that necessary for construction. The areas to be temporarily disturbed are considered unlikely to impact the viability or functioning of adjacent ecosystems (small magnitude). Where possible topsoil will be managed locally and natural regeneration or rehabilitation using native species will be undertaken in areas not required for the operation of the Project. For waterway crossings, water exclusion dams may be required during construction leading to a loss of habitat locally and restriction of movement by aquatic species.	Low	Small	Negligible

Impact	Description	Comment	Sensitivity	Magnitude	Significance
Permanent loss of habitat	Permanent loss of 8359 ha of habitat within the infrastructure footprint and inundation areas. Habitat loss includes 4050 ha of natural habitat. These areas will be cleared or inundated during construction.	The area of National Protection Forest within the main dam inundation area is 5180 ha (medium sensitivity). In the context of the surrounding area, the habitats are representative of the larger catchment and not considered unique. A diversity of flora and fauna species were reported to occur (based on ecological and village surveys) in the disturbance area and the habitat for these populations will be reduced within the catchment. Almost 50% (4050 ha) of the footprint is considered to be natural habitat. In the context of the Nam Ngiep sub-catchment the proportion of habitat to be removed to facilitate the Project represents approximately 4% of natural habitat in the sub-catchment and as such not likely to threaten the long-term viability of the habitat and biodiversity (medium magnitude). Habitat for threatened species is specifically assessed in ***Table 6.16***. For modified habitats approximately 46% (3856 ha) of the footprint is considered to be modified habitat. In the context of the Nam Ngiep sub-catchment the proportion of habitat to be removed to facilitate the Project represents approximately 13% of modified habitat in the sub-catchment and as such not likely to threaten the long-term viability of the habitat and biodiversity.	Medium	Medium	Moderate

Impact	Description	Comment	Sensitivity	Magnitude	Significance
Change in habitat characteristics	Transition of lotic (flowing water) aquatic habitat to lentic (still water) aquatic habitat. The inundation areas will submerge a 73 km reach of the Nam Ngiep River as well as any associated tributary reaches to 7497 ha of reservoir footprint.	The Nam Ngiep River is a flowing system that varies seasonally with rainfall in the catchment. Installation of the dam will transition the currently lotic habitats in the reservoir areas to lentic habitats. This change in character changes the ecosystem process of the aquatic habitat and in turn the suitability of the area for some native species. The baseline assessment identified a diversity of aquatic biota that utilise the main river and tributary habitats for the catchment for both foraging and breeding. The community includes species that migrate upstream for spawning. Some species will adapt to the modified conditions however a number of the species detected during surveys are migratory, requiring movement within the catchment for spawning. Within the impoundment, water quality is likely to change, in particular relating to dissolved oxygen, temperature and as a result of reduced flushing, nutrient levels. The effect of impoundment on the growth of plankton and benthos will be high due to organic loading in the first year of the reservoir impoundment. There is potential for a positive impact within the reservoir forage resources for fish increases. Conversely, the physico chemical characteristics of the water may impact downstream environments as the regulated releases occur. Releasing low oxygen water has potential to lead to fish kills and reduced productivity downstream of the dams. Overall, the existing environment provides habitat for nationally and IUCN listed species. Critical Habitat determination is required to identify the sensitivity of this impact (Medium-High) with further input form a fish specialist scheduled to be provided. Similarly, the area of habitat loss is substantial however Critical Habitat determination is required to identify the magnitude of this impact in accordance with the definitions (Medium-Large).	Medium	Large	Major

Impact	Description	Comment	Sensitivity	Magnitude	Significance
Temporary disturbance to fauna behaviors	Disturbance and displacement of resident fauna due to noise, light and/or vibration as a result of construction activities (excavation, blasting, clearing, spoil disposal, camps, plant and vehicle movement).	Noise and light disturbances have the potential to influence fauna breeding, roosting or foraging behaviour of native fauna. The consequences of these influences are dependent on the extent of disturbance but in extreme cases these factors can influence local populations if breeding and communication is inhibited. Excessive noise can impede fauna communication and deter the use of habitats nearby. Similarly, introducing light sources has the potential to deter foraging and dispersal activities of nocturnal species. The Project area contains a number of villages, farms and roads currently where human habitation is likely to induce a base level of disturbance to fauna in areas directly adjacent however the construction activities are likely to increase these types of disturbance and introduce them to areas where there is currently limited influence of noise, light and vibration. The habitats that may be impacted are common and widespread within the region (low sensitivity) and the loss will be limited to that necessary for construction. This impact will be temporary and localised hence unlikely to impact the viability/function of adjacent habitats (small magnitude).	Low	Small	Negligible

Impact	Description	Comment	Sensitivity	Magnitude	Significance
Barrier to movement and habitat fragmentation	Barrier to terrestrial fauna movement and habitat fragmentation	Regionally, the Nam Ngiep River currently plays a role in restricting movement of fauna in an east-west direction across the region however some movement by higher mobility species is likely to occur during the dry season especially when water levels are low and swimming distance is shorter. The inundation area of the dams will introduce a much wider water crossing that does not necessarily recede during the dry season as is currently experienced. In some areas the width may be too great for fauna movement to occur and as such the functionality of the corridor may be impacted (Magnitude medium) There are a number of larger fauna groups recorded within the Project area that can move large distances for breeding and foraging (Sensitivity medium). The riparian corridor is likely to provide corridor values in the north-south direction. It is expected that fauna currently utilising the riparian zone as a movement corridor will also be able to move along the vegetation adjacent to the newly inundated area. Similarly, the transmission line and access road also have potential to create a barrier to fauna movement. For the transmission line the footprint will be restricted to the pylon footprint and the line will be suspended and as such the barrier to movement will be limited. For the access road, the Project area has an existing road that is likely to create a barrier to movement for some fauna groups. The widening of the corridor may further restrict movement of groups currently crossing the corridor to move in an east-west direction. Surveys of the PPA recorded a number of IUCN listed species however most are highly mobile and unlikely to be impacted by widening of the corridor (sensitivity low). Temporary roads will be rehabilitated to return the continuous forest cover.	Medium	Medium	Moderate

Impact	Description	Comment	Sensitivity	Magnitude	Significance
	Barrier to aquatic fauna movement and habitat fragmentation	Installation of the dam and construction of watercourse crossings will introduce a barrier to water flows and flushing, and biota movement not previously experience in the region of the catchment. Fish migration is an important component for many fish species life cycle (Sensitivity medium) and the barrier that the dam wall creates will limit spawning area for a number of species known to occur in the Nam Ngiep River (including threatened species). An impact to breeding area availability has potential to influence native fish populations within and downstream of the Project (including threatened species discussed further below). Overall the dam infrastructure will reduce the area of waterway available for spawning within the catchment (Magnitude large).	Medium	Large	Major
Edge effects degrading habitat	The construction and inundation associated with the Project will generate newly disturbed forest edges around the margins of the reservoir, along access roads, the transmission line and at the infrastructure locations.	Edge effects are an indirect impact of land clearing. Where vegetation clearing occurs, adjacent vegetation and habitats are exposed to increased noise, light, dust and wind environment as well as increased competition from predators and invasive species. In extreme cases some of these effects have potential to alter the habitat characteristics of the ecotone and influence suitability for native flora and fauna. 'New' habitat edges will be created where infrastructure is located in natural habitat areas, not previously disturbed. In general, the habitats that may be impacted are common and widespread within the region (Low sensitivity) and the impact is not likely to impact the viability/function of adjacent habitats (Small magnitude).	Low	Small	Negligible

Impact	Description	Comment	Sensitivity	Magnitude	Significance
Alteration of flows	During reservoir impoundment, upstream flow has to be collected to meet storage requirements, limiting the flow to downstream aquatic habitats.	To minimise impact to downstream environments minimum flow to downstream is required. Water cannot be discharged from the main dam immediately after the closure of the diversion conduit inside the main dam. Instead, during this period, water will be released downstream from the re-regulation reservoir, which stores natural inflow from its side catchment (25 sq.km). Within 2 weeks, the reservoir water level at the main dam will reach the sill elevation of the bottom outlet, and the flow can be released downstream. The released flow from the re-regulation dam will gradually be increased from 5.5 m^3/s (the minimum required riparian released in accordance with concession agreement) to 27 m^3/s after starting impoundment of the main dam. These releases will be important to minimise the impact to aquatic habitat and aquatic flora and fauna (including threatened species) that utilise these areas.	Medium	Medium	Moderate

Impact	Description	Comment	Sensitivity	Magnitude	Significance
Degradation of habitat	Introduction of alien species and competition with native communities	Invasive or alien species have the potential to be introduced or spread throughout the Project area through increased movement of people, vehicles, machinery, vegetation and soil. An increase in the prevalence of weeds or other pests has the potential to reduce the quality of habitat for some native flora and fauna, including threatened species (Sensitivity medium). Invasive flora species can rapidly germinate in disturbed areas whereby affecting the ability of native vegetation communities to re-establish. Alien animals also have the potential to be introduced or increased in abundance. These animals may adversely impact native fauna as a result of increased competition for resources, predation or habitat degradation. Vehicle movement and activities which introduce a risk of invasion will be focussed along access track and construction areas (Magnitude small).	Medium	Small	Minor
	Accidental release of hazardous substances stored or used during construction phases.	The Project components include the storage and handling of hazardous materials, including refuelling. Accidental release or spill of these materials can be toxic to flora and fauna locally and downstream if substances are released into the aquatic environment. The Nam Ngiep River experiences substantial flows and as such it is likely that an accidental spill can be diluted such that impacts are localised (magnitude small) however the catchment provides habitat for nationally and globally listed species (Sensitivity medium).	Medium	Small	Minor

Impact	Description	Comment	Sensitivity	Magnitude	Significance
	Erosion and runoff at waterways crossings leading to downstream degradation of water quality, and aquatic habitats.	A range of Project activities have the potential to lead to indirect dust and runoff impacts to native flora, fauna and habitat during the construction phase as well as longer term edge effects and noise impacts. During construction, land preparation has the potential to generate dust which may settle on vegetation adjacent to the construction area. Excessive dust deposition on flora may act to suppress growth through limiting photosynthesis and the dusted foliage may also become unpalatable to foraging fauna. The construction activities will be temporary and short lived, and dust generation is likely to be localised to active work areas. Rainfall will generally remove dust from foliage. Land preparation will create exposed bare earth areas that are vulnerable to erosion (wind and/or runoff) until infrastructure construction or replanting is completed to stabilise the surface. Erosive processes transport and deposit sediment to downstream habitats (both aquatic and terrestrial). The indirect impact has potential to degrade downstream habitat areas or change habitat characteristics, and as such influencing suitability for native flora and fauna communities. The Nam Ngiep River experiences substantial flows and as such it is likely that an accidental spill can be diluted such that impacts are localised (magnitude small) however the catchment provides habitat for nationally and globally listed species (Sensitivity medium).	Medium	Small	Minor

Impact	Description	Comment	Sensitivity	Magnitude	Significance
Fauna mortality		Fauna mortality can occur during vegetation clearing activities in the event individuals are struck by vehicles and machinery. Animals that are unable to disperse during clearing activities are vulnerable to being injured or destroyed through interaction with machinery or falling debris. It is likely that most individuals will disperse (Sensitivity low) from clearing locations into adjacent habitats however some less mobile species may experience a localised reduction (Magnitude small) in abundance during this period, such as amphibians, reptiles and small mammals.	Low	Small	Negligible

Table 6.16 Assessment of Impacts to Biodiversity Conservation Values during Construction

Impact	Description	Comment	Sensitivity	Magnitude	Significance
Permanent national forest loss	Forestry Classification Mapping identifies areas mapped as National Protected Forest and Production Forest that will be permanently lost as the dam fills.	The main dam inundation area will directly impact 5180 ha of mapped National Protected Forest (Sensitivity medium). This will be a permanent loss of this area as the dam begins to fill. Protected forest is a national forestry classification. The land covers within the area are widely represented in the wider catchment and loss of this area is not considered likely to compromise the long-term viability of the remaining habitat (Magnitude medium)	High	Small	**Moderate**

Impact	Description	Comment	Sensitivity	Magnitude	Significance
Permanent habitat loss	IUCN Listed Critically Endangered and Endangered Species Habitat (terrestrial)	Habitat suitable for critically endangered or endangered IUCN listed species (Sensitivity high) will be directly impacted by the Project. An assessment of critical habitat status in accordance with the IFC PS6 and ADB Sourcebook guideline identified that there is no critical habitat for terrestrial species within the project area, however potential habitat does occur. The plant species habitat preferences include the natural habitats represented within the Project area and surrounds. The disturbance area is approximately 4% of the natural habitat within the Nam Ngiep sub-catchment. Mammal species that may be impacted include the Asian wild dog, Asiatic elephant, Sunda pangolin, Northern white-cheeked gibbon, Tiger, Fishing cat, Red-shanked langur and Phraye's leaf monkey. The disturbance area is dominated by natural habitat in particular deciduous forest of which most of these species inhabit. The majority of the mammals species are highly mobile although home ranges vary and some resident populations may have home ranges contained within the Project area. Bird species that may be impacted include the White winged duck and green peafowl. The white-winged duck is noted to prefer stagnant or slow-flowing wetland adjacent to evergreen, deciduous or swamp forest. The lentic habitat generated by the reservoir has potential to contribute some habitat values for the species. The Green peafowl is reported to occupy a variety of habitats including primary and secondary, tropical and subtropical, evergreen and deciduous forest types, mixed coniferous forest, swamp forest, open woodland, forest edge, bamboo, grasslands, savannah, scrub and farmland edge.	High	Small	**Moderate**

Impact	Description	Comment	Sensitivity	Magnitude	Significance
Permanent habitat loss	IUCN Listed Vulnerable Species Habitat (terrestrial)	Habitat suitable for vulnerable IUCN listed species (Sensitivity medium) will be directly impacted by the Project. This area is dominated by natural habitat in particular deciduous forest. The plant species habitat preferences include the natural habitats represented within the Project area and surrounds. The disturbance area is approximately 4% of the natural habitat within the Nam Ngiep sub-catchment. Mammal species that may be impacted include the Binturong, Guar, Malayan sun bear, Stump-tailed macaque, Northern pig-tailed macaque, Clouded leopard, Bengal slow loris, Pygmy slow loris, marbled cat, Sambar deer, Himalayan black bear and Large spotted civet. The disturbance area is dominated by natural habitat in particular deciduous forest of which most of these species inhabit. The majority of the mammals species are highly mobile although home ranges vary and some resident populations may have home ranges contained within the Project area. The Impressed tortoise, Indo-Chinese spitting cobra and King cobra occupy a variety of natural and modified habitats. This fauna group is susceptible to mortality during construction, predation by introduced species as well as loss of forage resources. Habitat availability in the wider catchment is well represented. Bird species that may be impacted include the Rufous-necked hornbill and Imperial eagle. Threats to these species would relate to hunting, fragmentation of forest and removal of large trees used for feeding and nesting. The land covers within the habitat area are widely represented in the wider catchment and loss of this area is not considered likely to compromise the long-term viability of the remaining habitat area (Magnitude small).	Medium	Small	**Minor**

Impact	Description	Comment	Sensitivity	Magnitude	Significance
Permanent habitat loss	IUCN Listed Critically Endangered and Endangered Species Habitat (aquatic)	At least 414 ha of habitat suitable for critically endangered or endangered IUCN listed species (Sensitivity high) will be directly impacted by the Project. This consists of approximately 73 km stretch of the Nam Ngiep River that will be converted from a lotic, seasonally fluctuating system to a lentic system. Further investigation is underway specific to the magnitude of the impact to these species. The big headed turtle would utilise some areas of aquatic habitat within the Project area. Little is known about the population of the species however preferred habitat includes narrow fast flowing, cool, rocky mountain brooks and streams. The lotic habitat created by the Project is not likely to be suitable and individuals would be required to relocate to upstream or downstream tributary habitat areas. The Giant barb, leaping barb, Striped catfish, Yellow tail barb and Thicklipped barb are also found in the aquatic habitats of the Project area. A number of these species will not persist in impoundment waters, as such this habitat area will be permanently lost for the species. Other species are migratory or rely on environmental flows from the Nam Ngiep catchment to trigger breeding. These two issues are addressed in the below Impact category.	High	Small	**Moderate**

Impact	Description	Comment	Sensitivity	Magnitude	Significance
Permanent habitat loss	IUCN Listed Vulnerable Species Habitat (aquatic)	At least 414 ha of habitat suitable for vulnerable IUCN listed species (Sensitivity medium) will be directly impacted by the Project. This consists of approximately 73 km stretch of the Nam Ngiep River that will be converted from a lotic, seasonally fluctuating system to a lentic system. The Asian small-clawed otter, smooth coated otter inhabit a variety of habitats through seem to prefer slower flowing and shallower areas. The lentic habitat generated by the reservoir has potential to contribute some habitat values for the species. The Snail-eating turtle and Siamese temple turtle are species reported to prefer slower flowing habitats with aquatic vegetation. The lentic habitat generated by the reservoir has potential to contribute some habitat values for the species. The fish species, Mrigal carp, Common carp, Bandan sharp-mouth barb and Jaguar loach migrate within freshwater areas of the river for spawning and the dams will generate a barrier to movement in this part of the catchment.	Medium	Small	**Minor**

Impact	Description	Comment	Sensitivity	Magnitude	Significance
	Migratory species	The potential impact of a change in environmental flows as result of the dam inhibiting natural flows has the potential to result in a significant impact to the aquatic biota community within and downstream of the impoundment. Further investigations are underway specific to the magnitude of the impact to these species such that understanding the significance of this impact can be resolved. During filling of the dam, the environmental releases must consider maintenance of downstream flows as dry river environment, even if only for a short period can have consequences to the local aquatic fauna community. Current plans for flow release during construction identifies that environmental releases can occur 2 weeks following impoundment. The minimum release volume is 5.5 m^3/s during impoundment, with an increase to 27m^3/s during operation.	High		-

6.2.3.3 *Mitigation and Management Measures*

Disturbance to habitat in modified and natural habitat areas during construction has potential to impact the local and downstream biodiversity as well as impacts to priority biodiversity values. Mitigation measures can be implemented to manage the disturbance during construction such that biodiversity values are not significantly impacted or impacts are reduced by the application of the mitigation hierarchy (avoid, minimise, mitigate and compensate through offsets).

In accordance with the hierarchy, avoidance measures were initially investigated with a number of route options assessed for both the access road and transmission line. For the access road an alternative alignment located outside the boundary of the Huay Ngua PPA was developed and through assessment of biodiversity values, the original route (as presented in *Section 5.2*) was deemed preferred due to a lower disturbance of natural habitat and other engineering considerations. For the transmission line an alternative to avoid alignment through the Huay Ngua PPA was developed and through assessment of biodiversity values was deemed preferred due to a lower disturbance to natural habitat and avoidance of disturbance within the PPA. This option has been depicted in *Section 5.2*. Detailed analysis of alternatives is documented in each of the respective EA and IEE documentation (*Appendix E* and *Appendix F*).

To further mitigate potential impacts to biodiversity values, the remainder of the mitigation hierarchy principle was applied. The impact assessment (***Table 6.17***) identified potential impacts to both modified and natural habitats, and habitats for conservation significant species. Modified habitat types were not identified to play a significant role in habitat suitability for priority biodiversity values.

Management measures specific to managing the natural environment will be incorporated into the Project Construction Management Plans and these will include (but not be limited to) those identified in ***Table 6.17***. These general environmental management measures will assist in reducing the potential for degradation of habitat, behaviour disturbance, fauna mortality and habitat fragmentation for native species.

Table 6.17 Mitigation and Management Measures, Construction Phase

Nature of Impact	Overview of Measures
Loss of habitat	• Strict rules against logging outside the approved construction areas and against wildlife hunting and poaching will be imposed on project staff, workers, and all contractors and personnel engaged in or associated with the Project, with penalties levied for anyone caught carrying and using fire arms, or using animal snares and traps, including fines and dismissal, and prosecution under the laws of the Lao PDR; • The design and layout plan will be prepared to minimise tree cutting and protected area disturbance where possible. The Project owner shall be directly responsible for dissemination to its staff and workers of all rules, regulations and information concerning these restrictions, as well as the punishment that can expected if any staff or worker or other person associated with the Project violate rules and regulations; • The planned clearance area for the construction works shall be clearly identified and marked to avoid accidental clearing; • Construction Contractor, in association with the Forest Guard, will schedule and implement routine inspection program throughout construction period to monitor clearing extent; • Construction Contractor will establish biological resource management program and management plan to manage the construction activities to be conducted and monitor compliance with relevant permits and environmental regulations in order to prevent potential impacts to terrestrial ecology, in particular, vegetation and wildlife; • Project will utilise or upgrade existing roads where possible to minimise unnecessary clearing requirements; • In natural habitat areas to be cleared, microhabitat features such as hollow logs will be relocated to adjacent natural habitat areas rather than being destroyed where possible.
Disturbance to fauna behaviour	• A wildlife protection team will be established to protect and rescue remaining wildlife in the proposed reservoir area; • Construction vehicles and machinery will be maintained in accordance with industry standard to minimise unnecessary noise generation; • Arrangement of transportation schedules will aim to avoid peak hours of road usage to minimise heavy traffic through habitat areas; • Traffic signs will be installed on all roads throughout construction areas depicting speed limits; • For construction areas requiring night-time lighting, lights will be used only where necessary and will be directed toward the subject area and away from habitat areas where possible; and • Commitment will be made to raise awareness of values of natural habitat areas to construction work force and make arrangements for restriction of poaching.
Barrier to movement and habitat fragmentation	• The Project shall implement landscaping and re-vegetation after completion of construction in suitable areas, including margins of the reservoir to establish a suitable riparian corridor; • In-stream works will be carried out in low-flow conditions where possible; and • The transmission line will not be fenced.
Edge effects	• Dust suppression techniques will be utilised during construction, to control the dispersion of dust created by clearing lands at the construction sites; • The Project shall implement landscaping and re-vegetation after completion of construction using native species where possible;

Nature of Impact	Overview of Measures
	• To avoid/minimize releasing sediment load into the river, erosion control measures will be implemented and maintained e.g. using silt fence and temporary re-vegetation to minimize sediment transport from steep slope releasing to the river and smaller waterways; and • Weed and pest management measures should be implemented in accordance with a Project weed and pest management plan to avoid introduction of weeds to natural and modified habitat areas.
Hydrology changes	• During construction, at least the normal flow in the river will be maintained through diversion. In case of flood period, the construction contractor must prepare the emergency programs such as increased waterway capacity in order to release the excess volume of water if required; • Flash floods during the rainy season should be including in safety plans provided for the construction site; • In-stream works for water crossings will be carried out in low-flow conditions where possible. Stabilisation measures will be used as appropriate (e.g. matting, sheet piles); • The local people will be made aware of changes to the river which could affect water transport and navigation locally; and • Water quality monitoring will be undertaken to inform adaptive management approaches such as altering the regulated release program.
Degradation of habitat	• Construction and domestic waste will be appropriately stored and disposed of to avoid attracting native and alien species to the construction areas; • For areas in direct runoff path to a watercourse, sediment and erosion control devices will be installed and maintained until vegetation replanting can occur to stabilise disturbed surfaces; • Oil, chemical and solid waste will be stored, and handled and disposed of by appropriately licenced waste management contractors; • Weed and pest management measures should be implemented in accordance with a Project weed and pest management plan to avoid introduction of weeds to natural and modified habitat areas; • Speed limits to maximum of 40 km/hr for construction vehicles will be enforced to limit noise and dust generation; • Construction materials and chemicals will be appropriately secured and locked down during flood season to avoid accidental release to the natural environment; • Engineering works will be designed to comply with the agreed water quality standards; • Water quality monitoring will begin as soon as possible after the Project begins, in order to control the quality of discharge of water to the Nam Ngiep River; and • Emergency response plan and procedures will be prepared and implemented for the construction activities of the Project. This will include emergency drills and education of Project workers.
Fauna mortality	• Speed limits to maximum of 40 km/hr for construction vehicles will be enforced to minimise potential for fauna strike; • Commitment will be made to raise awareness of values of natural habitat areas to construction work force and arrangements will be made for restriction of poaching and forest product collection; • Hunting wild animals will be strictly prohibited to apply for all staff; • Fishing and using of illegal fishing gear anywhere along the river will be prohibited; • UXO clearance and certification will be implemented for the whole construction area; and

Nature of Impact	Overview of Measures
	• Construction activities will only be commenced within the UXO clearance boundary.

In addition to the general measures for the management of potential impacts to the natural environment, measures specific to managing potential impacts to conservation significant values are also considered. Throughout the baseline assessment, priority biodiversity values have been identified in order to assess candidates for critical habitat in accordance with IFC PS6. Following assessment of each of the candidate species against the threshold criteria it was determined that no terrestrial species are likely to have critical habitat within the Project area. Ongoing investigation is being undertaken specific to aquatic species given the complexity of issues associated with migratory fish movement and potential changes to downstream environmental flows.

Although the Project area is not considered to be critical habitat for terrestrial species, it is acknowledged that potential habitat does occur within the Project area that will be permanently lost and that indirect impacts to these species may occur. As such, measures specific to these species have been considered and will be included and developed further for inclusion in a Project Biodiversity Action Plan (BAP) and appropriate management in biodiversity offset areas.

A BAP will be developed to document a strategy for refining the mitigation and management approach to conservation of biodiversity values, including key objectives, specific measures for the IUCN listed threatened species with potential to occur in the Project area, performance indicators and responsible parties.

Specific management actions will be required for biodiversity offset areas for species.

Table 6.18 Summary of Priority Biodiversity Values Management Measures, Construction Phase

Value/Species	Key threats	Specific management measures
IUCN listed flora species	Values for carpentry/timber or medicinal purposes	• Survey identified the presence of IUCN listed flora species within the disturbance corridor. These species are listed under IUCN will need to be specifically managed within the Biodiversity Action Plan and Biodiversity Offset Areas and replanting or propagation may be appropriate • Weed management measures should be implemented in accordance with a Project weed and pest management plan to avoid introduction of weeds to natural and modified habitat areas • Investigate opportunity for replanting the

Value/Species	Key threats	Specific management measures
		listed species including seed collection and propagation for relocation to offset locations • Prohibit the use of IUCN listed species for fire wood or construction material
Asian small clawed otter, Smooth coated otter	Trade driven hunting Habitat destruction	• Raise awareness of the species to discourage poaching and contribute to management through education of construction team members and local villagers • Rehabilitation of any disturbed areas as soon as practical after clearing • Utilise appropriate sediment and erosion control measures to limit sedimentation of waterways
Asian elephant	Hunting Habitat loss and degradation	• Raise awareness of the species to discourage poaching and contribute to management of human-elephant conflict through education of construction team members and local villagers • Restrict access to the elephant conservation area near Na village by construction teams and vehicles • Install appropriate elephant exclusion fencing at the elephant conservation area near Na village • Rehabilitation of any disturbed areas as soon as practical after clearing
Leopard, Tiger, Asiatic golden cat, Leopard cat, Golden jackal, Sambar, Southwest China serow, Dhole	Hunting Illegal trade (for some)	• Raise awareness of the species to discourage poaching and contribute to management through education of construction team members and local villagers • Rehabilitation of any disturbed areas as soon as practical after clearing
Fishing cat	Wetland destruction and degradation	• Rehabilitation of any disturbed areas as soon as practical after clearing • Establish watershed management to assist in maintain the quality of existing catchment habitats
Sun bear, Sunda pangolin, Bengal slow loris, Pygmy slow loris, Himalayan black bear	Hunting Exploitation for medicine (for some)	• Raise awareness of the species to discourage poaching and contribute to management through education of construction team members and local villagers • Rehabilitation of any disturbed areas as soon as practical after clearing • Pre-clearing survey for presence of individuals prior to tree felling
Northern white-cheeked gibbon, Red-shanked douc langur, Phayre's leaf monkey	Hunting	• Raise awareness of the species to discourage poaching and contribute to management through education of construction team members and local villagers • Rehabilitation of any disturbed areas as soon as practical after clearing • Pre-clearing survey for presence of individuals prior to tree felling
Wreathed hornbill, Great hornbill,	Hunting	• Raise awareness of the protection of the species to trade (live birds and feathers)

Value/Species	Key threats	Specific management measures
White winged duck, Greater coucal, Red-breasted parakeet, Darter		through education of construction team members • Rehabilitation of any disturbed areas as soon as practical after clearing
Green peafowl, Grey peacock pheasant, Silver pheasant, Siamese fireback, Lesser fish eagle	Habitat conversion	• Rehabilitation of any disturbed areas as soon as practical after clearing
Reticulated python, King cobra	Trade	• Raise awareness of the species to discourage poaching and contribute to management through education of construction team members and local villagers • Rehabilitation of any disturbed areas as soon as practical after clearing
Elongated tortoise	Hunting	• Raise awareness of the species to discourage poaching and contribute to management through education of construction team members and local villagers • Rehabilitation of any disturbed areas as soon as practical after clearing
Big-headed turtle	Hunting	• Rehabilitation of any disturbed areas as soon as practical after clearing • Raise awareness of the protection of the species from hunting/foraging by construction teams • Pre-clearing survey for presence of individuals prior to tree felling • Compensatory measures for unavoidable habitat loss including watershed management to assist in maintain the quality of existing catchment habitats
IUCN listed and migratory fish species	Overharvest Habitat fragmentation and degradation Changes in water quality and flow	• Maintain appropriate downstream flows through suitable watercourse crossing structure design • Limit impacts to water quality through appropriate sediment and erosion control during construction • Raise awareness of the protection of the species to discourage overfishing of the species where possible • Establish watershed management to assist in maintain the quality of existing catchment habitats

6.3 ANTICIPATED IMPACTS DURING OPERATION PHASES

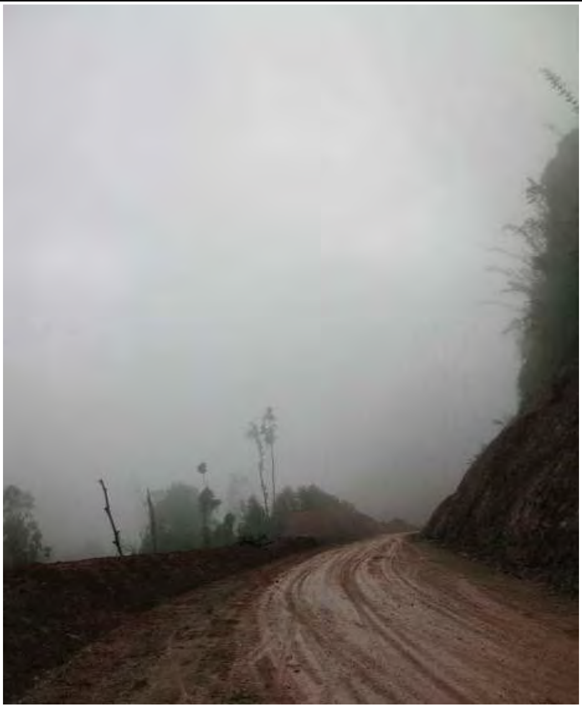
6.3.1 *Operation Impacts on Physical Environment*

6.3.1.1 *Meteorology*

The impact of the Project on climate during operation is uncertain, but is not expected to be significant. Climate, however, can have considerable impact on the construction and operation of the Project.

The creation of a reservoir and flooding of 66.94 km^2 of formerly forested and sometimes seasonally flooded land, including the 1.42 km^2 reservoir of re-regulation dam will likely result in some localized changes to air temperatures and relative humidity over the water and around the shore. Some potential exists for the reservoir to change the rates and intensity of occurrence of haze and fog (***Figure 6.8***), as well as result in increased down slope winds, and could result in cloud base creation or suppression.

Figure 6.8 Fog during Rainy Season



The magnitude of the changes will be small, localized and not particularly noticeable because of the comparatively small size of the reservoir, and the limited effects created by this new water body in relation to the dominant climatic influence of the seasonal monsoons. The reservoir will likely only contribute to minor microclimatic changes. The forested lands in the catchment and in the Project area will be important to help maintain and enhance localized climatic conditions.

6.3.1.2 *Geology, Landforms and Seismology*

After the water is impounded, the existing land in Zone 2 (Reservoir) and Zone 3 (Construction area) will change.

Geohazards, such as landslides and rock falls, may be induced by the inundation. Their movement may occur along the steep slope of riparian zone, which could be affected by the diminished vegetation and high water saturation, as well as intense or prolonged rainfall. The materials on the steep slopes will also gradually weaken from long-term weathering, infiltration of water, root wedging, and other physical processes such as cut-and-fill. The geohazards are more risky on the existing landforms that are cut for new roads or other construction sites.

However, the potential impacts to geohazards are not expected to be significant if suggested mitigation measures are implemented. During the operation phase, inspection of the dam structure and monitoring of water quality in the reservoirs and downstream are recommended.

Routine inspection of the dam structure is recommended, particularly after initial storage of water in the reservoir.

Water quality, in particular the amount of suspended solids and chemical characteristics e.g. mercury should also be monitored annually.

6.3.1.3 *Soils*

A field survey and soil physico-chemical analysis data of the resettlement site on the right bank of the re-regulation dam in July 2011 found that most areas are extremely acidic to very strongly acidic (soil pH 4.0 ~ 4.6). Organic matter and total nitrogen are found at low to medium levels. The soil contained low available phosphorus and very low to medium exchangeable potassium. The majority of soil types are Sandy Loam (SL) or Loam (L) texture, so they should not be a problem for agricultural production.

A field survey and soil physico-chemical analysis of flooded paddy fields around Ban Sopyouak and Ban Namyouak in Zone 2 UR was also conducted in July 2011 for a comparison study. The data shows that most areas are extremely acidic to very strongly acidic (soil pH 4.1 ~ 4.4) and organic matter and total nitrogen are found at low to medium levels.

The soils are generally considered as moderately suitable for rice cultivation, however some areas in the resettlement site are considered less suitable for rice cultivation. Predicted rice yield differs from 959 kg/ha to 1,601 kg/ha/year within the resettlement area. In order to increase rice yield, improvement in soil fertility with fertilizer and liming application plants should be implemented so that the resettled households can continue their traditional agricultural practices with higher rice yield.

__General Recommendations__

According to the soil analysis data (***Table 5.3*** to ***Table 5.6***), soil in the resettlement areas is suitable for both lowland rice and fruit trees, but other factors such as land form and soil depth also need to be considered. Lowland rice needs to be located on flat areas, which can have from low to high depth of soil; whereas fruit trees can be planted in all land forms where soil depth is greater than 75 cm. Because the soil in these villages is very acidic, it needs to be neutralized by lime, with other organic fertilizer or material added to improve soil organic matter and maintain soil fertility.

In fruit tree plantations, the rate of lime should be about 2-3 t/ha or about 5-10 kg/plant. For lowland rice, liming is not as essential and can be applied at lower rates. Nitrogen and phosphorus fertilizers would be important to increase lowland rice production, and should be applied at the rate of 60 kg N and 20-25 kg P_2O_5/ha for improved rice varieties. For potassium management, organic materials that can be found or available in this area should be used. Incorporating straw and applying other farm residue into the field can be the main sources of N, P and K. Therefore, efficient use of farm residue is very important to improve soil fertility.

__Mitigation Measures__

Often for soil management problems, there are several best management practices to choose from or to use in combination. Mitigation measures for potential impacts to soil during the operation phase of the Project include:

- Lime application on the sites where soil pH is very strongly acidic to extremely acidic.
- Use of Bio-char, which is an easy, inexpensive, and non-cutting method of soil improvement, which is made of husk by burning.
- Use of organic fertilizer, composed of leftover food, animal dung, bacteria, and water.
- Add limited amounts of chemical fertilizer, especially macronutrients such as N, P and K, in order to manage and balance plant nutrients in the soil.
- Implement infrastructure enhancement, as follows:
  - Irrigation system; pond and water way
  - Saddle dam; protect new resettlement are from flood of Nam Ngiep 1

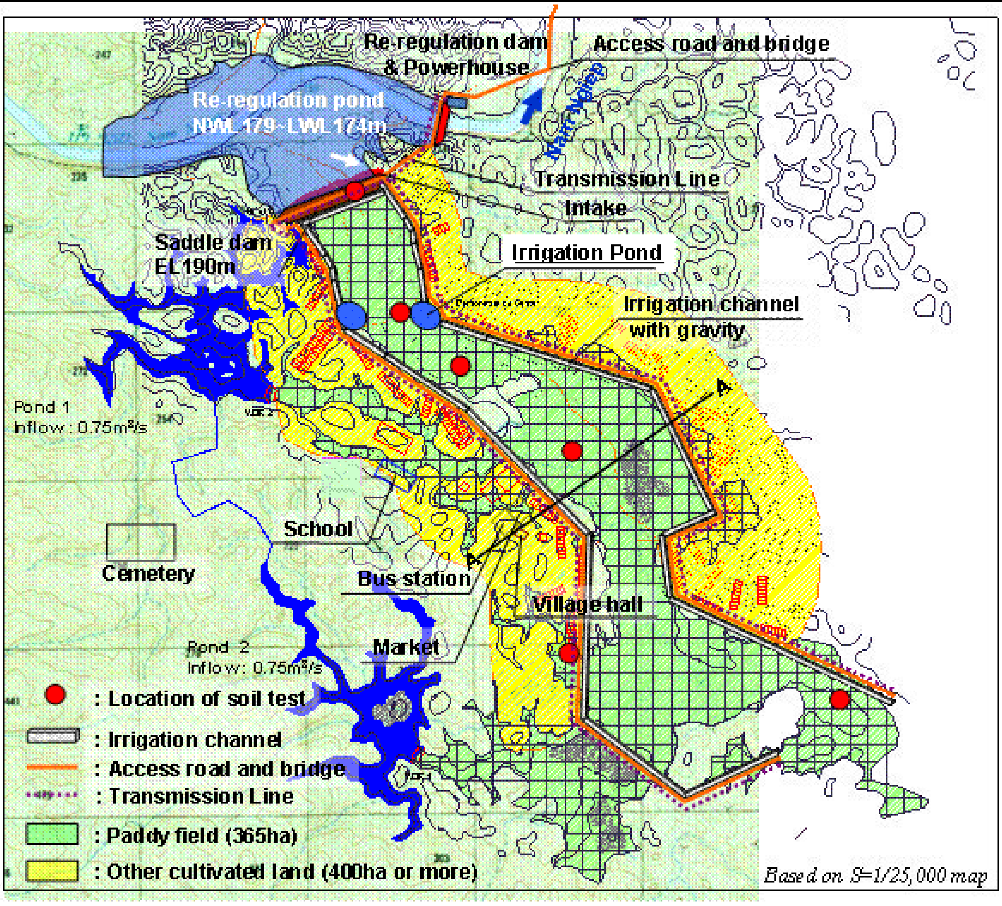
Figure 6.9 Practices of Using Bio-Char in Thailand.

Source: Huay Sai Royal Development Study Center (Thailand)

Figure 6.10 Practices of Using Organic Fertilizer in Thailand

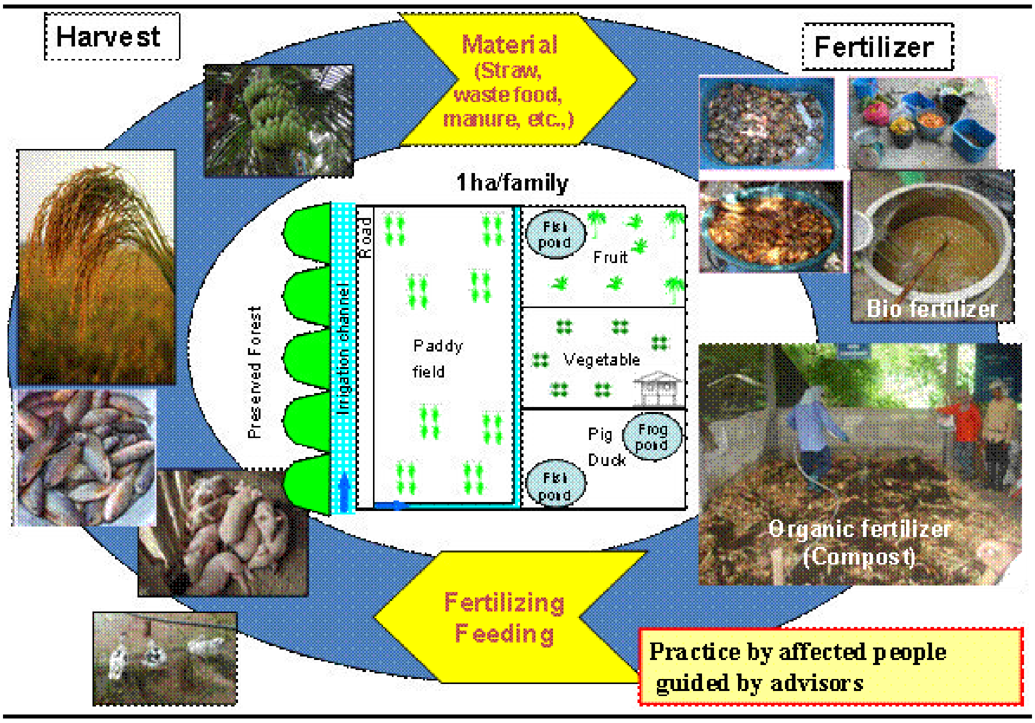
Source: Huay Sai Royal Development Study Center (Thailand)

Figure 6.11 Infrastructure within the Resettlement Area



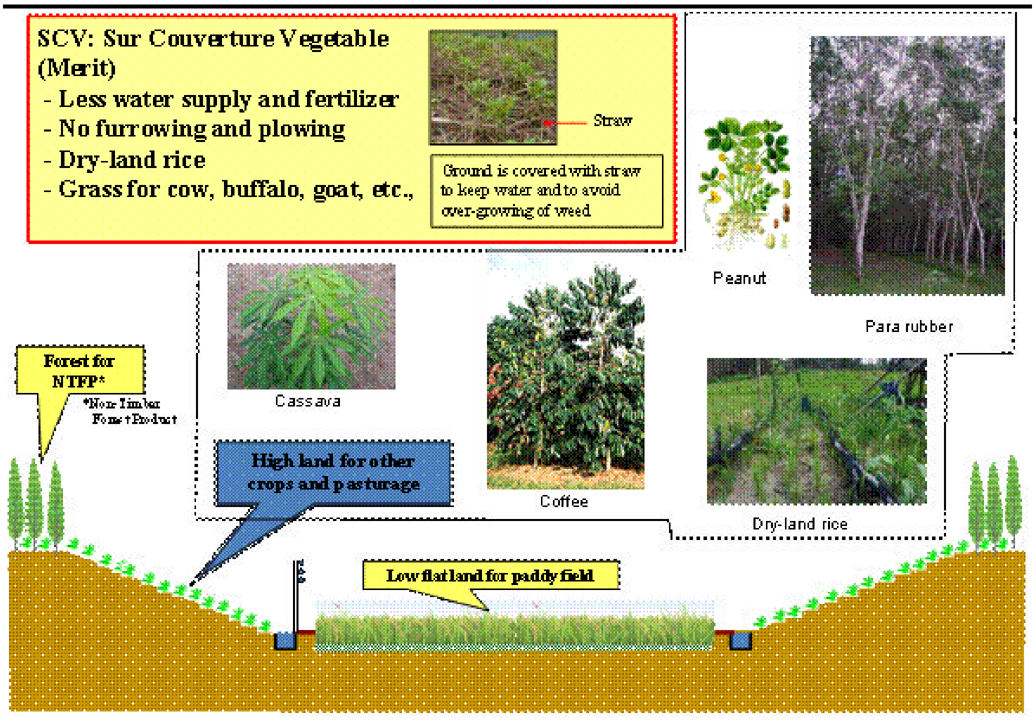
- Sustainable Lifecycle Management: The proper application of livestock manure can benefit soil by returning nutrients removed by crops, supplying organic matter to feed the soil biota, which in turn will help to improve soil structure. However, livestock manure must be handled properly to prevent pollution and to ensure the greatest economic benefit.

Figure 6.12 Sustainable Lifecycle Management



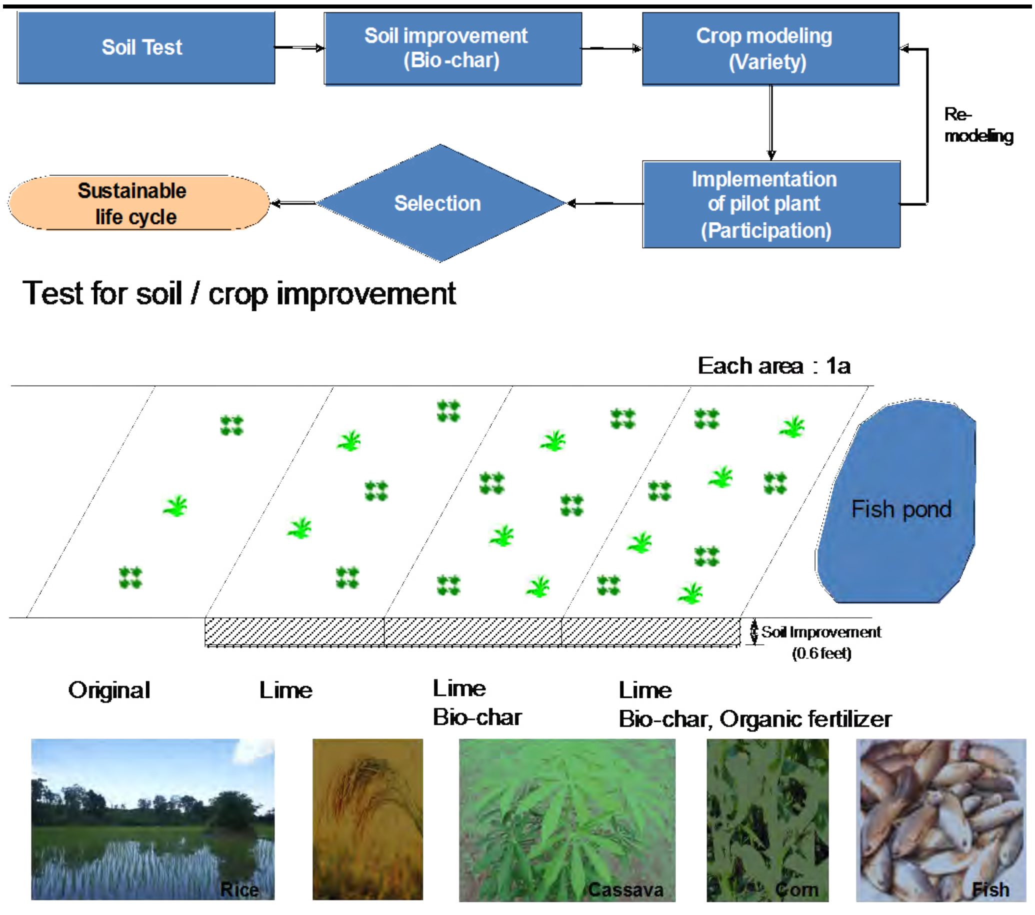
- Implement crop management as follows:
  - 'Cover crops', grown to protect the soil when the usual crop is not being grown, can help maintain soil structure, add organic matter, use excess nutrients and control pests.
  - Crop Rotation, by alternating forage or cereal crops with row crops, helps maintain fertility. The forage or cereal crops are seeded solidly over the area and help return residue and nutrients to the soil, while the row crops leave portions of the soil exposed for much of the year and return little residue to the soil.
  - Green Manure Crops are short-term cover crops used to cover and protect the soil between other crops, particularly after short-season crops such as peas. Green manure crops are grown for the plant material produced, which can then be returned to the soil to maintain soil organic matter levels – providing an excellent source of foodstuff for soil biota.
  - Soil conservation by erosion control plants such as vetiver grass, which can prevent loss of soil nutrients and improve capture and efficient use of water.

Figure 6.13 Crop Management



To achieve the above mentioned mitigation measures, a pilot plant will be constructed as shown in ***Figure 6.14***.

Figure 6.14 Pilot Plant



6.3.1.4 *Erosion and Sedimentation*

(1) Sedimentation

The sediment yield from the catchment and in the reservoir should be taken into account during the design life of the Project. The long-term protection of the catchment area is essential to ensure that sediment yields will remain at the current low level. Flows from the dam site are expected to remove sandbars and finer sediment from beds, leaving a coarser substrate. This removal of fine-grained stream substrate just downstream of the dam will likely result in the deposition of such materials further away from the Project, which could have significant adverse effects on aquatic habitat and species in areas outside the study area.

The creation of a large catchment area (3,700 km^2) should ensure that sediment yield will remain at the current estimated low level. Steeper slopes in the catchment area of the watershed could be subject to logging and slash and burn agriculture, which could reduce slope stability and lead to further erosion and sedimentation issues. It is important that prohibition of logging in the catchment area be enforced rigorously and that slash and burn activities be limited to and preferably reduced significantly from their current levels.

At Zone 4 (Downstream), mitigation measures will be essential to prevent or minimize adverse effects on aquatic habitat and associated species, particularly given the reliance of local people on fish and other aquatic or riparian wildlife species as food sources and for commerce.

(2) Erosion

Areas downstream of the main dam site and re-regulation dam are expected to experience some erosion, particularly in areas of instability that are sensitive to erosion. The situation should be periodically monitored by the ESMMU and measures taken to rectify the conditions if adverse impacts are found and identified.

Sensitive erosion areas are defined as follows:

- Areas with slopes >30%
- Areas within 30 m of a bank of a natural watercourse. Cut and fill slopes in areas of slope instability or erodible geology

Erosion is anticipated along the banks and on the bed of the excavated downstream channel, particularly in areas of unstable or poor soil conditions. These areas must be protected with suitable control and stabilization measures to minimize erosion of the banks and the streambed. This situation is to be monitored on a regular basis, and additional measures enacted if it is determined that erosion is threatening the structural stability of the downstream channel, especially downstream. Both remedial mitigation measures and compensation for the loss or interference with villagers' livelihoods should be considered, and the most appropriate measures or combination of measures applied on a case-by-case basis.

The following measures are planned to control sensitive erosion:

- The location of works in sensitive erosion areas will be minimized.
- Where possible, works in sensitive erosion areas will be restricted to the dry season.
- Clearing of sites will be undertaken in the sequence that sites are required for construction.

(3) Slope Stability

At Zone 2 (Reservoir), based upon the geological map and information of boring holes at the dam site, most of the foundation rocks are sedimentary rocks in the formations of Paleozoic (Devonian-Permian), and Mesozoic (Triassic-Jurassic-Cretaceous). These rocks are composed of sandstone, conglomerate, shale and mudstone. In the middle part of the reservoir, the late Paleozoic Granites are found intruded into the sedimentary rocks.

As the topography of the reservoir is mostly high mountainous range, the competent rocks, with shallow soil, sandstone, conglomerate and granites, are mostly found. Moreover, these rocks have excellent draining capability, so their slope stability is relatively solid and able to cope with the fluctuation of the reservoir.

The embedded high weathering rocks of shale and mudstone are found in some areas with mild slope topography. The slope stability is therefore not found to be critical due to the fluctuation of the reservoir.

6.3.1.5 *Reservoir and River Water Quality*

The assessment of impacts to water quality during operation of the Project is considered with reference to the standards reviewed in *Section 2.1.6*, and water quality simulations by The NEWJEC, an international engineering firm based in Japan (*Appendix G2*).

(1) Study Cases in South East Asia

A large number of hydroelectric dams have been constructed throughout Southeast Asia, which can help us understand the potential problems with the NNP1 Project. Three major biophysical environmental issues have been found with these dams:

- Large rates of sedimentation, as found in the dams in the Brantas River Catchment, Indonesia;
- Eutrophication and proliferation of exotic aquatic weeds; and
- Poor downstream water quality and changes in hydrological regime, as is found at the Bhumibol Dam, Nam Theun Dam, and Theun Hinboun Dam.

An example of reservoirs that resulted in the deterioration of water quality in this region was the Yali reservoir in Vietnam. It produced hydroelectric power and discharged water year round from the hypolimnion, harming downstream water quality conditions.

In Lao PDR, the impact due to water inundation has been recorded. During the early part of the rainy season, normally around August and September, the water quality downstream of Nam Ngum hydropower dam in the Lao PDR was found filled with the smell of hydrogen sulfide, which was highly toxic to the aquatic life there.

Generally, the water quality of small reservoirs in Southeast Asia is not affected by the stratification effect. In Thailand, dams with about 10-15 meters water depth sometimes reported thermocline effects. However, the stratification depends on many factors, including water body, environment, and polluted organic matter. Therefore, the designs of dams, especially the water head, usually include the aspects of stratification.

Even when the dam designs include prevention of stratification so as not to affect downstream water quality, low DO in the water can still occur from the high degradation rate of organic matter in the cleared topsoil of the upper reservoir and of remaining organic debris in the inundated area. However, in the longer-term operation of the dams, the water quality in reservoirs recovers. Moreover, colder temperatures, wind velocity and wave action during the cool season causes turnover, with the low-DO water in the hypolimnion layer naturally turning over and mixing with that of epilimnion zone, resulting in higher DO content in the hypolimnion zone which is discharged downstream.

In Thailand, Lao PDR and Vietnam, there are 17 hydro-power projects with stratified storage reservoirs, which periodically release anaerobic water with highly toxic hydrogen sulfide that affects downstream aquatic ecology and fisheries. There were 18 irrigation reservoirs with a depth of more than 10 meters that potentially showed the same negative downstream effects on water quality, depending on the reservoir operation.

To date, these reservoirs have implemented few to no mitigation measures to improve downstream water quality. The Mekong River Commission is investigating destratification of reservoirs to improve downstream water quality and enhance fisheries production. They have recently reviewed a very successful destratification operation in water supply storage of comparable size to these reservoirs in Southeast Asia, such as one case in Brisbane, Australia. Technology transfer of this technique is underway via the Mekong River Commission.

(2) Water Quality of the Project

Computer models were run to determine the quality of water expected at EL 280 m, the level of water discharge. The predicted change of temperature, DO, and SS varied monthly and at different distances downstream. The input for water quality models were extrapolated and assumptions made based on records of air temperature. *Appendix G2* provides greater detail on the method of computation of water level fluctuation and downstream water quality.

Inflow quality can be considered based on the water quality samples taken two times in different seasons, and also from the water quality of other nearby water courses. The average monthly temperature of the Nam Ngiep River calculated based on the measurement in 1999 appeared to be unusually high, so the water temperature was measured again in 2011. The water temperature has been analyzed based on the measurement in 2011.

Regarding the lack of long-term measurement data on water temperature, it is common practice to estimate water temperature based on air temperature by using a coefficient factor between measured water temperature and air temperature. Water temperature measured in March and April 2011 at the main dam site has been applied as input data for this analysis. For the simulation model, 2-D analysis is appropriate because the site specific condition is elongated.

Other computerized outputs focusing on DO were considered for impact assessment during the operational phase. SS is expected to have a major impact on water quality downstream during construction, while changes in water quality during water impoundment will be due to the high rate of anaerobic degradation.

Activities related to the construction of the dam and other construction activities, such as the worker camps, office, access roads, concrete mixing plant, stockyard, quarry, and disposal site are potential major sources of water pollutants.

The long term operations (the focus of this section) are divided into two sub-phases: the Initial Operation Phase, from 5 to 10 years after start of operations and the Normal Operation Phase, after 10 years of operation. The different types of impacts during these phases and the various changes of water quality (sediment, DO, phosphorous and nitrogen concentrations) potentially have adverse effects downstream unless appropriate mitigation measures are taken.

While the dam structures have been designed to minimize changes in water flow, it is still likely that there will be changes in water quality during the first years of operation. The reservoir may also release stratified into thermocline and hypolimnion zones, and the water from these zones could be released from riparian release conduit, intake, or spillway.

(2.1) Initial Operation Phase

The initial impounding plan will be prepared during the construction phase. After the designated water level is reached for electrical generation, the stacked water will be released following the normal operating schedule. It will take several months for the initial impounding and to fill to EL 320 m as its normal operating level. Water from EL 280 m will be discharged downstream.

During the early phase of water impoundment, organic matter in the soil and remaining plants (***Figure 6.15***) will degrade anaerobically, while some chemical components can be expected to leach from the concrete structures. This leaching and degradation can be expected to occur under anaerobic conditions for about seven years[3]. After that, the rate of leaching and degradation would become much lower, depending on the amount of organic matter remaining in the reservoir, the depth of the impounded water and the effect of the thermocline. Regular monitoring of water quality will help indicate the ability of the water in the Project reservoir to recover.

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1. Reference: Water Quality in Hydroelectric Project: Consideration for Planning in Tropical Forest Regions, WB Technical Paper No.20, 1984

Figure 6.15 Algal Bloom and Debris Degradation during the Early Stage of Water Impoundment of a Small Reservoir in Feung

After about ten years of water impoundment, the discharge quality may recover to Class 2 or Class 3 standard for surface water. Even so, water quality monitoring programs must be continued on a regular basis, because many external factors can affect water quality.

(2.2) Normal Operation Phase

During routine operation, the direct impacts on the water body include the load of sediment in the reservoir and the change in downstream water quality caused by altered flow pattern. The water level could induce stratification in the water body, forming a thermocline and hypolimnion. The water quality models reported that the thermocline occurred at about EL 250 m. Under this level, the degradation of plants and other organic sources would occur under oxygen-limited conditions. The depletion of dissolved oxygen significantly affects both physical and biological environmental characteristics of the downstream water.

The organic and nutrient loads from land uses in the river catchment will affect the quantitative and qualitative characteristics of the water. Natural forests, crops and communities are found throughout the catchment area. After the water has filled to the designed level, the stored water will inundate a large variety of terrestrial and riparian habitats, including natural plants and strips of crops along the shore. Water can continue to deteriorate from the dissolved components of these plants flowing into the reservoir, with runoff containing soil nutrients and sediment from the catchment settling in the reservoir.

Water quality models were run to predict the quality change of inflow and outflow or discharge due to the Project. Monitoring data of nearby reservoirs were used to calibrate the model.

The water at the inflow and the outflow at the main dam were selected for computer modeling. The water parameters assessed were water temperature, dissolved oxygen and suspended solids.

Water Temperature

1) Daytime water temperature in the reservoir

Inflow water temperature was estimated by using a correlation equation between air temperature and observed data of water temperature. The daytime water temperature at the dam site was observed in March and April of 2011. Measurements were carried out by measuring the water temperature immediately upstream of the main dam site in the morning, afternoon, and evening, to obtain daily averaged water temperature.

The correlation equation was conducted using both the observed water temperature in Taviang and the air temperature in Vientiane. An extrapolation method was used to estimate missing water temperature data.

Monthly average solar radiation in Nongkhai, Thailand, was observed from 2005 to 2008. Average solar radiation was estimated by using the Savinov's equation:

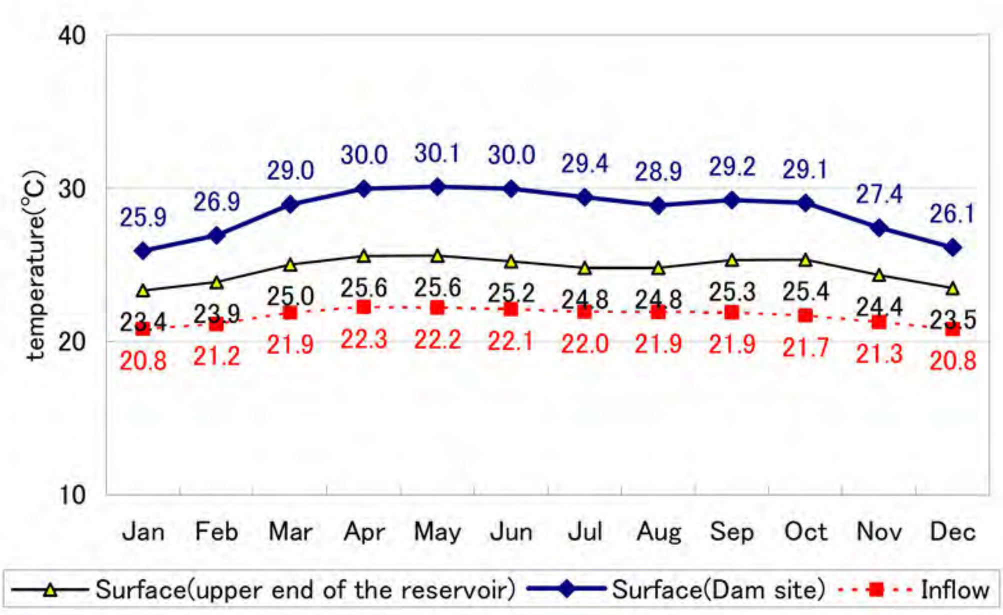
$$S_d = S_{df} \{1 - (1 - k)n\}$$

S_{df}: Total solar radiation into horizontal plane on a sunny day without a cloud (cal/cm^2/day)
n: Cloud coverage (0-1)
k: Constant (0.33 at latitude 20 degrees north)

The simulation of water temperature in the NNP1 reservoir and discharge was carried out, based on hydraulic data of eight (8) years (1991-1998).

The average daytime water temperature of the reservoir surface close to the dam was the lowest (25.9°C) in January while it was the highest (30.1°C) in May (***Figure 6.16***). The difference in the water surface temperatures between the reservoir and at the dam fluctuated throughout the year. The thermocline zone was predicted to form around EL. 250 m, and it may affect the water quality for eight years.

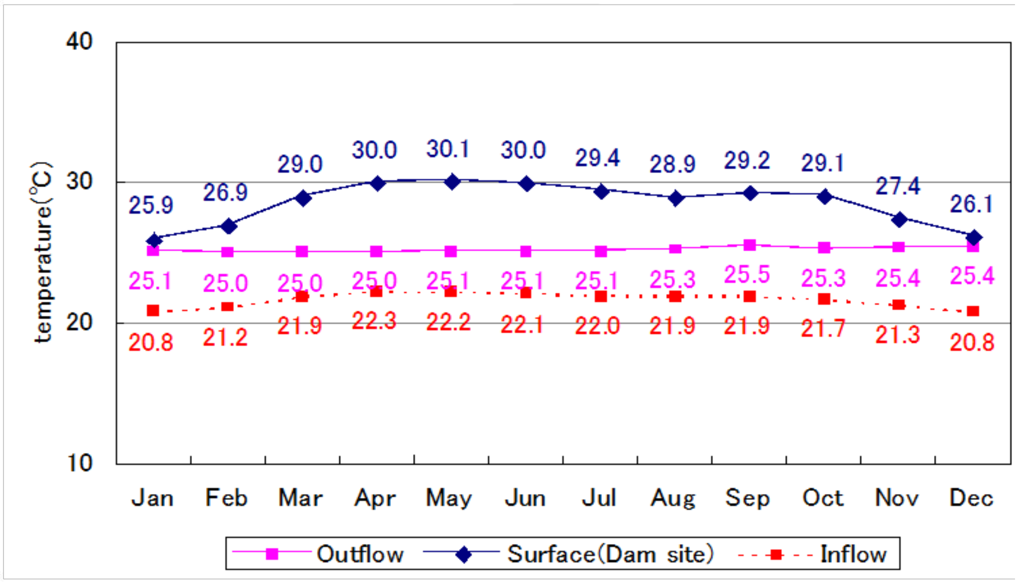
Figure 6.16 Monthly Daytime Water Temperature in the Reservoir



2) Daytime water temperature of discharged water

The water temperature of discharged water tends to be higher than that of the natural inflow (***Figure 6.17***). The temperature of the discharged water also tends to be lower than that of reservoir surface water close to the dam.

Figure 6.17 Comparison of Inflow and Outflow Water Temperature of NNP1



3) Daytime water temperature downstream

The water temperatures of the downstream river before and after dam construction were significantly different. The average temperature downstream after dam construction would be about 4°C higher than that before dam construction (***Figure 6.18***).

The temperature of discharged water gradually changes as the water flows downstream, eventually approaching the temperature of water before construction of the dam.

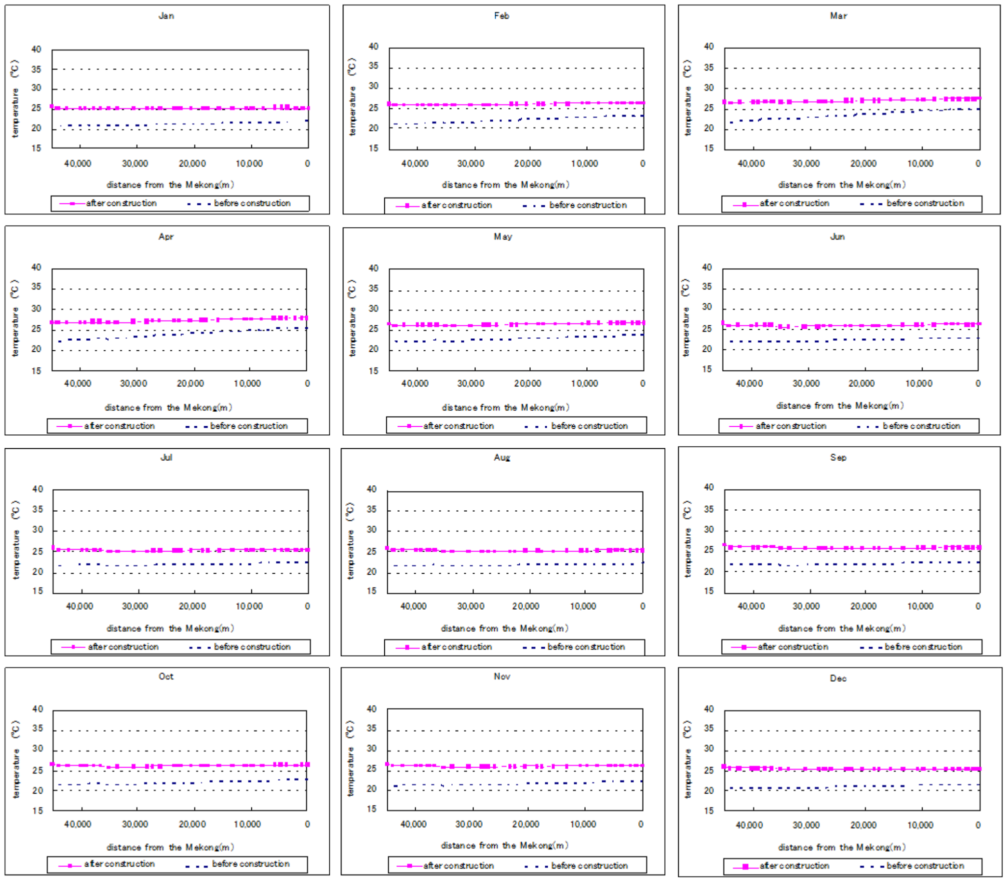
Due to the limits of available data on temperature, the impact assessment of water temperature on aquatic life in the Project area had to be made by indirectly linking the biochemical functions affected by temperature change. A change in water temperature could affect biochemical functions that control immune response, spawning, hatching, and survival rate of larva.

A study of small dams in warm climate areas assessed the impact of changing water temperature on fish and macro invertebrate communities below those dams. The main change downstream was that macroinvertebrates showed shifts in community composition below these small, surface release dams.[4] It can be expected that there will be changes in the community composition of macroinvertebrates in those areas downstream from the Project that will face significant increases (up to 4°C) in temperature.

The assessment of the temperature changes on aquatic organisms downstream is based on the results of a temperature model. An effective and regular monitoring system should be in place to determine the impact of the dam on downstream aquatic life during construction and throughout the operation of the dam.

1. Lessard, J. L. and Hayes, D. B. Effects of elevated water temperature on fish and macroinvertebrate communities below small dams. 19 (7), Pages 721 – 732. Published Online: 2 Apr 2003

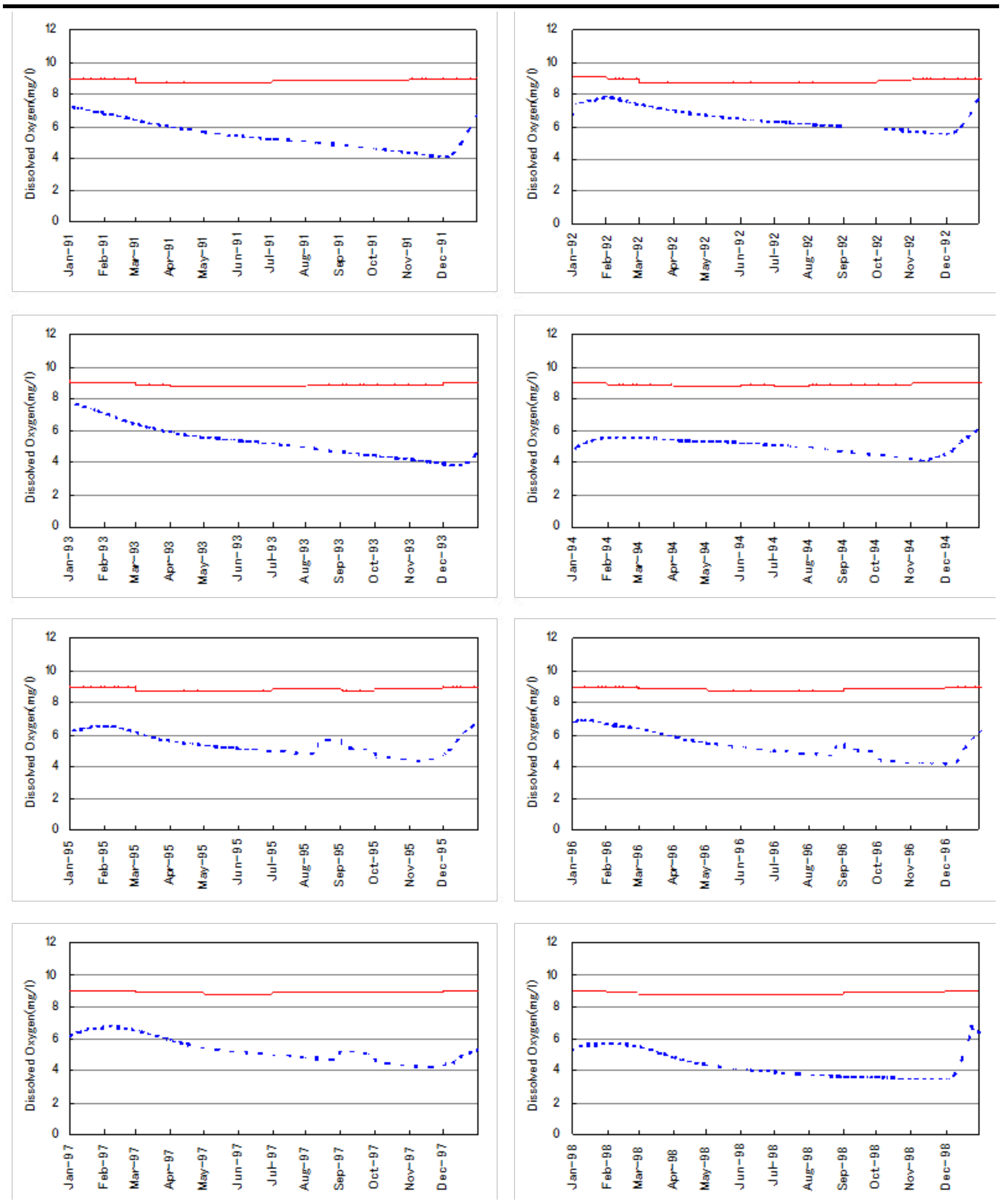
Figure 6.18 Comparison of Downstream Water Temperatures of NNP1



Dissolved Oxygen

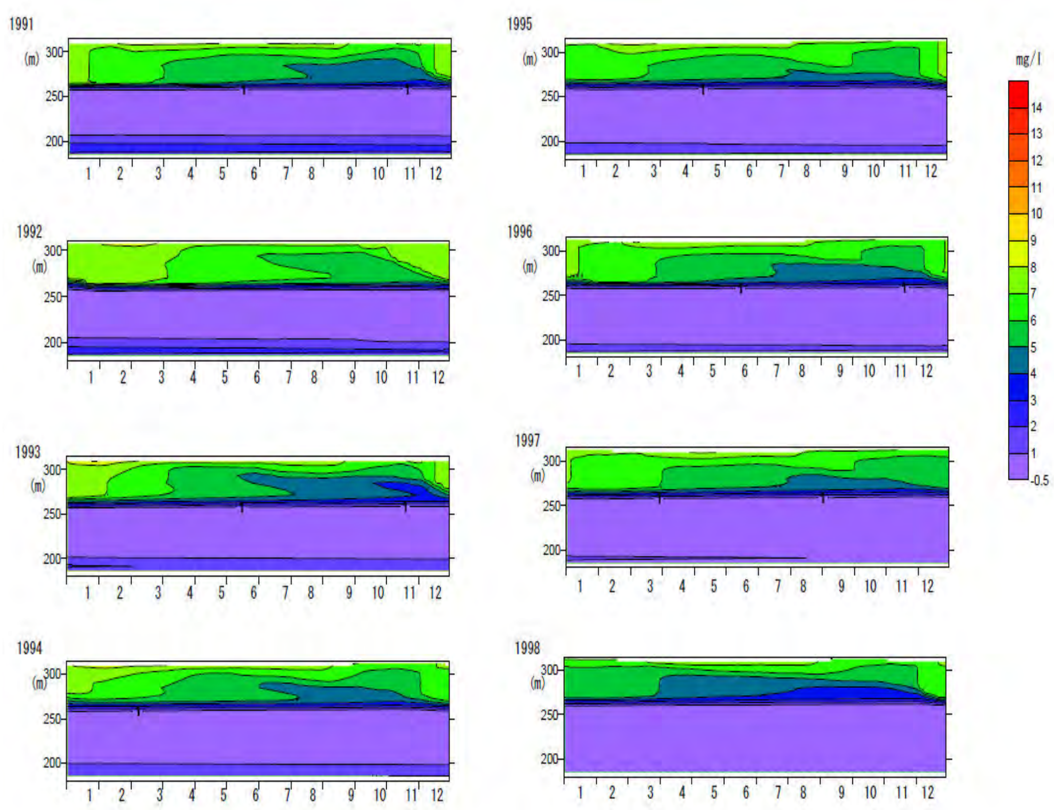
The prediction of DO change due to the Project was conducted by reviewing the impacts of similar dam projects, taking into account data over eight (8) years (1991-1998) from those dams, and comparing the results with that of the natural inflow. The result of the computation shows that the DO in the discharged water has a significant tendency to be lower than that of the inflow. The predicted range of the DO in the discharge varies from 3.5 mg/L to 7.9 mg/L throughout the year (***Figure 6.19***).

Figure 6.19 Comparison of Inflow and Discharged DO



Although the DO concentration deeper than the sill level of power intake is possibly less than 2mg/L, it is not likely that the DO in the discharged water be less than 2 mg/L (***Figure 6.20***).

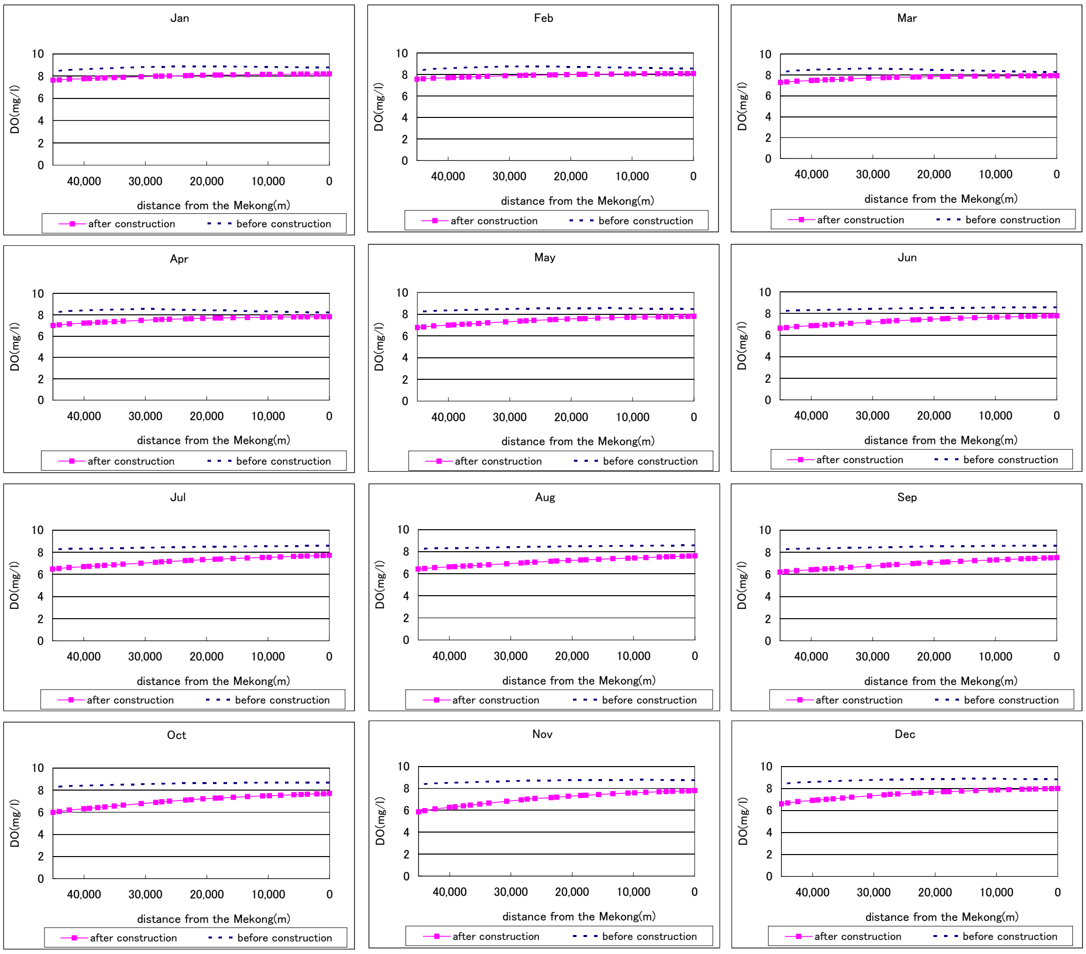
Figure 6.20 DO Concentration Variations by Depth of the Dam



DO concentration of discharged water from the re-regulating dam is over 6 mg/L for almost all of the year. The DO concentration increases gradually as the water flows further downstream due to oxygenation and dilution. (***Figure 6.21***)

There were three main sources of oxygen in the aquatic environment: 1) direct diffusion from the atmosphere; 2) wind and wave action; and 3) photosynthesis. Oxygen production from photosynthesis occurs during the day. Oxygen levels dropped at night because of respiration by plants and animals, including fish. These predictable changes in DO that occur every 24 hours are called the diurnal oxygen cycle.

Figure 6.21 Prediction of DO Changes per Month (Longitudinal Profile of the River)



According to the Department of Fisheries and Aquatic Sciences at the University of Florida, in natural conditions, a concentration of 5 mg/L DO is recommended for optimum fish health. Sensitivity to low levels of dissolved oxygen is species specific; however, most species of fish are distressed when DO falls to 2-4 mg/L. Mortality usually occurs at concentrations of less than 2 mg/L. The number of fish that could die during an oxygen depletion event is determined by how low the DO gets and how long it remains low.[5]

Oxygen depletion occurs when oxygen consumption exceeds oxygen production, and this can be caused by an overabundance of aquatic plants or algae in the reservoir, "turnover" of a body of water (stratification was predicted and the thermocline was about at EL 250 m), increased organic waste entering the reservoir, or death and decay of organic matter at the bottom of the impounded water.

According to the water quality models, the DO of discharge should be optimum for fish during the daytime. Low DO could be determined by

1. This document was reviewed from Fact Sheet FA-27, Department of Fisheries and Aquatic Sciences, Florida Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida. Reviewed May 1997, February 2003. Web Site at http://edis.ifas.ufl.edu.

observing fish behavior. Moribund fish may be seen at the surface trying to get oxygen. If many fish die simultaneously, that could indicate low DO. Certain weather conditions, such as when it is hot, still and overcast, can lead to reductions in DO. However, the most important factor affecting oxygen depletion is if the reservoir has heavy concentrations of decomposing organic matter. The product of degradation could be a good source of nutrients for algae or aquatic plant growth.

The Project will be responsible for conducting data collection and monitoring before and during reservoir filling, and post-inundation. Data collection for the Dissolved Oxygen (DO) profile will follow both during inundation and after inundation. The water samples will be collected at 4 stations as follows:

- Upstream in the main reservoir
- In the middle of the main reservoir
- Downstream in the main reservoir
- Immediately downstream of the re-regulation pond

At each station, samples will be collected from at least 5 different depths. In addition, if monitoring results show DO of less than 2 mg/ or any impacts to water quality occur as a result of the Project, the Project will carry out an investigation in order to discover the cause of such as impact, and installation of aeration equipment will be considered.

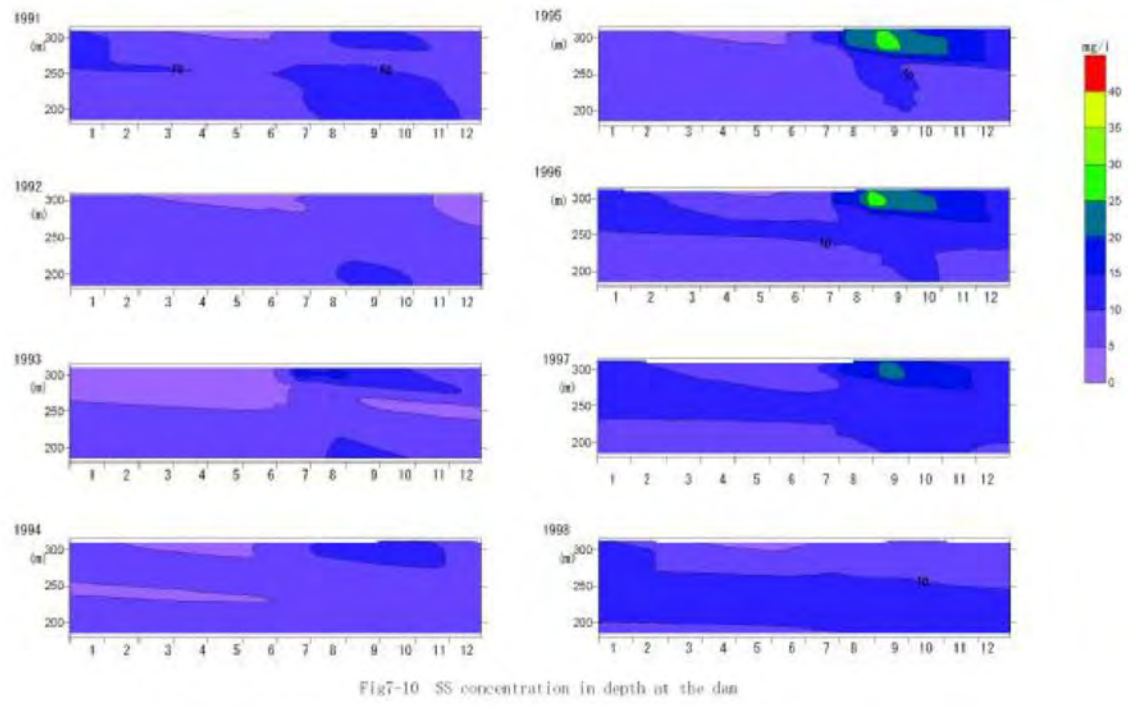
The details of data collection for reservoir water quality such as method, timing and frequency, are shown in *Concession Agreement Annex C: Environmental and Social Obligation (Appendix F)*.

Suspended Solids

The computation of suspended solids (SS) concentration of the reservoir was conducted based on the hydraulic data of eight (8) years (1991-1998) from similar sites. The results showed that the SS in the discharged water is lower than the SS of inflow since most SS would settle in the reservoir. It was shown that particles of SS less than 10 µm would be suspended and maintained in the reservoir for several months. In this computation, the fine particle size distribution at the site was assumed as 30% of less than 1 µm and 20% of 1-5 µm.

The SS concentration was computed and the result showed only about 10 mg/L to 20 mg/L of SS in the discharged water to downstream (***Figure 6.22***). This is less than one-tenth of the SS concentration in the water at present, before Project construction. SS settling is a major factor that would reduce nutrients for primary producer and consumers downstream. Jiménez-Montealegre et al, 2002, concluded that total solids sedimentation was highly correlated ($P \leq 0.01$) to fish weight and biomass, chlorophyll-a and total suspended solids[6]. After the dam is built, the reduction of nutrients downstream could occur because of reduced SS, and aquatic organisms could be affected by food depletion.

Figure 6.22 SS Concentration in Depth at the Dam



Sedimentation at the dam would also imply reduced levels of dissolved phosphorus ($P\text{-}PO_4$) concentrations, total phosphorus (TP) concentrations, nitrate ($N\text{-}NO_3$) and ammonium ($N\text{-}NH_4$) downstream during normal operation. However, during the early stage of inundation, the nutrients trapped in the reservoir could be a source for algal bloom.

The most critical period of the Project in terms of downstream water quality will be when the impounded water is first discharged. Water pollutants from point sources as well as non-point sources of agricultural drainage and open defecation that have accumulated under anaerobic conditions will certainly affect the water quality downstream. Given that pathogens such as bacteria, which can be responsible for waterborne diseases and contaminate the deposit sediment, can also be released along with sediments, steps need to be taken to monitor the water and educate local people about hygiene to prevent waterborne diseases.

Engineering practices should include the installation of sanitary toilets and animal manure pits in communities near the reservoir, as well as educating local people on improved sanitary practices to prevent nitrogen loads in the

1. Ricardo Jiménez-Montealegre, , Marc Verdegem, Jorge E. Zamora and Johan Verreth. Organic matter sedimentation and resuspension in tilapia (Oreochromis niloticus) ponds during a production cycle. Aquacultural Engineering. 26(1), 2002, Pages 1-12.

dam. Environmental study and monitoring programs, including studies of stratification at the dam and assessment of nutrient loading capacity upstream and downstream during the operation, need to be conducted. Indirect impacts on water quality during dam operation such as increased water temperature and conversion of lands around and near the reservoir to agriculture or other non-forest or non-natural conditions as a non-point source to the water quality of the dam need to be taken into consideration in the environmental study and monitoring program.

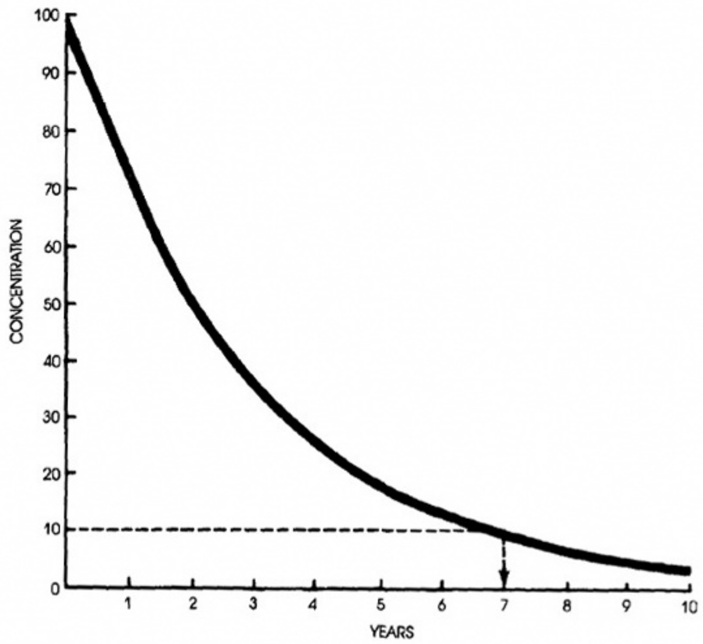
Engineering works will be designed to comply with the agreed water quality standards at various points in the purpose-built system, including the point of release into the Nam Ngiep River below the regulating dam site, and releases from the Nam Ngiep downstream into any natural watercourse or location of use. The water quality standards are set in order to assure that beneficial uses of the water are maintained. The Project owner and head construction contractor will be responsible to mitigate direct and indirect impacts on people and aquatic/terrestrial species through alternative means if water quality standards are not met.

The Project owners and the operators must also conduct water quality monitoring, especially during the first years of the operations phase, in order to control the quality of discharge of water at the dam site and through the turbines.

The first period of releasing impounded water is very vital to aquatic life downstream. Its flow and load information is of prime importance to water quality for the receiving water downstream. A grievance procedure is required so that the developer can receive complaints and take action immediately if the water quality downstream is not suitable for fish or leads to the death of fish. An immediate response to complaints should consist of sending staff to observe the dead fish, and to measure the DO levels of the water. Other responses, such as compensation for lost livelihoods from the loss of fish or aeration at the discharge point, shall also be implemented.

Based on the availability of the data, it is not practical to forecast the recovery period in accordance with "Water Quality in Hydroelectric Projects: Considerations for Planning in Tropical Forest Regions, Camilo E. Garzon, World Bank Technical Paper No.20, April 1984" as recommended by ADB. It states that, assuming recovery at 10% of the initial concentration value (e.g. mg/l), seven years would be required for complete renewal of the water mass (***Figure 6.23***).

Figure 6.23 Reservoir Recovery Process (Source: World Bank, 1984)



Nevertheless, the EIA Report presents the result of soil analysis from various villages in the Project area, and it was shown that the organic matter content at Ban Hat Gniun is in the range of 1.21 to 4.24%. To calculate the oxygen demand for organic release rate from the ground, the medium value of 2.75% is adopted.

The following assumption, applied in the Nan Theun 2 Project, can be adopted for calculation:

• Soil density	2.4 ton/m^3
• Depth from soil surface to be involved with oxygen demand	5 cm
• Therefore, the volume of soil involved with oxygen demand in 1 ha	= 100 m x 100 m x 0.05 m = 500 m^3
• The amount of carbon from ground within 1 ha would be calculated as	= 500 m^3 x 2.4 ton/m^3 x 2.75% = 33 ton

According to the Annex G of EAMP for Nam Theun 2 Hydroelectric Dam Project, Approximately 47% of the carbon would be consumed in methane production (Wetzel, 1983) and another 15~20% of total carbon would be degraded anaerobically to carbon dioxide (David Hamilton, 1997). Based on this study, approximate 35% of carbon would remain, so that carbon content is 33 ton/ha x 35% or 11.55 ton/ha (1,155 g/m^2).

As a result, the oxygen demand to be required for organic content in ground is 3,080 g/m^2(1,155 x 32/12)., where molecular weight of carbon (C) and carbon dioxide (CO_2) is 12 and 44, respectively, for mineralization process.

Therefore, during 7 years of recovery period, the daily oxygen demand (for ground) is equal to 1.2 g/m^2 (3,080/7/365).

Due to data limitation, oxygen demand for biomass above the ground could not be estimated. However, it is anticipated that timber logging and vegetation clearing is the preferred option, so the calculation would not be applied at this time.

Seasonal Variation

The variation of water quality, such as DO and water temperature, largely arises from the seasonal variation rather than hourly variation. Regarding the variation of SS, the hourly evaluation is appropriate in cases where there is a concern of turbid water. However, the reservoir of NNP1 has no concern of long term turbidity. In addition, the reservoir of NNP1 is considered as an annual regulation reservoir. Accordingly, the water quality simulation in the reservoir has been conducted over a daily interval.

Eutrophication of Reservoir Water

Eutrophication of the reservoir occurs naturally in situations where nutrients accumulate, or where they flow into systems on an ephemeral basis. Eutrophication generally promotes excessive plant growth and decay, favouring simple algae and plankton over other more complicated plants, and causes a severe reduction in water quality. When the algae sink to the bottom, they are decomposed, and the nutrients contained in organic matter are converted into inorganic form by bacteria. The decomposition process consumes oxygen, and deprives the deeper waters of oxygen, which in turn kills fish and other organisms, as well as decreases the water quality.

Another major potential source of nutrients in water bodies is cleaning detergent (due to the nitrogen and phosphorus content), which can often be found in domestic wastewater. However, this is not an issue for the Project as there are no dwellings, and thus no detergent discharge, in the reservoir area.

In the first several years after the filling of the reservoir, the level of oxygenation will be heavily determined by the organic material (biomass) left on the inundated land. This consists of wood, leaves, roots, other plant debris and organic acids in the soil.

To prevent eutrophication and preserve the water quality of the reservoir and downstream water, an efficient program for clearing biomass in the reservoir area will be carried out, and biomass should be removed from the reservoir before impounding. In addition, water quality monitoring of both the reservoir and downstream water will be routinely conducted, specifically for phosphorus, nitrogen, and zooplankton and phytoplankton biomass, to evaluate the occurrence of eutrophication after reservoir impoundment.

When the water from the reservoir passes through the gates or flows over spill ways, the oxygen will be automatically added into the flowing water. The level of oxygen addition will be varied by the velocity of flowing water.

Moreover, the Project design includes a "Riparian Release Conduit", a steel pipe of 0.8 m diameter, embedded in the dam body, controlled by two slide valves. A fixed-bar trash rack is located at the inlet to prevent entrance of large debris.

To the extent possible, the Project will follow the guidelines "Step-by-Step Environmental Guidelines for Biomass Removal from Hydropower Reservoirs in Lao PDR" (Environmental Management Support Programme, 2012).

Concession Agreement Annex C also contains information on biomass clearance, in Clause 71. Relevant excerpts are as follows:

"e. The Company shall not begin to impound water until after the Company: (i) completes the clearance of biomass from the Project's Reservoir and impoundment areas in accordance with the Biomass Guidelines; and (ii) satisfied all Company obligations under this Annex which are required by such date to have been completed in accordance with the terms and conditions hereof…."

The Project is also required to strictly follow the ESMMP-OP during operations, which has provisions for biomass clearing.

6.3.1.6 Air Quality

The operation phase does not consist of major activities that can create dust; hence, adverse impacts from dust are not likely after the operation phase begins. During operation, air pollution is expected to be very limited, caused more by vehicles traveling to and from the site than from any direct dam-related activities.

(1) Greenhouse Gas Emissions

All dams and reservoirs release significant amount of gasses that patronizes to global heat such as carbon dioxide (CO_2) and methane (CH_4) discharge. Very high initial content from organic materials, for example from wetland and swamps, emanate higher emissions due to anaerobic digestion of material at the bottom of the reservoir. NNP1's reservoir and inundated area is small compared to the storage volume for energy production.

Hydropower projects will release less GHG per produced energy unit than comparable thermal power plants. Hydropower plants are therefore eligible for "carbon credits" under certain conditions. The UN Clean Development Mechanism (CDM) uses the "power density" index (Watt installed capacity divided by the flooded surface area) as an indicator of eligibility for emissions credits. The CDM Executive Board has set 10 W/m^2 as the threshold value for allowing full carbon credit.

Table 6.19 Comparative Power Density Index

Hydropower Projects	Installed capacity (MW)	Reservoir (km^2)	Power Density Index (W/m^2)
Nam Ngum 3	440	27	16.3
Nam Ngum 2	615	122	5.0
Nam Ngum 1	155	371	0.4
Nam Theun 2	1,074	450	2.3
Nam Ngiep 1	290	69	4.2

During the operation phase, total GHG emissions from the Project are estimated to be approximately 152,117.4 ton CO_2 per year, from 69 km^2 inundation of reservoir area. This is estimated from hydropower reservoir emission factors of 60.4 kg CO_2/ha per day[7] (22.046 ton CO_2/ha per year) that has variance around ± 145%.

The implementation of vegetation clearance prior to the reservoir impoundment will reduce the release of CH_4 and CO_2 owing to decomposition of organic matter during operation and corresponding problems of greenhouse gas emission.

The Project will monitor greenhouse gas emissions, including methane, periodically in accordance with *Appendix 2 of Concession Agreement Annex C*. In case of an observed increase in the quantity of released methane is confirmed, appropriate measures will be implemented.

(2) Comparative Benefit of Project's GHG Emissions

The comparative benefit of the greenhouse gas (GHG) emissions of the Project are evaluated by comparing estimated GHG emissions of the hydropower project with typical emission factors for all power sources from both the Thailand Grid (0.5113 ton CO_2/ MWh[8]), and the Lao PDR grid (0.135 ton CO_2/ MWh[9]), representing the destinations of electricity from the NNP1 Project. Combining the above emission factors with the annual generation of

1. Good Practice Guidance for Land Use, Land-Use Change and Forestry, IPCC National Greenhouse Gas Inventories Programme, 2003.

1. http://forums.asialeds.org/wp-content/uploads/2013/11/SESSION-5-Jiro-Ogahara-LEDS_Asia_Ogahara_20130927.pdf

2. LEDS Workshop 2013 Manila, September 30, 2013.

1,546 GWh from the main dam power station and 105 GWh from the re-regulation power station, total emissions would be approximately 804,644.8 ton CO_2 per year for traditional power sources.

Comparing this with the expected annual emissions of 152,117.4 ton CO_2 from the NNP1 hydropower plant during operations, overall emission reduction due to implementation of the NNP1 Project in place of other traditional power sources would be approximately 652,527.4 ton CO_2.

(3) Impact on Local Climate

With regards to the Project's potential impact on local climate, a comparison can be made with the Nam Ngum 3 project, as it is of a similar size and in a similar location (NN3 has a reservoir area of 27 km^2 and a 1,411 MCM storage capacity, while NNP1 has a 69 km^2 reservoir area and a 1,192 MCM storage capacity). The impacts of climate change on the Nam Ngum River Basin were considered in the Nam Ngum 3 Cumulative Impact Assessment. The results from the analysis indicated that a slight increase in precipitation was anticipated, of up to 25% in the March-May period, and small changes (0-10%) throughout the rest of the year. Similar local climate effects would be anticipated for the Nam Ngiep 1 hydropower Project.

6.3.1.7 Potential Contaminated Sites

The possibility of site contamination during Project operation will be low, since only a few hazardous materials, such as flammable fuels and pesticides, will be used. In the operation phase, there will be very few vehicular movements related to the operational and maintenance work of the dam within the Project area, thus only small amounts of fuels and petroleum products will be required. Some pesticides and fertilizers may be used for landscape control and maintenance. These chemicals may be contaminated if they are over-used and improperly stored. Meanwhile, this contamination would be limited only to the areas where applied.

Recommended mitigation measures for each of the activities are as follows:

1) Use of hazardous chemicals

- Users of pesticides and fertilizers must follow proper application methods.
- Overuse of hazardous chemicals, such as fuels, pesticides and fertilizers, must be avoided to prevent soil and water pollution.

2) Spillage prevention

- Vehicles carrying pesticides and fertilizers for landscaping must be covered on the route between the storage warehouse and the landscape site.

- Hazardous chemicals must be well sealed before use.

6.3.1.8 *Hydrology*

The criteria for selecting the Normal High Water Level (NHWL) are as follows:

(1) Low flow analysis

The catchment area at the dam site was estimated to be 3,700 km^2, with natural average discharge of 148.4 m^3/s or 4.68 billion m^3/year. The design specifications of the Nam Ngiep 1 Hydropower Project for operation are shown in ***Table 6.20.***

1) Maximum monthly inflow/outflow

The maximum monthly natural flow of the Nam Ngiep River was found to be about 483 m^3/s. A design flood with a 1000-year probability is 5,210 m^3/s. After completion of dam construction, monthly outflow in the dry season will decrease, and in the rainy season will increase, because the main dam reservoir can regulate the discharge between seasons.

The spillway of the main dam is a gated type. Therefore the normal water level and flood surcharge level can be set at the same level of EL.320 m. At the water level of EL.320 m, the spillway can discharge flood flow of 5,210 m^3/s (flood 1,000-yr return period). The design flood of 1,000-yr return period is relatively large and is not likely to occur. Therefore, the upstream area of the main dam with elevation higher than EL.320 m will be safe from flooding.

2) Riparian Release

The operation of the main dam would intentionally release water ("riparian release") downstream to maintain normal functions of the river. Cases of specific discharge of 0.15 $m^3/s/100\ km^2$ for Nam Ngiep 1 (***Table 6.19***) have been adopted, and the minimum discharge after the initial impounding shall not be less than 27 m^3/s during operation. The flow pattern of the riparian release is shown in ***Table 6.21***.

Table 6.20 Flow Requirement in Annex C of CA during Operation Phase

River reach	Absolute Minimum Flow	[Water depth]	Max Fluctuations
Downstream of the re-regulation dam	Min 27 m^3/s at all times in the dry season and in the rainy season	Min water depth in m in the entire reach from downstream of the re-regulating pond until [*km] during dry and rainy season	• 1.7 m Max fluctuation in any 24 hour period • 1.7m Max fluctuation in any period of seven consecutive days • Max rate of change is 0.6n m/h • Max frequency in

River reach	Absolute Minimum Flow	[Water depth]	Max Fluctuations
		respectively (measured at the deepest point in any cross-section)	events per 24 hours and in any 7 days consecutive period

Spillway gates would be operated during the flooding period in accordance with the spillway gates operation rules to minimize the downstream impacts. Before operating the spillway gates, information regarding expected water level increase would be disseminated to downstream area in accordance with the spillway gates operation rule and the emergency action plan.

From the hydrologic study, the ecological implication of minimum flow during dry season is also very important for project operation. Dry season flow downstream from the construction site and the dam should not be less than the existing flow regimes, which is 26.4 m^3/s as the minimum average monthly river flow at Nam Ngiep dam in 30 years (1971-2000). During the operation phase, the Project proposes to release a minimum flow of 27 m^3/s into the downstream for maintaining the existing functions of the river, such as the drinking water supply, navigation water depth, and irrigation of downstream villages.

Table 6.21 Flow of Riparian Release

Condition	Cases	Flow rate (m^3/s)
Without Dam (natural inflow to main dam)	Min. average monthly river flow in 30 yr (1971-2000), estimated by Tank Model	26.4
	Min. daily river flow in 30 yr (1971-2000), estimated by Tank Model	23.5
With Dam (immediately downstream of re-regulation dam)	Min. flow rate during dry condition	27.0
	The riparian release during extreme drought year included specific discharge of 0.15 $m^3/s/100\ km^2$	5.5

3) Weekly Operation

The maximum reservoir elevation of the main dam is EL 320.0 m, and the minimum operating level would be at EL 296.0 m. Drawdown of the reservoir normally occurs during the dry season, with filling occurring during the wet season. During periods of high inflow the maximum reservoir elevation could be achieved, resulting in water discharge through the spillway gates. The discharge of normal operation of the main power station was designed at 16-hour peak generation on weekdays and Saturday. There is to be no operation on Sundays except during the rainy season.

The operation of the re-regulation reservoir is based on a maximum reservoir elevation of EL179.0 m. The minimum operating level is at EL 174.0 m. The re-

regulation reservoir is for storing the discharged water from the main dam for 16-hour peaking power generation, re-using it for power generation and releasing it downstream evenly on 24-hour basis to regulate the downstream flows. The discharge of the re-regulation power station is for 24 hours everyday.

Operations staff will operate the main power station in accordance with the operations manual. The maximum discharge through the turbines at the main dam is indicated at 230 m^3/s. The electricity generated at the main power station will be delivered to EGAT by the 230kV transmission line and common 500kV transmission line through the substation located in Ban Nabong. The re-regulation power station could provide maximum power of 18 MW for domestic supply when the maximum discharge is controlled at 160 m^3/s.

(2) Impacts from dam operations

- Upstream and Reservoir Areas

Impacts are assessed by considering changes of discharges of riparian rivers, water levels and velocities. One of the most important impacts that NNP1PC have to consider and try to avoid is water levels above EL 320 m, that would flood the villages and their agricultural lands that are located just above EL 320 m. The impacts of loss of productive land or residential area reservoir area located at or below 320 m will be compensated, but not those above EL 320 m.

Backwater levels due to dam structure should be included in operation management. The expected duration of backwater flooding on areas above EL 320 m are of particular concern. The operation during peak floods should include duration of the flooded period so that the flooding will not damage crops and property. The perceptions of the local residents about these events will also be critical, since they may need to anticipate occurrences of irregular floods. Proper procedures for human and animal evacuation will be required, along with training of local residents and dam staff on these procedures. The local residents will also need to be aware of the grievance procedures that will provide them compensation for any losses that occur from flooding above EL 320 m.

If floods exceed the design flood, an Emergency Action Plan (EAP) is proposed to mitigate such an event. Impacts could be minimized by the provision of adequate information and by good communications between the Project staff and the local residents.

- Downstream

The possible impacts from Project discharge are changes of water levels, water velocity and backwater effect at the confluence of Mekong River.

These can be considered a positive impact to the area at the confluence of the Mekong River because the dam and reservoir will control most of the rainy season flow of the Nam Ngiep River. Flows during the rainy season will be lower with the dam than they are naturally. As a result, the reservoir, dam, and re-regulation dam will lead to reduction of flooding at the confluence of the Mekong River.

During the wet season, water level from the re-regulation dam to the confluence of the Mekong River will change. The level of the river downstream will decrease in a range of 0.5 to 0.7 m during July and August because of re-regulation dam operations. The downstream area that would be affected by the decreasing levels will be the area between km 0 to km 22.53 from the re-regulation dam in August and between km 0 to km 27.33 in July. During the lower water levels, more sections of the river will be narrower. The biggest reduction of the river width is expected at km 17.74, with decrease in width of 16.35 m in June. Water velocity will have its maximum decrease in July and August, at about 0.2 m/s lower than the natural water velocity.

In the dry season, the dam operations will contribute to about 0.5-0.7 m higher water levels than under natural conditions. This can be considered as a positive impact for the downstream, since there will be increased flow even during the drier periods. The higher water levels will occur over almost the entire downstream segment of the river during March and April. The river width will also expand during the dry season. The increasing width of the river can be greatest, with an increase of 31.77 m compared to the width under natural flow without the dam, occurring at km 21.64 in May.

This change in water level, river width, and water velocity during wet season will be minor, since the operating discharge was planned to comply with natural conditions over 30 years.

The backwater effect during peak floods is a concern of local people living downstream, especially those in Pakxan (Public consultation in Pakxan dated on April 22, 2008). According to the Hydrological Study and Water quality modeling results, it is clear that the construction of the NNP1 should reduce the possibility of flooding at Pakxan since the release from the proposed dam to the Mekong River during the wet season should be lower than natural flow in order to store water for power generation in the dry season. The water level of the Nam Ngiep River downstream of the dam should be equal or lower to the condition before the construction during June to September (wet season) and the water level there should be higher during December to May (dry season). On the other hand, the construction of the proposed dam will reduce the risk of flooding at Pakxan since the released flow from Nam Ngiep River, which is a main tributary, is reduced during flood prone season.

The irregular flooding of communities located along the Nam Ngiep River near the Mekong River, however, could be misunderstood to be caused by flows from the Nam Ngiep River, when in fact, they are almost entirely due to fluctuations in the Mekong River. Effective information and communication plans should be established for downstream communities. Potential causes of any flooding around Pakxan should be disseminated thoroughly to the people in the area. Moreover, to confirm this fact, water measurement stations downstream of the re-regulation dam should closely monitor conditions following the construction, and information regarding water flow and its level should be disclosed to the public.

Downstream farmers may have concerns over lack of available water source. If the river does not dry out, farmers are not anticipated to have any problems to draw water from the river. Moreover, farmers only infrequently require additional water apart from rainfall during the wet season. The runoff downstream of the re-regulation dam will increase during the dry season about 60.3% and decrease 21.7% in the wet season (***Table 6.22***).

Table 6.22 Runoff at Re-Regulation Dam

Month	U/S Re-regulation Dam (mcm)		D/S Re-regulation Dam (mcm)	
	Before Const.	After Const.	Before Const.	After Const.
Jan	204.9	340.2	204.9	345.0
Feb	157.5	294.2	157.5	298.8
Mar	151.1	308.8	151.1	314.2
Apr	159.4	319.6	159.4	323.7
May	288.2	391.0	288.2	390.2
Jun	565.1	400.5	565.1	398.1
Jul	748.6	488.0	748.6	482.4
Aug	822.3	537.3	822.3	531.4
Sep	678.1	552.1	678.1	545.6
Oct	422.4	415.7	422.4	411.4
Nov	288.5	311.6	288.5	312.6
Dec	245.1	335.9	245.1	340.2
Total	4,731.2	4,694.9	4,731.2	4,693.6
Dry Season (Nov-Apr)	1,206.5	1,910.3	1,206.5	1,934.5
% Change		58.3		60.3
Wet Season (May-Oct)	3,524.7	2,784.6	3,524.7	2,759.1
% Change		-21.0		-21.7

With the Project development, the downstream agricultural area will be safer from flooding in the wet season and will have more water in the river in the dry season.

In terms of spillover occurrence and frequency at the main dam and re-regulation dam, based on a 30-year simulation period (1971-2000), most spills occur in July-September. For the main dam, the average spill rate is 5.8 cms annually, with a frequency of 2.2 days/month. More spills occur at the re-regulation dam, with a rate of 16.3 cms annually and spill frequency of 7.4 days/month.

Recommended mitigation measures to minimize the impacts on hydrology are provided as follows:

- Water levels at major locations/communities, especially downstream from the dam site to Pakxan should be monitored continuously. Additional monitoring points may be considered if needed. This data must be analyzed periodically for electricity production. Water levels must be controlled as near the natural level as possible to avoid negative impacts to the local residents and to the environment.
- The water level should be controlled to flow as close as possible to normal or natural levels at all times.
- Local residents in downstream communities should be informed how the river fluctuations will change because of the dam, and how they can then use the river as effectively as possible under the new hydrologic conditions.
- NNP1PC must install staff gauge of water level along the river downstream from proposed dam site especially areas of the communities to let local people be aware of the water level.
- The time for any floods to travel along the river downstream from the dam must be forecast, and local residents must be informed.
- A flood warning system must be installed in the river between the dam to the first main tributary.
- Information on water level analysis must be available to the public at all times, so people can prepare themselves for the periods of higher and lower flow. In case of extreme events, the Project must inform people of the expected time and duration of extreme low flows or extreme high flows.
- In case of flooding of downstream agricultural areas because of the failure of dam operations, the developer has to compensate the local people for the losses.
- The minimum guaranteed release of water should be provided in order to protect the various ecological conditions found in the riparian environment below the intake weirs. Further Project monitoring will be necessary to gauge the health of the ecosystem and environmental performance of the release flow rates and to enable suitable responses in operational management of the release discharges.

6.3.2 *Operation Impacts on Biological Environment*

6.3.2.1 *Approach to Assessment of Impacts*

The approach for the assessment of impacts used for this section is the same as that used in "6.2.3 Construction impacts on biological environment".

6.3.2.2 *Impacts to Biodiversity Values*

Table 6.23 summarises the threats to biodiversity values related to the activities during construction. These threats to biodiversity are derived from IFC 6 and relate to the activities that are likely to occur during Project operation. ***Table 6.24*** provides an assessment of significance for the natural and modified habitats within the Project area.

Table 6.23 Threats to Biodiversity Values during Operation

Term	Description
Disturbance	Disturbance to, or displacement/exclusion of a species from foraging habitat due to operational and maintenance activities. This includes lighting.
Alteration of Flow Regime	Effects on habitats caused by alterations to natural flow regime.
Mortality	Mortality of individual fauna species as a result of poaching and hunting.
Mortality	Mortality of individual fauna species as a result of vehicle or machinery strike or falling debris during transmission line maintenance vegetation clearing activities.

Table 6.24 Assessment of Impacts to Habitats during Operation

Impact	Description	Comment	Sensitivity	Magnitude	Significance
Disturbance	Disturbance to, or displacement/exclusion of a species from foraging habitat due to operational and maintenance activities.	Operational activities that have potential to disturb native fauna include the use of night lighting at infrastructure and facility locations. Lighting required for operation and safety at the facilities can influence nocturnal foraging behaviours as well as disrupt sleep patterns of crepuscular species.	Low	Small	Negligible
Alteration of Flow Regime	Barrier to aquatic fauna movement and habitat fragmentation	Installation of the dam and construction of watercourse crossings will introduce a barrier to water flows and flushing, and biota movement not previously experience in this region of the catchment. Fish migration is an important component for many fish species life cycle (Sensitivity medium) and the barrier that the dam wall creates will limit spawning area for a number of species known to occur in the Nam Ngiep River (including threatened species). An impact to breeding area availability has potential to influence native fish populations within and downstream of the Project (including threatened species discussed further below). Overall the dam infrastructure will reduce the area of waterway available for spawning within the catchment (Magnitude large). Environmental flows are further discussed in Appendix D and below.	Medium	Large	Major
Fauna mortality	Mortality of individual fauna species as a result of poaching and hunting.	A key threat to the IUCN Red Listed species with potential to occur within the Project area and surrounds is poaching and hunting for a food source or for trade. The Project will introduce new avenues to access the region and potentially increase the incidence of these activities, as such resulting in greater poaching pressures to native species populations.	Medium	Medium	Moderate

Impact	Description	Comment	Sensitivity	Magnitude	Significance
Fauna mortality	Mortality of individual fauna species as a result of vehicle or machinery strike or falling debris during transmission line maintenance vegetation clearing activities.	Fauna mortality can occur during vegetation clearing activities in the event individuals are struck by vehicles and machinery. Vegetation clearing or lopping will be required to maintain the safe vegetation height beneath the transmission line. Animals that are unable to disperse during clearing activities are vulnerable to being injured or destroyed through interaction with machinery or falling debris. It is likely that most individuals will disperse (Sensitivity low) from clearing locations into adjacent habitats however some less mobile species may experience a localised reduction (Magnitude small) in abundance during this period, such as amphibians, reptiles and small mammals.	Low	Small	Negligible

6.3.2.3 *Environmental Flows and Aquatic Ecology*

Water levels in the Nam Ngiep River depend mainly on seasonal rainfall. Near the confluence with the Mekong River, water levels also depend on flows of the Mekong catchment. Water levels are high in the wet season and low in the dry season. Turbidity and availability of natural fish food are high in the wet season and low in the dry season. Spawning normally occurs during the wet season though there is variation between species. The key potential long term impacts to aquatic biota as a result of the change in environmental flows relate to changes in water quality, restriction of fauna movement, altering natural behavioral triggers such as spawning, and altering downstream habitat characteristics.

In addition, the dam infrastructure will restrict migration pathways of some fish species that might migrate downstream to upstream and or upstream to downstream for feeding, spawning and or other purposes during their lifespan. These impacts can influence the lifecycle of a species, including species listed on the IUCN Red List. Additional specialist investigation is currently scheduled to further understand the significance of this potential impact. The operation of the

Impacts to Water Quality

There is potential for impacts to water quality through the first year of inundation as a result of the decay of organic matter in the reservoir area. This is further discussed in *Section 6.3.1.5*, however has potential to have consequential impacts to aquatic biota habitat suitability. This will have adverse effects on aquatic species in the reservoir and downstream from the dam. The water and sediment during this period will generate gases that may be toxic to fish and other aquatic species.

Water quality in the reservoir, especially in the years immediately following first inundation, will be critical to maintaining productive fisheries. Reservoir water quality at the time of first inundation will depend largely on the amount of biomass, particularly rapidly decomposing soft-biomass, within the reservoir basin and the extent of stratification of the water column creating anoxic conditions. This reduced level dissolved oxygen will be caused by an annual reservoir turnover, and it will lead to significantly stunted fish growth, even if occurring for a short period.

Adaptation to new conditions like those that will be found in the reservoir will be the main challenge for some species, especially of small cyprinids, that will need new habitats for their spawning and feeding for the young. This is likely to be the case for *Cirrhinus molitorella, Poropuntius sp., Puntius brevis, Onychostoma sp., Hampala dispar, Labeo erythropterus, Hemibargrus wyckioides, Neolissochilus blanci, Scaphognathops theunensis, Chitala lopis.* A fisheries management program should introduce and maintain indigenous fish populations by finding new breeding and feeding habitats in after the construction phase, both in the reservoir and in other parts of the river.

Effects of impoundment on aquatic biology in the NNHP-1 reservoir will likely be similar to what has occurred elsewhere in Lao PDR and in other tropical conditions. The organic loading in the first years of inundation will be high, which can promote the growth of plankton and benthos, and these in turn can increase production of fish.

Rapidly decomposition of soft biomass in the reservoir at the time of first inundation will cause stratification of the water column creating anoxic conditions. Poor water quality caused by an annual reservoir turnover in December-January for 3 up to at most 5 years may cause harmful to fish and reduce aquatic productivity. Artificial circulation systems are usually considered economically unfeasible for a reservoir such as this. Mitigation measures are thus limited to biomass removal before inundation and reservoir storage management until the first year, when the problem of poor water quality may be spread downstream.

In the event of insufficient biomass clearance and rapidly deteriorating water quality, one option is to release poor quality water from the lower levels of the dam. Appropriate countermeasures are needed if monitoring shows significant deterioration of water quality. These countermeasures should ensure maintenance of aquatic life downstream from the dam.

A fish enhancement program may be required. This may consider stocking, fishing zones, conservation zones and preservation zones (spawning grounds) in the reservoir in response to data obtained from monitoring.

Apart from harmful to fish immediately after the dam closure due to the habitat change and by low water quality, some of the river fish might thrive initially in the new lacustrine conditions. For these species, the tributaries flowing into the Nam Ngiep above the dam may prove to be important new spawning and feeding areas. If this is found to occur, those new areas should be protected.

Downstream Habitats and Migratory Triggers

Maintaining the seasonal flow of water in the areas downstream from the dam will be important to help maintain the fish and other aquatic resources in the catchment. To minimize downstream fisheries losses, a minimum amount of water discharge should be ensured. *Appendix D* describes the results of the environmental flows assessment and the proposed flow regime. This operating condition should be sufficient to minimize downstream fisheries losses due to changes in water level.

Aquatic biology in the newly formed reservoir and in the downstream should be monitored in accordance with a Biodiversity Action Plan. During the operation period, monitoring should be done twice each year, once in the dry season and again in the wet season, starting from year 2 until year 10. After then, fisheries resources should be sufficiently stabilized, and monitoring can be done once every 3 years. The aquatic biota to be monitored must include plankton, benthic invertebrate animals, aquatic weeds and fish.

6.3.2.4 *Mitigation and Management Measures*

Disturbance to terrestrial and aquatic habitats during operation of the Project relate to disturbance that may result from vehicle movements, ROW maintenance and the increased risk of native fauna hunting and poaching as a result of increased access to the region and consequences of changes to environmental flows. The Biodiversity Action Plan will incorporate measures specific to these impacts and include long term monitoring requirement to allow for adaptive management when required.

Management measures specific to managing the natural environment will be incorporated into the Project Operation Management Plans and these will include (but not be limited to) those identified in ***Table 6.25*** These general environmental management measures will assist in reducing the potential for degradation of habitat, behaviour disturbance, fauna mortality and habitat fragmentation for native species.

Table 6.25 Mitigation and Management Measures, Construction Phase

Nature of Impact	Overview of Measures
Disturbance to fauna behaviour	• A wildlife protection team will be established to protect and rescue remaining wildlife in the proposed reservoir area; • Vehicles and machinery will be maintained in accordance with industry standard to minimise unnecessary noise generation; • For areas requiring night-time lighting, lights will be used only where necessary and will be directed toward the subject area and away from habitat areas where possible; and • Speed limits to maximum of 40 km/hr for construction vehicles will be enforced to minimise potential for fauna strike.
Altered flows	• A suitable environmental flows release plan will be developed to minimise the impact of altered river flows to downstream environments. This will consider the outcomes of the current study being undertaken and the recommendations that are developed.
Fauna mortality	• Commitment will be made to raise awareness of values of natural habitat areas and arrangements will be made for restriction of poaching and forest product collection; • Hunting wild animals will be strictly prohibited to apply for all staff; and • Fishing and using of illegal fishing gear anywhere along the river will be prohibited.

6.3.2.5 Residual Impacts on Biodiversity Values

This section of the report documents the residual biodiversity values impacted following the application of the avoidance and mitigation steps of the following mitigation hierarchy.

Mitigation and management approaches have been considered to avoid, minimise and mitigate potential impacts to biodiversity as a result of Project activities. In general, many of the indirect impacts to biodiversity values can be minimised, such as behavioural disturbances, degradation of habitats, edge effects and barriers to terrestrial fauna movement.

The residual impacts identified relate to unavoidable loss of 4050 ha of natural habitat. *Section 5.2*, ***Table 5.2***, identified the area of each vegetation type that will be directly impacted within the Project area. Direct disturbance to habitats will be minimised where possible however this impact assessment has identified an unavoidable loss and as such compensatory measures must be considered. The next step of the mitigation hierarchy necessitates consideration biodiversity offsets for residual impacts.

A Biodiversity Offset Design Report has been developed (*Appendix B*) to provide an analysis of the approach to offset identified residual biodiversity values in accordance with the Business and Biodiversity Offset Program documents.

The residual impacts are quantified below.

6.3.2.6 Residual Impacts on Habitats

The residual impacts identified for the NNP1 Project relate to unavoidable habitat loss within the operational footprint of the Project (including habitat for IUCN listed species) and barrier to aquatic fauna movement as a result of the dam wall. Direct disturbance to habitats will be minimised where possible however this impact assessment has identified an unavoidable loss of approximately 4,050ha of natural habitat and 3,549 ha of modified habitat. ***Table 6.26*** summarises the breakdown of land cover types that will be permanently removed or altered.

Table 6.26 Impacted Land Cover Areas within the Project Area

Land Cover	IFC Habitat Class	Code	Area (ha)			Total (ha)
			Main dam	Re-regula-tion dam	Resettle-ment	
Deciduous Forest	Natural	DF	2721	132	56	2909
Evergreen Forest	Natural	EF	508	27	0	535
Old Fallow Land	Modified	OF	1321	194	163	1678
Young Fallow Land	Modified	YF	1036	143	82	1261
Bamboo	Natural	B	241	127	132	500
Slash and Burn	Modified	SB	328	27	19	374
Rice Paddy	Modified	RP	107	5	15	127

Land Cover	IFC Habitat Class	Code	Area (ha)			Total (ha)
			Main dam	Re-regula-tion dam	Resettle-ment	
Water	-	W	368	42	0	410
Grassland	Modified	G	108	0	0	108
Urban Area	Modified	U	38	3	0	41
Rock	Natural	R	1	0	0	1
Cloud	-	CL	4	0	0	4
Shadow	-	SH	16	0	0	16
			6797	700	467	7964

6.3.2.7 *Residual Impacts on Species*

ERM has applied a risk based assessment of species values to determine the significance of impacts on biodiversity values following mitigation. ***Table 6.27*** outlines the terrestrial species that have been identified that have residual impacts remaining after mitigation. ***Table 6.27*** outlines the fish species that have residual impacts on their habitats following mitigation[1].

Table 6.27 Terrestrial Species with Residual Impacts Following Mitigation

	Species	
Flora	Dipterocarpus turbinatus	Afzelia xylocarpa
	Shorea roxburghii	
Mammals	Asian small clawed otter	Southwest China serow
	Asian elephant	Dhole
	Smooth coated otter	Sun bear
	Sunda pangolin	Bengal slow loris
	Leopard	Pygmy slow loris
	Tiger	Asiatic golden cat
	Fishing cat	Leopard cat
	Phayre's leaf monkey	Sambar
	White-cheeked gibbon	Himalayan black bear
	Golden jackal	
Birds	Wreathed hornbill	Red-breasted parakeet
	Great hornbill	Darter
	Green peafowl	Rufous necked hornbill
	White winged duck	Crested argus
	Greater coucal	Spot-bellied eagle owl
	Siamese fireback	Red-collared woodpecker
	Silver pheasant	Hoopoe
	Grey peacock pheasant	
Reptiles	Reticulated python	Elongated tortoise
	King cobra	Big-headed turtle

Table 6.28 Aquatic species with residual impacts following mitigation

Species name	Common name

1. It should be noted that further assessment of the aquatic values are currently being undertaken to determine the presence of fish species in the Nam Ngiep River and the impacts of the proposal from the development.

Species name	Common name
Poropuntius deauratus	Yellow tail brook barb
Cirrhinus cirrhosus	Mrigal carp
Cyprinus carpio	Wild common carp
Scaphognathops bandanensis	Bandan sharp-mouth barb
Yasuhikotakia splendida	Jaguar loach
Cirrhinus molitorella	Mud carp
Mekongina erythrospila	
Hemibagrus wyckioides	Redtail catfish
Luciosoma bleekeri	Apollo shark minnow

6.3.2.8 *Residual Impacts on Human use Values*

From a human use perspective the impacts relate to ecosystem services values lost from the direct use of biodiversity values. It is evident that villagers in the Project area regularly use local terrestrial and aquatic biodiversity – e.g. as a food source – largely for subsistence purposes. However, the dependence on natural resources varies by village and is primarily associated with accessibility. For example, remote villages tend to rely more heavily on biodiversity (e.g. medicinal plants as access to pharmaceuticals is limited).

Development of the project will likely impact the ability of villagers to access both tangible human use provisioning services and intangible cultural heritage values. This includes:

- Hunting, gathering and fishing. This typically includes small animals, such as squirrels and rats, and flora species, such as bamboo and mushrooms. The flora and fauna are primarily consumed within the household;
- Collection and use of medicinal plants;
- Cultural heritage, such as cemeteries. In most cases, villagers did not identify intangible cultural heritage values, which may be attributed to relatively recent settlement of the local villages; and
- Collection of timber products to be used as fuel or in construction.

Table 6.29 Summary of Anticipated Impacts from the Project and Mitigation Measures - Pre-Construction and Construction Period

Environmental Aspects	Nature of Impact	Concerned Activities (that would cause impacts)	Impact Area	Magnitude and Level of Impacts: Low	Medium	High	Proposed Mitigation Measures
Physical Environment							
Topography	Changing on Topography	Modification of landscape	• Dam and other civil works area • Access routes and adjacent				• No mitigation measure is needed that relate solely to changes in topography but limitation of works only construction boundary should be conducted.
Meteorology	Not expected	Reservoir clearing and burning (if any)	Reservoir				• Limitation and controlling the dispersion of dust created by site preparation activities.
Geology, Landforms and Seismology	Landslide and rock movement	Earthquake and Seismic events	Project area				• Take into account with all geological survey data at design stage • Continuous monitoring and investigation after Project commencement
Erosion and Sedimentation	• Erosion on disturbed area • Increased sediment load in the environment	• Site clearing • Excavation works • Slope stabilization • Underground works	Project area				• Land clearing activities during dry period should be performed as much as possible. • Best practices for excavation and working in riverbed should be conducted. • Limitation of land disturbs activities only in design construction boundary. • Stockpiled should be separated and stabilized. • Appropriate drainage should be implemented. • Erosion and Sediment Control Plan especially during the wet season should be developed and implemented. • Appropriate standards of drainage works, sediment traps, diversion, culverts and other structures designed to treat water before discharge into natural and/or constructed watercourses should be conducted.

Environmental Aspects	Nature of Impact	Concerned Activities (that would cause impacts)	Impact Area	Magnitude and Level of Impacts			Proposed Mitigation Measures
				Low	Medium	High	
Reservoir and river water quality	Increasing of pollution into the environment	Discharge of wastewater from worker camps	River				• To provide designate wastewater treatment facilities. • On-site toilets at working areas and toilet facilities at worker camps should be installed with adequate number of workforce • Direct discharge of wastewater into natural receiving water is not allowed.
		Release of contaminants into water during construction	River				• To provide designed contaminants treatment facilities for each significant construction sites.
Reservoir and river water quality		Increasing in sediment load downstream	Downstream				• To conduct best practice in management of earthworks • To provide designed settling ponds for sediment settling before release to environment. • Implementation of mitigation measures for erosion and sedimentation control is strictly required.
Noise and Vibration	Noise of construction activities impacts to surrounding area	• Cutting and land excavation • Moving of equipments • Material transportation • Blasting works	Ban Hat Gniun				• Appropriate and sufficient PPE for noise protection shall be provided to all workers. • Sound-control devices on equipment should be maintained in good condition.
			Communities around main construction and communities along construction route Worker Camps				• Construction activities that may generate harmful noise should be limited only in day time, e.g. 6 am to 7 pm. • People shall be warned in advance with blasting works. • Trespassing to the blasting area shall be strictly control.
	Vibration of construction activities impacts to surrounding	Blasting	Communities				• To assure that blast-related vibrations and keeping of air blasts at offsite residential and other occupied structures are as low as possible. • Measured on the ground adjacent to a residential or other occupied structure should be implemented

Environmental Aspects	Nature of Impact	Concerned Activities (that would cause impacts)	Impact Area	Magnitude and Level of Impacts: Low	Medium	High	Proposed Mitigation Measures
	area			■			• Monitoring records of air blast and vibration should be documented in detail.
Air Quality	Increased dust particles and fugitive dust into atmosphere	• On-site machinery (off-road emissions) • Land clearing and excavation activities • Construction activities (e.g. quarry, crushing plant) • Road traffic on unsealed gravel road surface • Underground activities	• Quarry sites • Crushing and Batching plants • Road construction areas • Embankment and channel construction • Haulage of materials • Construction of worker camps • Communities around main construction and communities along construction route		■		• Minimize dust generating activities. • Keep stockpiles for the shortest possible time. • Dust suppression system to minimize dust from construction activities and transportation should be implemented. • Machinery and dust generating activities should be located away from sensitive receptors. • Best practice such as vehicles cleaning and routine maintenance should be implemented for all Project equipment and machineries
Potential Contaminated Sites	Contaminated of chemical and hazardous into environment	• Chemical storage • Drum reconditioning or recycling • Electric transformers • Explosive product and storage • Landfill operation	Project area		■		• Avoid operation of the proposed quarry site and solid waste landfill near the river. • Register and record all of potentially hazardous chemicals and waste with their movements. • Appropriated training should be conducted for all workers responsible for handling hazardous waste. • Best practice and emergency response procedure will be developed

Environmental Aspects	Nature of Impact	Concerned Activities (that would cause impacts)	Impact Area	Magnitude and Level of Impacts			Proposed Mitigation Measures
				Low	Medium	High	
		• Pest control • Petroleum product and oil storage					and implemented for all construction sites. • Warning/safety signs and rules must be located in the most appropriate places. • Trenches should be provided to divert contaminated runoff to a designed precipitation pond.
Hydrology	Change in flow during construction of Dam	• Construction of the Dam and Diversion	Downstream				• River diversion works shall be constructed during low flow season. • In case of floods, the construction contractor must prepare emergency plans and procedures to release excess water in ways that will not affect downstream communities. • The possibility of flash floods during the rainy season should be included in safety plans during construction period. • Warning system on water level fluctuation must be installed at major locations/communities downstream of the proposed dam site.
	Change in flow during Reservoir impoundment	• Reservoir impoundment	Upstream Downstream				• To complete the resettlement activities according to Resettlement Action Plan and national standards. • Public consultation with local residents must be conducted frequently. • Training should be given to local residents in downstream communities to provide public readiness in case of emergency situations. • Public consultation with local residents must be conducted frequently.
Biological Environment							
Terrestrial Ecology/Wildlife	Disturbance of wildlife	• Temporary and permanence access road through the forest areas • Reservoir clearing	Upstream area, Reservoir and downstream area				• Wildlife protection team will be established to protect and rescue wildlife during inundation period. • Strict rules against logging outside the approved construction areas and against wildlife hunting and poaching will be imposed on Project

Environmental Aspects	Nature of Impact	Concerned Activities (that would cause impacts)	Impact Area	Magnitude and Level of Impacts			Proposed Mitigation Measures
				Low	Medium	High	
		• Reservoir impoundment					staff, workers, and all contractors and personnel engaged in or associated with the Project, with penalties levied for anyone caught carrying and using fire arms, or using animal snares and traps, including fines and dismissal, and prosecution under the laws of the Lao PDR • The Project owner shall be directly responsible for dissemination to its staff and workers of all rules, regulations and information concerning these restrictions, as well as the punishment that can expected if any staff or worker or other person associated with the Project violate rules and regulations. • The remaining forest areas in the catchment, and especially in those areas close to reservoir, a forest and wildlife conservation and management program considered as a biodiversity offset measures need to be implemented.
Forest, Vegetation Cover	Loss of some valuable forests and timber species	• Reservoir and sites clearing • Trees cutting and removal • Reservoir impoundment	Reservoir and all construction areas				• To complete the detailed survey of tree species that shall be removed • Regulations and Laws related to forest shall be considered and implemented • Compensation shall be applied according to Resettlement Action Plan • Forest protection and management (including compensatory reforestation program) shall be carried out in the watershed area (or catchment area) as discussed in the Biodiversity offset design report
Introduction of pests and weeds	Damage to habitats	• Construction activities • Movement of vehicles and equipment	All construction areas				• All machinery and tools will be thoroughly washed down prior to use to help prevent the spread of weeds and plant pathogens. • To avoid the spread of non-endemic species between different areas of the construction site, topsoil and vegetation (for mulching) removed from an area during site-clearing activities will as far as practical only be reused on that area. • Construction wastes will be appropriately stored and disposed of

Environmental Aspects	Nature of Impact	Concerned Activities (that would cause impacts)	Impact Area	Magnitude and Level of Impacts			Proposed Mitigation Measures
				Low	Medium	High	
							such that pest and/or native fauna cannot access hazardous or domestic waste items. • Landscaping and re-vegetation will utilise locally native species. • To avoid the spread of non-endemic species between different areas of the construction site, topsoil and vegetation (for mulching) removed from an area during site-clearing activities will as far as practical only be reused on that area. •
Aquatic Biota	Decrease of fish population	• Earth works that may produce sediment adding to water turbidity • Establish of worker camp	River				• To avoid/minimize releasing sediment load into the river, e.g. using nylon screens to minimize sediment from steep slope releasing to the river. • Cofferdam and diversion tunnels shall be conducted to allow water in the Nam Ngiep continual and free flowing to the downstream, as it did prior to impoundment • Fishing and using of illegal fishing gear anywhere along the river should be prohibited.

Table 6.30 Summary of Anticipated Impacts from the Project and Propose Mitigation Measures - Project Operation Phase

Environmental Aspects	Nature of Impact	Concerned Activities (that would cause impacts)	Impact Area	Magnitude and Level of Impacts			Proposed Mitigation Measures
				Low	Medium	High	
Physical Environment							
Meteorology	• Localized changes to ambient air temperatures and relative humidity, and water temperature at downstream • Changing on the rates and intensity of haze and fog • Increased down slope winds • Changing of cloud base creation or suppression	The creation of a reservoir and inundation of forest area	Localized climatic condition				• To develop water quality model for prediction and further planning. • Adequate recording of meteorological data shall be conducted continuously during operation.
Geology, Landforms and Seismology	Reservoir-induced earthquake / Geohazards	The creation of reservoir that exert pressure to cause an earthquake	Reservoir				• Routine inspection of dam structure is recommended, particular after initial storage of water in the reservoir

Environmental Aspects	Nature of Impact	Concerned Activities (that would cause impacts)	Impact Area	Magnitude and Level of Impacts: Low	Medium	High	Proposed Mitigation Measures
Soil	• Low level of soil fertility • Unsuitable of land form and soil depth	Agricultural production	Resettlement sites				• Improvement in soil fertility should be considered. • Crop management should be conducted. • To prevent loss of soil nutrient with appropriate erosion control.
Erosion and Sedimentation	Soil erosion in the watershed area	Increasing of agricultural	Watershed area				• Watershed Management Plan should be implemented.
	Build up of sediments in reservoir	The creation of reservoir	Reservoir area				• Erosion and sedimentation control plan should be implemented.
	Erosion occur along the riverbank	Regulating water release will alter the characteristic of water flow and scorching effect on the river bank	Downstream				• Regularly monitoring of riverbank erosion should be implemented.
Reservoir and River Water Quality	Increased organic matter and nutrients in reservoir	Decaying of residual biomass	Reservoir				• To remove as much vegetation from reservoir before impoundment.
	Release of water with low dissolved oxygen	Consequence of decaying of biomass in the reservoir	Downstream				• To develop water quality model for prediction and further planning. • Engineering works might be needed if water quality results show significant deterioration of water quality. • Water quality monitoring plan should be conducted during the initial phases of operation. • Water quality, the amount of suspended solid and its chemical parameters e.g. mercury contents should also be monitored annually.

Environmental Aspects	Nature of Impact	Concerned Activities (that would cause impacts)	Impact Area	Magnitude and Level of Impacts			Proposed Mitigation Measures
				Low	Medium	High	
Air Quality	Not expected	Air pollution is caused by vehicles traveling to and from the site than from any direct dam-related activities	Road link to project area				• No mitigation necessary
Potential Contaminated Sites	Contaminated of chemical and hazardous into environment	Using and storage of hazardous materials such as flammable fuels and pesticides	Project area				• The use of the pesticides and fertilizers must follow proper application methods. • Overuse of hazardous chemicals such as fuels and pesticides and fertilizers must be avoided to prevent soil and water pollution.
		Spillage of chemical or hazardous materials	Project area				• Vehicles carrying pesticides and fertilizers for landscaping must be covered on the route between the storage warehouse and the landscape site. • Hazardous chemicals must be well sealed and instruction to use shall be clarified.
Hydrology	Flood impact on villages and their agricultural lands that are located above EL 320 m.	Water level in reservoir is above EL 320 m during wet season	Upstream and Reservoir area				• Management of the reservoir water levels should be conducted • If flood exceed the design flood, Evacuation Action Plan (EAP) should be proposed. • Provision of adequate information and interactive two ways communications between the Project and the local communities should be maintained
	Backwater effect at the confluence of Mekong River	Project discharge	The confluence of Mekong River				• To develop water quality model for prediction and further planning.
Hydrology	Changing of	Water releasing	Downstream				• Water levels at major locations/communities, especially

Environmental Aspects	Nature of Impact	Concerned Activities (that would cause impacts)	Impact Area	Magnitude and Level of Impacts: Low	Medium	High	Proposed Mitigation Measures
	water level and water flow						downstream from the dam site to Pakxan should be monitored continuously. • Additional monitoring points may be considered if needed. • Water levels should be regulated as much as possible similar to normal level prior to Project development to avoid negative impacts to the local residents and to the environment. • Downstream communities should be informed of the characteristic change on river fluctuations, and how they can then use the river as effectively as possible under the new hydrologic conditions. • Highest water level marker should be install along the river downstream, especially those that close to communities, should be installed. • Provide in place flood forecasting system and early warning protocol for the downstream communities to give an ample time for evacuation if necessary. • A flood warning system should be installed in the river between the dam to the first main tributary. • In case of extreme events, the Project must inform people about the expected time and duration of extreme low flows or extreme high flows. • In case of flooding of downstream agricultural areas because of the failure of dam operations, compensation process shall be provided to the local people for their losses. • The minimum guaranteed release of water should be provided in order to protect the various ecological conditions found in the riparian environment below the intake weirs. • Operational management of the release discharges shall be monitored.
Biological Environment							
Terrestrial Ecology/Wildlife	Disturbance of wildlife	Continuous impact from construction phases	Upstream area, Reservoir and				• Strict rules against logging outside the approved construction and inundated areas.

Environmental Aspects	Nature of Impact	Concerned Activities (that would cause impacts)	Impact Area	Magnitude and Level of Impacts: Low	Medium	High	Proposed Mitigation Measures
			downstream area				• wildlife hunting and poaching will be imposed on Project staff, workers, and all contractors and others engaged by or otherwise involved with the Project, with penalties levied on anyone caught carrying and using fire arms, or using animal snares and traps, including dismissal and prosecution under the laws of the Lao PDR.
Introduction of pests and weeds	Damage to habitats	• Movement of vehicles and equipment	All construction areas				• All machinery and tools will be thoroughly washed down prior to use to help prevent the spread of weeds and plant pathogens. • To avoid the spread of non-endemic species between different areas of the construction site, topsoil and vegetation (for mulching) removed from an area during site-clearing activities will as far as practical only be reused on that area. • Construction wastes will be appropriately stored and disposed of such that pest and/or native fauna cannot access hazardous or domestic waste items. • Landscaping and re-vegetation will utilise locally native species. • To avoid the spread of non-endemic species between different areas of the construction site, topsoil and vegetation (for mulching) removed from an area during site-clearing activities will as far as practical only be reused on that area.
Terrestrial Ecology/Wildlife							• Wildlife specialists should be engaged to monitor the conditions of the wildlife species in the Project area. • Wildlife protection plan linked with the forest management plan, which aims to manage and protect the forest and wildlife in the watershed area, should be provided.
Aquatic Biota	• Changing of habitats for fish, especially spawning grounds • Decreasing	Permanent barrier to fishes migration paths from dam closure	Upstream, Reservoir area, and Downstream				• Appropriate fish enhancement program should be provided and implemented. • Fishing zones, conservation zones and preservation zones (spawning grounds) should be considered in the reservoir according to the data obtained from monitoring • New settlements, clearing of new agricultural lands, and establishment of factories around the reservoir area should be

Environmental Aspects	Nature of Impact	Concerned Activities (that would cause impacts)	Impact Area	Magnitude and Level of Impacts: Low	Medium	High	Proposed Mitigation Measures
	of fish populations • Harmful to fish due to anoxic condition • Reducing of aquatic productivity	Rapidly decomposition of soft biomass in the reservoir at the time of first inundation	Reservoir area			■	prohibited • Appropriate countermeasures are needed if monitoring shows significant deterioration of water quality eg. additional aeration structure. • For fish species, the tributaries flowing into the Nam Ngiep above the dam may be a new spawning and feeding area. If it occurs, that new areas should be protected.
	Downstream fisheries losses	Project discharge	Downstream			■	• Maintaining the seasonal flow of water in the areas downstream from the dam. • Minimum amount of water discharge should be controlled. • Aquatic biology should be monitored at least twice a year, once in the dry season and again in the wet season, starting from year 2 until year 10, after that should be done once every 3 year. Aquatic life to be monitored including plankton organisms, benthic invertebrate animals, aquatic weeds and fish.

7 STUDY OF ALTERNATIVES

This section aims to provide a brief comparison of the possible alternatives to the Project, and rationale for choices in Project design. The alternatives were considered in order to decide the optimal design and operational modes to minimize the possible impacts to the environment from the Project.

7.1 NO-PROJECT ALTERNATIVE

Considering the power development policies from a global level down to national level, the No-Project alternative (no development of NNP1) would not comply with (i) the Greater Mekong Sub region's strategy for the energy sector, (ii) the Lao national development priorities, (iii) the GOL's plans and policies for the power sector, (iv) the MOU signed between GOL and the Government of Thailand, and (v) the MOU signed between GOL and the developer.

Lao PDR has the largest hydropower potential of countries in the Lower Mekong Basin, but only a small percentage of that potential has been developed. Coal is another important energy source in the country. According to Lao PDR government's policy, resource development would be accomplished through two main strategies:

(1) To supply reliable power to meet with the country's demand as well as promote economic and social development; and
(2) To enhance hydropower energy for exporting to neighbouring countries.

It is expected that the growth of Greater Mekong Sub region (GMS)'s energy demand would not be achieved if the power production of NNP1 is not properly developed. Power outages may potentially occur, and also the country would not have enough money for development of other projects.

The Electricity Generating Authority of Thailand (EGAT) regularly prepares a Power Development Plan (PDP) for least-cost system expansion. PDP 2010 proposes a total capacity increase of more than 21,500 MW from 2010 through 2020 to cover forecasted power consumption and planned retirements (5,933 MW).

Several candidates for power plants have been taken into consideration under PDP 2010 with the least cost approach: (1) clean coal, (2) combined cycle gas turbine (CCGT), (3) nuclear, and (4) pumped storage hydro plant.

For clean coal, there is no immediate implementation plan because of many constraints like location, greenhouse gas emissions and public acceptance. The first clean coal plant is scheduled for 2019, while nuclear projects require long lead times, heavy investment, and establishment of nuclear in-country capacity.

As there is an issue of public acceptance on nuclear projects, PDP 2010 only considered 5 units with a maximum power generation share of 10% starting in 2020. Pumped storage operates as a peaking plant and is usually developed as a complimentary generating facility to base load power plants such as coal and nuclear, and therefore would not strictly replace NNP1.

PDP 2010 also considered other criteria beyond cost minimization. Thailand's fuel supply diversification is already highly concentrated with natural gas accounting for 58% of generation as of January 2011. Therefore, PDP 2010 focused on the importance of diversifying and securing alternative sources of fuel for power generation with the goal of decreasing power generation from natural gas to about 50% by 2030. New gas fired power plants would be developed to replace retiring plants.

PDP 2010 also recognizes that there are promising power purchase projects from neighbouring countries. PDP 2010 targets to source up to 25% of the overall power requirements by 2030 from neighbouring countries.

In case the Project was to be replaced by another power plant of equivalent operational characteristics, the CCGT or another import hydropower project would be the most appropriate alternative.

The sponsors of the Project have signed a tariff Memorandum of Understanding with EGAT and the Project has progressed toward a draft power purchase agreement, the Project therefore has been included in PDP 2010 as a firm addition.

The main environmental impacts of NNP1 have been determined to be flooding of about 7,700 ha of land, of which about 3,200 ha are at present covered by forest. The resettlement sites will also require clearing of additional forest land for agriculture. Given the changes in water flow, there is also expected to be some change in the aquatic ecosystems.

With the Project's implementation, mitigation measures would be taken that will protect and enhance the remaining forests of the Nam Ngiep watershed. Additionally, fishery resources would be monitored and replenished as needed. Water quality would also be closely monitored. Agricultural production would be supported to become more sustainable.

Conversely, without the Project, existing trends of forest, land, and water use can be expected to continue. These trends include: deforestation from illegal logging and conversion to agriculture, land degradation from unsustainable agricultural practices, and overfishing and pollution of water resources with increased population along the rivers.

Without the Project, it is likely that these resources will continue to be exploited at unsustainable levels. If the Project goes ahead, if the environmental monitoring system is in place and effectively implemented, and the recommended mitigation measures are implemented, it is likely there would be an overall lesser environmental degradation than if the Project was not implemented.

7.2 *ENERGY ALTERNATIVES*

A wide range of fuels and power-generating technologies are currently available. Because this Project is to produce electricity primarily for sale to Thailand, the potential alternative energy sources should consider those that might be used in Thailand as well as in Lao PDR. Petroleum, lignite, coal, and natural gas are nonrenewable resources. While lignite and natural gas are both found in Thailand and used for electricity generation, any expansion of their use for additional electricity production is not recommended because of the high rate of greenhouse gas emissions from these sources, even with newer technologies. The main causes of greenhouse gas emissions in hydropower projects are related to construction (production of steel and concrete, transport of materials to site, and during construction) and by the decay of biomass that was covered by the reservoir and the oxidation of surface sediment on the reservoir. The larger the reservoir, the greater the emissions can be expected. Even so, these emissions are much less than those emitted by production of electricity with any of the fossil fuels.[1] For the NNP1 Project, the reservoir will be narrow but long, so the surface area is relatively small, and any emissions from oxidation of surface sediment should not be great.

Among the renewable energy sources, hydropower is at present the most viable both technically and economically for exploitation in Lao PDR, given its many rivers and streams in the steep mountains. Use of any other renewable energy source such as solar or wind power at this stage of the country's development would require the import of large amounts of materials and equipment at great cost, with little opportunity to regain those costs.

7.3 *PROJECT DESIGN ALTERNATIVES*

The study of alternatives analyzes information from previous studies including the Phase I (1998-2000) and Phase II (2001-2002) feasibility studies conducted by Nippon Koei Co., Ltd. for JICA, and the Technical Report by The Kansai Electric Power Co., Inc. and Electricity Generating Authority of Thailand.

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1 Spadaro, J.V., Langlois, L., and Hamilton, B. (2000) "Greenhouse Gas Emissions of Different Electricity Generating Chains", *IAEA Bulletin*, 42 (2), pp 19-24.

7.3.1 Small-Scale Hydropower Alternatives

Another alternative would be the implementation of many small-scale hydropower generators along the river, rather than one large dam with its hydropower plants. These would not be feasible for both economic and environmental reasons. The fluctuation of river flow between wet and dry seasons in a monsoon climate are too great for a small-scale hydroelectric system to work. Furthermore, the electricity produced by the small-scale schemes would be appropriate for use by small local communities, but not for higher production for larger towns or cities, or for sale to other countries, or use elsewhere in Lao PDR, unless all the small systems were linked in a grid. However, if a large enough number of small-scale systems were linked to produce electricity for use elsewhere in the country or for export, the cost of infrastructure to transmit the electricity over great distances in the steep terrain of the Nam Ngiep watershed and in much of Lao PDR would be prohibitive. Operation and maintenance costs would also be massive, since each small-scale system would require its own personnel to look after it.

7.3.2 Project Location

The Project site (Main dam site) is located on the Nam Ngiep River some 145 km northeast from Vientiane, or about 40 km north from Pakxan. The Project site is accessible from the capital of Vientiane first by National Highway 13 South, about 120 km to the intersection of Provincial Route 4, just before reaching the city of Pakxan. After about 20 km, Provincial Route 4 reaches Ban Nonsomboun, where there is a road branching off to Ban Hat Gniun. This road goes 21 km to Ban Hat Gniun, which is located 10 km away from the main dam site. Travel from Vientiane to the Project site takes about 4.5 hours by car. The roads between Vientiane and Ban Nonsomboun are paved, after which there are only dirt roads to the Project site.

While access to the dam site from downstream of the Project site, as described above, is easier, it is also accessible from upstream, from Phonsavanh in Xieng Khouang Province, near the source of the Nam Ngiep River. There are roads going down the river valley for most of the distance, until some 20 km before the dam site. The Nam Ngiep River flows in a predominantly south-southeast direction through a mountainous region, then turns east into a steep gorge. The river exits the gorge about 7.7 km upstream from Ban Hat Gniun, after which it again flows mainly south-southeast through the hilly areas downstream. The dam is to be located at the end of the 7 km gorge that cuts straight through the mountain range that connects Mt. Huasua to the northeast and Mt. Katha to the southwest. Given the topography, this has been determined as the most preferable location for the hydropower project, so as to ensure sufficient capacity of the reservoir and appropriate location for the various components of the Project.

7.3.3 *Alternative Dam Sites*

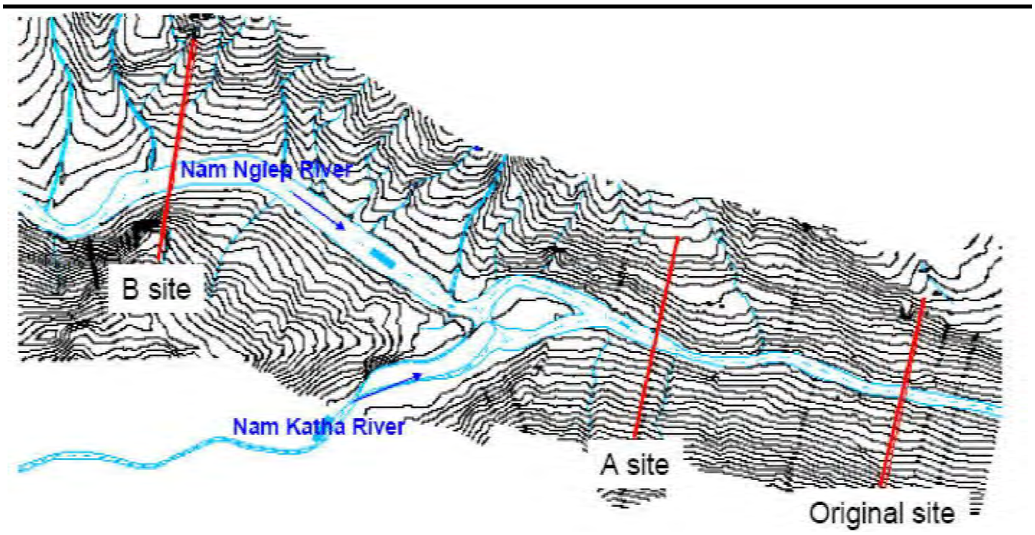
7.3.3.1 *Overview*

For dam site selection, JICA-F/S studied only the downstream section of the gorge from the Nam Katha River junction. The Review Report issued thereafter proposed another dam site at the uppermost location of the gorge (A site). However, very little study of the peripheral area of the uppermost dam site was done. For this reason, preliminary selection of several promising sites was made through desk study, and these sites were then checked through several site reconnaissance and field surveys. The survey results were evaluated and compared to establish the final dam site.

As a result of the study, a new location 1.0 km upstream of the Nam Katha River junction (designated as B site) was also evaluated as a potentially viable location for the dam site, in addition to the original site and the A site. At B site, rock outcrops were identified and the riverbed was free of boulders that are deemed problematic for the excavation work of the dam and the river diversion or from the viewpoint of water shut-off. These three sites were compared in terms of their economic, topographical and geological, and technical aspects.

For the comparative study, existing drilling data were available for the original site. However, topographical and geological data were absent for the A site and the B site. New topographical and geological surveys were conducted for these sites. ***Figure*** 7.1 shows the alternative locations of each dam site (The KANSAI Electric Power Co., Inc., 2011).

Figure 7.1 Alternative Location of Each Dam Site

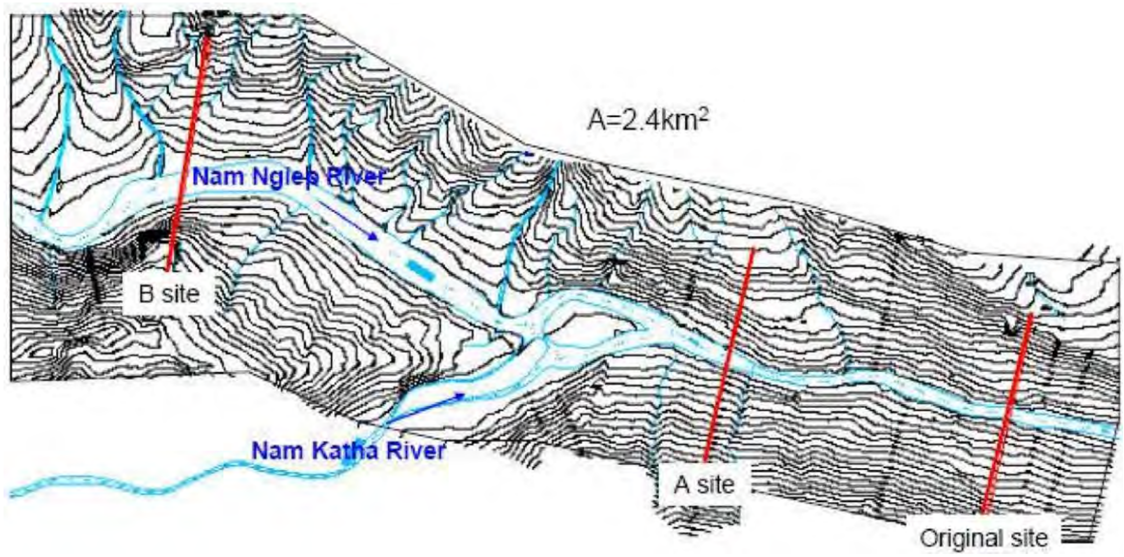


Source: Technical Report, 2011

7.3.3.2 *Topographical Survey*

The existing topographical map available for the comparison of the 3 sites was of 1/10,000 scale, prepared by an aerial photo survey for JICA-F/S. However, the accuracy of this topographical map was insufficient for comparative evaluation of the dam sites. A new topographical map of 1/2,000 scale was prepared through ground surveys. The ground survey coverage area is approximately 2.4 km^2, to include the original site, the A site, and the B site, as shown in ***Figure 7.2***. The JICA-F/S did not establish any benchmarks near the dam site area. Based on the Pakxan base point, new benchmarks were established in the periphery of the site by the GPS survey (The KANSAI Electric Power Co., Inc., 2011).

Figure 7.2 Topographical Survey Coverage



Source: Technical Report, 2007

7.3.3.3 *Geological Survey*

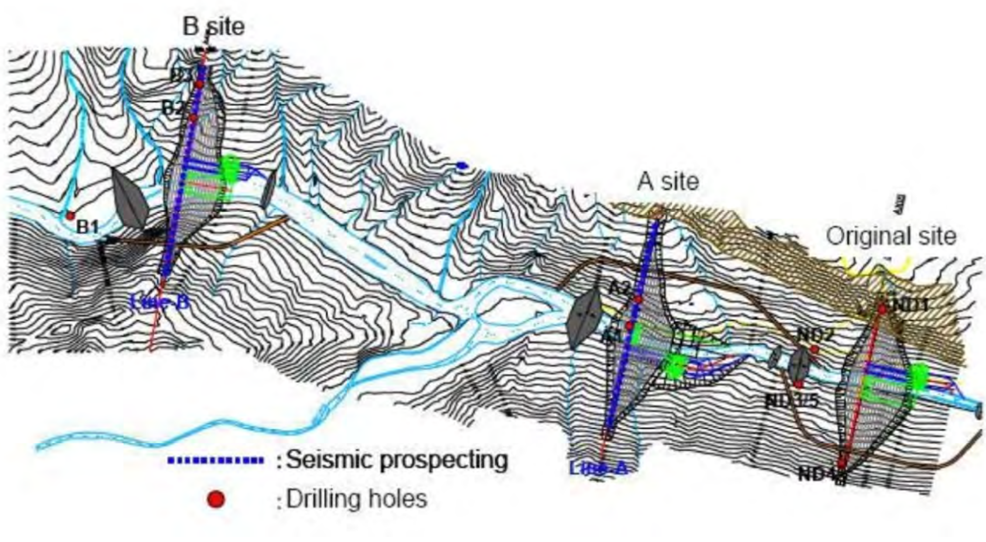
The geological surveys conducted over A site and B site include site reconnaissance, seismic wave prospecting, drilling surveys, and alkali-aggregate reaction tests.

The seismic wave prospecting was to verify the weathering conditions of the foundation rock, and the drilling surveys aimed to identify the thickness of the river deposit. Meanwhile, JICA-F/S conducted the alkali-aggregate reaction tests and reported a "positive alkali-aggregate reaction". Since these test results have a great impact on the quarry site planning and the dam type selection, it was decided to conduct the same tests again for the purpose of confirming the applicability of the aggregates for concrete. The quantities found at each site are given in ***Table 7.1***. ***Figure 7.3*** shows the survey location plan. Data from the original site were already in JICA-F/S (The KANSAI Electric Power Co., Inc., 2007).

Table 7.1 Geological Survey Quantities

Item	B site	A site	Original site
Seismic wave prospecting	1 traverse line (L = 800 m)	1 traverse line (L = 800 m)	-
Drilling survey	B1: 75 m	A1: 75 m	ND1: 150 m
	B2: 50 m	A2: 50 m	ND2: 100 m
	B3: 50 m	-	ND3: 100 m
	-	-	ND4: 150 m
	-	-	ND5: 100 m (Incline)
Total	3 holes, 175 m	2 holes, 125 m	5 holes, 600 m

Figure 7.3 Geological Survey Plan



Source: Technical Report, 2007

Table 7.2 provides the topographical and geological characteristics of each site on the basis of the survey results. No single positive alkali-aggregate reaction was observed for the same tests conducted at this time.

Table 7.2 Comparison of Dam Sites

Dam-site	Topographic features	Geologic conditions
Original site	• Location: 1.2 km downstream from the Nam Katha River • River channel: 30-40 m wide (dry season), forming a rapid • Topographic profile: - Both banks: steep about 30°, covered with big boulder	• Rock types: Alternation of sandstone, conglomerate, mudstone but sandstone and conglomerate predominant • Geologic structure: Beds dipping downstream-ward with 10-15° and a fold zone running in the same direction of river on the lower portion of right bank • Foundation: Generally good - River deposit: 15 m in thickness - Talus deposit: thickly (20-22 m) covered from the shoreline to the middle of slope on both banks • Excavation depth: 20 m at the river channel, 15-45 m on both banks • Permeability: generally small of 5 Lu or less under the excavation line
A site	• Location: 0.5 km downstream from the Nam Katha River • River channel: 30-40 m wide (dry season), forming a rapid • Topographic profile: - Both banks: about 30° up to dam crest level (EL. 325 m), but after that 15° on the left bank - Covered with big boulder exceeding 5 m in diameter • A small topographic protrusion due to gushing out of slide debris exists on the downstream left bank.	• Alternation of sandstone and mudstone • Foundation: Red mudstone lying under the river channel is deteriorated to 30 m in depth by a folding running along river channel - River deposit: 11.2 m (drill hole A-1) - Talus deposit: 10-15 m in thickness but 20 m at the dam crest on the left bank • Excavation depth: 27-30 m at the river channel, 15-25 m on the slopes of both banks • Permeability: More than 10 Lu down to 40 m in depth under the river channel, 15 Lu down to 50 m in depth in the middle of left bank but unknown (no data) for the right bank
B site	• Location: about 1 km upstream of the junction of Nam Katha River. • River channel: 60-70 m wide (dry season), forming a backwater • Topographic profile is asymmetrical between the left and right banks. - Left bank: gentle about 20° - Right bank: steep 40-45° up to EL. 300 m and after that gentle 20°	• Rock types: Alternation of sandstone and mudstone • Foundation: Generally good except following locations - A fold zone passes on the middle of left bank - A fractured zone is expected on the right bank upper portion. - River deposit: 15-20 m in thickness (drill hole B-1) - Talus deposit: less than 10 m on the right bank, while rocks crop out on the right bank • Excavation depth: 20 m under the river channel, 15-30 m on the slopes of both banks • Permeability: Relatively low under the river channel, 30 Lu down to the depths 25-30 m on the left bank , unknown (no data) on the right bank

Source: Technical Report, 2011

7.3.3.4 *Evaluation and Determination of Dam Sites*

Comparisons of the three sites were made regarding topography, geology, workability and economic efficiency. The study confirmed that the original site proposed by JICA-F/S located 1.7 km upstream of the gorge exit was the optimum site (***Table 7.3***).

Table 7.3 Dam Site Comparative Evaluation Result

Item	B site	A site	Original site
Topography	A	A	A
Geology	B	C	A
Workability	A	B	B
Economic efficiency	C	B	A
Comprehensive evaluation	B	C	A

Source: Technical Report, 2007 A: Good, B: Fair, C: Poor

Workability of the original site was given an evaluation of B because blasting to crush boulders to small pieces may require time and cofferdams built on the boulder stratum may present technical difficulty to ensure water cut-off. This means that for detailed design and implementation, boulders should be handled with sufficient caution.

The environmental impact of these three alternatives did not differ significantly. First, the reservoir area would be the same for the three alternatives because the NWL of 320 meters had been fixed for environmental and social reasons, to minimize the number of people who had to be resettled and to minimize environmental impacts. Second, given the similar topography, in particular the dimension of the gorge among the alternative dam sites, excavation volume would not differ significantly. Third, the access road for all the sites would have to be from downstream, and an access road to the present dam site, located farther downstream than other alternative sites, would be the shortest, thus resulting in less impact to the environment.

7.3.4 *Alternative Dam Type*

7.3.4.1 *Overview*

In selecting the dam type, JICA-F/S compared Concrete Faced Rockfill Dam (CFRD) and Roller Compacted Concrete Dam (RCC) methods in terms of topographical and geological conditions, ease of materials procurement, and economic efficiency, and eventually decided on the CFRD type. A comparative study on CFRD and RCC was conducted again for the original site, which has been adopted as the dam site.

The Review Report, 2004 re-evaluated the comparison of CFRD and RCC and changed the type to RCC. Selection of dam type was reassessed according to the following benchmarks.

7.3.4.2 *Comparison between CFRD and RCC*

In the JICA-F/S, the dam layout was composed mainly of two river diversion tunnels, a concrete faced rockfill dam (CFRD), a spillway with gated overflow portion, an intake structure and power waterway, a surface type powerhouse and outlet facilities. The CFRD was selected taking into account the site topography and geology, availability of construction material, and technical as well as cost advantages, compared with both an earth core rockfill dam (ECRD) or a roller compacted concrete dam (RCC).

The ECRD would require a considerable amount of soil for embankment, and was discarded as an alternative because of insufficient soil materials. The placement of core material would also have to be interrupted during the rainy season.

The development of RCC caused a major shift in the construction practice of mass concrete dams and locks. The traditional method of placing, compacting, and consolidating mass concrete was at best a slow process. Improvements in earth-moving equipment made the construction of earth and rock-filled dams speedier and, therefore, more cost-effective. Thus, the RCC differed from conventional concrete, principally in its consistency requirement.

Depending on the complexity of the structure, RCCs costs were generally 25% to 50% less than that of conventional concrete. The economic analysis for dam type selection of the RCC which was proposed in the Review Report, 2004, and the original CFRD recommended in JICA-F/S II, 2002 was carried out as shown in ***Table 7.4***. The result is that there would be no major cost difference between the two dam types.

Although some figures were revised in later study, the comparison described in ***Table 7.4*** shows that the RCC type of dam is more preferable from an economic perspective.

The RCC dam is also preferable from an environmental perspective. It requires less volume of filling materials such as concrete aggregates extracted from the quarry site in comparison to other alternatives such as a rockfill dam. Furthermore, RCC dams can utilize fly ash, which is the waste produced in coal-fired thermal power plants, and it is planned for this project to replace cement with fly ash at rate of more than 50%.

The excavation volume is also less because the spillway for an RCC type dam is installed within the dam body whereas that for a rockfill dam is installed separate from the dam body.

Table 7.4 Comparison of RCC and CFRD Dam Types for NNP1

Factor	Items	Unit	Review Report	JICA F/S(Phase-II)
			Report in 2004	2002
Catch. Area	Catchment area at dam site	km^2	3,700	3,700
	Annual average basin rainfall	mm	1,873	1,873
	Average run-off coefficient	-	0.67	0.67
Reservoir	Probable maximum flood (PMF)	m^3/s	14,220	14,220
	Mean annual sediment flow	$t/km^2/yr$	500	500
	FSL (Full supply water level)	EL.m	320	320
	MOL (Minimum operation level)	EL.m	296	296
	Gross storage capacity	$mil.m^3$	2,241	2,241
	Effective storage capacity	$mil.m^3$	1,192	1,192
	Reservoir area at FSL	km^2	66.9	66.9
Main dam	Dam type	-	RCC	CFRD
	Dam height, crest length	m	151	151
	Dam crest length	m	600	513
	Dam volume	$mil.m^3$	2.6	7.3
Power plant	Design discharge	m^3/s	230	230
	Annual mean runoff	m^3/s	147.2	147.2
	Rated head	m	127.7	136.2
	Plant capacity	MW	260	260
	Annual output	GWh	1,327	1,327
Economic analysis	Total construction cost	US$ mil.	313	344
	Unit cost	US$/kW	1,204	1,323
	Economic internal rate of return (EIRR)	%	21.6	19.5
	Financial) internal rate of return (FIRR)	%	14.4	13.1
Required resettlement	Number of villages	Nos.	4	4
	Number of Households	H/H	239	239
	Population	People	1,609	1,609

Note: (1) Revised Project features in Review report are shown in italic/bold/red color.
(2) RCC (Roller Compacted Concrete Dam), CFRD (Concrete Faced Rockfill Dam)
Source: Review Report of the Feasibility Study by JICA, 2004.

7.3.4.3 Risk Determination on Dam Type Selection

If the CFRD dam type were selected, overtopping caused by flooding during the construction period was regarded as one of the largest risk factors. If the RCC dam type were selected, securing aggregate for concrete mixing in the vicinity of the site would be a vital requirement. Through the newly conducted alkali-aggregate reaction tests, it was verified that there was no evidence of alkali-aggregate reaction, which ensured that the aggregate available near the dam site could be used.

After all the study results were taken into consideration, RCC was selected as the dam type (The KANSAI Electric Power Co., Inc., 2011).

7.3.5 Project Optimization Study of the Main Power Station

7.3.5.1 Project Optimization Study of JICA-F/S

The main power station (peak operation time of 16 hours) proposed in the Project optimization study (optimum reservoir operation) of JICA F/S is shown in ***Table 7.5***.

Table 7.5 Project Optimization Study of the Main Power Station (proposed by JICA)

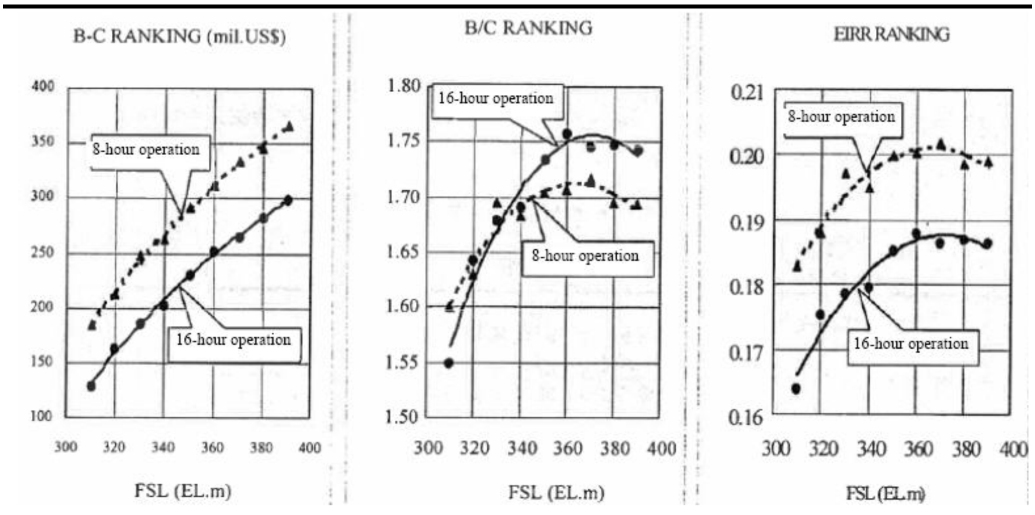
Flood Water Level (FWL)	EL. 320.0 m
Normal Water Level (NWL)	EL. 320.0 m
Rated Water Level (RWL)	EL. 312.0 m
Minimum Operation Water Level (MOL)	EL. 296.0 m
Maximum Plant Discharge	230 m^3/s

Source: Technical Report, 2007

(1) Normal Water Level (NWL) of the main reservoir

Setting the NWL at near EL 370 m optimizes the economic efficiency of the Project (***Figure 7.4***), but it would also mean that 14 villages in the Thaviang area would be inundated. Analysis of the area show that if NWL is set at more than EL. 370 m in pursuit of greater economic efficiency, many villages would be immersed and large scale relocation required. Recognizing this result of the economic efficiency study, JICA-F/S established the NWL at EL 320 m in order to minimize the relocation of local residents because of this Project.

Figure 7.4 Relation b/w NWL and Economic Efficiency of Project



Source: JICA-F/S, 2002

Table 7.6 Elevation of Villages Upstream of the Main Reservoir

No.	Village Name	Lowest Elevation (m) of Village
1	B. Pou	316
2	B. Nakang	324
3	B. Hatsamkone	326
4	B. Phiengta	321
5	B. Dong	326 to 330
6	B. Phonngeng	326 to 330
7	B. Nasong	330
8	B. Nasay	338
9	B. Viengthong	343

Source: Technical Report, 2007

Land utilization distribution is compared for reservoir water level below EL 320 m and below EL 360 m in ***Figure 7.5***. Summation of utilized land area for each elevation in Thaviang area is presented in ***Figure 7.6***. The results of the surveys showed that at the dividing line of EL 320 m, the land utilization area increases markedly.

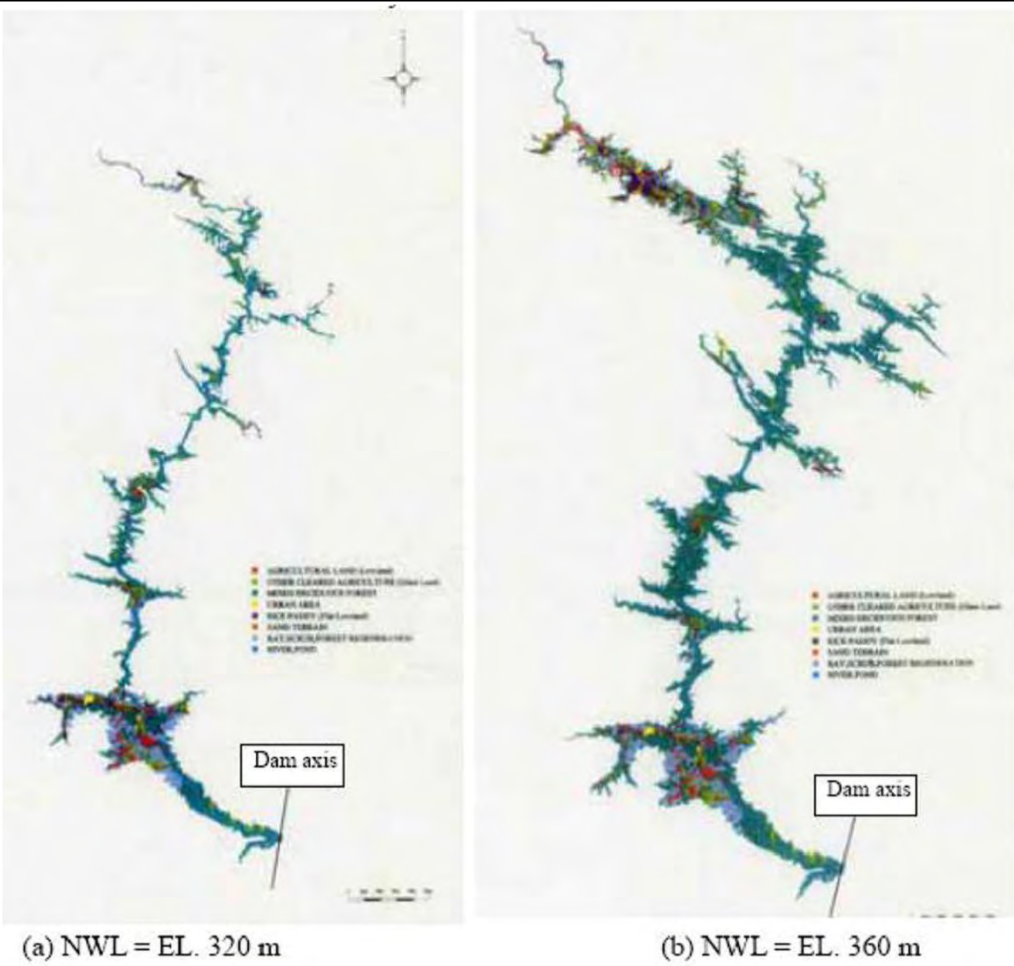
(2) Flood Water Level (FWL) of the main reservoir

FWL and NWL were established at the same level in consideration of the reservoir backwater effect, during flood season, on the villages located upstream of the main dam at around EL 320 m. At times of flooding, reservoir storage effect could not be expected. The spillway, therefore, should be designed to be capable of keeping the water level of the reservoir below NWL by discharging the flood waters safely.

(3) Maximum plant discharge of main reservoir

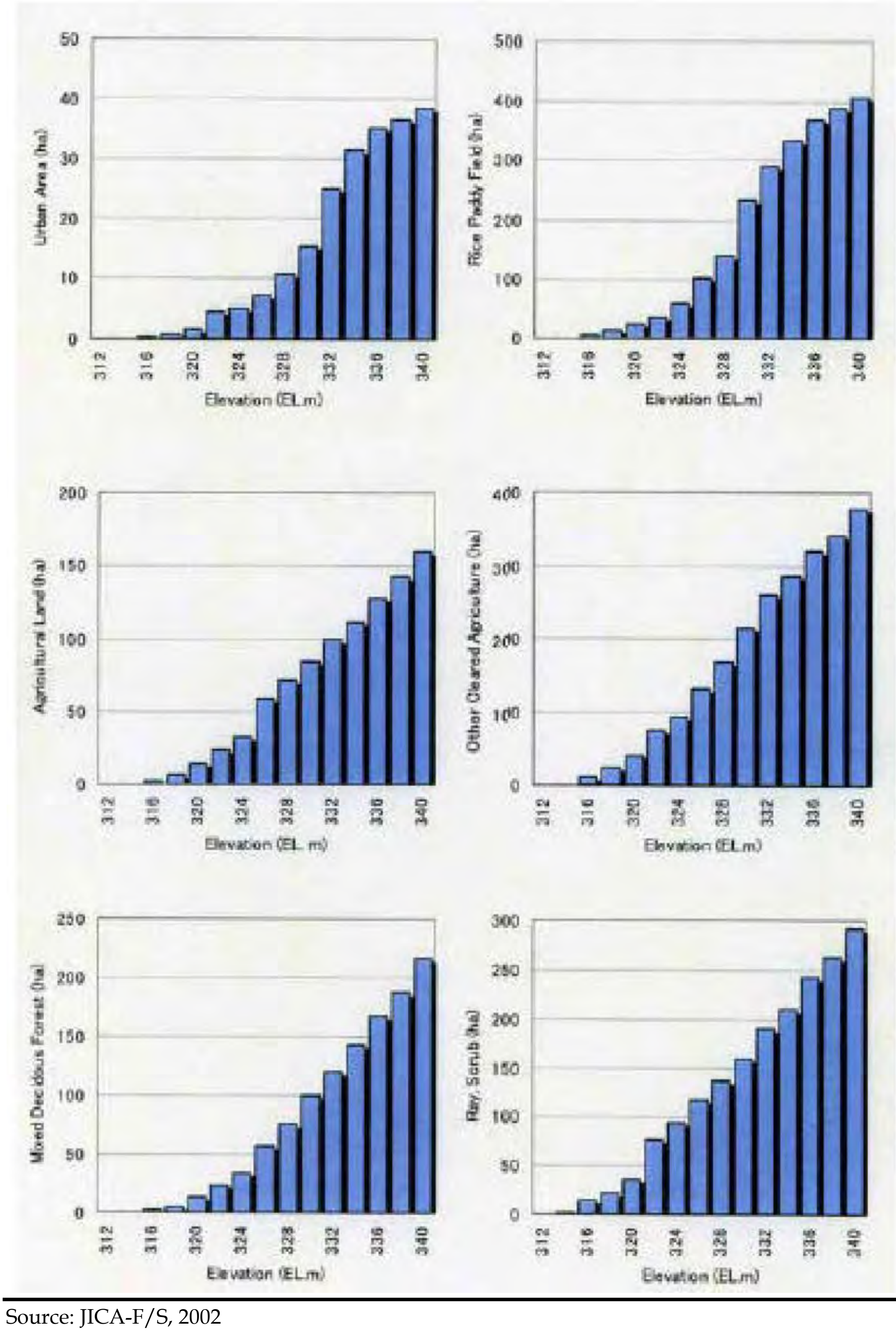
The maximum plant discharge was determined so that the annual peak energy for 95% dependability of the total analyzed period (30 years) should not fall below 80% of the annual average peak energy. The maximum plant discharge depended on the level set for NWL and MOL.

Figure 7.5 Land Utilization of Areas to be Inundated at NWL 320 and 360 m of the Main Reservoir



Source: JICA-F/S, 2002

Figure 7.6 Area of Main Types of Land Utilization per Elevation in Thaviang Area (excerpted from JICA-F/S)

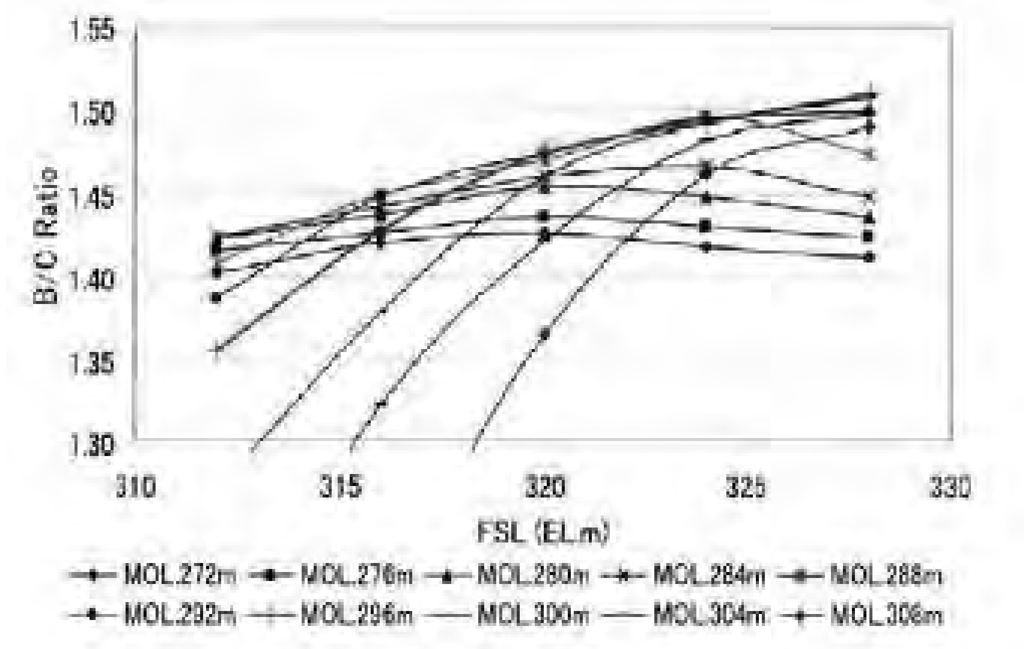


Source: JICA-F/S, 2002

(4) Minimum Operation Water Level of main reservoir

Under the above-mentioned conditions, it was concluded that the combination of NWL of EL 320 m, MOL of EL 296 m, and maximum plant discharge of 230 m^3/s offers the best economic efficiency (B/C) for the Project (***Figure 7.7***), with the least environmental and social impacts.

Figure 7.7 Relation among NWL, MOL and Economic Efficiency (B/C) of Project



Source: JICA-F/S, 2002

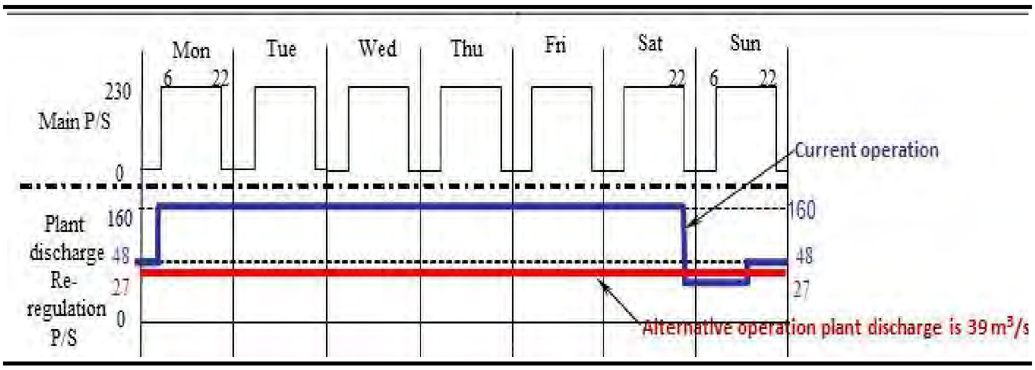
7.3.6 *Project Operation Regime Alternative*

Project operation regime alternatives were studied during operating hours for the Re-Regulation power station, as shown in ***Table 7.7*** and ***Figure*** 7.8. From an environmental perspective, Alternative 1 offers a favourable plant discharge rate in terms of maintaining downstream environmental flows.

Table 7.7 Study of Alternatives for Operation of Re-Regulation Power Station

Item	Alternative 1 (Current Operation)	Alternative 2
Weekend operation (Total 32 hours)	A) 15 hours: Plant discharge of 48 m^3/s "Minimum discharge" B) 17 hours: Discharge water of 27 m^3/s from re-regulation gate	32 hours; Plant discharge of 39 m^3/s
Turbine and Generator	1 turbine and generator, Total discharge: 160 m^3/s ×1 * 48 m^3/s is minimum plant discharge guaranteed by the Contractor	2 turbines and generators, Total discharge: 80 m^3/s × 2 =160 m^3/s * Minimum plant discharge of 39 m^3/s is possible
Minimum water depth	0.945 m "Q=27 m^3/s"	1.05 m "Q=39 m^3/s"
Water level fluctuation	1.47 m (160 to 27 m^3/s), 1.0 m. in average	1.6 m at maximum, 0.9 m in average
Civil cost (USD)	Foundation : 6.87, Building 2.13 (V= 12,200m^3)	Foundation: 9.44; Building: 4.14 (V= 23,800m^3)
Metal Cost (MUSD)	Intake gate: 2.54 M , Tailrace gate: 0.71 M	Intake gate: 2.91 M Tailrace gate: 0.81 M
EM cost (MUSD)	30 M（160m^3/s * 1）	34.1 M（80m^3/s * 2 ）
Total cost (MUSD)	42.25	51.4
Energy Generation (MWh)	104,000	105,190
Unit generation cost (USD/kWh)	**0.406**	**0.489**

Figure 7.8 The Alternatives of Operation of Re-Regulation Power Station



7.4 FACILITIES DESIGN ALTERNATIVES

7.4.1 Access Road Route Alternatives

Alternatives for the access road, including alternative routes and levels of rehabilitation/upgrades, have been considered to identify the various scenarios that are financially and technically feasible, with the minimum environmental and social impact. In particular, alternatives were considered to minimize the length of road within protected areas.

7.4.1.1 *Alternatives from Ban Nonsomboun to Ban Hat Gniun*

The Alternative Route starts from Ban Nonsomboun, along the same route of the Proposed Road, and branching at KP 8.5 to the Alternative Road, connected to the Existing Access Road at KP 16.0 again and reaching to Ban Hat Gniun through Ban Thahuea. The Alternative Road was checked by site reconnaissance on 2 and 3 October 2013. A comparison of specifications for each plan is shown in ***Table 7.8.***

Table 7.8 Specifications of Proposed Road and Alternative Route

	Proposed Road	**Alternative Route**
Construction period	Built by French support in 1993 The road between Ban Sisavath and Ban Thahuea is often flooded during the rainy season and French improved accessibility to Ban Thahuea and shifted the road alignment, higher elevation than that of the Alternative Route constructed in 1960s.	Originally built by French and US troops in 1960s. After completion of the existing road, this road looks to be no longer used.
Existing road width	5 m to 10 m	1.0 m to 3.5m
Total length (Ban Nonsomboun to Ban Hat Gniun)	21.2 km [(PPA) 11.8 km + 10.4 km]	22.7 km [(PPA) 8.7 km + 14.0 km]
Total length passing through PPA	11.8 km	8.7 km
Road condition	Dirt road	Dirt road and footpath
Accessibility during rainy season	Accessible by car	Inaccessible during the wet season
Road users	Villagers, collectors of wood and tree butcher	Villagers but for access to agricultural land only
Land use inside PPA	Forest	Forest and paddy field
UXO and land use survey	Conducted	Not yet conducted
Electricity	22 KV transmission line is under construction along the road	No plan
Method of access road construction	Improvement of existing dirt road by increasing road width and creating pavement.	Almost a new road and careful consideration of drainage is required

The assessment of the Proposed Road and Alternative Route indicated that each scenario would have similar environmental and social impacts into natural environment, affected area inside PPA, environmental impact, land acquisition, existing right of way inside PPA, construction approval and construction cost. The study result of access road between Ban Nonsomboun and Ban Hat Gniun show no significant difference between the Original Plan and the Alternative Plan in terms of environmental and social impacts to Huay Ngua PPA (see ***Table 7.9***).

Table 7.9 Comparison of Environmental and Social Impacts, and Feasibility of Proposed Road and Alternative Route

Proposed Road	Alternative Route	Conclusion
Natural Environment		
Land along the existing road alignment has already been developed with houses or agriculture lands. IEE for was conducted and ESMMP-CP is prepared.	The road used by villagers is narrow and has only limited usage, mostly by people walking or riding a motorbike. Vegetation cover has almost recovered to the equivalent of natural conditions. IEE and ESMMP-CP have not yet been completed.	Alternative Plan will require more land/ forest clearance works.
Affected area inside PPA		
Road length within PPA: 11.8 km Affected area: 3.54 ha. This is calculated as: Road construction width 8 m less Existing road width 5 m = 3 m 3 m x 11.8 km	Road length within PPA: 8.7 km Affected area: 3.91 ha. This is calculated as: Expanded road width 8 m less existing road width 3.5 m = 4.5 m 4.5 m x 8.7 km	Alternative Route will require more forest clearance within PPA.
Environmental Impacts		
If an access road is constructed, there may be a negative impact to biodiversity in protected areas (for example, easy access to illegal logging) as well as a positive impact (improved management of protected areas through NNP1 offset program).	If an access road is constructed, there may be a negative impact to biodiversity in protected areas (for example, easy access to illegal logging) as well as a positive impact (improved management of protected areas through NNP1 offset program).	Each road passes through and near protected areas. Similar impacts for each scenario.
Land acquisition		
There is no private land between KM 8.3 and KM 15.5 of Access Road "junction to Access Road"	Based on initial estimates of the road width, including backfilling to reach sufficient height of the road to protect it from flooding, would require the acquisition of approximately 46,000 m^2 of paddy rice fields and some areas of other privately held land along the alternative route.	Alternative Plan will require more land acquisition and thus affect more Project Affected Peoples "PAPs" directly through the loss of paddy rice fields and other lands.

Proposed Road	Alternative Route	Conclusion
Existing right of way inside PPA		
Bolikhamxay Province has already set the right of way within the PPA with a width of 30 m along the Access Road.	Not yet set. Actual width of the road on site may be deemed as right of way.	Proposed Road preferred.
Construction Approval		
Approved its construction by GOL already	Not yet approved	Planning process for Proposed Road is further progressed.
Construction cost (Ban Nomsomboun to Ban Hat Gniun)		
USD 4.2 M	Preliminary estimate Approximately USD 6.9 M Total road length is 1 km longer than Proposed Road. The Alternative Road passes through lowland "paddy field" which is inundated during the wet season, and natural forest. A higher embankment, more soil improvement, box culvert, and pipe culvert will be needed.	The construction cost of Alternative Plan is much higher than that of Original Plan.

It must be noted that the Alternative Road would be very close to Phou Ngou PPA. Also, in certain sections of the Alternative Road, the vegetation would recover to almost natural conditions due to infrequent use of the route.

The Alternative Road would also cause significant increase of construction cost for the Access Road. Considering additional time needed for re-survey, topographic and geological survey, UXO survey, land use survey, re-design, ESMMP-CP and re-approval process by GOL, the Alternative Road may cause delay of commencement of construction works and impacts to project feasibility. Thus the Proposed Road is preferred.

7.4.1.2 *Alternative from Ban Hat Gniun to Dam Site*

Due to the need to access multiple locations in the construction area between Ban Hat Gniun and the Dam Site, and geographic constraints, including steep topography, a requirement for access via each side of Nam Ngiep, and an objective to minimize watercourse crossings (in order to minimize impacts to water quality, hydrology and aquatic habitat), there are few available alternatives to consider in this stretch of the access road.

The use of only the JICA road was considered, as this is an existing road. However, due to the steep and complex topography of the road, long-term use of the road would require substantial maintenance and repair costs. Therefore, it was determined that additional new roads were required.

During the design phase, the base case and realignment alternatives were investigated more thoroughly. Comparisons of each alternative were carried out and discussed with local authorities in order to obtain consensus and agreement before the alignment was finally selected.

There have been two alternatives of access road alignments adopted in NNP1, as shown in ***Figure 7.9*** and ***Figure*** 7.10

Figure 7.9 *Previous Proposed Alignment (2008)*

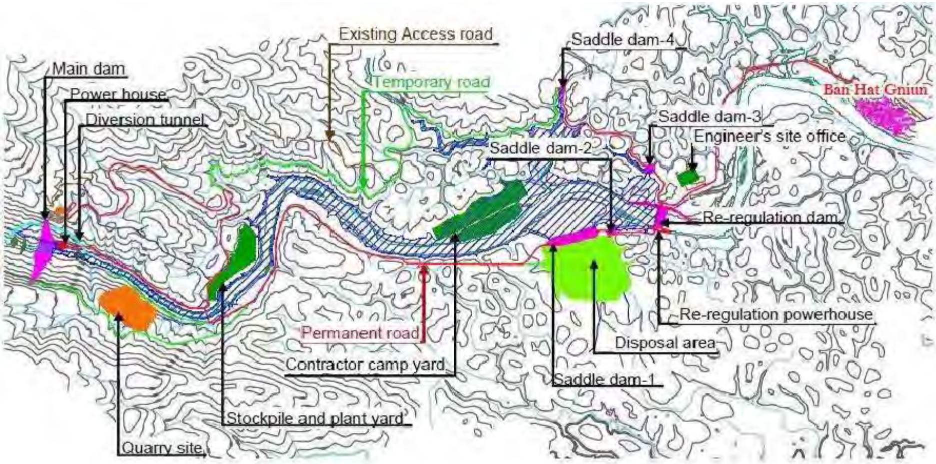
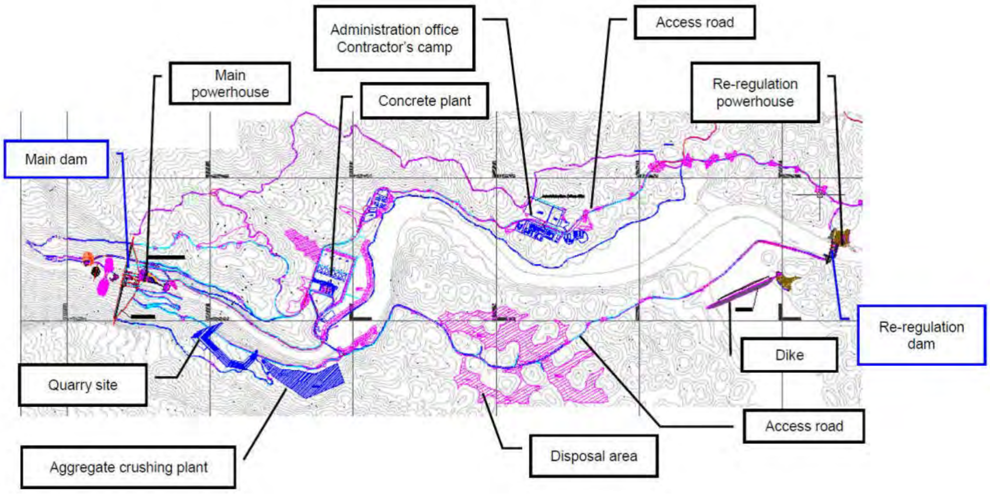


Figure 7.10 *Current Alignments (2013)*



Key differences between the current alignment of the access road is the location of the permanent road. The previous permanent road alignment was located in the right bank through the re-regulation power house. The current permanent road, which enables access to the power house of the main dam and re-regulation dam at the left bank only, has shifted from the right bank to the left bank. This is due to the re-regulation power house having shifted from the right bank to left bank in order to reduce construction cost for power house construction by omitting a bridge for access to the power house. This alignment therefore requires less works in the river than the previous alignment.

There is also an alternative in term of schedule. The construction schedule shall avoid the rainy season to minimize impacts to water resources and sediment. Moreover, to secure the Commercial Operation Date (COD) at January 2019, the diversion tunnel works should be started from the beginning of July 2014. However, the commencement of road construction works to approach the location of the diversion tunnel works has been delayed from April to October 2013. Thus, the JICA road improvement is newly required in order to recover the construction schedule of road construction works. The upgrading works are to repair the muddy, damaged and eroded section by replacing gravels and soil, and to set side ditches as drainage without expanding the existing road width.

There will be a new temporary road to be constructed from the JICA road to the Dam Site. Construction methods to be adopted are cut and fill.

7.4.2 Transmission Line Alignment Alternatives (230 kV Line)

The purpose of the transmission line is to transmit electrical power from the Main Dam site to the Nabong collector substation in Vientiane. A number of alternative route alignment scenarios were considered to fulfill this purpose in a financially and technically feasible way, and with minimum environmental and social impact. This included consideration of alternative route alignments and two alternative substation layouts.

Considerations in the selection of alternatives included:

- Reliability of power transmission, by minimizing the risk of line outage and maximizing opportunities to rapidly repair the line if damage occurs;

- Avoidance of significant environmental features, such as protected areas or other forest areas of biodiversity value;

- Avoidance of significant socioeconomic features, such as large settlements, villages, houses, businesses, other infrastructure and industry; and

- Cost effectiveness, including efficient design and minimizing the route length, construction access and maintenance access points.

In addition, options for substation layout exist. The selected option, however, will depend upon agreement between Government of Laos and the current substation operator, Nam Ngum 2.

7.4.2.1 *Alternative Route Alignment*

The transmission line has undergone a number of route alignment changes since pre-feasibility studies, based on changes in the environment and social conditions of the region and the availability of additional information as environmental investigations progress. A summary of the changes to the alignment since 2002 to 2014 as show in ***Table 7.10.***

Table 7.10 ***Summary of the Transmission Line Alignment Changes***

Alignment Version	Description
Prefeasibility route (November 2002)	Intersected areas of mixed forest and two residential areas.
EGAT route (August 2007)	Avoided Wat Ptabat Phansane Temple. Avoided areas of mixed forest, residential areas and Wat Ptabat Phansane Temple.
Initial IEE route (February 2011)	EGAT route was found to intersect area frequently used by elephant herd. Avoided areas of mixed forest, residential areas, Wat Ptabat Phansane Temple and area frequently used by elephant herd.
IEE V1 route (January 2014)	Huay Ngua PPA was established in 2010, and initial IEE route was found to intersect the PPA. Alternative routes considered, and alternative that avoided Huay Ngua PPA was selected.

Source: NNP1PC 2013

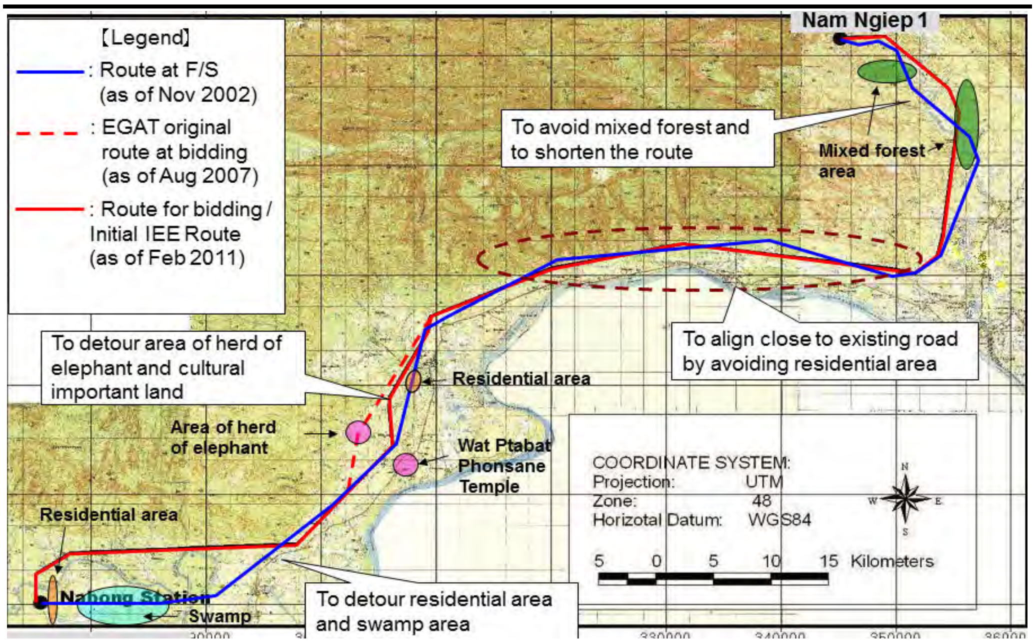
The original route alignment was designed prior to the official announcement of the creation of Huay Ngua PPA. The original route alignment was studied in the initial IEE (January 2012). However, following the creation of the PPA, it was identified that the original alignment traversed the PPA. The following alternative routes were considered to avoid the PPA:

- Option 1: the alignment runs along the east bank of Nam Ngiep, adjacent to an existing access road that circumvents Huay Ngua PPA, then from south of Huay Ngua PPA runs parallel to the EDL transmission line route.

- Option 2: the alignment remains on the west bank of Nam Ngiep, passing the eastern site of Huay Ngua PPA, and rejoins the original alignment south of Huay Ngua PPA. The gradient on the west bank is steep.

Based on the assessment of the cost, constructability, reliability and environment and social impacts provided in ***Table 7.11***, Option 2 was considered the preferred option.

Figure 7.11 Alternative Alignments Considered for the Project Transmission Line



Source: NNP1PC 2013

Table 7.11 Comparison of Environmental and Social Impacts, and Feasibility of Proposed Road and Alternative Route

Consideration	Original	Option 1	Option 2 (subject of this IEE)
Length/cost	Approx. 125 km	Approx. 136 km (+11km)	Approx. 124 km (-1km)
	Mitigation cost to be considered	Higher cost due to long distance	Equivalent cost to original budget
	Poor	Poor	Good
Constructability/ operability	Aligned in intermountain area with moderate slope, and accessibility with some distance from the existing access road.	Aligned in intermountain area with moderate slope, and easy accessibility adjacent to the existing access road.	Aligned in intermountain area with steep slope, and difficult accessibility away from the existing access road.
	Good	Excellent	Fair
Reliability	A certain distance from NNP River	A certain distance from NNP River	Must avoid the flooded area because close to NNP River
	High reliability due to alignment located in intermountain area with moderate slope	High reliability due to alignment located in intermountain area with moderate slope	Must avoid possible landslide area due to rather steep slope
	Excellent	Excellent	Good
Environmental impact	Impacts on PPA with longer length	Impacts on PPA with shorter length	No impacts on PPA
	Tree cutting and bush clearance are required	Tree cutting and bush clearance are required	Tree cutting and bush clearance are required
	Fair	Good	Excellent

Consideration	Original	Option 1	Option 2 (subject of this IEE)
Social impact	No residential area	Passing close to Thahuea village	No residential area
	Excellent	Poor	Excellent
Evaluation	Fair	Good	Good

7.4.2.2 *Substantion Layout Alternative*

Nabong substation was designed and constructed for collective use, i.e. for collection of electricity generated by multiple Independent Power Producers (IPPs). From the substation, electricity is stepped-up from 230 kV to 500 kV and exported to Thailand by 500 kV Nabong transmission line. Nabong substation and Nabong transmission line should be embedded into the Lao National Grid System. Currently, Nabong substation and Nabong transmission line is owned, operated and used solely by Nam Ngum 2. The transmission line is operated at 230 kV, although has been designed for 500 kV. There are two options for the use of Nabong Substation by NNP1PC:

- **Option 1 -** Once other IPPs, including Nam Ngiep 1, are permitted to sell electricity by EGAT, ownership of Nabong substation and Nabong transmission line would be transferred from Nam Ngum 2 to the Government of Laos. The substation would then be expanded and upgraded (by installing additional transformers) to allow other IPPs to connect. The transmission line would then be operated at 500 kV. In this option, Nabong substation, including transformers, and Nabong transmission line should be shared by all interconnected IPPs.

- **Option 2 –** If asset transfer is not successful, GOL will need to construct a second substation adjacent to the existing Nabong substation to enable NNP1PC to interconnect to Nabong transmission line. With this option, a new substation would be constructed very close to the existing Nabong substation. Based on the collocation of the two substations, the environmental impacts of both options are considered equivalent, with the only difference being a requirement for an extra few hundred metres of the 500 kV transmission line to interconnect the existing Nabong transmission line downstream of Nabong substation.

The option selected will depend on the agreement reached between GOL and Nam Ngum 2 (as the Operator of Nabong Sub-station).

7.4.3 *Spoil Disposal Site Alternatives*

Two options for soil disposal sites were considered: 1) a single spoil disposal site at a large designated site for the Project, or 2) multiple spoil disposal sites distributed along the construction area. The comparison of spoil disposal site alternatives in terms of environmental impacts is shown in ***Table 7.12.***

Table 7.12 The Comparison of Spoil Disposal Alternatives

Comparison	Alternatives	
	One Spoil Disposal Site	**Multiple Spoil Disposal Sites**
Advantages	Easier for management and monitoring of the spoil itself as it is in one place. Very clear boundary demarcations and fence establishment if required, landscaping and re-vegetation. Disturb acquisition land for only one location.	Each spoil is close to the construction site. Therefore the dust and noise from trucking to the spoils will not disturb the surrounding environment such as: villagers and wildlife. Limited areas to manage, better and effective in terms of: - Drainages establishment, - Sediment and erosion control, - Emission and noise control, - On site traffics and access management, and - Rehabilitation of the sites can be done easier. Save much cost for transportation in distribution of the spoil disposals.
Disadvantages	Long way to the spoil disposal sites from each construction site, increased noise and dust to the villagers and wildlife along the route. Difficult for management in one large spoil disposal site, as follows: - Stability of the spoil slope, - Erosion and sediment effects, - Landscaping (change the existing surrounding landforms), - Rehabilitation, and - Traffic and access control. High costs for transportation from far construction sites.	The spoil disposal areas are scattered, more acquisition land disturbed. More effort required on environmental monitoring and follow up, landscaping and re-vegetation for all spoil disposals

Based on the above, the Project proposed 7 sites for spoil disposal, distributed close to the construction sites, totalling 32.7 ha. The capacity of all disposal areas is around 3,465,000 m^3. Spoil disposal area locations are shown in ***Figure 7.12*** and details of each location are presented in ***Table 7.13***.

According to *Annex D2 of the Project Concession Agreement*, the disposal area is a temporary functional area of the Project, until the construction period ends or until that area contains spoil at maximum volume capacity. The Project will shape and manage the spoil disposal area to maintain good conditions, such as slope, height and flatness. Management of the areas will include grassing before handing the areas over to GOL.

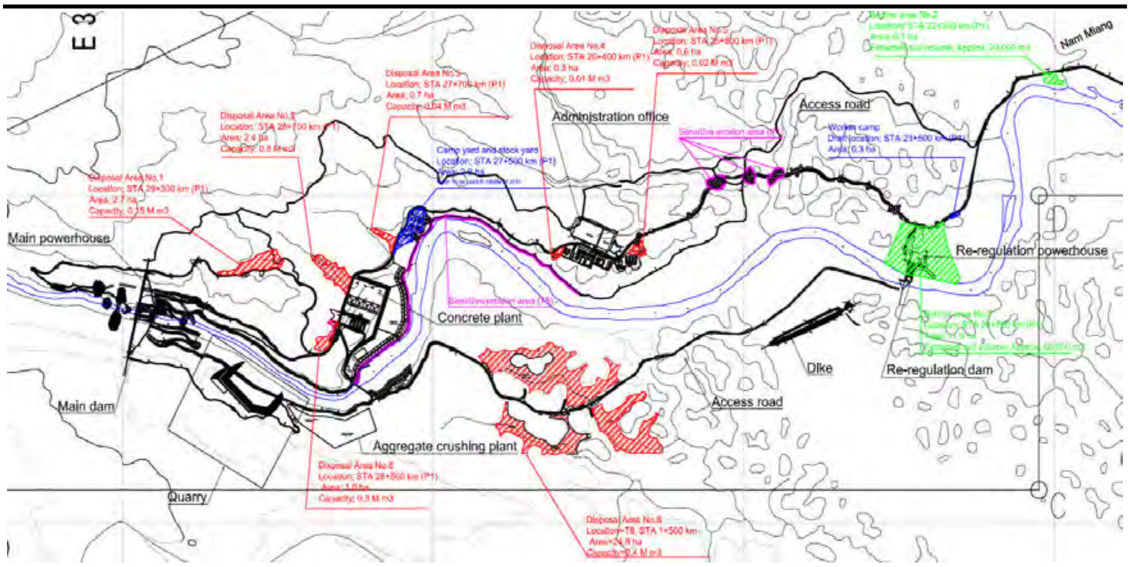
The EMP-Sub Plan 02 for Spoil Disposal is proposed as a guideline for safety precautions during construction, and for minimizing the environmental impact of spoil disposal areas of the Project.

Table 7.13 *Capacity of Spoil Disposal Areas*

Description	Location	Area (ha)	Perimeter (m)	Capacity Volume (m³)	Expected Disposal Volume (m³)
Disposal No.1	Permanent Road STA. 29+400 km.	2.7	780	151,000	130,000
Disposal No.2	Permanent Road STA. 28+100 km.	2.4	790	810,000	88,000
Disposal No.3	Permanent Road STA. 27+700 km.	0.7	480	42,000	U/C
Disposal No.4	Permanent Road STA. 26+400 km.	0.3	260	12,000	U/C
Disposal No.5	Permanent Road STA. 25+800 km.	0.6	480	20,000	U/C
Disposal No.6	Right Bank Soil Disposal Road	25	6,100	2,400,000	2,100,000
Disposal No.8	Permanent Road STA. 28+500 km.	1.0	-	30,000	U/C
	Total	**32.7**	**8,890**	**3,465,000**	

Note: *U/C: under consideration

Figure 7.12 *The Spoil Disposal Area Locations of the Project*



8 PUBLIC CONSULTATION AND INFORMATION DISCLOSURE

8.1 INTRODUCTION

Public consultation and disclosure began in 2007 and has continued to be a key component throughout the development of the Project.

The goal has been to ensure opportunities exist for stakeholders to be involved in Project design, including potentially affected people. More specifically, the objectives are to:

- Ensure that stakeholders concerns are incorporated in the Project design and implementation;
- Increase stakeholder awareness and familiarity with the Project;
- Ensure transparency in the decision-making process; and
- Enhance the potential benefits by directly involving relevant stakeholders.

These objectives are being met through a comprehensive public consultation and disclosure process, which has been ongoing for a number of years. This has included:

- Sharing relevant Project information at the earliest stages of the Project;
- Providing on-going opportunities to input to the Project; receiving feedback from Project stakeholders; and
- Utilising outputs from the consultation process to inform the Project design, including proposed management measures and corresponding management plans.

The following sections describe the consultation process that has been undertaken.

8.2 CONSULTATION TECHNIQUES

The techniques used have reflected the diversity of the stakeholders involved. Techniques included:

- Face-to-face communication, including focus group discussions and village meetings, during which participatory rural appraisal techniques were used;
- Use of visual representations of information, including pictures, diagrams, posters and 3D visual representations;
- Establishment of information centers;
- Direct contact with stakeholders, including electronic mail and telephone conservations;
- Dissemination of information; and

- Site visits, particularly for international stakeholders.

In selecting techniques consideration was given to the following:

- **Cultural norms and sensitivities** to ensure that strategies align with cultural norms;
- **Local community structures**, including governance structures;
- Presence of **women and vulnerable groups** to ensure that these groups are not marginalised. Engagement with women and other vulnerable groups has received special attention. The participation of women and other vulnerable groups has been encouraged, for example by organising women's or vulnerable group only focus group discussions;
- Potential **language** barriers. Consultation activities have largely been conducted in Loa. However, in villages with Hmong residents, the information presented was translated during the consultation activities into Hmong;
- **Literacy rates**. Where possible consultation has been conducted using face-to-face communication and visual representation of information as well as participatory rural appraisal techniques to overcome issues in literacy; and
- **Intimidation and/ or coercion.** In consulting with stakeholders, steps were taken to ensure intimidation and/ coercion did not occur.

8.3 PROJECT STAKEHOLDERS

Through extensive scoping and preliminary study findings a list of relevant internal and external, primary and secondary stakeholders was developed. The stakeholders largely fell into one of the following four categories:

- Villagers located in the Project area who may be affected directly and indirectly by the Project;
- Project Developers, including KANSAI, EGATi and Lao Holding State Enterprises (LSHE);
- The ADB and other potential fund organisations; and
- Non-governmental organisations (NGOs).

Table 8.1 further details of each stakeholder category, including whether the stakeholder is likely to be positively (+) or negatively (-) impacted by the Project and the issues, questions and concerns likely to be of interest to the stakeholder.

Table 8.1 Summary of Stakeholders

Stakeholder	Potential Impact	Key Stakeholders' Interests in the Project
Primary Stakeholders		
Directly affected people who will lose their property or lose livelihood opportunities due to inundation of the NNHP1 reservoirs, and/or construction of various Project components	(-)(+)	• Environmental, economic, social and cultural impacts of the Project • Effected properties and associated compensation • Resettlement and livelihood restoration measures • Employment opportunities • Grievance management
Indirectly affected people, who are in the same communities as some of the directly affected people, or who share the Nam Ngiep basin	(-)(+)	• Project impacts • Consultation opportunities • Employment opportunities • Livelihood restoration measures • Grievance management
Laborers and other staff	(+)	• Living conditions in workers' camp • Health and safety management • Provision of training
Village Organizations Village Headman and Deputy Village Security (Konglon) Police Health Volunteers (Orsomor) Lao Youth Lao Women's Union Front for National Construction	(-)(+)	• Resettlement sites • Grievance management • Project management
Secondary Stakeholders		•
Developers EGAT-i KANSAI LHSE	(+)	• Cost effective management and implementation • Efficient and effective stakeholder consultation • Reputation
Financiers ADB	(+)	• Cost effective management and implementation • Reputation • Compensation and livelihood restoration • Adherence to financier standards and expectations

Stakeholder	Potential Impact	Key Stakeholders' Interests in the Project
GOL (via various line ministries) Prime Minister's Office Ministry of Natural Resources and the Environment (MONRE) Ministry of Agriculture and Forestry Ministry of Communication, Transport, Post and Construction Ministry of Industry and Handicrafts DOE Ministry of Labour and Social Welfare Ministry of Information and Culture Ministry of Education Ministry of Health	(-)(+)	• Return on investment to the country • Integration with the National Development Plan 2010-2015 and the Millennium Development Goals • Minimization of environmental, economic, social and cultural impacts • Compensation and livelihood restoration • Community development • Grievance management • Effective communication •
GOL Authorities at Provincial Level: Vientiane Province, Bolikhamxay Province, Xieng Khouang Province	(-)(+)	• Integration in provincial development plans • Employment opportunities (including the selection of employees)
GOL Authorities at District Level: Hom District, Bolikhan District, Pakxan District, Thaphabath District, Pak Ngum District, Thathom District	(-)(+)	• Integration in district development plans • Employment opportunities (including the selection of employees) Benefit to the district and local people • Resettlement and livelihood restoration • Community development
NGOs and other external stakeholders	(-)(+)	• Environmental, economic, social and cultural impacts • Resettlement and livelihood restoration • Protection of vulnerable groups

8.4 CONSULTATION ACTIVITIES

Table 8.2 provides a list of the meetings that have been undertaken since 2007. The meetings have provided an opportunity to:

- Present up to date Project information and raise awareness about the Project; and
- Receive feedback from stakeholders.

In the initial consultation meetings focused on collecting and disseminating information regarding the Project design. This included the data collection on social and environmental characteristics in order to provide a baseline for predicting potential Project impacts. As part of this process, information was disseminated to stakeholders that detailed the Project, including the potential social and environmental changes likely to arise as a result of the Project.

The next phase of consultation meetings sought to gain feedback from stakeholders regarding design alternatives (which were devised based on the initial consultation activities) and proposed management measures. For example, meetings were undertaken as part of GOL-commission commissioned study of alternatives, economic analysis, and the environmental management plans. This included the dissemination of updated Project information.

The feedback received during these meetings has been used to update and amend the Project design. Examples of changes that can be attributed to consultation include:

- Revisions to the transmission line route, in order to avoid, to the extent possible, an elephant conservation area;
- A change in planned reservoir height. The reservoir has been lowered from early plans – from 360 m above sea level to 320 m above sea level - to reduce the impact on villages in the upper reservoir. This will help reduce the number of villages that will need to be resettled;
- Changes in the minimum downstream flows to help sustain environmental values, including fish; and
- Changes in the location and composition of the resettlement sites, including the community infrastructure and the process and materials to construct the housing.

Table 8.2 Summary of Stakeholder Meetings

Stakeholder Group	Date	Consultation Activity
Stakeholders including international financial institutions, MONRE, GOL organizations and agencies, general public, and NGOs	May 2011	Consultation and discussion at Hom District
	July 2011	Technical workshop and site visit to proposed resettlement site by MONRE
Provincial Level: Bolikhamxay, Vientiane, and Xieng Khouang Province representatives	April 2008	Consultation and discussion at Bolikhamxay Provinces
	April 2008	Consultation and discussion at Xieng Khouang Province
	April 2008	Consultation and discussion at Vientiane Provinces
	April 2012	Consultation and discussion by Vientiane, Xieng Khouang and Bolikhamxay Province
District Level: Bolikhan, Pakxan, Hom, and Thathom District representatives	January 2008	Public consultation at Bolikhan District
	January 2008	Consultation and discussion at Hom District and Bolikhan District
	February 2008	Consultation and discussion at Thathom District
	June 2008	Consultation and discussion at Hom District and Bolikhan District
	July 2008	Consultation and discussion at Thathom District

Stakeholder Group	Date	Consultation Activity
	November 2008	Consultation and discussion at Hom District
Zone 1 & 2UR villages, including villagers and village authorities	February 2008	Consultation meetings across the Project area
	July 2008	Consultation meetings across the Project area
	July 2011	Household and village survey at three villages
	October 2011	Consultation meeting at Ban Pou
	October 2011	Consultation meeting at Ban Hatsamkhone
	October 2011	Consultation meeting at Ban Piengta
	December 2012	Focus group discussions at Ban Pou
	December 2012	Focus group discussions at Ban Hatsamkhone
	December 2012	Focus group discussions at Ban Piengta
	August 12013	Village consultation meeting at Ban Pou
	August 2013	Village consultation meeting at Ban Hatsamkhone
	August 2013	Village consultation meeting at Ban Piengta
	May 2013	Villagers of the three villages visit a prospective resettlement area, Thong Nam Pha.
Zone 2LR villages, including villagers and village authorities	October 2007	Consultation meeting at Ban Houypamom
	October 2007	Consultation meeting at Ban Sopyouak
	November 2007	Consultation meeting at Ban Sopphouan
	November 2007	Consultation meeting at Ban Namyouak
	November 2007	Meeting with the Office of Energy and Mines Viengkham District
	January 2008	Consultation meeting at Hom District
	April 2008	Consultation meeting at the Viengkham District
	July 2011	Development proposal at Ban Sopyouak Village
	August 2011	Development proposal at the Houay Soup area for the representatives of 4 villages
	August 2011	Interview to four village about the Project Development proposal
	September 2011	Consultation meeting at Ban Namyouak
	September 2011	Consultation meeting at Ban Sopyouak
	September 2011	Consultation meeting at Ban Sopphouan
	September 2011	Consultation meeting at Ban Houaypamom
	March 2012	Consultation meetings at 4 villages
	July 2013	Consultation meeting among representatives of four villages of 2LR, and Ban Hat Gniun & Ban Hatsaykham
	August 2013	Consultation meeting at Ban Namyouak

Stakeholder Group	Date	Consultation Activity
	September 2013	Consultation meeting at Ban Sopphuane
	September 2013	Consultation meeting at Ban Houaypamom
	September 2013	Consultation Meeting at Ban Sopyouak
	September 2013	Consultation with elders of all four villages
	December 2013	Field visit
Zone 3 villages, including villagers and village authorities	October 2007	Consultation meeting at Ban Hat Gniun
	January 2008	Consultation meeting at Ban Hat Gniun
	April 2008	Consultation meeting at Ban Thahuea
	June 2008	Consultation meeting in the Bolikhan District
	September 2011	Consultation meeting in the Pakxan District
	September 2011	Consultation meeting in the Pakxan District
	September 2011	Consultation meeting at Ban Hatsaykham
	November 2013	Focus group discussions at Ban Hatsaykham
	July 2013	Consultation meeting with Ban Hat Gniun and Ban Hatsaykham
	July 2013	Consultation meeting among representatives of four villages of 2LR, and Ban Hat Gniun and Ban Hatsaykham
Zone 5 villages, including villagers and village authorities	October 2007	Consultation meeting at Ban Hat Gniun
	November 2008	Consultation meeting at Ban Pha-Ane
	November 2008	Consultation meeting at Ban Phukatha
	November 2008	Consultation meeting in the Hom District
	September 2011	Consultation meeting at Ban Hat Gniun
	September 2011	Consultation meeting at Ban Thahuea
	November 2013	Focus group discussions at Ban Hat Gniun
	November 2013	Focus group discussions at Ban Thahuea
Other resettlement areas	November 2008	Consultation Meeting at Ban Pha-Aen and Ban Phukakatha

Interaction with stakeholders has not been limited to specifically designed consultation activities, but has also included a host of surveys that have been conducted.

Further details on the outcomes and the materials presented during the stakeholder engagement activities is contained in the *Social Impact Assessment Report- Nam Ngiep 1 Hydropower Project* and the *Resettlement and Ethnic Minority Development Plan Report – Nam Ngiep 1 Hydropower Project*.

8.5 *PUBLIC DISCLOSURE*

Disclosure and accessibility to Project information has been a key focus of the consultation process. To further enhance accessibility, centers were set-up in July 2008 in each of the respective districts within the Project area. The centers provide an avenue for stakeholders to readily access information or provide feedback about the Project as well as raise relevant questions or lodge inquiries.

Copies of relevant documents have been made available publicly available. This includes key project documents that will be released for 120 day period before the ADB board of executive directors begins consideration of the Project for approval. A translation of these documents will be provided to the GOL.

In addition, the Project has in place community liaison officers. The officers are responsible for day-to-day interactions with villagers, including issues and questions that may arise relating to design and implementation of the Project.

8.6 *GRIEVANCE REDRESS MECHANISM*

A grievance redress mechanism has been developed to address grievances raised by stakeholders across the Project. The GRM will be used to address all grievances (e.g. environmental issues, social concerns), regardless of the issues raised by stakeholders. The GRM is described in *Chapter 9*.

8.7 *FUTURE CONSULTATION ACTIVITIES*

Consultation will continue throughout the life of the Project. This will include engagement during implementation during construction and operation.

The next engagement activities include:

- The release of key Project documents. These documents will be available for 120 day period before the ADB board of executive directors begins consideration of the Project for approval. A translation of these documents will be provided to the GOL; and
- A stakeholder forum. The forum is scheduled for April 2014, which will provide an opportunity to update stakeholders on progress to date. The forum will be held at Pakxan, Bolikhamxay Province.

9 GRIEVANCE REDRESS MECHANISM

9.1 INTRODUCTION

The Project has the potential to affect the interests of thousands of people, which may result in differences in perception and expectations. These differences may lead to conflicts between potentially affected persons (PAPs), including individuals, households or groups in the communities, on the one hand, and the government, the developer, and those hired to implement the Project on the other. A grievance redress mechanism (GRM) has therefore been established to achieve the following objectives:

- Promote productive relationships with local communities and identify community concerns through consultation, disclosures, participatory planning and decision making (as described in *Chapter 6*) with PAPs in order to prevent grievances wherever possible and maximize environmental and social benefits;

- Address and resolve differences or grievances associated with the Project through established GRM procedures, as outlined in the following sections.

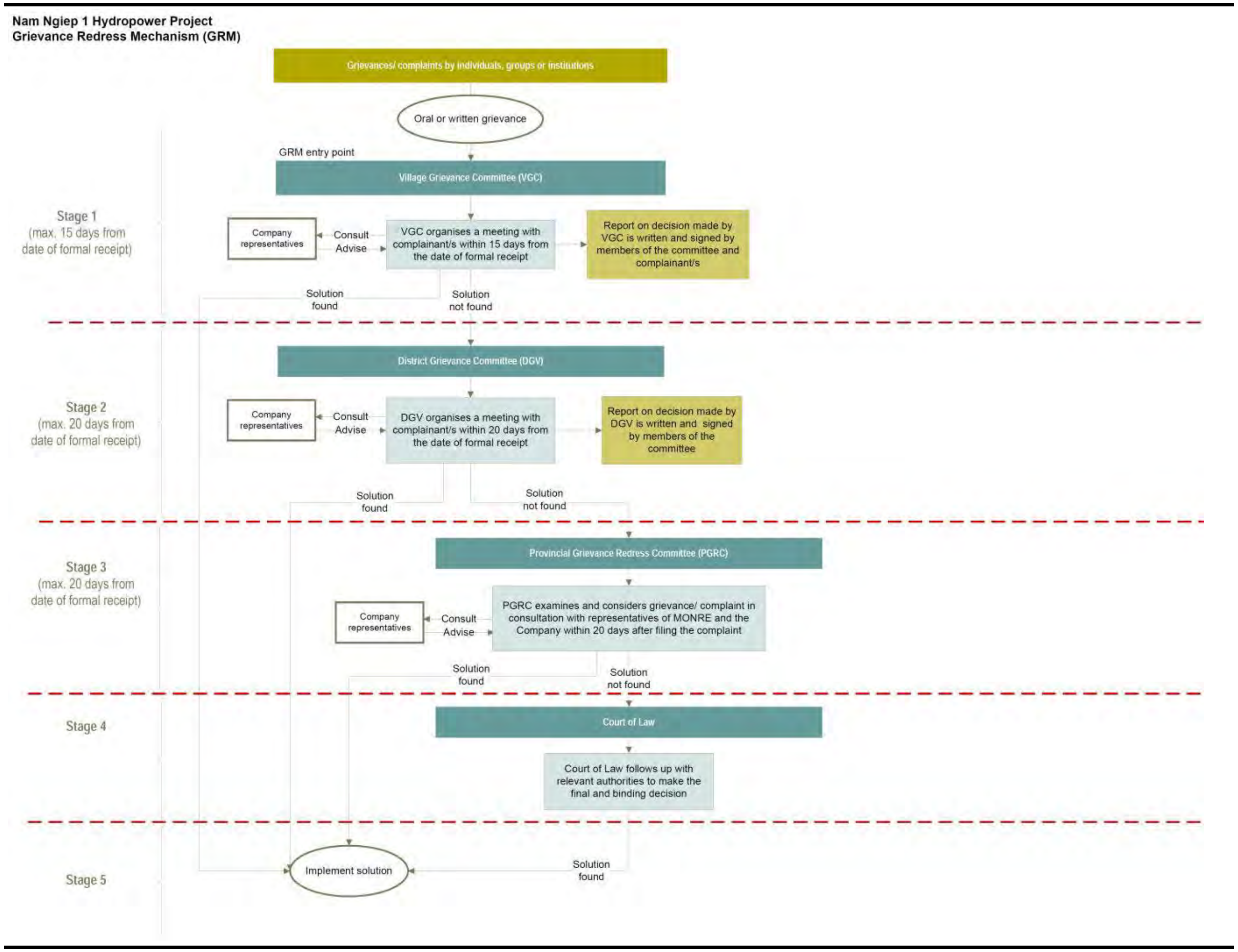
The GRM will address all grievances raised by PAPs, including those associated with land acquisition, compensation, resettlement and livelihood restoration, and environmental matters.

9.2 GRIEVANCE REDRESS MECHANISM

The GRM, in the first instance, seeks to resolve disagreements or stakeholder concerns before they evolve into grievances. This is done through ongoing engagement with stakeholders throughout the Project, particularly the PAPs. The resulting informal negotiations and discussions will be conducted in a transparent manner and will be appropriately documented. This includes agreements that are reached, which will be voluntarily signed by all parties involved in the negotiation.

In cases where concerns or conflicts cannot be resolved through consultation and / or discussions, the GRM has established a hierarchy of grievance committees and procedures to receive and resolve grievances. These committees and procedures are summarized in ***Figure 9.1***.

Figure 9.1 Project Institutional Structure



Stages and timeframes associated with the GRM procedures are as follows:

- Stage 1: PAPs will register grievances on any aspect of compensation, relocation or unaddressed losses with the Village Grievance Committee. The Village Grievance Committee will organize a meeting within 15 days from the date of formal receipt of the grievance with the complainants to resolve the issue using its traditional methods of conciliation and negotiation; the meeting will be held in a public place and will be open to other PAPs and villagers to ensure transparency. The report on the decision of the Village Grievance Committee must be in writing and must be signed by all members of the committee. If any members of the committee dissent from the opinion of the majority, those members can note their dissent as part of the report of the decision. The aggrieved party and the Project representatives should also sign and indicate their agreement or disagreement with the decision.

- Stage 2: If either the PAP or the Company is not satisfied with the decision of the Village Grievance Committee, or if the Project does not abide with the decision of the Village Grievance Committee, an appeal can be made directly by the Project or by the PAP, or by the Village Grievance Committee on behalf of the PAP. Other persons or organizations, such as local NGOs, mass organizations like Lao Women's Union, or other representatives of the PAP, can ensure that the appeals are forwarded to the District Grievance Committee. The District Grievance Committee will keep a public log of all claims and grievances it receives, including a summary of the decisions made, and must also make public all reports on the decisions made by the committee. The meeting of the District Grievance Committee will be held in a public place, no more than 20 days from the date of formal receipt of the grievance. Representatives from the Company must be available to provide any necessary information to the committee on entitlements, compensation rates, mitigation measures, and any other relevant information concerning the grievance. The report on the decision of the District Grievance Committee must be in written and must be signed by the members of the committee.

- Stage 3: If the PAP is still not satisfied with the decision of the District Grievance Committee or if the Project does not abide by the decision of the District Grievance Committee, an appeal can be made to the Provincial Grievance Redress Committee. The Provincial Grievance Redress Committee will examine and consider the complaint or grievance in consultation with representatives of MONRE and the Company within 20 days after filing the complaint.

- Stage 4: If the PAP is still not satisfied with the decision of the Provincial Grievance Redress Committee, or in the absence of any response within the stipulated time, the grievance can be submitted to the Court of Law by the PAPs or a representative of a non-profit organizations or the Village Grievance Committee on behalf of the PAPs or at the request of the Project. The Court of Law will follow up with the relevant authorities to make the final and binding decision.

- Stage 5: In case that the Project is found responsible for negligence, the Project will cover in full all administrative and legal fees incurred by the PAPs in the GRM process at the district, provincial and MONRE levels and in the Court of Law. Complaints and grievances concerning impacts during construction will be considered up to and for no more than one year after the official date of completion of construction.

9.3 *ESTABLISHMENT OF THE COMMITTEES*

The GRM procedures will be managed by a hierarchy of grievance redress committees, comprising the members outlined in ***Table 9.1***.

Table 9.1 Grievance Redress Committee Members

Committee	Committee Members
Village Grievance Committee	• The village head (chairperson); • Representatives of local village authorities; • Village elders; and • Representatives from community organizations, including the Lao Women's Union.
District Grievance Committees	• Representative of the District Authority (chairperson); • Local village leader(s)/ head(s); • Representatives from the PAPs, other than village leader(s)/head(s); • Local village elders and/or other local community organizations, including the Lao Women's Union; • Representatives from local not-for-profit organizations; and • Representatives from the Project team.
Provincial Grievance Redress Committee	• Representative of the provincial authority. This individual will become the chairperson; • Representatives from the provincial or district authority' • Representatives from the PAP (eg a representative from a village directly affected by the Project); • Representatives from community organizations, including the Lao Women's Union; • Representatives from a local not-for-profit organization; and • Representatives from the Project team.

The various committees will be established prior to commencement of the Project, in particular the resettlement activities. This will be done by making a formal request to the GOL for the relevant authorities in each province to establish the Provincial and District Grievance Committees. The District Grievance Committees will be given the authority to establish Village Grievance Committees in villages affected by the Project.

9.4 CONSULTATION

Success of the GRM is dependent on stakeholders being aware of the GRM, including how to access the mechanism. Stakeholders have been informed on a number of occasions about the GRM. This is further described in Chapter 8.

9.5 ADB ACCOUNTABILITY MECHANISM

As partial funding for the Project is being sought from the ADB, the environmental and social safeguards of the ADB will also apply to the Project. This includes the ADB Accountability Mechanism (AM) – a procedure through which a stakeholder can seek a solution or redress for their grievances.

The mechanism has two key components. The first, led by the Special Project Facilitator (SPF), is to respond to grievances raised by stakeholders affected by ADB-funded projects.

The second component is led by the Compliance Review Panel (CRP), which consists of three members. The focus is on investigating issues of alleged non-compliance by ADB with its operations policies and procedures that has or is likely to cause direct and material harm to PAPs.

All grievances are received by the Complaint Receiving Officer (CRO). It is the CRO's responsibility to then direct the grievance to either the SPF or the CRP.

Project stakeholders will be informed of the AM process and provided with a Lao language brochure describing the process and their rights.

10 ENVIRONMENTAL MANAGEMENT PLAN

For each of the potential environmental impacts described in *Chapter 6*, measures are suggested either to prevent those impacts or to mitigate their effects. This chapter (the Environmental Management Plan) presents the various preventative and/or mitigation measures proposed for the different types of impacts, the responsible agencies, and where these are not part of the usual construction or operation activities, the cost estimates and duration of the measures. As with the description of the impacts, the environmental measures are presented here in two parts: (1) the pre-construction (1 year) and construction phases (6 years) and (2) the operations phase (27 years).

This Environmental Management Plan (EMP) is also supplemented by 17 EMP Sub-Plans, which have been developed as guidelines for minimizing environmental impacts from specific activities of the Project, primarily during construction. These 17 EMP Sub-Plans can be found in *Appendix H*, and, where appropriate, have been cross-referenced within this chapter.

The Environmental Management Plan (EMP) will be updated and/or revised, both for construction and operation phases, to adapt the measures to the prevailing conditions and/or additional monitored impacts during the construction period.

Additionally, to strictly prevent and decrease the impacts or to mitigate their effects, the Contractor's Environmental Management Plan (Contractor's EMP) will be developed both of the Environmental and Social Management and Monitoring Plan (ESMMP) and Site Specific Environmental and Social Management and Monitoring Plan (SSESMMP), to comply with ADB's guidelines and requirements. The details of ESMMP and SSESMMP shall be presented in terms of:

- Reporting requirements;
- Emergency response procedures;
- Capacity development and training measures;
- Performance indicators to check the effectiveness of the mitigation and management actions considered;
- Residual impacts analysis and provision of relevant compensatory measure (also in monetary terms); and
- The monitoring measures shall be included parameters, methods and sampling locations for the Project environmental aspects.

10.1 *ENVIRONMENTAL MITIGATION MEASURES FOR PHYSICAL IMPACTS*

10.1.1 *Environmental Mitigation Measures during Pre-Construction and Construction Phases*

10.1.1.1 *Landslides and Seismicity*

(1) Objective

- To prevent landslides.
- To avoid reservoir induced seismic activity.

(2) Actions to be Taken

The slope and geology around the reservoir are not conducive to landslides. Given the size of the reservoir and the height of the water at the dam, reservoir induced seismic activity is not expected.

The Project shall provide proper design to prevent landslides and seismicity impacts. It is strongly recommended that detailed mapping and coring explorations should be carried out prior to detailed design and dam construction. The Dam Safety Review Panel (DSRP), comprised of international hydropower experts, has an agreement between ADB and the Project. The scope of the Dam Safety Review Panel reflects all aspects of dam safety in terms of flood hydrology, seismology, engineering geology, rock mechanics/underground excavations, sedimentology, dam design, hydraulic design, planning and design of dams and hydropower facilities, construction of dams and hydropower facilities, concrete technology, specifications and manufacturers' proposals.

The DSRP will also review the various detailed plans required to be prepared in accordance with the plan for construction supervision and quality assurance, the instrumentation plan, the operation and maintenance plan, and an emergency preparedness plan.

During the initial storage of the reservoir, routine visual inspections shall be made to evaluate the safety of the dam. Routine visual inspections shall also be made of the slopes around the construction area and the reservoir for signs of any landslides and continuous monitoring and investigation after Project commencement

(3) Responsible Unit / Agency

NNP1PC /Environmental Management Office (EMO).

(4) Cost Estimate (USD)

No additional costs expected.

(5) Work Plan:

Continuous during pre-construction and construction phase

	Work Plan	Frequency	Pre construction	Construction Phase (year)					
				1	2	3	4	5	6
1	Monitoring for landslide and other signs of seismic activity	Yearly							

10.1.1.2 *Erosion and Sedimentation*

(1) Objective

- Minimize sediment generation from construction activities i.e. site clearing, excavation.
- Protect and minimize soil erosion from cut/fill activities.
- To prevent sedimentation in the river from erosion caused by construction activities or from topsoil stockpiles, or surplus waste piles.
- To monitor and report on the planned control measures related to soil erosion, landslide and rock movements.
- To estimate the predicted level of sediment-related situations which will occur at the Project site (i.e. soil erosion, landslide and rock movements).

(2) Actions to be Taken

Erosion and sediment controls and mitigation measures will be developed and implemented by NNP1PC, Contractors and Sub-contractors according to the recommendations in EMP Sub-Plan 01: Erosion and Sediment Control and also related measures in Sub-Plan 02: Spoil Disposal, Sub-Plan 10: Landscaping and Re-vegetation, and Sub-Plan 11: Vegetation Clearing. All EMP Sub-Plans can be found in *Appendix H* of this report. A summary of key mitigation measures are as follows:

- The location of works in sensitive erosion areas will be minimized.
- Where possible, works in sensitive erosion areas will be restricted to the dry season.
- Clearing of sites will be undertaken in the sequence that sites are required for construction.
- Soil erosion and sediment control practices should be installed prior to any major soil disturbance.
- Land clearing and slope stabilization activities should be conducted in their proper sequence and disturbed areas are to be suitably protected and maintained until permanent protection is established.

- Areas should not be prematurely exposed prior to the ability to temporarily or permanently protect such areas against erosion. More specifically, only areas intended for immediate construction activity will be cleared of vegetation and topsoil, in cognizance of the overall construction schedule.
- Any and all disturbed areas that are not subject to construction traffic will receive temporary protection and stabilization via means such as erosion blankets/mats or temporary seeding that is capable of protecting the areas until permanent stabilization measures are put in place. Therefore, after initial disturbance or rough grading, all areas subject to erosion should receive suitable control measures such as a temporary seeding in combination with straw or a suitable material.
- Soil and spoil removed during the construction process will be stockpiled separately and stabilization measures implemented. The stockpiles will be constructed with smooth slopes and free draining patterns. Topsoil stockpiles will be deep ripped to provide for moisture retention and re-growth. Drainage and erosion from the stockpiles will be controlled by locating them in areas away from drainage lines. The erosion of the base of the dump will be prevented by providing a diversion bank uphill to prevent any runoff from reaching the pile, and at the same time constructing a silt fence, if necessary, to contain any runoff resulting from the pile.
- Ridges maybe created on topsoil stockpiles to provide for moisture retention to assist re-growth and slow runoff.
- Soil and spoil piles will be placed in such a manner that will avoid areas of drainage lines in order to control drainage and reduce erosion discharge from the stockpiles. Such piles shall be placed in a manner that does not interfere with temporary surface flows or established watercourses.
- Potential problems with erosion along the base of waste or soil surplus piles must be considered in planning the location of such sites.
- Waste or surplus materials shall not be placed in areas subject to potential flooding and inundation or in manmade or natural watercourses.

Erosion and sedimentation should be controlled during the construction phase of the power plant. Wherever possible, land clearing and vegetation removal should be conducted in as small a footprint as possible to ensure as much of the original ground cover is maintained in its existing condition.

Site specific plans will be prepared for each construction site and will include plans for monitoring erosion and sediment control. All work plans related to the control of erosion and sediment will be implemented prior to the commencement of any construction works on the site.

In terms of erosion control as part of the Project, the major effort at construction sites will focus on the management of erosion of excavated surfaces, especially during the wet season when the volume of runoff is expected to be high. A Site Management Plan, which includes a sub-plan for erosion and sediment control will be prepared by the lead Contractor for use at all the construction sites. It will include environmental management and pollution control techniques for all areas of activity, including drainage measures for underground works. It will also include a Water Quality Monitoring Plan. The plan will meet the appropriate standards and include the development of drainage works, sediment traps, diversions, culverts and other structures designed to treat water to reach an acceptable quality before discharge into natural and/or constructed watercourses.

There shall be regular monitoring of the control measures, to assure they are up to standard and follow the best practices. As conditions change during construction, revisions shall be made to predicted levels of sediment-related situations that may occur at the Project site (such as soil erosion, landslide and rock movements).

(3) Responsible Unit/Agency

- For all prevention and mitigation measures: NNP1PC / Contractor / Sub-Contractor.
- For monitoring: Environmental Management Unit (EMU) and EMO.

(4) Cost Estimate (USD)

- For prevention and mitigation measures: included in construction costs
- For monitoring and controlling: USD 10,000 per year (USD 5,000 for sedimentation monitoring and USD 5,000 for soil erosion and sedimentation control)

(5) Work Plan:

- For prevention and mitigation measures: by task
- For monitoring and controlling:

	Work Plan	Frequency	Pre construction	Construction Phase (year)					
				1	2	3	4	5	6
1	Monitor soil erosion, landslide rock movements and sedimentation	occasional	━	━	━	━	━	━	━

10.1.1.3 *Reservoir and River Water Quality*

(1) Objective

To control the quality of discharge through water courses.

(2) Actions to be Taken

Water quality monitoring of reservoir and river water will be developed and implemented by NNP1PC, contractors and sub-contractors according to the recommendations in EMP Sub-Plan 04: Water Quality Monitoring. Also, related measures in Sub-Plan 01: Erosion and Sediment Control, and measures specified in *Appendix 2 of Annex C of Concession Agreement* shall be implemented.

1) River water quality

Most of the potential sources of water pollution shall be controllable by using best practices on-site, for example:

- Installation of waste water treatment plant for worker camps
- Safe disposal of vehicle maintenance oils;
- Safe storage of chemicals and disposal of used containers;
- Attention to concrete shuttering to prevent accidental spillage of wet cement into water courses, and prevention of washing cement mixing equipment in water courses;
- Attention to best practices for earth moving and other heavy works when working near water courses; and
- Removal of surplus vegetation in the reservoir area prior to impoundment.

The construction sites including the worker camps, offices and construction areas will need to be provided with potable water and adequate sanitation facilities, including installation of wastewater treatment facilities. In order to avoid water pollution caused by waste generated from construction sites and worker camps, regular waste collection shall be part of the camp requirements. Solid waste shall be taken to a managed waste disposal facility. The location of the temporary and permanent camps and water and waste treatment facilities shall be determined during the detailed design phase after discussions with the contractor.

Water quality issues related to construction activities shall be managed by the Contractors, under the monitoring and supervision of NNP1PC, which shall check on a regular basis, the water quality parameters measured by the Contractors by doing its own analysis.

2) Reservoir water quality

During and immediately after impoundment, the breakdown of vegetation left in the reservoir area has the potential to cause reductions in water quality in the reservoir due to biological oxygen demand, oxygen depletion, and release of hydrogen sulfide and methane. However, NNP1PC shall ensure that the burnt material shall be managed properly to prevent nutrient loading in the reservoir and downstream areas.

The objectives of the pre-impoundment preparation will be:

- To maximize income to the province from commercially viable timber (this is discussed separately in *Appendix H* in Sub-Plan 11: Vegetation Clearing;
- To minimize adverse impacts of high initial oxygen demand;
- To reduce the amount of floating debris in the reservoir;
- To control nutrient concentrations and risk of eutrophication during initial filling;
- To improve the conditions for aquatic life and fisheries potential of the reservoir;
- To clear the way reservoir navigation and artisanal and commercial fisheries;
- To create stable lake shorelines;
- To adequately manage the material from biomass clearance program to prevent nutrient loading into the reservoir; and
- To minimize greenhouse gas emissions.

A monitoring program shall be carried out to assure water quality is maintained. Samples are recommended to be taken at the sites upstream locations (at least 2 locations sites – one relatively far from the construction area and one near the dam site), in the construction area (at least one site), and downstream (at least 2 sites – one just downstream from the re-regulating dam and another farther downstream) before the start of construction as the base-line. However, the selected water quality stations should be selected from among the sampling stations used to test water quality in same station of *Chapter 5*, so there is some continuity of findings and the results can be used as a baseline). Throughout and up to the end of the construction phase, monthly samples shall be taken to test the chemical and physical quality of the water.

Specifications of monitoring are as follows:

- Monthly to observe parameters of physical and chemical water quality (temperature, pH, conductivity, turbidity, suspended solid, total dissolved solid), chemical water quality (calcium, magnesium, sodium, potassium, chloride, electric conductivity) biological water quality (DO, COD, BOD_5, planktonic algae, chlorophyll), and bacteriological water quality (total coliform and fecal coliform); and heavy metals such as lead and mercury.

- Seasonally to report all the above parameters, plus Mn.
- A laboratory outfit will be established at the field station, or in the location found the most appropriate. The monitoring system will primarily be based on a combination of field kit analysis for some of the water parameters and laboratory analysis. Sampling will be carried out by the EMU and/or EMO staff.
- The monthly report should present aggregate data in table and format, accompanied by narrative explanation and interpretation. A separate section should summarize the water quality situation and changes related to the project and project activities.

(3) Responsible Unit/Agency

- For all prevention and mitigation measures: NNP1PC / Contractor / Sub-Contractor – except removal of commercial timber, which is responsibility of Provincial Agriculture and Forest Office.
- For monitoring: EMU and EMO.

(4) Cost Estimate (USD)

- Monthly monitoring plan: USD 10,000/year
- Seasonal monitoring plan: USD 5,300/year

Total yearly budget for Reservoir and River Quality Monitoring Program: USD 15,300/year or USD 91,800 for the six years of construction phase

(5) Work Plan:

	Work Plan	Frequency	Pre construction	Construction Phase (year)					
				1	2	3	4	5	6
1	Monthly monitoring plan	Monthly							
2	Seasonal monitoring plan	Seasonal (3 times a year)							

10.1.1.4 Vegetation Clearing

Vegetation clearing in the reservoir area prior to inundation is critical to the water quality of the reservoir and downstream of constructions during the first years of operation. With less vegetative matter remaining in the water, there is less organic matter to decay and the water quality will be better.

(1) Objective

To mitigate the impacts of water quality deterioration due to decaying organic matter (i.e., plants and forest matter).

(2) Actions to be Taken

Vegetation clearing will be developed and implemented by NNP1PC, Contractors and Sub-contractors according to the recommendations in EMP Sub-Plan 11: Vegetation clearing and also related in Sub-Plan 05: Chemical Products and Spillage Management, Sub-Plan 07: Emission and Dust Control, and Sub-Plan 12: Waste Management and Disposal.

For biomass clearance in reservoir areas, GOL shall have the right to survey, cut and extract, in accordance with applicable laws and regulations, any and all commercial timber in and from the site of the Project, including the reservoir, dams, powerhouse(s), spillway(s), switchyard(s) and camp areas, before the commencement of impoundment by the Company, to avoid potential impacts of biomass clearance of the Project. In addition, the Concession Agreement would not allow additional forest outside the Project area to be cleared without approval by GOL.

The provincial government will be requested to adjust its regional logging plan to give precedence to commercial logging of the reservoir area. The proposed plan shall be in accordance with the existing forestry laws and regulations. Upon completion of the commercial logging operations, contracts will be made available for bidding for timber salvage operations that remove timber of marginal use from the inundated area. Both the provincial and district governments will be asked to collaborate with the Environmental Management Unit (EMU) and Environmental Management Office (EMO) to ensure that these operations are constrained to the reservoir area. The district government will also be asked to encourage the collection of all Non-timber forest products (NTFPs) by affected villagers from the reservoir area prior to clearing and burning. Specific expenses incurred by the government as a result of conducting these operations will be reimbursed by NNP1PC.

The final slashing and burning of the reservoir area will commence at the dam wall and will progress upstream over a three year period. The clearing operation will avoid removing stumps as disturbed soil may release a far greater amount of nutrients into water courses. This requirement favors the use of manual labor as heavy machinery tends to push over the standing timber and attached stumps. The work will be largely undertaken by hand, but heavy machinery will be used as necessary where remnant timber is too large to be effectively cleared manually; additionally, machinery may be used after burning where large timber remnants need to be restacked and burned for a second time.

The clearing operation will maintain a 100m wide buffer zone of vegetation around the perimeter of the reservoir, or from FSL to MOL minus 5 m height, so that the intact root structure of the trees will help maintain the structural integrity of the soil embankments and reduce shoreline erosion and wave erosion. This will also provide shelter for fish. However all vegetation on the slopes above FSL shall be retained to protect these areas and along the major tributaries, this buffer zone could be reduced to 20m along each bank to control sediment movement.

A monitoring program will be implemented that involves the District Agriculture and Forestry Office (DAFO), the village development coordination committee (VDCC), the EMU and the EMO.

Guidance on clearance operations might include:

- Removal of the maximum quantity of commercially viable timber (except in some designated buffer zones). As evacuation of logs from the reservoir area may be difficult, costly and cause negative impacts on surrounding forest areas (because of the creation of access roads), transformation on-site with portable sawmills and removal of logs by flotation during the filling phase shall be considered.
- Cutting, clearing and burning a maximum of the remaining vegetation. Experience from other related Projects indicates that it is possible, and indeed preferable, to rely on hand clearing in areas inaccessible by heavy equipment. This approach is also in line with the request of major funding agencies that this major infrastructure Project generate benefits not only to the national government but also to local communities: hand clearing will certainly create labor needs which can be fulfilled through local hiring.
- Avoiding removing stumps that can destabilize ground conditions, since disturbed soil may accelerate the release of nutrients in the water, and increase the quantity of such nutrients.
- Hauling as much as possible of the burnt vegetation residual from the reservoir area to avoid nutrient loading in the reservoir and downstream.

In order to reduce intrusion into restricted areas outside the Projected clearance zone, strict rules which prohibit poaching and logging outside the approved construction areas will be imposed on Project staff, workers, and all contractors engaged to the Project, with penalties levied for anyone cutting trees, collecting NTFPs or burning vegetation outside approved areas. NNP1PC shall be directly responsible for dissemination of all regulations and information concerned to its staffs and employees as well as for any misconduct made by its staff and workers.

Further details of management and mitigation measures for vegetative clearing activities can be found in Sub-Plan 11: Vegetation Clearing (*Appendix H*).

(3) Responsible Unit/Agency

NNP1PC will have the overall responsibility for the implementation of the Biomass Clearance Plan through the following: (i) provision of management, planning and control through EMO; (ii) engaging a Contractor with appropriate technical and management expertise to clear the proposed reservoir area; and (iii) provide training for clearance team staff in operations methods, health and safety, UXO surveys and management, physical cultural resources (PCR) Chance Find Procedures, environmental awareness, etc.

(4) Cost Estimate (USD)

USD 527,124 for vegetation clearing and USD 64,866 for timber logging per clearing areas; the budget must be prepared during preconstruction phase and the clearance shall be finished before impounding.

(5) Work Plan:

Work Plan		Frequency	Pre construction	Construction Phase (year)					
				1	2	3	4	5	6
1	Vegetation Clearing Plans								
	- Identification of vegetation to be cleared								
	- Demarcation of reservoir perimeter and the Full Supply Level (FSL)								
	- Clearing and removal methods for soft biomass (to avoid haze), timber								
	- Procedures to avoid re-growth of vegetation								
	- Use of herbicides								
	- Retention of large trees								
	- Erosion and sediment controls								
	- Tree cutting								
	- Storage and disposal of timber products								
	- Removal of partially burnt biomass and ashes								
	- Impacts on agricultural land use								
	- Responsibility and need of UXO clearance at certain areas within the reservoir								
	- Safety measures and procedures during UXO clearance								

10.1.1.5 *Noise and Vibration*

Most of the noise and vibration issues are easily controllable through best practices. Impacts will be temporary, during the construction period, and of limited significance, considering that the dam site is located two kilometers from the nearest village, distant from forests possibly still inhabited by wildlife and also the villages along the Project access road.

(1) Objective

- To reduce the potential impacts of noise and vibrations on sensitive receptors and structures, if any.
- To monitor noise and vibrations during construction and from transportation and construction activities.
- To report measurements to the relevant organization(s).

(2) Actions to be Taken

Noise and vibration control and mitigation measures will be developed and implemented by NNP1PC, Contractors and Sub-contractors according to the recommendations in EMP Sub-Plan 08: Noise Control and also related in Sub-Plan 02: Spoil Disposal, Sub-Plan 03: Quarry and Construction Layout Management, Sub-Plan 13: Environmental Training for Workers, Sub-Plan 16: Construction of Work Camps. Noise and vibration standard level shall be in compliance with the Lao National Environmental Standard for Noise and Vibration standards as presented in *Appendix I*.

<u>Measures for Noise Control Plan:</u>

1) Minimize Noise Generation at Source

- All noise-generating construction equipment shall be operated with sound control mechanisms by using proper sound dampening devices and good maintenance.
- Provide workers with ear protection.

2) Reduce Transmission of Noise to Receivers

- Noise sources will be sited as far as possible from villages, construction camps and settlement areas.
- Persons who are subjected to noise levels greater than 80dB(A) may request noise protection gear to limit damage to their hearing.
- Noise barriers will be installed at the construction camp and near villages along access roads if noise levels are found to exceed standards during monitoring.

3) Construction and Blasting Hours

- Prepare blasting procedures and blasting schedule, and inform and post in all nearby communities.
- Activities generating harmful noise and located within 1 km of a settlement should be restricted to reasonable hours (from 6:00 to 20:00), or starting at an earlier time or ending at a later time if agreed upon with the affected residents in the nearby communities.
- If blasting is found to exceed specified levels of noise and vibration in nearby communities, controlled blasting or alternative blasting or excavation measures shall be used in the specified areas, so noise or vibration levels are not exceeded.

<u>Measures for Vibration Control Plan:</u>

- Assure that in no instance shall blast vibration, as measured on the ground adjacent to a residential or other occupied structure, be allowed to exceed the frequency-dependent limits specified in the

Alternative Blasting Level Criteria contained in USBM Report of Investigations 8507.

- Keep air blasts at offsite residential and other occupied structures as low as possible; in no instance shall air blasts, as measured at a residence or other occupied structure, be allowed to exceed the 0.013-psi (133 dB) limit recommended in USBM Report of Investigations 8485.
- Monitor and record air blast(s) and vibration(s) for blasts within 1,000 feet (330 m) of worker camps and other occupied structures to verify that measured levels are within the recommended limits at those locations.
- Air blast and vibration monitoring shall be made at the nearest offsite residential or other occupied structure.
- Specific locations and distances where air blast(s) and vibration(s) are measured shall be documented in detail along with measured air blast and vibration amplitudes.

Additional key mitigation measures are as follows:

- Maintain all construction vehicles and heavy equipment in good mechanical condition.
- Limit the speed of all vehicles to 30 km/hr. in community areas.
- All vehicles should switch off engine when parking.
- Noise and vibration monitoring program will be routinely conducted and sampling locations, parameters specified as Noise and vibration standard level shall be in compliance with the Lao National Environmental Standard for noise and vibration standards as provided in *Appendix I.*

(3) Responsible Unit/Agency

- For all prevention and mitigation measures: NNP1PC / Contractor / Sub-Contractor.
- For monitoring: EMU and EMO.

(4) Cost Estimate (USD)

The expense of implementation shall be included in good management practices of construction sites and access road.

Monitoring: USD 5,000, for instruments, materials and analysis and result report.

(5) Work Plan:

	Work Plan	Frequency	Pre construction	Construction Phase (year)					
				1	2	3	4	5	6
1	Set and implement noise and vibration control plan								
2	Monitor noise levels: normal	monthly							
3	Monitor noise levels: periods of blasting, other loud activities	weekly							
4	Monitor vibration levels: normal	monthly							
5	Monitor vibration levels: periods of blasting	weekly							

10.1.1.6 *Air Quality*

Most of the air quality issues are easily controllable through best practices, and will be temporary for the construction period. They will likely have limited significance, given that the dam site is located two kilometers from the nearest village and along access road.

(1) Objective

- Minimize and prevent noise impact and nuisance from construction activities (i.e. heavy machine, vehicle, quarry, blasting, etc.) and transportation on access road to people, wildlife, and sensitive areas.
- Minimize dust emission from transportation, stockpiling, quarry and construction activities.
- Protect health impacts of construction workforce.
- To monitor air quality during construction period.
- To report measurements to the relevant organization(s).

(2) Actions to be Taken

Air quality control plan and mitigation measures will be developed and implemented by NNP1PC, Contractors and Sub-contractors according to the recommendations in EMP Sub-Plan 07: Emission and Dust Control and also related in Sub-Plan 01: Erosion and Sediment Control, Sub-Plan 12: Waste management and disposal, and Sub-Plan 14: Traffic and access.

Measures for Emission and Dust Control Plan:

1) Site Planning

Machinery and other dust-causing activities should be located away from sensitive receptors.

2) Construction Traffic

- All vehicles should switch off engines when stopped, and vehicles should not be left idling.

- All vehicles should be washed or cleaned before leaving the site.
- Loads entering and leaving the site should be covered if they are expected to contribute to the creation of particles or dust.
- The emissions from construction equipment that result from diesel fuel combustion are expected to be relatively minor and localized. However, combustion engines should be inspected on a regular basis and adjusted as required to minimize pollution levels.
- In the event that combustion engines are used underground, suitable ventilation measures must be taken to avoid air pollution and health/safety issues. Additional ventilation may also be needed to limit the exposure of workers to toxic gases released from excavated rock in underground work.

3) Demolition Works

- Use water as needed to suppress dust dispersion by winds.
- Cutting equipment should use water as suppressant or other practical ventilation systems.
- Securely cover skips and minimize drop heights.

4) Site Activities

- Minimize dust generating activities.
- Use water as suppressant where applicable.

Additional key mitigation measures include the following:

- Watering of exposed surfaces will be implemented in the following situations:
    - During windy conditions.
    - When visual inspection indicates excessive dust generation.
    - In response to complaints by external parties.
    - During period of heavy traffic uses on unsealed haul roads, if necessary.
- A maintenance program for the construction vehicle fleet will be implemented.
- Dust will be controlled to be in compliance with applicable standards by implementing the following dust minimization measures.

(3) Responsible Unit/Agency

- For all prevention and mitigation measures: NNP1PC / Contractor / Sub-Contractor.
- For monitoring: EMU and EMO.

(4) Cost Estimate (USD)

The expense of implementation shall be included in good management practices of construction sites.

Monitoring: USD 10,000, for instruments, materials and analysis and results report.

(5) Work Plan:

	Work Plan	Frequency	Pre construction	Construction Phase (year) 1	2	3	4	5	6
1	Prepare emission and dust control plan		▬						
2	Monitor emissions and dust levels	monthly		▬	▬	▬	▬	▬	▬

10.1.1.7 *Potential for Site Contamination*

(1) Objective

- To prevent site contamination.
- To monitor and report measurements to the relevant organization(s).

(2) Actions to be Taken

NNP1PC, Contractor and Subcontractors will be responsible to follow best practices to avoid contamination of the sites and waters with hazardous waste, explosives, and chemicals. Recommendations for potential site contamination shall be followed according to Sub-Plan 05: Chemical Products and Spillage Management, Sub-plan 06: Emergency Plan for Hazardous Materials, Sub-plan 12: Waste Management and Disposal and also related on Sub-plan 02: Spoil Disposal, Sub-Plan 03: Quarry and Construction Layout Management and Sub-Plan 16: Construction of Work Camps.

1) Explosives

Explosives shall be registered and stored in locked and guarded facilities located underground or sufficiently protected by bunding, and located close to the areas for use. Whenever the explosives are moved, the amount, date, and name of user shall be entered in log books at the storage facility and at other critical sites, to the place where it is being used. Only sufficient supplies of explosive material, adequate for a reasonable period, shall be stored in these facilities, to limit the possibility of any leakage or other accidents.

Explosive boxes shall be labelled with an “explosives” sign, and “explosives” posters shall be clearly shown at each site storage facility. Fire fighting equipment shall be kept available next to each storage facility.

NNP1PC, contractors and subcontractors will be responsible for regular monitoring of the storage and use of explosives. The EMU and EMO will carry out unannounced spot checks to monitor compliance with safe practices.

2) Chemicals and other hazardous materials

All chemicals considered potentially hazardous shall be stored safely and registered, so that the types of chemicals, the quantities being stored, and the amounts being used will be known. Whenever the chemicals are moved, the amount, date, and name of user shall be entered in log books at the storage facility and at other critical sites, to the place it is being used. Hazardous chemicals should only be handled by trained personnel.

Acids, coagulants and flocculants shall be stored within a separate containment area to avoid comprising the water treatment facility. A bund shall be constructed around the perimeter to contain a spill if it were to take place. Acids are also stored at batching plant sites where they are used to buffer plant effluents before discharge in a stream.

Chemicals to be stored and used on any construction site will be selected, where possible, in accordance with general best practices and recommendations for environmental conservation.

Pesticides for vector control (i.e., mosquitoes) and for vegetation control will be selected in accordance with the list of recommended pesticides provided by the EMO and following the environmental safeguards of the ADB.

Hazardous chemicals shall be stored sufficiently separate to avoid accidental mixture.

Fuel shall be stored safely, in bunded storage yards. There shall be registers of fuel deliveries and fuel disbursements, to reconcile the quantities brought into the site and the quantities used.

All areas where hazardous materials are stored or used shall have separate water drainage systems so that storm water is collected and contained. Only after being determined safe can it be released. If determined not safe, it shall be treated before being released or, if that is not possible, collected and discarded according to the hazardous waste management procedures.

NNP1PC, contractors and subcontractors will be responsible for regular monitoring of the storage and use of chemicals and other hazardous materials. The EMU and EMO will carry out unannounced spot checks to monitor compliance with safe practices.

3) Non-hazardous waste

Solid waste will be divided according to combustible solid waste, non-combustible and non-putrescible solid waste, non-combustible and putrescible solid waste, and hazardous waste. All non-hazardous waste will be stored and disposed of in accordance with a waste management plan for each type of waste.

Septic tanks will be installed and other wastewater treatment facilities will be built and operated to assure all wastewater is treated to safe levels before release.

NNP1PC, contractors and subcontractors will be responsible for regular monitoring of the storage and disposal of non-hazardous solid waste and wastewater. The EMU and EMO will carry out unannounced spot checks to monitor compliance with safe practices.

4) Hazardous waste

Waste oil and other liquid hazardous materials waste shall be collected by a liquid waste removal tanker and disposed of at a safe temporary disposal area for hazardous waste.

All waste considered as potentially hazardous shall be registered and labelled in order to follow up on the type of waste, the quantities generated and stored, and the quantities being disposed according to the hazardous waste management procedures. Movements to waste disposal sites will be registered. The information will be logged in a register, which will be located in each key stage of removal and at the storage sites of the hazardous waste.

In the event of a spill of any hazardous material, work shall cease in the immediate vicinity and the area cleared of all personnel except those involved in clean-up activities.

All construction activities will be undertaken in a manner that minimizes the generation of waste as far as practical. This will be incorporated into all construction site planning and activities.

All hazardous waste shall be stored in a single waste storage site, prior to being transported off site in safe and appropriate vehicles to hazardous waste disposal and treatment facilities.

NNP1PC, contractors and subcontractors will be responsible for regular monitoring of the storage and use of chemicals and other hazardous materials. The EMU and EMO will carry out unannounced spot checks to monitor compliance with safe practices.

(3) Responsible Unit/Agency

- For all prevention and mitigation measures: NNP1PC / Contractor / Sub-Contractor.
- For monitoring: EMU and EMO.

(4) Cost Estimate (USD)

The expense of implementation shall be included in good management practices of construction sites.

Monitoring: USD 10,000, for instruments, materials and analysis.

(5) Work Plan:

	Work Plan	Frequency	Pre construction	Construction Phase (year) 1	2	3	4	5	6
1	Prepare site contamination monitoring plan								
2	Monitor transport, storage, and handling of hazardous materials and other potential contaminants	At least weekly: unscheduled							

10.1.1.8 *Hydrology*

<u>Water Levels</u>

(1) Objective

- To monitor water levels both of upstream and downstream.
- To inform the local people about water levels and related issues.

(2) Actions to be Taken

Water levels at major locations/communities, especially downstream from proposed dam site to Pakxan, shall be monitored continuously. This data must be analyzed periodically for electricity production. Water levels must be controlled to as near the natural level as possible to avoid negative impacts to the local residents and to the environment.

Specific downstream and upstream measures are as follows:

2.1) Downstream

- River diversion works shall be constructed during low flow season.
- In case of floods, the Contractor must prepare emergency plans and procedures to release excess water in ways that will not affect downstream communities.
- The possibility of flash floods during the rainy season shall be included in safety plans during construction period.
- Warning system on water level fluctuation must be installed at major locations/communities downstream of the proposed dam site.
- Training shall be given to local residents in downstream communities to provide public readiness in case of emergency situations.
- Public consultation with local residents must be conducted frequently.

2.2) Upstream

- To complete the resettlement activities according to Resettlement Action Plan and national standards.
- Public consultation with local residents must be conducted frequently.

(3) Responsible Unit/Agency

- EMU and EMO.

(4) Cost Estimate (USD)

- Set up three (3) gauging stations: USD 30,000 per station, totaling USD 30,000.
- Monitor water levels and reporting: USD 1,000 per year (6 years of construction phase, USD 6,000).

(5) Work Plan:

	Work Plan	Frequency	Pre construction	Construction Phase (year)					
				1	2	3	4	5	6
1	Set up three (3) gauging stations in downstream area								
2	Monitor water levels	weekly (daily in emergencies)							

Flood Warning

(1) Objective

- To establish early warning systems in the event of floods.
- To train local people for emergency flood situations.

(2) Actions to be Taken

- The possibility of flash floods during the rainy season shall be included in safety plans for the construction sites. Construction materials for both the diversion channel and the dam structure must be well secured and stored during the potential flooding season. To avoid any loose construction materials getting caught in the floodwaters, several mitigation measures must be taken. These shall include setting up netting downstream of the dam site to capture loose materials and floating debris, and for earth and non-floating material, preparing open spaces or ponds to collect such materials. This is the responsibility of the contractor.
- Warning systems on water level fluctuation must be installed at major locations and communities downstream of the proposed dam site.
- Local residents must be kept informed of water level fluctuations so they can adjust their water transport or navigation plans.

- If flooding occurs that is determined to have been caused by construction activities and is not due to natural phenomena, NNP1PC shall accept responsibility for losses and prepare adequate compensation of such losses to the local people who are affected by the Project.

(3) Responsible Unit/Agency

- For Development of plan and warning system: NNP1PC, Construction Contractor, and EMO.

(4) Cost Estimate (USD)

- Installation of flood warning system: USD 5,000 per system, totaling USD 15,000 for three stations.
- Training: USD 2,000 per year.

(5) Work Plan:

	Work Plan	Frequency	Pre construction	Construction Phase (year)					
				1	2	3	4	5	6
1	Installation of flood warning system in downstream area (three stations)								
2	Reporting to communities	As needed							

10.1.2 *Environmental Mitigation Measures during Operations Phase*

10.1.2.1 *Seismicity*

(1) Objective

- To prevent landslides.
- To avoid reservoir induced seismic activity.

(2) Actions to be Taken

- The slope and geology around the reservoir are not conducive to landslides. Given the size of the reservoir and the height of the water at the dam, reservoir induced seismic activity is not expected.
- During the first years of storage of the reservoir and operation, routine visual inspections shall be made to evaluate the safety of the dam. Routine visual inspections shall also be made of the slopes around the construction area and the reservoir for signs of any landslides.
- Routine inspection of dam structure is recommended, particular after initial storage of water in the reservoir.

(3) Responsible Unit/Agency

- NNP1PC and EMO.

(4) Cost Estimate (USD)

No additional costs expected.

(5) Work Plan:

Occasional during first 8 years of operation

	Work Plan	Frequency	Operation Phase (year)								
			1	2	3	4	5	6	7	8	>8
1	Monitoring for landslide and other signs of seismic activity	occasional									

10.1.2.2 *Soil*

There are two concerns with soil fertility. First is the need to have fertile soils for the resettlement sites, so the resettled villagers will be able to obtain as much or even higher yields for their crops than in their original communities. Second is the possible effect of the dam on downstream communities: although the river does not now have much effect on soil fertility downstream (there is no seasonal flooding that leaves fertile deposits, and most of the agricultural land downstream lies well above the river level), it is better to monitor soil fertility until the water quality in the reservoir and downstream stabilizes, in the event of any unexpected impacts.

(1) Objective

- To prevent loss of soil nutrient with appropriate erosion control.
- To improve soil fertility in the resettlement area to a level as good as or better than the soils in the original settlements.
- To monitor soil fertility in agricultural lands downstream of the reservoir for any potential changes that may be caused by changes in water quality and hydrology.

(2) Actions to be Taken

- Conduct soil survey and collect soil samples on agricultural lands in the downstream areas and resettlement sites.
- Implement a soil improvement program in the resettlement area.

(3) Responsible Unit/Agency

- For improving the soils in the resettlement areas: Resettlement Management Unit and Social Management Office.
- For monitoring soil fertility: EMU and SMO.

(4) Cost Estimate (USD)

- For the soil improvement program: this is part of the Resettlement and Ethnic Minority Plan.
- For the monitoring: USD 10,000 every 2 years, until operation phase year 8. (totally USD 40,000, 4 times).

(5) Work Plan:

	Work Plan	Frequency	Operation Phase (year)								
			1	2	3	4	5	6	7	8	>8
1	Soil improvement in resettlement sites		—	—							
2	Conduct soil surveys at resettlement sites	Every 2 years	●		●		●		●		
3	Conduct soil surveys downstream	Every 2 years	●		●		●		●		

10.1.2.3 *Erosion and Sedimentation*

(1) Objective

- To prevent sedimentation in the river upstream from the dam by erosion caused by the clearing of large areas of forest by logging and for agriculture and the expansion of farmland into steeper slopes.
- To prevent sedimentation in the reservoir from cleared lands on slopes around the reservoir.

(2) Actions to be Taken

- Community based forest management supported by the GOL will be promoted. All villages in the watershed have their own conservation reserve forests for village uses.
- Villagers will be trained to help monitor forest use, including illegal logging which could contribute to erosion and sedimentation.
- To prevent loss of soil nutrient with appropriate erosion control.

A vegetative buffer will be maintained around the reservoir by the Project, to prevent erosion and sedimentation from the surrounding slopes into the reservoir.

The EMU and EMO will conduct occasional monitoring of the land use in the watershed, to determine areas of greater risk of erosion and sedimentation. These organizations will also conduct occasional monitoring of the slopes and vegetative buffer around the reservoir, to assure they are not eroding.

(3) Responsible Unit/Agency

- Provincial Agriculture and Forestry office (PAFO) and District Agriculture and Forestry office (DAFO), and the Social Management Office (SMO).
- For monitoring: Environmental Management Unit (EMU) and EMO

(4) Cost Estimate (USD)

- Implementation: to be included as part of watershed management, which is included in the biodiversity offset program.
- For monitoring and controlling: USD 10,000 per year (USD 5,000 for sedimentation monitoring and USD 5,000 for soil erosion and sedimentation control).

(5) Work Plan:

For monitoring:

	Work Plan	Frequency	Operation Phase (year)								
			1	2	3	4	5	6	7	8	>8
1	Monitor soil erosion, landslide rock movements and sedimentation	occasional									

10.1.2.4 *Reservoir and River Water Quality*

(1) Objective

- To conduct intensive monitoring of water quality at selected sites upstream from the reservoir, in the reservoir, and downstream from the dams, until the water quality stabilizes.
- To conduct regular monitoring of water quality at selected sites upstream from the reservoir, in the reservoir, and downstream from the dams.

(2) Actions to be Taken

(2.1) Intensive Water Quality Monitoring Program (short- to medium-term)

The Intensive Water Quality Monitoring Program will last for at least eight years, or until the water quality has become balanced and stabilized (based upon monitoring of water quality by the EMU and EMO). There will be frequent tests of several key parameters, and occasional tests of a broader range of parameters:

- Biweekly tests – to observe temperature, pH, conductivity, turbidity, SS, DO, COD, BOD_5, total coliform and fecal coliform.

- Three times a year – to observe physical water quality (temperature, pH, conductivity, turbidity, suspended solid, total dissolved solid), biological water quality (DO, COD, BOD_5, P, PO_4^{3-}, N, NO_3^-, NH_3), bacteriological water quality (total coliform and fecal coliform), and Mn.
- As needed, to observe whichever parameters are considered important, in response to an emergency (such as, fish dying downstream, foul odors, excessive algal growth) or complaints from people around the reservoir or downstream.
- Major parameters of DO and temperature will be measured at five depths at the four sites twice a week during impoundment, and four times a year after impoundment, The water samples will be collected at 4 stations as follows:

    - Upstream in the main reservoir.
    - In the middle of the main reservoir.
    - Downstream in the main reservoir.
    - Immediately downstream of the re-regulation pond.

(2.2) Routine Water Quality Monitoring Program (long-term)

- Seasonal Monitoring Plan: After the eighth year of operation, or if the EMU and EMO have determined before then that the water quality has become stabilized and balanced under the new hydrological conditions, the routine water quality monitoring Program will be implemented in place of the more intensive Program . The monitoring parameters include physical and chemical water quality (temperature, pH, conductivity, turbidity, suspended solid, total dissolved solid), biological water quality (DO, COD, BOD_5, P, PO_4^{3-}, N, NO_3^-, NH_3), bacteriological water quality (total coliform and fecal coliform), and Mn; and will be conducted every four months (three times a year.

(3) Responsible Unit/Agency

EMU and EMO

(4) Cost Estimate (USD)

(4.1) Intensive Water Quality Monitoring Program (short- to medium-term, potentially for the first 8 years of operation).

- Biweekly Monitoring Plan: USD 19,700 /year (totally USD 157,600)
- Seasonal Monitoring Plan: USD 5,300 /year (totally USD 42,400)

Total annual budget for the comprehensive Intensive Water Quality Monitoring program: USD 25,000 /year (or USD 200,000 for the first eight years of operation phase).

(4.2) Routine Water Quality Monitoring program (after the 8th year of operation, or whenever water quality has become stabilized and balanced under the new hydrological conditions).

Seasonal Monitoring Plan: USD 5,300 /year (totally USD 42,400 assume water quality become stabilized and balance at 8th year of operation phase).

(5) Work Plan:

	Work Plan	Frequency	Operation Phase (year)								
			1	2	3	4	5	6	7	8	>8
Intensive Water Quality Monitoring Program (short- to medium-term)											
1	<u>Biweekly Monitoring Plan:</u> Temperature, pH, conductivity, turbidity, SS, DO, COD, BOD_5, total coliform and fecal coliform	Biweekly									
2	<u>Seasonal Monitoring Plan:</u> Temperature, pH, conductivity, turbidity, suspended solid, total dissolved solid, DO, COD, BOD_5, P, PO_4^{3-}, N, NO_3^-, NH_3 total coliform and fecal coliform, and Mn.	Seasonal (3 times a year)									
Routine Water Quality Monitoring Program (long-term)											
1	<u>Seasonal Monitoring Plan:</u> Temperature, pH, conductivity, turbidity, suspended solid, total dissolved solid, DO, COD, BOD_5, P, PO_4^{3-}, N, NO_3^-, NH_3 total coliform and fecal coliform, and Mn.	Seasonal (3 times a year)									

10.1.2.5 Groundwater Quality Monitoring

Although there is not expected to be any major impact on the quality of groundwater downstream from the dam, occasional monitoring of the quality of groundwater will be conducted, to determine if there is any change in groundwater tables and quality due to seepage.

(1) Objective

To monitor the quality and other characteristics of the groundwater in areas downstream from the dam.

(2) Actions to be Taken

- Conduct occasional tests of groundwater quality and levels.
- Respond to any reports by villagers of changes in groundwater quality and levels.

(3) Responsible Unit/Agency

EMU and EMO.

(4) Cost Estimate (USD)

USD 5,000 per test, once every 3 years (year 1, 4 and 7, total USD 15,000 of 3 times).

(5) Work Plan:

	Work Plan	Frequency	Operation Phase (year)								
			1	2	3	4	5	6	7	8	>8
1	Impact assessment of ground water hydrology and quality	Once every 3 years until stabilization	●			●			●		

10.1.2.6 *Potential for Site Contamination*

As noted in the previous chapter, controlled amounts of lubricant, fuels and petroleum products will be used by a small number of vehicles. Some pesticides and fertilizers will be used for landscape control and maintenance; exposure would be limited only to the areas where such chemicals are directly applied.

(1) Objective

Monitoring of the use of these materials will be part of the operations procedure for the Project.

(2) Actions to be Taken

- The use of the pesticides and fertilizers must follow proper application methods.
- Overuse of hazardous chemicals such as fuels and pesticides and fertilizers must be avoided to prevent soil and water pollution.
- Vehicles carrying pesticides and fertilizers for landscaping must be covered on the route between the storage warehouse and the landscape site.
- Hazardous chemicals must be well sealed and instruction to use shall be clarified.

(3) Responsible Unit/Agency

- For monitoring: EMU and EMO.

(4) Cost Estimate (USD)

The expense of implementation shall be included in good management practices of construction sites.

Monitoring: USD 10,000, for instruments, materials and analysis.

(5) Work Plan:

	Work Plan	Frequency	Operation Phase (year)								
			1	2	3	4	5	6	7	8	>8
1	Monitor transport, storage, and handling of hazardous materials and other potential contaminants	At least weekly: unscheduled									

10.1.2.7 *Hydrology*

<u>Water Level Monitoring</u>

(1) Objective

- To monitor water levels.
- To inform the local people about water levels and related issues.

(2) Actions to be Taken

- Management of the reservoir water levels shall be conducted.
- If flood exceed the design flood, Evacuation Action Plan (EAP) shall be prepared and in case of exceed flood, EAP shall be implemented.
- Provision of adequate information and interactive two ways communications between the Project and the local communities shall be maintained.
- To develop water quality model for prediction and further planning.
- Water levels at major locations/communities, especially downstream from the dam site to Pakxan, shall be monitored continuously. Additional monitoring points may be considered if needed. This data must be analyzed periodically for electricity production. Water levels must be controlled to as near the natural level as possible to avoid negative impacts to the local residents and to the environment.
- Downstream communities shall be informed of the characteristic change on river fluctuations, and how they can then use the river as effectively as possible under the new hydrologic conditions.
- The highest water level marker shall be install along the river downstream, especially those that close to communities, shall be installed.

(3) Responsible Unit/Agency

EMU and EMO.

(4) Cost Estimate (USD)

Monitor water levels and reporting: USD 1,000 per year (Total 27 years of operation phase, USD 27,000).

(5) Work Plan:

	Work Plan	Frequency	Operation Phase (year)								
			1	2	3	4	5	6	7	8	>8
1	Monitor water levels	weekly (in extreme case, daily)									
2	Prepare report to publication	Yearly									

Flood warning plan

(1) Objective

- To establish early warning systems in the event of flooding.
- To train local people for emergency flood situations.

(2) Actions to be Taken

- Local residents in downstream communities shall be informed how the river fluctuations will change because of the dam, and how they can then use the river as effectively as possible under the new hydrologic conditions.
- The time it will take for any floods to travel along the river downstream from the dam must be forecast, and local residents must be informed.
- A flood warning system must be installed along the river between the dam and the first main tributary.
- Information on water level analysis must be available to the public at all times, so that people can prepare themselves for the periods of higher and lower flow. In case of extreme events, the Project must inform people of the expected time and duration of extreme low flows or extreme high flows.
- In case of flooding of downstream agricultural areas because of dam operations, NNP1PC has to compensate the local people for the losses.

(3) Responsible Unit/Agency

NNP1PC, EMU and EMO.

(4) Cost Estimate (USD)

Training: USD 2,000 per year (total 27 year of operation phase, USD 54,000).

(5) Work Plan:

Work Plan	Frequency	Operation Phase (year)								
		1	2	3	4	5	6	7	8	>8

Work Plan		Frequency	Operation Phase (year)								
			1	2	3	4	5	6	7	8	>8
1	Training and follow up	yearly									

10.2 *ENVIRONMENTAL MITIGATION MEASURES FOR BIOLOGICAL IMPACTS*

Mitigation measures for biological impacts during the construction phase and operation phase for the main dam area and inundation area are outlined below.

Site specific management for the access road and transmission line is outlined in the attached EA and IEE for both components of the Project (See *Appendix E* and *Appendix F*).

A comprehensive biodiversity offset program has been designed to be implemented in the Nam Ngiep Watershed and additional candidate offset sites. This offset program is designed to manage the biodiversity within the Nam Ngiep watershed post construction to improve and maintain biodiversity values. A comprehensive Biodiversity Action Plan should also be prepared for implementation for all project areas to cover all mitigation measures required.

The components of the mitigation measures for the construction phase include a wildlife rescue and education program; wildlife protection and conservation awareness program; management of habitat and vegetation clearing; management of aquatic habitats; management of pests and weeds; and landscaping and restoration.

10.2.1.1 *Wildlife Rescue and Education Program*

A program to rescue and protect any wildlife left within the reservoir area will be implemented to manage wildlife during the inundation phase of the reservoir.

Wildlife Rescue Program

(1) Objective

To rescue wildlife that might be affected by inundation.

(2) Actions to Be Taken

- Rescue and relocate the wildlife
- Ensure that personnel are prepared and necessary equipment is available for rescuing and relocating wildlife when needed
- During vegetative clearing and impoundment of the reservoir, wildlife in the project area will be captured, removed and kept in captivity as appropriate until relocation and release can occur.

- Injured animals that have been identified in the project area will be rescued and treated.
- Strict rules against wildlife hunting and poaching will be imposed on project staff, workers, and all contractors engaged to the project, with penalties levied for anyone caught carrying or using firearms, or using animal snares or traps.
- The sale of wildlife and NTFP products by local people to construction workers and staff will be banned.

(3) Responsible Unit/Agency

- The Company will provide the necessary financial support to GOL to implement appropriate measures to rescue wildlife.
- In particular relevant GOL authorities will identify viable and comparable host ecosystem; located within the Nam Ngiep watershed or outside.
- To Implement Program: Provincial Agriculture and Forest Office (PAFO), District Agricultural and Forest Office (DAFO), Developer, and Contractor
- To Monitor the Implementation: EMU and EMO

(4) Cost Estimate (USD)

USD $30,000 for survey, USD $80,000 for the rescue and protection of wildlife animals, USD $10,000 for monitoring.

(5) Work Plan:

	Work Plan	Frequency	Pre construction	Construction Phase (year)						Operation Phase (year)			
				1	2	3	4	5	6	1	2	3-8	>8
1	Survey all wildlife in the affected portions of the project area and in other wildlife habitats in the project area	Twice before construction											
2	Capture and remove the wildlife from the affected area and release	Upon finding the animals											
3	Release wildlife in a new habitat	At appropriate time											

<u>Wildlife protection and conservation awareness</u>

(1) Objective

- To educate all construction staff and villagers on wildlife conservation, anti-poaching regulations and relevant penalties for violation of regulations
- To manage wildlife during the construction phase of the project
- To protect against logging and poaching through a village-based monitoring program

(2) Actions to Be Taken

- Hold meetings with all construction staff and villagers to relay pertinent information
- Use various media channels - print, radio, and television - to convey the new regulations to all persons within the project area
- Engage the village communities in monitoring and protecting wildlife and their habitats.
- For areas requiring night-time lighting, lights will be used only where necessary and will be directed toward the subject area and away from habitat areas where possible.
- All heavy vehicles are only permitted to use roads during daylight hours to minimize the disturbance of wildlife and the potential for wildlife deaths from traffic.
- A speed limit of 30 km/hr shall apply to all project vehicle movements to protect wildlife.
- All project staff prohibited from harvesting any forest products and hunting wildlife.

(3) Responsible Unit/Agency

- Implementation: PAFO, DAFO, EMO, Social Management Office (in work with villagers).
- Monitoring: EMU, EMO.

(4) Cost Estimate (USD)

US$ 27,000 per year; USD $10,000 for monitoring.

(5) Work Plan:

	Work Plan	Frequency	Pre construction	Construction Phase (year)						Operation Phase (year)			
				1	2	3	4	5	6	1	2	3-8	>8
1	Training construction staff, workers and villagers	yearly											

	Work Plan	Frequency	Pre construction	Construction Phase (year)						Operation Phase (year)			
				1	2	3	4	5	6	1	2	3-8	>8
2	Media distribution	As appropriate											
3	Monitor logging and poaching	monthly											
4	Monitor animal habitat	yearly											
5	Monitor animal diversity and density	yearly											

Management of habitat and vegetation clearing

(1) Objective

- Reduce disturbance of flora and fauna, including flora and fauna listed on the IUCN Red List, due to construction activities

(2) Actions to Be Taken

- No clearing will occur in natural habitat areas or protected areas without approval from the relevant government authority.
- Clearing activities will be strictly controlled, including clearly marking areas of clearing, fencing areas to be protected, and for clearing that will occur adjacent sensitive areas (such as near known locations of threatened species) clearing will be undertaken using hand tools.
- Species listed as restricted in Laos or listed on the IUCN Red List, such as *Dipterocarpus alatus* will be clearly marked and avoided during construction.
- Strict rules against logging outside the approved construction areas and wildlife hunting will be imposed on all personnel
- To educate all construction staff and villagers on vegetation clearing and habitat protection during construction
- To protect against habitat and vegetation clearing program through a village-based monitoring program.

(3) Responsible Unit/Agency

- Implementation: PAFO, DAFO, EMO, Social Management Office (in work with villagers).
- Monitoring: EMU, EMO.

(4) Cost Estimate (USD)

US$ 35,000 per year; US $10,000 for monitoring per year.

(5) Work Plan:

	Work Plan	Frequency	Pre construction	Construction Phase (year)						Operation Phase (year)			
				1	2	3	4	5	6	1	2	3-8	>8
1	Training construction staff, workers and villagers	yearly											
2	Media distribution	As appropriate											
3	Monitor vegetation and habitat clearing	Monthly											
4	Monitor logging activities	yearly											
5	Village monitoring program	yearly											

Management of aquatic habitats

(1) Objective

- Reduce degradation of habitat and barrier to movement of aquatic species. Earth works that may produce sediment adding to water turbidity along the river and natural stream to be minimized.
- Enable environmental flows to mimic natural flow regimes and protect habitats downstream.

(2) Actions to Be Taken

- To avoid/minimize releasing sediment load into the river, e.g. using silt fence and temporary re-vegetation to minimize sediment from steep slope releasing to the river.
- Sediment pond or traps will be installed at the end of water drainage way.
- Ensure no activities pollute the aquatic environment.
- Fishing and using of illegal fishing gear anywhere along the river should be prohibited.
- In-stream construction will be undertaken in low-flow conditions where possible and bank stabilization measures (e.g. matting and sheet piles) will be used where appropriate to manage bank erosion and downstream habitat degradation.
- Implement an environmental flow regime downstream of the re-regulation dam.
- Fishing and using of illegal fishing gear anywhere along the river will be prohibited by all staff.

(3) Responsible Unit/Agency

- Implementation: PAFO, DAFO, EMO, Social Management Office (in work with villagers).
- Monitoring: EMU, EMO.

(4) Cost Estimate (USD)

US$ 55,000 per year; US $10,000 for monitoring per year

(5) Work Plan:

	Work Plan	Frequency	Pre construction	Construction Phase (year)						Operation Phase (year)			
				1	2	3	4	5	6	1	2	3-8	>8
1	Training construction staff, workers and villagers	yearly											
2	Implement management activities to prevent impact on the aquatic environment	monthly											
3	Monitoring program	yearly											

Management of pests and weeds

(1) Objective

- Reduce degradation of habitat through the introduction of pests and weeds during construction.
- Ensure the appropriate rehabilitation of disturbed areas with native endemic species.

(2) Actions to Be Taken

- All machinery and tools will be thoroughly washed down prior to use to help prevent the spread of weeds and plant pathogens.
- To avoid the spread of non-endemic species between different areas of the construction site, topsoil and vegetation (for mulching) removed from an area during site-clearing activities will as far as practical only be reused on that area.
- Construction wastes will be appropriately stored and disposed of such that pest and/or native fauna cannot access hazardous or domestic waste items.
- Landscaping and re-vegetation will utilize locally native species.
- To avoid the spread of non-endemic species between different areas of the construction site, topsoil and vegetation (for mulching) removed from an area during site-clearing activities will as far as practical only be reused on that area.

(3) Responsible Unit/Agency

- Implementation: PAFO, DAFO, EMO, Social Management Office (in work with villagers).
- Monitoring: EMU, EMO.

(4) Cost Estimate (USD)

US$ 55,000 per year; US $15,000 for monitoring per year.

(5) Work Plan:

	Work Plan	Frequency	Pre construction	Construction Phase (year)						Operation Phase (year)			
				1	2	3	4	5	6	1	2	3-8	>8
1	Training construction staff, workers and villagers	yearly											
2	Implement management activities to prevent spread of pests and weeds	monthly											
3	Monitoring program	yearly											

Rehabilitation of disturbed areas (habitats)

(1) Objective

- Reduce degradation of habitat through appropriate rehabilitation of habitats.
- Ensure the appropriate rehabilitation of disturbed areas with native endemic species.

(2) Actions to Be Taken

- All area disturbed by construction activity will be landscaped to reflect natural contours and restore suitable drainage paths.
- Undertake replanting in all locations agreed with local authorities. Re-establishment of vegetation will be implemented in disturbed areas except surface of rock, if necessary, and commenced at the earliest possible opportunity. Appropriate local species of vegetation will be used.
- Local depressions created by construction activities will be either backfilled or drained to prevent ponding wherever possible.
- Watercourses, which have been temporarily diverted by the contraction activities, will be restored to their former flow paths and riparian zones rehabilitated.

- Rehabilitation activities will be in accordance with the Biodiversity Action Plan (BAP).
- Residual impacts to natural habitat areas and threatened species habitat will be managed through implementation of the Biodiversity Offset Design (BOD) Report.
- Conduct monitoring and maintenance to ensure effectiveness of protect tree replanting and landscaping plan. Reasonable remedial measures (e.g. replacing dead or damaged replanted tress and other vegetation types) shall be implemented in case of the damage due to project activities.
- Use grading methods and facilities such as rounding benching, terracing, and retaining walls (as appropriate) to reduce the amount and/or severity of earthwork and related topographic alteration/vegetation removal.
- During replanting/vegetation works, new alien plant species (i.e., species not currently established in the country or region of the project) shall not be used unless carried out with the existing regulatory framework for such introduction. Invasive species shall not be introduced into new environments.

(3) Responsible Unit/Agency

- Implementation: PAFO, DAFO, EMO, Social Management Office (in work with villagers)
- Monitoring: EMU, EMO

(4) Cost Estimate (USD)

US$ 80,000 per year; US $20,000 for monitoring per year.

(5) Work Plan:

	Work Plan	Frequency	Pre construction	Construction Phase (year)						Operation Phase (year)			
				1	2	3	4	5	6	1	2	3-8	>8
1	Training construction staff, workers and villagers	yearly											
2	Implement management activities to revegetate disturbed areas	monthly											
3	Monitoring program	yearly											

10.3 *UNEXPLODED ORDINANCES (UXO)*

(1) Objective

To facilitate service for and management of UXO survey and clearance.

(2) Actions to be Taken & Methodology

The unexploded ordinances clearance of all construction activity areas and access road of the Project will be developed and implemented by NNP1PC, Contractors and Sub-contractors according to the recommendations in EMP Sub-Plan 15: Unexploded Ordnance (UXO) Survey and Disposal and also related in Sub-Plan 05: Chemical Products and Spillage Management and Sub-Plan 13: Environmental Training for Workers.

The present Project description revealed that the dam site, including the areas within the reservoir and the resettlement areas, has less contamination with UXO than initially believed. However, measures for survey and disposal of UXO shall be conducted to ensure the safety of all concerned parties. Such measures may include:

- UXO clearance and certificate shall be implemented for the whole construction area.
- All construction activities shall be commenced within the UXO clearance boundary.
- Contracting an appropriately qualified organization to undertake the work.
- Planning for survey and disposal work.
- Vegetation clearing for UXO works.
- Requirements for survey and disposal.
- Marking of cleared areas and clearance reports.
- Construction worker training.
- Notification of local communities.
- Reporting requirements.

UXO specialists will carry out surveys of sites that are to be excavated and will remove and destroy any UXO encountered, especially within the areas where the map suggests the possible remains of UXO. Areas that have been given the "all-clear" for construction will be demarcated. UXO pathfinders will need to assist the field clearing teams to sweep, identify, and dispose of UXO. Workers will receive health and safety training, including a training component on UXO recognition and management.

(3) Responsible Unit/Agency

NNP1PC and EMO

(4) Cost Estimate (USD)

USD 600,000 per clearing area; the budget must be prepared before preconstruction phase

(5) Work Plan:

	Work Plan	Frequency	Pre construction	Construction Phase (year)					
				1	2	3	4	5	6
1	Survey and clear UXO in construction site								
2	Survey and clear UXO in resettlement site								
3	Survey and clear UXO in reservoir area								

10.4 *CULTURAL PROPERTIES*

To the extent possible, construction activities will be done so as to avoid any physical effect on known sites of cultural, religious, archeological or historical significance. This includes remains left by previous human inhabitants and unique natural environmental features, as well as those of importance to current inhabitants.

Key staff, including personnel in the Environmental and Social Division (ESD) will be trained to identify potential sites or items of cultural significance. Construction workers will be trained in the appropriate reporting and communication procedures shall they come across any potential an previously unidentified sites or items of cultural, religious, archeological or historical significance.

If a possible cultural property is reported, the ESD will determine if that site or item has potential significance. If it is determined to be of potential significance, work within 50 m radius of the finding will be ceased immediately. The ESD will notify NNP1PC within 24 hours of such a finding, and temporary fencing or similar protection be placed to mark the 50 m radius of the finding. Experts will be called in to determine if the site or item is of significance, and if so, whether any additional investigation of that area is needed. No work will be carried out within that 50 m radius until the expert(s) are satisfied that any other items of importance have been excavated or that the site has been sufficiently investigated. The ESD will then inform NNP1PC that work can commence within that area. Shall the experts determine that further protection of the site is required, the ESD will inform NNP1PC and the site be protected as needed.

Details of measures to be taken to protect cultural properties are presented in EMP Sub-Plan 09: Cultural Resources and also related Sub-Plan 13: Environmental Training for Workers (*Appendix H*).

10.5 *WORKERS' HEALTH AND OCCUPATIONAL SAFETY*

All components of the workers' camps, including accommodations, sanitation facilities, water supply and other infrastructure, recreation facilities, kitchens and dining areas, and medical facilities, will need to adhere to and be maintained at internationally accepted health and safety standards.

The workers and other project personnel will be provided training in prevention of several diseases, including mosquito-borne diseases, intestinal diseases, and HIV/AIDS and other venereal diseases. They will also be given training in proper use of sanitary facilities, use of proper drinking water, and proper disposal of waste.

Workers and other project personnel will be trained in proper work safety measures and practices. First aid teams will be assigned at each of the construction sites in case of accidents.

Medical facilities will be provided at the Project site. A doctor shall be available within reasonable distance from the construction site if an accident occurs or in case of serious illness.

Water and drainage facilities will be maintained to avoid breeding of mosquitoes. Pesticides will be used to control against mosquitoes and other pests only if deemed necessary. In those cases, the selection of pesticides must follow these conditions: the pesticides shall have negligible adverse impact on humans, they shall be effective against target species, they shall have minimal effect on non-target species and the natural environment, and they shall be safe for the personnel who apply them.

Mitigation measures of workers' health and safety recommended for all the construction of work camps are presented in EMP Sub-Plan 16: Construction of Work Camps and also related in Sub-Plans 13: Environmental Training for Workers, and Sub-Plan 17: Project Personnel Health Program.

10.6 *CUMULATIVE AND TRANS-BOUNDARY IMPACTS*

Given the concurrent operation of the Nam Ngiep 2 Hydropower and Nam Ngiep 3 Projects, as well as other likely Projects within the Nam Ngiep River watershed that can have impacts on the environment of the watershed, the NNP1 Project shall encourage the GOL to establish a Nam Ngiep Watershed Management Committee to coordinate all efforts that relate to the protection and management of the watershed. The biodiversity offset program includes recommendations for measures to manage the watershed.

In addition, a separate Cumulative Impact Assessment (CIA) report has been prepared for this Project, "*Nam Ngiep 1 Hydropower Project Cumulative Impact Assessment*", consistent with the IFC's Draft (External Peer Review)-*Cumulative Impact Assessment Guidance Note for Private Sector in Emerging Markets*. The CIA report focused on the identified Valued Environmental and Social Components (VECs) (ESSA&IFC 2012)[1].

[1] Valued Environmental and Social Components (VECs) are environmental and social attributes that are considered important in assessing risk. The VECs identified as a result of the literature review are:

VEC1: Terrestrial biodiversity and habitats
VEC2: Aquatic biodiversity and habitats
VEC 3: Ecosystem services

11 ENVIRONMENTAL MONITORING PROGRAM

11.1 TYPES OF MONITORING

Environmental monitoring for the Project will be carried out at three levels, as follows:

1) Routine monitoring of activities and conditions during construction and operation by the Contractor and/or Subcontractors. To ensure mitigation measures are fully implemented, each compliance report will be made available and will be provided to NNP1PC with a readily accessible record of construction progress, photographic documentation, and documentation of compliance with the Project environmental requirements.
2) Periodic (sometimes unscheduled) monitoring of impacts and of compliance by two organizations established for this purpose: the GOL's Environmental Management Unit under MONRE and the Environmental Management Office under the Owner's Environmental and Social Department.
3) Occasional monitoring of impacts and of compliance by a third party external monitor.

11.1.1 *Routine Monitoring by Contractors and Subcontractors*

For all pre-construction activities, and during construction and operations stage, NNP1PC, Contractors, and Subcontractors will monitor their activities on a regular basis, and the internal organization requires an inspection team with environmental skills or trained personnel. For all their work, NNP1PC, Contractors and Sub-contractors are to monitor for potential adverse impacts, including but not limited to those that have been identified by this EIA, and they are to comply fully with all standards and safeguards.

An Environmental and Social Management and Monitoring Plan for Construction Phase (ESMMP-CP) shall be developed to define detailed mitigation and monitoring actions to be implemented during the construction phase of the Project, which defines the roles and responsibilities and institutional arrangements of environmental management. Site Specific Environmental and Social Management and Monitoring Plans (SSESMMP) shall also be prepared, and shall be implemented for each of the main construction sites and for other distinct activities that may have environmental impacts. These plans will be part of the contractual obligations for the Contractors and Subcontractors. In addition, an Environmental and Social Management and Monitoring Plan will be prepared for the Operations Phase (ESMMP-OP) prior to commissioning of the Project.

Both the ESMMPs and the SSESMMPs will provide details of the various actions and measures intended to prevent adverse environmental impacts or, if they cannot be prevented, to mitigate the adverse impacts. The ESMMPs and SSESMMPs will also provide details of the monitoring procedures: how the monitoring will be done for the various potential adverse impacts, how and what will be measured or observed, who is responsible for monitoring, and the frequency of such monitoring. Indicative examples of environmental monitoring activities are presented in *Section 11.2* below, based upon the example of environmental management sub-plans in *Appendix H*.

Results of field observations, either documenting compliance or non-compliance with environmental requirements, will be reported on standard forms. The use of these standard forms will help ensuring that compliance-related observations are recorded in a consistent manner and in a standard format. The information can be entered into the database that will be used to track the status and allow analysis of non-compliance situations.

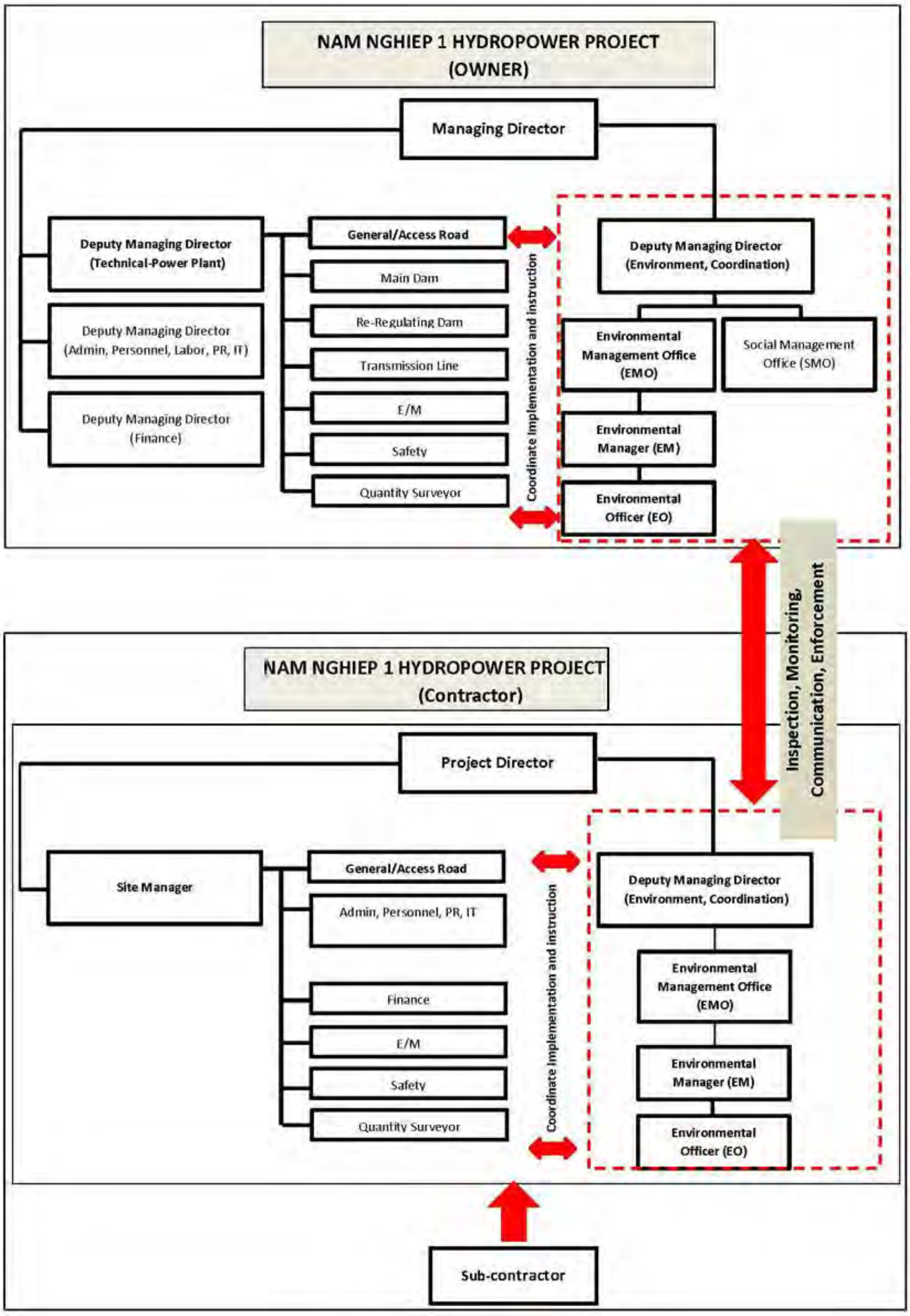
The technical details of the monitoring measures will be included in the ESMMP, SSEMP and Contractor's EMPs, including parameters, methods and sampling locations for the Project environmental aspects.

Monitoring activities complying with the applicable standards/guidelines will primarily concern water quality, air quality, noise and vibration. For ambient air, noise and water quality, sampling and analysis shall be carried out, relying on certified equipment and/or laboratories. Laboratory analysis will be provided by registered third party.

11.1.2 Periodic and Regular Monitoring by GOL and NNP1PC

To assure that NNP1PC, Contractors and Subcontractors comply with the environmental standards and safeguards, the GOL will establish an Environmental Management Unit (EMU) within the Ministry of Natural Resources and Environment (MONRE). NNP1PC will also establish an Environmental and Social Division, which will include an Environmental Management Office (EMO) as counterpart to the EMU. The institutional arrangements of the Project, including these organizations, is presented in ***Figure 11.1.***

Figure 11.1 Project Institutional Structure



The EMU will serve several functions on behalf of MONRE: coordinating with other GOL agencies involved in environmental aspects of the Project; carrying out inspections and monitoring compliance with the environmental measures, standards and safeguards by NNP1PC, Contractor, and Subcontractors; advising MONRE on environmental matters of the Project; and serving as liaison between the GOL and the Lao people (including without limitation PAPs) as well as any external organizations and agencies concerning environmental aspects of the Project. A key function will be to hold public consultations on environmental matters.

The EMO shall serve as the main arm of NNP1PC in assuring the Project follows the measures to prevent or mitigate adverse environmental impacts. EMO shall be central focal point, responsible for all environmental obligation of NNP1PC and for ensuring compliance with all the environmental standards and safeguards. The environmental monitoring plans shall be prepared for Contractors and Subcontractors, assuring these monitoring plans are implemented, and carrying out its own surveys and regular monitoring with proper documentation and reporting of the findings.

To effectively manage the environmental performance of the Project, the EMO will set up an Environmental Management System (EMS) to process and record all data generated from the monitoring program, including compliance issues, management decisions and corrective actions taken. Anticipated documentation to be filed in the system includes:

- Active and obsolete printed versions of the EMP, ESMMP-CP, ESMMP-OP, sub-plans and site plans;
- All site plans as approved by NNP1PC;
- All communications which have environmental implications;
- All environmental monitoring reports from EMO and the contractor's staff;
- Quarterly Reports;
- Complaints register;
- Training materials;
- Training attendance registers;
- Non-compliance special reports;
- Lao environmental legislation;
- Permits, legal documents and authorizing letters;
- Monthly site meeting minutes;
- Occupational Health and Safety (OH&S) reports; and
- Disciplinary procedures.

11.1.3 External Monitor

An external monitor will be engaged by the GOL, funded by NNP1PC, to conduct annual reviews of the effectiveness of the environmental measures carried out by the Project to ensure compliance with the contractual obligations. It is the responsibility of NNP1PC to provide available documentation, information and data requested by the auditor. The external monitor should have international experience in environmental auditing and monitoring.

Non-conformances or observations identified during audits will be subject to the provisions of corrective action. The audit report will be submitted to NNP1PC for implementation and action.

The external monitor should be engaged throughout the construction phase and for the first years of operations phase (at a much reduced level reflecting the significantly fewer environmental impacts during this phase), until the hydrological conditions and water quality have stabilized.

11.2 SPECIFIC MONITORING ACTIVITIES AND CRITERIA

Environmental Aspect	Monitoring Action	Frequency of Monitoring	Monitoring Criteria
WATER QUALITY MANAGEMENT & POLLUTION CONTROL			
Drinking water and water supply	Visual inspection of treatment facilities	Weekly	Cleanliness of system, etc.
	Visual inspection of water sources protection	Monthly	Location, distance to pollution sources, fencing, information signs
	Water quality Monitoring in residence and main worker camps	Weekly monitoring of potable water	Color, Odor, Free chlorine , Total coliforms, Fecal coliforms, Hardness, Turbidity, Iron, Manganese
		Every 6 months	Sulphate, Mercury, Copper, Lead, Arsenic, Cadmium
	Water quality random monitoring in temporary camps	Weekly monitoring of potable water	Same as above
	Visual inspection of treatment facilities and water protection sources	Twice a month	Cleanliness of facility, maintenance register review, availability of chemicals and spare parts
	Review Company monitoring data	Twice a month	Compliance with design criteria
	Random sampling of main camps and temporary camps when required	Monthly	Color, Odor, Free chlorine , Total coliforms, Fecal coliforms, Hardness, Turbidity, Iron, Manganese
Effluents	Routine sampling of treated effluents by operating Company	Weekly during wet season Monthly during dry season, based on observed discharge incidents	Temperature, pH, Suspended Solids (SS), DO, Fecal coliforms, Oil & Grease
	Visual Inspection of sedimentation/effluent pond	Weekly	Cleanliness of station, drainage of sludge and

Environmental Aspect	Monitoring Action	Frequency of Monitoring	Monitoring Criteria
	design, maintenance, etc.		screenings storage area, total infiltration of treated effluent
	Review of monitoring data	Weekly inspection by ESM	Compliance with effluent design criteria
	Random sampling of treated effluents	Bi-weekly during wet season Monthly during dry season, based on observed discharge incidents	Discharge, Temperature, pH, SS, Total coliforms, Fecal Coliforms , DO, COD, Oil & Grease
	Registration of sludge movements	When required	Visual observation ; Date & volumes of movements from station to disposal area and from septic tanks to station
	Review of sludge movements registration	Monthly	Date & volumes of movements; Cross check with landfill reception records
Worker camps (main)	Routine maintenance and monitoring of Company	Weekly	Cleanliness of camps and maintenance of drainage and sanitation facilities
	Registration of septic tank emptying operations	When required	Date of maintenance and facility concerned
	Visual Inspection of camps' waste water and rainstorm water drainage	Monthly	General cleanliness of camp; Collection and drainage of all water from sanitary facilities and canteens; Stormwater drainage
	Review of septic tank emptying operation register	Monthly	Date of maintenance and facility concerned
Workers Camps (temporary)	Routine maintenance and monitoring of Company	Weekly	Cleanliness of camps, maintenance of drainage and sanitation facilities
	Registration of maintenance	When required	Toilets regularly maintained
	Visual inspection of facilities and camps	Twice a month	Appropriate systems in place; Condition of toilets; Indication of defecation around the camp
	Review of maintenance register	Monthly	Date of maintenance and facility concerned
Construction areas	Visual inspection of implementation of pollution control measures	Daily/weekly	Refueling area and practice; Temporary storage of chemicals; Temporary storage of wastes
	Sampling of drainage water at area outlet	Weekly	SS, oil and fuel, FC
	Review of monitoring data	Monthly	SS, oil and fuel, Fecal Coliforms

Environmental Aspect	Monitoring Action	Frequency of Monitoring	Monitoring Criteria
	Random sampling of stormwater outlet	Bi-weekly during wet season Monthly during dry season, based on observed discharge incidents	pH, SS, Temperature, Fecal coliforms, DO, Oil & Grease
Maintenance areas (workshops, garages)	Visual inspection implementation of pollution control measures	Routine	Refueling area and practice; Bunded storage for HM as waste engine oil, grease, hydraulic oil; Stormwater design (hydro-carbon separation pit)
	Ensure presence and maintenance of spill response equipment kit according to products stored	Weekly	Presence of equipment according to standard; Procedures posted in the premises; Emergency response team identified and trained
	Registration of used waste generated	Daily registration by garages and workshops as concerned	Date and volumes
HYDROLOGY			
Spoil Disposal and Borrow area	Ensure spoil disposal areas located and designed in accordance with hydrological requirements	As required when delineating disposal site	Visual observation; Design and effective delineation of disposal site compared on map photo or GPS control
	Register claims from communities regarding flooding, etc.	As required	Location, Type of problem
	Ensure natural drainage respected or mitigated during earthworks and site development	Weekly	Visual observation
	Monitor spoil areas	Twice a month inspection	Visual inspection
	Record presence of impeded drainage and ponding or velocity increases	Twice a month inspection	Visual inspection
Erosion Control Measures	Ensure implementation of erosion control measures	Weekly	Visual observation; Design documentation
	Ensure implementation of sediment transport reduction measures	Weekly	Visual observation
	Monitor stormwater drainage from concerned areas	Twice a month	Suspended solids (SS)
Top soil	Ensure top soil properly	Weekly	Visual observation;

Environmental Aspect	Monitoring Action	Frequency of Monitoring	Monitoring Criteria
protection	managed and preserved for eventual use in restoration	during large excavation works; as requested thereafter	Design documentation
	Monitor application of design standards for erosion control and topsoil protection	Twice a month	Visual observation
BIODIVERSITY CONSERVATION			
Clearing	Ensure demarcation and tree marking for clearing and respect of clearing limits	Daily observation during clearing by Forestry Department	No. of trees
	Ensure log evacuation completed before work starts	Weekly	Visual observation
	Monitor clearing operations by Company to ensure no trees felled	As required	According to Project design and clearances given
Revegetation/ Compensatory Reforestation Program	Ensure revegetation done with native species GOL to identify areas for reforestation program within or outside the watershed area	As needed, control site and nursery	Species used not considered as exotic or invasive alien species
	Check species used	As needed	Species used are suitable
Wildlife Conservation and management	Ensure hunting ban respected	Daily observation	Control at check-points the transport of any dead or alive wild animal; Presence of hunting gear; Workers cooking wildlife meat
	GOL to identify areas for wildlife conservation and protection Delineate sensitive natural areas to be avoided and indicate by flagging	Random observation	Direct observation of non-avoidance by contractor staff
	Ensure all staff attended environmental awareness program	Random observation and review of training attendance register	Visual observation; At least 80% of workers on site at any time attended awareness program
	Monitor conservation efficiency	Direct random observation	Number of issues of non-compliance observed, including persons having not attended awareness program
	Weed monitoring	Random observation	Visual observation
CHEMICALS AND WASTE MANAGEMENT			
Non-Hazardous Waste Landfill	Visually inspect and evaluate, with emphasis on review of clay and/or synthetic liner permeability	Weekly	Design criteria
	Monitor maintenance and	Weekly	Access restricted, waste

Environmental Aspect	Monitoring Action	Frequency of Monitoring	Monitoring Criteria
	management of landfill		compacted, absence of hazardous waste, pest control effectiveness
	Visual inspection of leachate leakage	Rainy season	Pollution indicators
	Random sampling of well water and stormwater	Seasoning	Absence of pollution indicators
	Monitor landfill site cleanliness and management	Monthly	Visual inspection of facility
	Monitor slope stability of disposal	Weekly	Visual inspection
Garbage collection	Ensure regular collection of garbage	Weekly	Visual inspection and organization of unit
	Monitor effectiveness of garbage collection	Twice a month	Visual inspection during site visits, especially regarding equipment and presence of uncontrolled waste dumping sites along roads
Hazardous Waste	Ensure temporary storage sites comply with safety obligations	Weekly site inspection	Visual observation of Containers, labels, collection register, drainage water control, etc.
	Ensure appropriate HW registration and disposal of waste in accordance with obligations	Weekly	Registration, design of storage area (bunded and fenced area), container quality, labeling, spill response kits, safety procedures posted, workers in charge trained and PPE available
	Inspection of temporary and main HW disposal sites	Twice a month to monthly	Same criteria as directly above
Hazardous Chemicals	Ensure appropriate hazardous material registration, storage and handling in accordance with safety regulation	Weekly	Registration, design of storage area (bunded and fenced area), containers quality, labeling, spill response kits, safety procedures posted, workers in charge trained and PPE available
	Inspection of hazardous material management	Monthly	Same criteria as directly above
	Eventual safe disposal of hazardous wastes and chemicals	As required	According to national specifications and safeguards.
CULTURAL PROPERTIES			
	Ensure no cultural site, when notified prior to works, is disturbed without community agreement	When required	Visual observation; Documentation review and site visit
	Ensure procedure implemented if heritage artifacts discovered	When required	Visual observation; Notification to Owner; Effective application of decisions on site; Temporary fencing of zone

Environmental Aspect	Monitoring Action	Frequency of Monitoring	Monitoring Criteria
			and signs posted
	Monitor appropriate procedural implementation if heritage artifacts discovered	Daily to monthly (risk based) checks at identified sites	Effective suspension of works; Temporary fencing of zone and signs posted; Subsequent conservation measures implemented
ACCESS TO SITE AND ROAD SAFETY			
Traffic and Access	Ensure implementation of road signs and speed reduction bumps	Daily observations	Visual observation; Compliance with design
	Ensure respect of signs and speed limits and parking areas by Project drivers	Daily observations	Register any observed non-compliance on Project roads and on public roads
	Check road signs and observe respect of speed limits and parking areas	Daily observations	Direct observation; Number of non-compliances observed in a month
	Ensure trucks and vehicles appropriately maintained (engine, breaks, tires, lamps)	Daily observation and registration of vehicles' service maintenance	Non-conformity observed on the road; Register of truck/car maintenance for sub-contractors
	Ensure truck load not overweight, stabilized and covered if bulk	Daily observation	Non-conformity observed on the road, registered with plate number and driver's name
	Monitoring of traffic safety	Daily observation, random control point once a month	Direct observation, systematic control regarding truck condition and load, and identified use of alcohol or drugs by drivers
	Ensure watering of roads is provided in residential areas and in dangerous/dusty road sections to limit dust emission	Daily observation in dry season	Visual observation; Number of watering /day; Number of watering trucks
	Registration of driving training attendance	Monthly	Visual observation; At least 80% of drivers on site at any time attended driving training
Barriers	Ensure all areas of works and contractor compounds are adequately fenced	Weekly	Visual inspection
WORKERS' HEALTH AND SAFETY			
Health awareness program	Ensure all workers attended awareness program	Weekly	Registration of training attendance
	Review training register to confirm employee training	Twice a month or monthly depending on turnover of worker	At least 80% of staff at any time has received training
STD and AIDS prevention program	Ensure program implemented	Bi-monthly	At least 80% of staff at any time has received induction course;

Environmental Aspect	Monitoring Action	Frequency of Monitoring	Monitoring Criteria
			Posters printed and posted; Leaflet printed and distributed; Prophylactics available and number distributed
Pre- employment and annual medical checks	Ensure pre-employment and routine annual medical checks for all staff, with particular emphasis on checking for respiratory illness and STDs	Monthly	Visual observation; Number of pre-employment checks; Number of routine annual checks; Statistics of disease incidence
	Review registers	Quarterly	Number of medical checks compared to number of staff recruited
Medical facilities	Ensure medical facilities implemented, equipped and appropriately staff	Monthly	Visual observation; Staff and equipment available per facility; Number of consultations registered
	Monitor efficiency and cleanliness of medical facilities	Monthly	Visual observation; Inspection of medical supplies and sterile procedures
Vector control	Ensure measures implemented in worker camps and in construction sites	Weekly	Camps' inspection for hygiene; Awareness posters posted in camps and on working places; Medicine for treatment available to staff; Prevalence statistics
	Monitor enforcement of control and effects	Monthly	Visual observation from camps inspection; Review of medical register
Hygiene related disease control	Ensure effective implementation of reporting of water-borne diseases and food- borne illness reporting, investigation and remediation procedures	Weekly	Visual observation; Number of cases and events; Implementation of sanitation and waste management practices; Observation of good personal hygiene practices
OCCUPATIONAL HEALTH AND SAFETY			
First Aid Training and Field Implementation	Ensure Foremen and key personnel of "at risk" activities received first aid training	Monthly	Registration of personnel attending training and subsequent job affectation; Ensure responsible staff for explosive chemical and hazardous waste management has attended training
	Ensure first aid kits available and fully supplied	Weekly	Review of equipment and location
	Monitor first aid equipment and capacity	Quarterly	Visual observation of equipment; Review register of first aid training attendance
Injury / Illness	Verify implementation of	Monthly	Register and compile injuries

Environmental Aspect	Monitoring Action	Frequency of Monitoring	Monitoring Criteria
reporting	occupational injury and illness reporting procedure		and illness (occupational)
	Review OH&S efficiency	Quarterly	Review register of occupational injuries and illness for percentage of change from previous quarter
Safety procedures	Verify availability and use of appropriate equipment and procedures	Monthly	Visual observation of procedure posters in key sites: hazardous material storage, explosive storage, construction sites, garages, sticker in trucks, etc.
	Verify adequate signage and barricades in hazardous construction zones	Daily during field visits	Visual observation
	Review OH&S accident prevention activities	Quarterly	Visual observation and questioning of workers during site inspection; Number of non-compliance issues detected, and trends
Community Relations			
Community liaison	Ensure participation of community / leaders in all monitoring activities which directly affect them	Bi-monthly	Regular contact with individuals and community leaders recorded
	Check employment opportunities	Monthly	Ensure APs are given the opportunity to provide labor or services to the Project if they so wish (monitored through community liaison)
Grievance Redress	Ensure function of grievance redress mechanism	Monthly	Grievance Redress process is implemented as designed, and grievances and complaints being heard
	Check Grievance Register	Twice a month	Ensure all grievances recorded have been subject to a prompt response
Compensation	Ensure disbursement of funds	Twice a month	Ensure all funds and actions for compensation have been disbursed/executed by the Project by liaising with communities
Security	Check police records	Twice a month	Inspect police reports of Project related security issues. Ensure that women's security is adequately catered for.
Migrant Labor	Check eligibility	Weekly	Ensure no child labor is utilized by inspection of site and employment records
	Monitor dependents	Weekly	Ensure living conditions of dependents are acceptable to the Project by site inspection

Environmental Aspect	Monitoring Action	Frequency of Monitoring	Monitoring Criteria
Fuel	Check that Company is providing cooking fuel to workers and their families	Weekly and Monthly	Visual inspection of camps; Inspection of Company fuel purchase
Shelter	Check quality of accommodation at camps	Twice a month	Ensure no un-authorized indigenous materials are used for building by visual inspection and check of Company purchase orders; Ensure provision of separate single and married quarters by visual inspection
Facilities	Check for presence of acceptable sanitation, washing and bathing facilities	Monthly	Ref. water quality parameters above; Ensure no washing and bathing directly in water courses or discharge of wastewater directly to streams, etc.; Visual inspection
Personal Safety Equipment	Ensure all workers adequately equipped with PPE]	Routine	Visual inspection to determine use of proper footwear, hard hats, goggles/masks, gloves etc., where required. Refer to Appendix H, Section SP17.

12 BUDGET FOR ENVIRONMENTAL ISSUES

12.1 INTRODUCTION

The budget for environmental issues of the Project is addressed in *Concession Agreement Annex C: Environmental and Social Obligation*, which includes indicative environmental and social obligation budgets for the following Project phases: 1) before commercial operation date (COD), which includes 1 year for pre-construction and 6 years for construction phase, and 2) after COD, which includes the initial years (1-8 years) of the operation phase.

The summary of budget proposed in *Concession Agreement Annex C* is shown in ***Table 12.1***, and the detailed 10 year indicative budget is shown in ***Table 12.2.***

Table 12.1 Summary of Environmental and Social Obligation Budgets

Item		Budget before COD (USD)	Budget after COD (USD)	Total Budget (USD)
1	Resettlement site development cost	15,534,990	0	15,534,990
2	Compensation cost	3,580,024	0	3,580,024
3	Livelihood restoration	3,231,068	1,380,206	4,611,274
4	ESD, EMU, PRLRC, RMU operation and working group	9,000,550	2,076,950	11,082,500
5	Environmental management cost*	2,803,189	3,437,000*	6,240,189
6	Watershed Management cost**	367,076	1,809,844	2,176,920
	Sub-total	34,521,896	8,704,000	43,225,896
7	Independent Advisory Panel	1,396,904	181,903	1,578,807
8	Fund	3,595,020	4,110,000	7,705,020
	Grand total	**39,513,820**	**12,995,903**	**52,509,723**
	Contingency	3,452,190	870,400	4,322,590

Note : * The estimated budget of 27 years of operation phase after COD.
** Note that the money allocated to the Watershed Management Cost has been allocated biodiversity offset management cost.

Table 12.2 Detailed of 10 Years Indicative Budgets

Item		10 Years Budgets (USD)							
		Pre	C1	C2	C3	C4	C5	C6	O1-O3
1	Resettlement site development cost	0	0	0	7,767	7,767	0	0	0
2	Compensation cost	0	0	0	1,790	1,790	0	0	0
3	Livelihood restoration		87	87	260	144	1,620	1,033	1,380
4	ESD, EMU, PRLRC, RMU operation and working group	186	2,112	1,312	1,402	1,307	1,398	1,289	2,077
5	Environmental management *	792	329	284	284	404	405	307	3,437
6	Watershed management cost**	0	32	67	67	67	67	67	1,810
	Sub-total	**978**	**2,559**	**1,749**	**11,570**	**11,479**	**3,491**	**2,696**	**8,704**
7	Independent Advisory Panel	431	284	136	136	136	136	136	182
8	Fund	0	1,479	489	407	407	407	407	4,110
	Grand total	**1,408**	**4,322**	**2,374**	**12,113**	**12,023**	**4,034**	**3,239**	**12,995**

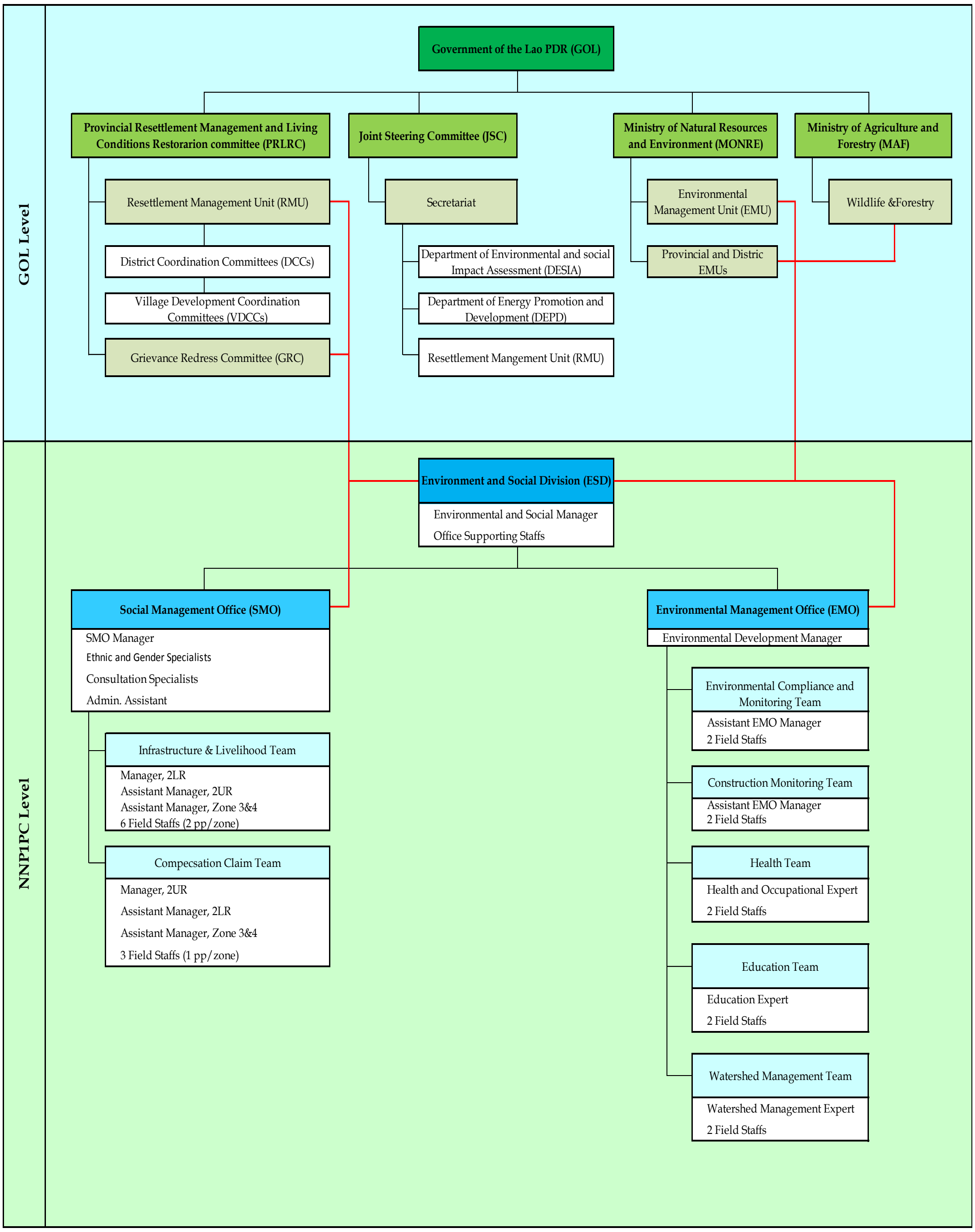
Note : * The estimated budget of 27 years of operation phase after COD.
** Note that the money allocated to the Watershed Management Cost has been allocated biodiversity offset management cost.

An indicative budget is presented for the environmental management and monitoring of the Nam Ngiep 1 Hydropower Project (NNP1). There are four components to this budget, as follows:

- An estimate of the personnel and operating costs for the Environmental and Social Division of the NNP1 Project (***Table 12.3***), following the Project organization charge of the NNP1PC level, as shown in ***Figure 12.1***.
- Estimated costs for the Environmental Management Unit (***Table 12.4***).
- Estimated program budget for the various activities to be conducted under the Environmental Management Plan as mention in *Chapter 10* (***Table 12.5***) that ware estimated during construction phase and 27 years of operation phase.
- Estimated budget for the Biodiversity Offset Management (including Watershed Management), as detailed in *Appendix B* (***Table 12.6***).

Budgets will be re-evaluated regularly to suit realignment of NNP1 organization, operation unit and updating of environmental management plan. The new proposed budgets shall be consistent at least with the budgets proposed in *Appendix 3 of Annex C of Concession Agreement.*

Figure 12.1 NNP1PC Level of Project Organization Charge



Source: Appendix 5 of Annex C of Concession Agreement

12.2 *Indicative budget for Environmental Management and Monitoring of the Nam Ngiep 1 Hydropower Project*

12.2.1 *Personnel and Operating Costs*

Table 12.3 Personnel and Office Operation Costs

ESD Personnel														
ESD	**Monthly salary**	**No. people**	**Total/ month**	**Pre**	**C 1**	**C 2**	**C 3**	**C 4**	**C 5**	**C6**	**O 1**	**O 2**	**O 3**	**Total**
Environmental and Social Manager	12,500	1	12,500		150,000	150,000	150,000	150,000	150,000	150,000				900,000
Central Budget - Consultants/Part Time	2,500	1	2,500		30,000	30,000	30,000	30,000	30,000	30,000	30,000	30,000	30,000	270,000
Secretary	400	2	800		9,600	9,600	9,600	9,600	9,600	9,600	4,800	4,800	4,800	72,000
A. Social Management Office:														
Social Management Director	3,000	1	3,000		36,000	36,000	36,000	36,000	36,000	36,000	36,000	36,000	36,000	324,000
Infrastructure and Livelihood														
Manager, 2LR	2,000	1	2,000		24,000	24,000	24,000	24,000	24,000	24,000	24,000	24,000	24,000	216,000
Assistant Manager , 2UR	1,500	1	1,500		18,000	18,000	18,000	18,000	18,000	18,000	18,000	18,000	18,000	162,000
Assistant Manager, Zone 3&4	1,500	1	1,500		18,000	18,000	18,000	18,000	18,000	18,000		0	0	108,000
6 field staff (2pp/zone)	700	6	4,200		50,400	50,400	50,400	50,400	50,400	50,400	50,400	50,400	50,400	453,600
Compensation Claim Team														
Manager, 2UR	2,000	1	2,000		24,000	24,000	24,000	24,000	24,000	24,000				144,000
Assistant Manager , 2LR	1,500	1	1,500		18,000	18,000	18,000	18,000	18,000	18,000				108,000
Assistant Manager, Zone 3&4	1,500	1	1,500		18,000	18,000	18,000	18,000	18,000	18,000				108,000
3 field staff (1 pp/zone)	500	3	1,500		18,000	18,000	18,000	18,000	18,000	18,000				108,000
B. Environmental Management Office														
Environmental Development Manager	3,000	1	3,000		36,000	36,000	36,000	36,000	36,000	36,000	36,000	36,000	36,000	324,000
Construction Monitoring Team														
Assistant EMO Manager	1,500	1	1,500		18,000	18,000	18,000	18,000	18,000	18,000				108,000
2 field staff	500	2	500		6,000	6,000	6,000	6,000	6,000	6,000				36,000
Environmental Monitoring Team														
Assistant EMO Manager	1,500	1	1,500		18,000	18,000	18,000	18,000	18,000	18,000	18,000	18,000	18,000	162,000
2 field staff	500	2	1,000		12,000	12,000	12,000	12,000	12,000	12,000	12,000	12,000	12,000	108,000
Consultant														0
Health and Occupational Safety Team														

ESD Personnel

ESD	Monthly salary	No. people	Total/ month	Pre	C 1	C 2	C 3	C 4	C 5	C6	O 1	O 2	O 3	Total
Health and Occupational Expert	1,500	1	1,500		18,000	18,000	18,000	18,000	18,000	18,000				108,000
2 Field Staff	500	2	1,000		12,000	12,000	12,000	12,000	12,000	12,000				72,000
Education Team														
Education Expert	1,500	1	1,500		18,000	18,000	18,000	18,000	18,000	18,000				108,000
2 field staff	500	2	1,000		12,000	12,000	12,000	12,000	12,000	12,000				72,000
C. Office staff														
Accountant (Assistant Manager)	800	1	800		9,600	9,600	9,600	9,600	9,600	9,600				57,600
Accountant	500	1	500		6,000	6,000	6,000	6,000	6,000	6,000				36,000
Driver	300	6	1,800		21,600	21,600	21,600	21,600	21,600	21,600	7,200	7,200	7,200	151,200
House Keeper	300	6	1,800		21,600	21,600	21,600	21,600	21,600	21,600	7,200	7,200	7,200	151,200
TOTAL ESD PERSONNEL		50	54,400		622,800	622,800	622,800	622,800	622,800	622,800	231,600	231,600	231,600	4,467,600

ESD OFFICE OPERATING COSTS

OFFICE OPERATING COSTS	Cost/ unit	No. units	Total/ month	Pre	C 1	C 2	C 3	C 4	C 5	C 6	O 1	O 2	O 3	Total
Office Operating Costs	1,000	1	1,000		12,000	12,000	12,000	12,000	12,000	12,000	4,000	4,000	4,000	**84,000**
Vehicle Operating and Maintenance Costs	1,000	6	6,000		72,000	72,000	72,000	72,000	72,000	72,000	24,000	24,000	24,000	**504,000**
Motorcycle Operating &Maintenance Costs	100	10	1,000		12,000	12,000	12,000	12,000	12,000	12,000	4,000	4,000	4,000	**84,000**
Communications: radio/etc.	1,000	1	1,000		12,000	12,000	12,000	12,000	12,000	12,000	4,000	4,000	4,000	**84,000**
Stationery and consumable	3,000	1	3,000		36,000	36,000	36,000	36,000	36,000	36,000	12,000	12,000	12,000	**252,000**
Travel Costs for Staff to and from site	35	400	14,000		168,000	168,000	168,000	168,000	168,000	168,000	56,000	56,000	56,000	**1,176,000**
TOTAL OFFICE OPERATING COSTS					**312,000**	**312,000**	**312,000**	**312,000**	**312,000**	**312,000**	**104,000**	**104,000**	**104,000**	**2,184,000**

ESD Office and Staff's Dormitory Building and Office Equipment

Description	Cost/ unit	No. Units	Total	Pre	C 1	C 2	C 3	C 4	C 5	C 6	O 1	O 2	O 3	Total
Office Building (Base Camp)	126,000	1	126,000		126,000									**126,000**
Office Furniture and Equipment	0	1	0		0	5,000	5,000	5,000	3,000	2,000	2,000	2,000	2,000	**26,000**
Computer, Laptop, Printer, etc	50,000	1	50,000		50,000	5,000	5,000	5,000	3,000	2,000	2,000	2,000	2,000	**76,000**
Staff Dormitory Building	54,000	2	108,000		108,000									**108,000**
Furniture Dormitory	0	1	0		0	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	**24,000**
2 UR Office Rental	500	12	6,000		6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	**54,000**

ESD OFFICE OPERATING COSTS														
2 LR Office Rental	500	12	6,000		6,000	6,000	6,000	6,000	6,000					**30,000**
Pakxan Office	2,000	12	24,000		24,000	24,000	24,000	24,000	24,000	24,000	24,000	24,000	24,000	**216,000**
Total					**320,000**	**49,000**	**49,000**	**49,000**	**45,000**	**37,000**	**37,000**	**37,000**	**37,000**	**660,000**
Vehicles	**Cost/unit**	**No. Units**	**Total**	**Pre**	**C 1**	**C 2**	**C 3**	**C 4**	**C 5**	**C 6**	**O 1**	**O 2**	**O 3**	**Total**
Vehicles: 4 Wheel Drive	30,000	6	180,000		180,000									
Motorcycles	3,000	10	30,000		30,000									
Total Vehicles					**210,000**									
Total					530,000	49,000	49,000	49,000	45,000	37,000	37,000	37,000	37,000	
Grand Total	7,755,600													

12.2.2 Environmental Management Unit

Table 12.4 Support to EMU

EMU	Cost/day	Number	No. Days/ Time	C 1	C 2	C 3	C 4	C 5	C6	O 1	O 2	O 3	Total
EMU Personal	50	10	9	4,500	4,500	4,500	4,500	4,500	4,500	4,500	4,500	4,500	**40,500**
Accommodation	20	10	6	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200	**10,800**
Transportation (Car+fuel+driver)	150	3	9	4,050	4,050	4,050	4,050	4,050	4,050	4,050	4,050	4,050	**36,450**
Meeting Room Fee	500	1	3	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	**13,500**
TOTAL EMU				**11,250**	**11,250**	**11,250**	**11,250**	**11,250**	**11,250**	**11,250**	**11,250**	**11,250**	**101,250**

12.2.3 Environmental Management and Monitoring Activities

Table 12.5 Environmental Management and Monitoring Program Budget

Item		Unit	No. year	Unit Price	Amount	Pre-Cons.	C1	C2	C3	C4	C5	C6	O1	O2	O3	O4-O8	>O8
EMP Budget for Physical Impacts																	
1	Land slide and seismicity monitoring	Yearly	-	-													
2	Erosion and sediment																
2.1	Sediment monitoring	Yearly	16	5,000	80,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	25,000	5,000
2.2	Soil erosion and sedimentation control	Yearly	16	5,000	80,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	25,000	5,000
3	Water quality																
3.1	Monthly water quality monitoring program	Monthly	6	10,000	60,000		10,000	10,000	10,000	10,000	10,000	10,000					
3.2	Biweekly water quality monitoring program	Biweekly	8	19,700	157,600								19,700	19,700	19,700	98,500	
3.3	Seasonal water quality monitoring program	3 times per year	33	5,300	174,900		5,300	5,300	5,300	5,300	5,300	5,300	5,300	5,300	5,300	26,500	00,700
3.4	Groundwater quality monitoring	Every 3 year until 8th year of OP	3	5,000	15,000								5,000			10,000	
4	Water level monitoring																
4.1	Setting up stations	once	1	30,000	30,000	30,000											
4.2	Water level monitoring and report	Yearly	33	1,000	33,000		1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	5,000	19,000
5	Flood warning																
5.1	Installation flood warning system 3 stations	once	1	15,000	15,000		15,000										
5.2	Flood training program	Yearly	33	2,000	66,000		2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	10,000	38,000
6	Vegetation clearing plans																
6.1	Timber Logging	Total area	1	527,124	527,124		87,854	87,854	87,854	87,854	87,854	87,854					
6.2	Vegetation clearing	Total area	1	64,866	64,866		10,811	10,811	10,811	10,811	10,811	10,811					

Item		Unit	No. year	Unit Price	Amount	Pre-Cons.	C1	C2	C3	C4	C5	C6	O1	O2	O3	O4-O8	>O8
6.3	Weed and pest	Yearly	14	12,000	168,000		12,000	12,000	12,000	12,000	12,000	12,000	12,000	12,000	12,000	60,000	
7	Air quality, noise and vibration monitoring																
7.1	Noise and vibration monitoring program	Monthly	6	5,000	30,000		5,000	5,000	5,000	5,000	5,000	5,000					
7.2	Air quality monitoring program	Monthly	6	10,000	60,000		10,000	10,000	10,000	10,000	10,000	10,000					
8	Site contamination monitoring	At least weekly	6	10,000	330,000		10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	50,000	190,000
9	Soil fertility monitoring	Every 2 year until 8th yr of OP	3	10,000	40,000								10,000		10,000	20,000	
10	UXO survey and disposal	once		600,000	600,000	200,000	200,000	200,000									
EMP Budget for Biological Impacts																	
11	Wildlife protection program	Yearly															
13	Wildlife conservation awareness	Yearly		12,000	168,000		12,000	12,000	12,000	12,000	12,000	12,000	12,000	12,000	12,000	60,000	
14	Wildlife protection	Yearly		30,000	90,000		30,000	30,000	30,000								
	Total Budget of EMP				2,789,490	240,000	420,965	405,965	05,965	175,965	175,965	175,965	87,000	72,000	82,000	390,000	357,700

12.2.4 *Biodiversity Offset Management*

Table 12.6 Biodiversity Offset Management Budget

The following proposed budget for the offset program has been derived from *Concession Agreement Annex C: Environmental and Social Obligation* for the management of watershed and biodiversity related items. As discussed in the Biodiversity Offset Report, it is recommended that money is invested by NNP1 and offset management work is undertaken using the returns on those invested funds. Further discussion on the allocation of budget items is required to occur to agree on the reallocated budget amounts.

Item	Description	Investment Allocation	Annual Return on Investment*
Administration (3-5% of total capital)	Funds allocated to MONRE, PONRE and the NNP1 Offset Committee to establish and administer the biodiversity offset.	$690,000	$41,400
Forested and riverine areas of the PKK NPA	Funds allocated to protect and enhance the biodiversity values of the NPA.	$4,355,000	$261,000
Forested and riverine areas of the Nam Ngiep Watershed	Funds allocated to protect terrestrial and aquatic biodiversity values of the watershed.	$4,355,000	$261,000
Watershed management activities within the Nam Ngiep watershed	Funds allocated to perform watershed management activities within the reservoir and below the dam wall.	$4,355,000	$261,000
	Totals:	**$13,755,000.00**	**$824,400.00**

Note: * *Assumes an inflation adjusted 6% investment return per annum*

13 INSTITUATIONAL ARRANGEMENTS

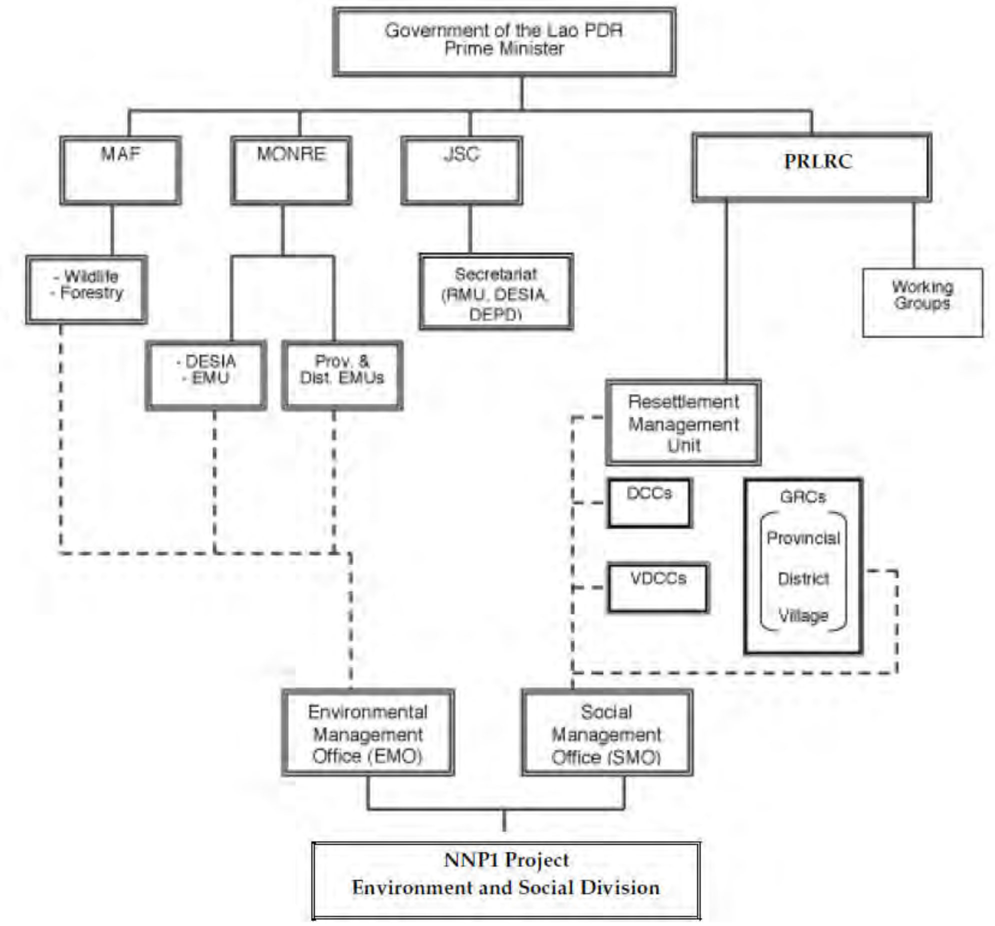
While it is the responsibility of the Project owners and developers to mitigate any adverse environmental impacts and to assure environmental conditions will enhance the lives and livelihoods of the people in the Project area, it is the responsibility of the government to monitor the effectiveness of the mitigation measures, to facilitate public participation and involvement, and to assure the rights and the livelihoods of the people affected by the Project are protected. To the extent possible, mitigation measures and development activities are to be carried out through or with the cooperation of the government at the local, district, provincial and national levels.

The institutional arrangements for the NNP1 build upon existing institutional structures that have been established for hydropower Projects or that otherwise concern environment or social issues relating to this Project. The institutional arrangements are intended to provide the means to implement the environmental and social mitigation measures, development activities, and monitoring most effectively, while also building the capacity of local residents, administrative organizations, and government agencies.

The institutional arrangements are also set up in to facilitate the concerns and needs of the Project stakeholders. This includes a framework for ongoing stakeholder consultation and participation and a mechanism to resolve grievances that may arise.

The institutional arrangements are presented in ***Figure 13.1***. This includes government structures and Project level structures that have or will be established as part of the Project. Each of these structures is described in further detail in this chapter.

Figure 13.1 Overall Institutional Arrangements



13.1 GOVERNMENT INSTITUTIONAL ARRANGEMENTS

The following section describes the institutional arrangements that will be established by the GOL.

13.1.1.1 *Joint Steering Committee*

The roles of the GOL at the national level will be provided through the Joint Steering Committee (JSC) and the Ministry of Natural Resources and Environment (MONRE) as the primary supervisory and monitoring body. A Secretariat of the JSC will include key government agencies and organizations involved in the environmental and social components of the Project, specifically the Department of Environmental and Social Impact Assessment (DESIA) of MONRE, the Department of Energy Promotion and Development (DEPD) of the Ministry of Energy and Mines, and the Resettlement Management Unit (RMU) established for this Project.

13.1.1.2 *Environmental Management Unit*

An Environmental Management Unit (EMU) will be established in MONRE to oversee the implementation and monitoring of environmental components of the Project. Environmental components will be carried out by relevant government agencies in MONRE and in the Ministry of Agriculture and Forestry (MAF). Provincial and District EMUs will be established, consisting of the heads of the relevant government offices for the various environmental aspects of the Project.

EMU staff will be engaged full time on this Project. They can be seconded from other offices or engaged on a contract basis.

Provincial EMUs will be established in each of the provinces affected by the Project, and District EMUs will be established in each of the districts affected by the Project, to assist the EMU in monitoring the environmental impacts and the mitigations measures of the Project.

The Environmental Management Unit in the central office will consist of the following staff:

- The Director of the EMU will be the Director-General of the DESIA of MONRE;
- Personnel from the Financial and Planning Division of MONRE; and
- Personnel from other divisions of MONRE as required.

The number of staff will be kept to a reasonable number, only as required, and only for the period that is required.

The primary tasks of the EMU are to:

- Review and make recommendations on the environmental management plans (EMPs);
- Monitor the implementation of the EMPs (both during construction and during operation), through independent and joint field monitoring and inspection;
- Monitor compliance with the safeguards and environmental obligations of the Project;
- Monitor all environmental and labour grievances;
- Inspect and identify measures to solve environmental and labour issues created by the Project;
- Coordinate with central and local government agencies in the implementation of the EMPs;
- Review environmental reports produced by the Project; and
- Recommend the selection of an independent monitoring agency (IMA) for environmental matters, and coordinate work of the IMA on environmental matters.

The central EMU will also provide direction to the provincial and district EMUs in regards to field monitoring and the implementation of environmental mitigation and prevention measures.

The EMU will continue to function for the first three years of operations, to assure the Project's continued monitoring of environmental conditions and continued compliance with environmental safeguards and obligations.

13.1.1.3 Provincial Resettlement and Livelihood Restoration Committee

A Provincial Resettlement and Livelihood Restoration Committee (PRLRC) has been established to be the lead organization in approving policies and plans, entitlements, and activities, and supervising and monitoring the implementation of social measures, including resettlement, and to provide the mechanism for public involvement, for decisions on compensation, and for the expression and resolution of grievances.

As the majority of resettlement activities will be in Bolikhamxay Province, the chairperson of the PRLRC will be the Governor of Bolikhamxay Province. The Vice Governors of Vientiane and Xieng Khouang Provinces will serve as vice-chair persons. Other members will be District Heads of all the Districts affected by the Project, Directors of the relevant Provincial government offices, and a representative from the Lao Front for National Reconstruction. The Head of the RMU will serve as Secretary to the Committee.

Although the main work of the PRLRC involves resettlement and other social issues, it is inevitable that it must also deal with environmental matters that affect the people in the Project areas. Some of these are:

- Assuring GOL agencies assist with the proper use of land for agriculture and other uses by the resettled communities and by others in the Project area, so as to limit any detrimental impacts on the Project;
- Assuring GOL agencies provide adequate protection of the forests by the resettled communities and other communities in the Project area; and
- Assuring GOL agencies help monitor fish and other aquatic life in the Nam Ngiep and its tributaries, and provide assistance if the Project has any harmful impacts on fish or other aquatic life used by the local residents for food and/or their livelihoods.

The PRLRC will continue to function for the first three years of operations, when resettlement works are to be completed.

13.1.1.4 Resettlement Management Unit

A Resettlement Management Unit (RMU) has been established by the PRLRC. The RMU administers the resettlement, compensation, livelihood restoration, and other social development activities associated with the Project. A list of according activities has been outlined in the *Appendix 2 of Annex C of Concession Agreement*.

The RMU will be headed by a Manager, who should have with first-hand experience with resettlement, compensation and rural development issues. Three (3) RMU Co-Coordinators shall be senior qualified officials, one from each Province (Bolikhamxay, Vientiane, and Xieng Khouang), with first-hand experience with resettlement, compensation and rural development issues, and selected from GOL line agencies at the provincial level, to work under the direction of the RMU Manager and coordinate the implementation of the social measures in their respective provinces. RMU Members will be selected from GOL line agencies at the provincial level, with other technical staff contracted to assist as needed with the implementation of the social measures.

As with the PRLRC, the RMU is responsible mainly for resettlement and related social matters. However, it will also be concerned with environmental matters as they affect the lives and livelihoods of the people in the Project area, and as the environment is potentially affected by actions of the resettled communities and by other communities in the Project area.

13.1.1.5 District Coordination Committees

The PRLRC will establish District Coordination Committees (DCC) on recommendation of the RMU in districts affected by the Project. The DCCs will work under the supervision of the PRLRC and the RMU, and in cooperation with the Social Management Office (SMO). The DCCs will help implement the various registration surveys, resettlement, compensation, livelihood restoration, and other social development works of the Project.

The DCCs will consist of the District Governor, as Chairperson, and representatives from the District Natural Resources and Environment Office, the District Public Works and Transportation Office, the District Agriculture and Forestry Office (DAFO), the District Health Office, the District Education Office, the District Information, Culture and Tourism Office, the District Labour and Social Welfare Office, Police, Militia and Army, the Lao Youth Union, the Lao Women Union (LWU), Lao Front for National Construction (LFNC), and other contract staffs required.

13.1.1.6 Village Coordination Committees

The DCCs will establish Village Development Coordination Committees (VDC) as necessary in those villages affected by the Project. With the support of the Social Management Officer and DCCs, the VDCs shall be the implementing body for the management and implementation of the resettlement, livelihood restoration, and other social development works and activities. The VDCs are expected to represent the villagers in the affected areas, and to voice their concerns and assure their needs are met.

The VDCs will consist of the Head of the Village as Leader of the committee, and village authorities (Mass organizations, public security, defense, etc.), village elder representatives (Naew-Home), Lao Women's Union representatives, other skilled members of the community, representatives of all ethnic groups, and representatives of all vulnerable groups, as members.

13.2 *PROJECT INSTITUTIONAL ARRANGEMENTS*

At the Project level, the Project owners will establish an Environment and Social Division (ESD) of the Project. The ESD will consist of:

- an Environmental Management Office (EMO), to enable the Project to meet all its environmental obligations; and
- a Social Management Office (SMO) to enable the Project to meet all of its social obligations.

The ESM's role will be to ensure that the mitigation and monitoring measures are implemented and that the standards in the schedules of the EMPs, SDP, and REMP and those that are also applicable to the construction and operation of the Project are applied. Among the ESD's responsibilities will be to:

- Manage the environmental, social, economic and resettlement components, using consultant inputs as required;
- Monitor and report to the developer on the effectiveness of implementation of the mitigation measures, social development activities, and resettlement program;
- Coordinate activities during construction and after construction with relevant government agencies, with the aim of improving the environmental performance of the Project during its operating phase; and
- Detect breaches of the standards during compliance monitoring and mitigation measures and resolve the problems. Report on the outcome.

The ESD will act as the first point of contact for the EMU and other offices of MONRE and indirectly (through the EMU and MONRE) for all other government agencies or offices, corporations, or NGOs involved in the mitigation of environmental, social, and economic impacts of the Project and/or sustainable economic and social development of the people affected by the Project. The ESD will be the main contact between the Project developer and the Projected affected people concerning environmental matters.

An Environmental and Social Deputy Managing Director (DMP) will be appointed to head the ESD on a full time basis. The DMP will closely work with the SMO and EMO Managers, which are responsible for the work of the respective offices. The DMD will report directly to the NNP1 managing director.

The role of the DMP will be to ensure that the mitigation and monitoring measures are implemented and that the standards in the schedules of the

EMP, Social Development Plan (SDP), and Resettlement and Ethnic Minority Development Plan (REDP) and those that are also applicable to the operation of the Project are applied. Breaches of the standards detected during compliance monitoring and mitigation measures undertaken to resolve the problem and the success or otherwise of these measures will be reported to the NNP1 managing director.

13.2.1.1 Environmental Management Office

The major tasks of the Environmental Management Office (EMO) are to:

- Collect the baseline data and information and conduct subsequent monitoring of all aspects of the environment and labour that could be affected by the Project, such as fish and other marine resources, hydrology, water quality, river bank erosion, forest cover, etc.;
- Coordinate with the EMU and other GOL agencies to implement the mitigation measures in the EMP; and
- Assist the EMU in public consultations on environmental matters with stakeholders.

The EMO will include an environmental monitoring team and a construction monitoring team. The environmental monitoring team will be responsible for:

- Carrying out as planned the daily, weekly or monthly monitoring of various environmental and labour conditions;
- Preparing reports for the ESD Manager to present to the appropriate government agencies for the timely management of the environment in the Project area; and
- Coordinating with the EMU and other GOL agencies in the implementation of mitigation and prevention measures.

The construction monitoring team is responsible for:

- Preparing detailed plans with the contractors on the management and mitigation of environmental aspects of different construction sites, including access roads and transmission lines;
- Ensuring the contractors provide adequate environmental facilities and management for the work sites;
- Monitoring safety of the workers in the work sites; and
- Preparing draft Environmental Instructions for environment management, for consideration by the Environment Working Groups and EMU, to be followed by all contractors and sub-contractors in the Project.

Additional roles and responsibilities may be assigned as part of an EMP. This includes the roles and responsibilities that are implemented by contractors or subcontractors.

The Environmental Management Office (and its teams) will continue to function throughout the first three years of the operation phase, but in gradually reduced numbers and roles, eventually with only the Environmental Compliance and Monitoring Team, which will then become included as part of the regular operations staff. The only exception is the construction monitoring team, which will conclude its activities at the end of construction.

13.2.1.2 Social Management Office

The Social Management Office (SMO) will work directly with the PRLRC and the RMU to provide technical and financial assistance in all infrastructure development and in the provision of all livelihood planning and programs, as well as in the implementation and monitoring of the relocation process for households in the new resettlement areas. Together with the RMU, it will carry primary responsibility for livelihood restoration and improvement for the new and adjacent villages. In addition, it will coordinate with the RMU in all compensation and relocation issues related to Project Construction Lands.

The SMO will be headed by a Manager with proven resettlement implementation experience, who will report directly to the ESD Manager, and work closely with the RMU and other GOL support staff. The SMO will consist of three sections.

The infrastructure section will work with the RMU to provide technical and financial assistance in all infrastructure development. The tasks of the team in the infrastructure section will be as follows:

- Ensure access to new sites/adjacent villages through the construction of new bridges and roads; and rehabilitation or upgrading of existing transportation facilities;
- Develop low land paddy fields with organized irrigation system and non-acid soil;
- Ensure effective water supply is provided to all new sites/adjacent villages, through the installation of wells and piping systems;
- Ensure irrigation is well constructed and water is available when appropriate and operational at new sites/adjacent villages;
- Ensure that housing and other relevant structures are constructed at new sites; and that community and service buildings for resettled people and adjacent villages are constructed or rehabilitated;
- Ensure that all new sites have reliable electricity supplies and linked to the Lao grid where feasible, and in accordance with GOL planning; and
- Ensure that all APs receive secure land and property tenure documents in accordance with CA and ADB's SPS requirements.

The resettlement section will work directly with the RMU to provide assistance in relocating households, including implementation and monitoring of the relocation process for households in the new resettlement area. It will coordinate with the RMU in all relocation issues.

The livelihood restoration section will coordinate with the RMU to develop suitable agricultural cropping systems and release fingerling into the reservoirs, and carry out extension and technical support work to ensure food security and income targets for resettled people and villagers in adjacent villages. Key responsibilities include:

- Introduction of sustainable agriculture with bio-organic fertilizer;
- Ensure sustainable livestock and aquaculture development for all households (resettled people and adjacent population) in the adjacent villages by operating demonstration farm in the resettlement site;
- Establish Project nursery(s) for the development of tree crops and domesticated NTFPs and support their proliferation with extension work;
- Facilitate management of the village forest resources through zoning, regulations and raising awareness;
- Investigate markets and marketing-chains for agricultural produce and forge links with middlemen and cash crop companies;
- Develop handicraft and small-scale business opportunities and identify market channels; and
- Monitor livelihood development until income targets are reached and sustained.

The Project lands and compensation team will coordinate with the RMU on all compensation matters. Specific tasks include:

- Liaise with infrastructure section to ensure all infrastructures are in place for villagers who have to resettle;
- Liaise with livelihood section to ensure APs benefit from livelihood activities, where required;
- Coordinate with the RMU to evaluate the assets lost due to construction activities; and
- Coordinate with the RMU to undertake cash compensation to entitled APs.

In addition, a consultation team, health team, education team and community development teams will be established. Their roles will be to implement and monitor consultation activities and community development plans.

On the health side, this will include the following tasks:

- Facilitate preparation of a comprehensive health and occupational safety strategy and implementation plan for the Project staff and construction workers;
- Facilitate preparation of a comprehensive long-term health strategy and implementation plan for the Project-affected groups;

- Oversee improvements to community health facilities and the transfer to and orientation/training of Ministry of Health (MOH) staff for these facilities;
- Establish baseline data on the health status of the population in Project-affected villages; facilitate annual surveys to measure changes in health status against the baseline; report to the Project proponent, MOH and any other relevant GOL line ministry on changes in health status;
- Liaise with MOH at national, provincial and district level to link Project supported activities with GOL health initiatives;
- Provide direct mentoring and support to Provincial Health Office (PHO) and District Health Office (DHO) staffs to conduct regular monitoring and supervision of health facilities and service delivery standards;
- Liaise with health and safety officers appointed by dam-site construction companies on issues related to effects on the population of adjacent villages of risks to health such as water pollution, dusts, and vehicular accidents; and
- Liaise with multilateral, bilateral and NGO agencies active in health sector programs, to maximize cooperation and minimize duplication; participate in MOH activities to facilitate sector-wide coordination.

In terms of education, the team will be responsible for:

- Facilitating development of a comprehensive education and training strategy and plan for Project-affected groups outside the resettled communities;
- Overseeing the reestablishment and upgrading of school facilities;
- Assisting District and Provincial education authorities in recruiting teachers and link up with GOL education initiatives; and
- Monitoring education programs and school attendance.

The Social Management Office (and its sections) will continue to function for the first three years of operation, or if needed so long as there remain resettlement matters to implement or to monitor. However, the number of staff and the number of teams will be reduced as their functions are completed.

13.3 GRIEVANCE REDRESS COMMITTEES

Grievance Redress Committees will be established to facilitate the GRM process. These are further described in *Chapter 9*, including committee members, roles and responsibilities.

14 REPORTING AND REVIEW

The reporting and review procedure provided here is indicative. The final procedure will need to be prepared after detailed construction plans are completed and negotiations with the supervising government agencies (SGAs) finalized.

14.1 REPORTING BY NNP1PC

14.1.1 Regular Reporting

14.1.1.1 Monthly Reports

During the period commencing from the first day of the month immediately following the construction works through and including the end of the concession period, NNP1PC shall prepare and submit to MONRE (both hard copy and digital version) monthly reports (in a unified format to be approved in advance by MONRE) covering the following items, and certified as true, complete and correct by NNP1PC Managing Director:

- Progress made to date on implementation of the measures assessed against the approved measures and monitoring programs;
- Difficulties encountered in implementing the environmental measures, recommendations for remedying those difficulties, and steps proposed to prevent or avoid similar future difficulties;
- Number and type of non-compliances with the measures, and proposed corrective actions and timelines for completion of those actions;
- Relevant information from reports received by NNP1PC from construction contractors, sub-contractors (if any), and NNP1PC itself;
- NNP1PCAccidents or incidents relating to the environmental, social, and welfare of stakeholders; and
- Monitoring data of environmental parameters and conditions as committed in this EIA, the ESMMP-CP, and SSESMMP.

14.1.1.2 Annual Reports

The NNP1PC shall prepare and submit the annual report to MONRE no later than sixty (60) days following the end of each calendar year (both hard copy and digital version), covering the following items:

- A summary of the items covered by the Monthly Reports required above;
- Gantt diagram showing the activities (construction works, environmental measures, monitoring) carried out during the period, against what was planned for that period;

- Description and analysis of hydrology data (water flow, water level, inundation) and water quality (surface water, wastewater discharges from camp and construction sites, worker's drinking water and/or village and households water supply);
- Description and analysis of wildlife and fishery monitoring data;
- Description and analysis of hazardous substances waste data;
- Description and analysis of environmental incidents and accident data;
- Progress of planned outputs and performance objectives;
- Account of the environmental performance (including status of Adverse Impacts) of Company's activities, the Project and any other related activities;
- Significant problems encountered and remedial measures taken; and
- Identification of any deviation from the ESMMP-CP, and EMP.

14.1.2 Emergency Reporting

In the event of any accident, non-compliance, or other incident that may cause an adverse environmental impact, or may reasonably expect to have or lead to an adverse impact on the environment or on any persons, NNP1PC will report in writing as soon as possible, but no more than seven (7) days after becoming aware of such an incident. This report will be sent to the relevant representative of MONRE (such as the Director of the EMU), as well as to the Department of Energy Promotion and Development of the Ministry of Energy and Mines.

NNP1PC will also inform the affected persons of any such adverse environmental impact within no more than seven (7) days of becoming aware of such an accident, incident or non-compliance and of the actual or possible impacts, or sooner if immediate action must be taken to avoid harmful impacts to the Affected Peoples.

14.2 REPORTING BY INDEPENDENT MONITORING AGENCY

An Independent Monitoring Agency (IMA) is to be engaged by GOL and funded by NNP1PC to monitor and evaluate compliance with environmental safeguards and measures. The IMA will include well qualified experts in environmental and social monitoring, and will have the objective to ensure compliance of the Company activities with its environmental and social contractual obligations. This monitoring will be undertaken mainly for GOL agencies, lenders, and the general public.

Independent monitors will not implement field surveys or their own monitoring system in the field, but will focus on (i) improvement of the project monitoring activities, (ii) improvement of environmental and social measures to be implemented by ESD, (iii) improvement to be made in the grievance redress procedures to be implemented through the Project, and (iv) compliance with agreed entitlements and other obligations.

The independent monitors will receive the NNP1 monthly progress reports. The team will visit the different project sites during the construction and operation phase of the project on a bi-annual basis. The field visits should not interfere with ongoing construction activities or ongoing resettlement activities, and ESD will help to coordinate interviews with contractors' representatives, village authorities and project affected households, as required.

After the field visits, joint meetings will be held with representatives of ESD, GOL agencies including MONRE, IFIs and the lenders, and IMA will prepare reports of its findings after each evaluation and otherwise according to the Terms of Reference for the IMA.

14.3 SUMMARY OF REPORTING AND DISCLOSURE ARRANGEMENTS

The proposed reporting arrangements related to environmental and social issues are presented in ***Table 14.1***.

Table 14.1 Proposed Reporting Arrangements

Report & Documents	Source	Frequency (times/year)	Disclosure [a]
Monthly Report	NNP1PC	12 during construction,	Yes
Annual Report	NNP1PC	2 during operations	Yes
Independent Monitoring Agency (IMA) Report	IMA	2[b]	Yes

[a] Public disclosure either on the Project's website, or that MONRE, and on applicable IFIs website.

[b] IMA will review the quarterly reports and other pertinent information, and submit semi-annual reports.

14.4 REVIEW BY GOL

The GOL agency responsible for review of environmental reports prepared by the NNP1PC and by the IMA will be the Environmental Management Unit (EMU).

The EMU will be responsible for any subsequent reporting of information from the reports of NNP1PC and of the IMA to other offices in MONRE and to other GOL agencies.

14.5 MONITORING AND INSPECTION

14.5.1 Monitoring Arrangement

Monitoring arrangements proposed for the NNP1 have been discussed at several occasions in consultations with various parties involved: the persons affected by the Project, the Company, the GOL, IFIs and the lenders. The objectives were to find the most efficient way to monitor and report progress and compliance with obligations, without burdening unnecessarily any of the parties, disrupting project activities and creating a counterproductive monitoring and reporting fatigue.

Monitoring inspection and its reporting are an integral part of the environmental management system, as they establish how the Project performs against environmental commitment. Schedules and procedures for monitoring and inspection should be developed at the outset in order to:

- Identify any negative impacts from construction activities;
- Assess the effectiveness of control measures;
- Demonstrate compliance with regulatory conditions; and
- Identify if further controls/corrective action is required.

Monitoring and inspection programs will be implemented for the duration of the construction phase of the Project. The program includes:

- Routine monitoring and inspection conducted by the Environmental Officer; and
- Compilation of monitoring and inspection report with non-compliance.

14.5.2 *Monitoring by ADB and other Lenders*

Representatives of ADB and lenders will be involved in regular field visits to monitor the project's progress in implementing environmental and social measures. Prior notice will be provided to the project before field visits. ESD will provide further information on specific local environmental and social activities and help to coordinate interviews with contractors' representatives, village authorities, and project affected households, if required.

14.5.3 *Monitoring and Inspections by MONRE*

MONRE will have the opportunity to carry out inspections at any time, by giving ESD at least one day notice prior to field visits, and will be accompanied in the field by at least one representative of ESD.

MONRE and ESD will have meetings after the monitoring and inspections in the field to discuss the recommended improvements to be made in the implementation of environmental and social measures. The outcome of the discussion during these meetings will be reported by ESD in its monthly reports.

All field visits by any monitor, inspector and visitor shall be coordinated by ESD to minimize disturbance to households as well as disruption to project activities.

14.5.4 *Monitoring and Inspection by ESD*

The NNP1 ESD will carry out monitoring and inspection as per the ADB, MONRE, and other lenders' requirements. NNP1's contractors will also carry out inspection and monitoring as required.

NNP1's ESD and all parties above will have regular meetings after completion of the monitoring and inspections in the field to discuss findings and recommended improvements to be made in the implementation of environmental and social measures at each of the construction sites, at a frequency specified in the EMP.

Information and results collected during each visit will be reported on a standard form, provided in a format agreed by MONRE, as a monthly report and yearly report submitted to MONRE. Likewise, monitoring activities and results complying with the Applicable Standards (*Appendix I*)/guidelines will be conducted.

The non-compliance procedure was provided by NNP1's contractors to prevent the failure to fulfil environmental-related objectives and targets have been found. Correction of non-compliance will be identified to help identify solutions and prevent the recurrence of the issue.

The subjects as below shall be addressed in non-compliance procedure that was approved by NNP1's ESD;

i) Work should be stopped in the event of serious non-compliance situation
ii) Follow-up visits will be required to verify that the situation has been improved appropriately
iii) Investigations will determine the causes of incidents and appropriate measures to prevent similar incidents

14.5.5 Monitoring and Inspection by Independent Advisory Panel (IAP)

The Independent Advisory Panel (IAP)'s scope is comprehensive; it extends to the setting, design, and plans for construction and operation. This includes review of all relevant environmental assessments, operational and construction plans, environmental management and monitoring plans, resettlement action plans, plan for indigenous peoples and associated reports on project progress and corrective actions.

The Project recruits four (4) distinguished international specialists and recognized national or sub-regional leaders from business, legal community and/or major institutions to form the Independent Advisory Panel (IAP) as the Project sponsor's requirement. These specialists will have the expertise in (i) biodiversity assessment; (ii) protected/conservation area management, (iii) social assessment on involuntary resettlement and (iv) Indigenous Peoples.

14.6 *UNANTICIPATED ENVIRONMENTAL IMPACTS – ADAPTIVE MANAGEMENT*

Adaptive management is a structured, iterative process of optimal decision making in the face of uncertainly, with an aim to reducing uncertainty over time via system monitoring. Projects such as NNP1, pursuing sustainability strategies, should employ an adaptive management framework to ensure that the organization is prepared to address unexpected and unanticipated impacts, and able to change their plans and procedures accordingly.

During the development phase of the Project, consultants have set up a general environmental and social management framework plan for NNP1PC, and later NNP1PC, based on the requirements and agreements by GOL and the IFIs, will implement the various measures and programs. However, during monitoring and subsequent analysis, it may turn out that the environmental and social impact assessments of the project will require updating. It is therefore necessary that the environmental management plans and social action plans contain confirmation surveys as well as different monitoring activities to better assess the actual adverse, but also the positive, Project impacts. Resulting from the updates of environmental and social impact assessments, the actual mitigation, offsetting and compensation measures may need to be readjusted, which in turn may change the presently allocated budgets and financing for these measures.

15 CONCLUSION AND RECOMMENDATIONS

15.1 CONCLUSION

15.1.1 *Project Information*

Project Name:	Nam Ngiep 1 Hydropower Project
Project Owner:	Nam Ngiep 1 Power Co., Ltd (a consortium comprised of the Kansai Electric Power Co., Inc. from Japan, EGAT International Co., Ltd. from Thailand, and Lao Holding State Enterprise (LHSE) from the Lao PDR)
Nature of Project:	Build Operate and Transfer
Project Location:	The Project site (Main dam site) is located on the Nam Ngiep River, 145 km northeast from Vientiane and approximately 40 km north from Pakxan District, Bolikhamxay Province, Lao PDR.
Content of Construction:	The construction contents include a main power station and a re-regulation power station. The main dam of the main power station creates the reservoir with the normal water level (NWL) at EL. 320.0 m. and minimum operating level (MOL) at EL. 296.0 m, by which the main power station generates the power of 272.8 MW (Plant output at the switchyard). The re-regulation dam of the re-regulation power station is planned to re-regulate and stabilize the maximum plant discharge of 230 m^3/s. It is released from the main power station to the downstream area of the re-regulation dam. The re-regulation power station is planned to generate the power of 18 MW (Plant output at the switchyard). Associated facilities, including quarry site, access roads, spoil disposal areas, and transmission lines, will also be constructed as part of the Project.

15.1.2 *Existing Environmental Quality*

15.1.2.1 *Surface Water Quality*

Generally, surface water quality in the Project area ranges from moderate to good, depending on the level of human activities near the Project area where the water was tested. However, the quality of water could be poor when there are more human activities. There is evidence that water quality is being deteriorated, especially in the lowland plains of Pakxan District near the Mekong River. In upstream reaches of the Nam Ngiep River, water quality has remained relatively undisturbed until recently, when villagers shifted their cultivation and grew industrial trees. Even with a low population, the agricultural practices and residential activities can directly pollute the Nam

Ngiep River. Water samples were collected along the river to cover all types of existing land usage, including natural areas, agriculture lands, residential areas, and other types of discharges that change or lead to deterioration in water quality.

The studies revealed that natural water temperatures ranged between 24°C to 31°C in the dry season and 24°C to 30ºC in the rainy season. Other physical properties, such as conductivity, salinity and hardness, were typical of good freshwater and less disturbed forest found in the upper catchment. Turbidity values were low in the dry season, but became higher in the rainy season. The higher value could be the result of suspended sediments, which were higher in the rainy season. Average concentration of suspended sediments was about 83 ppm in the dry season and 17 ppm in the rainy season.

DO concentrations were high, ranging from 7 to 10 mg/L. Analysis of nutrient concentrations showed that the nitrate concentration in the dry season was higher than in the rainy season. The increasing of nitrates during the rainy season might be due to runoff discharged from residential communities and animal farms along the riverside. The runoff could flush animal and human wastes, which accumulated on the land during the dry season, into the river during the early rainy season.

In general, the water quality of water samples collected in the rainy season was classified as Class 2 according to the Thai Surface Water Standards. This is defined as very clean fresh surface water resources can be used for consumption with simple water treatment. It was also appropriate for aquatic organisms for conservation, fisheries and recreation. However, the quality of water in the dry season fell to Class 3 according to the Thai standard, which is medium clean fresh surface water resource. Class 3 water can be used for agriculture, but requires water treatment prior to use for consumption. BOD_5 was found to increase across seasons, likely caused by the nutrients flushed from the agricultural lands and residential areas into the river during the start of the rainy season.

15.1.2.2 Groundwater Quality

Groundwater quality of the sample collected from the well at Ban Xomxeun was good according to the Groundwater Quality Standard for Drinking Purpose as notified in the Lao National Environmental Standard. However, the water was slightly acidic, and was found to carry waterborne diseases, as found in the WHO/UNICEF Joint Monitoring Programme. It is to be noted that residents of Ban Xomxeun do use water from the well and also from the Nam Ngiep River for their domestic use.

As for potential water contamination from existing mineral resources and mines, the chance of contamination from mines is extremely small since the closest mines are located quite far from the Project reservoir.

15.1.2.3 Noise and Vibration

Only one community, Ban Hat Gniun, about 3 km from the construction site to the west, is close enough to the dam site to be affected by noises and vibrations during construction or operation phase. As of 2012, there are 395 residents in Hat Gniun and 86 students attending the Hat Gniun Completed Primary School. The acoustic environment normally consists of natural sounds such as wind blowing through trees, birds, and pets. The main noise source of the village is the hand tractor, a popular form of local transport.

The actual background noise and vibrations were unable to be measured for this Project. Because of this, references to other Projects and activities similar to the NNP1 Project were compared and applied to the noise and vibration assessment. In particular, the background sound levels of the Hutgyi Hydropower Project in Kayin state, in the south of Myanmar, were compared for the purposes of the noise and vibration assessment. Preliminary sound measurements of Hutgyi Hydropower Project were carried out in April 2007 by measuring equivalent sound level at 1 hour, Leq 1 h. Sound level was 60 dB(A) in the small towns, with vehicular noise as the loudest source. The sound level was even lower in rural areas where the major noise sources usually came from natural sounds such as wind and birds. Noise sources at Ban Hat Gniun were mostly the two-wheel tractor and the natural acoustic environment, so sound levels would likely be between 40 to 60 dB.

15.1.2.4 Air Quality

The baseline ambient air quality of the Project site could not be obtained because there is no permanent air quality monitoring station in the Project area, and conducting site specific monitoring was also not possible because the required permission was not granted during the period of field assessment. However, the Project area has a low density of industrial and transportation activities, and there are no sources of major pollutants in the Project area, hence air quality is expected to be good. In addition, the study results found in "The Lao PDR Environment Monitor 2005" of the World Bank showed that overall air quality is currently at acceptable levels in both urban and rural areas in Lao PDR. Therefore, it is reasonable to expect that the ambient air quality in the Project area is considered to be in good quality.

15.1.2.5 Potential Contaminated Sites

Potential contamination sites were considered for both hazardous and non-hazardous sources. For hazardous sources, data on the presence of hazardous industries on or near the dam site and the Nam Ngiep basin were considered. As no potential mineral resources are located in the region, there was no contaminated site from minerals or mineral extraction that could cause hazardous contamination in the Project area. There are also no industrial activities within or immediately adjacent to the Nam Ngiep River basin, and there are only minimal agricultural activities.

For non-hazardous contamination, similar assessment was made of existing sources of waste, and potential contamination sites were determined. Generally, household waste was openly dumped and scattered around the residential areas. These wastes were mostly organic and plastic waste. Plastic bags remained scattered throughout the villages. Furthermore, waste from animals such as water buffaloes, cows, and fowl can be carried by runoff and flow through the riverbank down to the river body.

15.1.2.6 *Terrestrial and Aquatic Ecology and Wildlife*

Terrestrial ecoregions are natural ecological communities with shared species, dynamics and environmental conditions and offer a useful way of understanding the biodiversity within an area (ADB & UNEP, 2004). The ecoregion associated with the Project area is characterised by a variety of forest associations including montane hardwoods, mixed conifer-hardwood forests, open montane forests, and open conifer forests (Wikramanayake *et al.*, 2002). These forests have been subject to heavy logging pressure and much of the forest cover of central Lao PDR is subject to existing forestry operations, or occurs within approved forest leases. Slash and burn agriculture is a land use that is still practiced widely in central Lao PDR, including the Project area (ERM 2013b).

The biodiversity values have been described in accordance with the requirements of IFC Performance Standard 6 and ADB Environmental Safeguard Policy. A combination of field survey, desktop review, village interview, consultation with species specialists and geospatial analysis was undertaken to describe the existing characteristics of the Project area. Field sampling was undertaken in 2007 and in the wet and dry seasons of 2013. Additional aquatic surveys are scheduled to assist in further understanding of the significance of the fish biodiversity and values of the area for migratory species.

The vegetation within the Project area is dominated by forest (natural habitat) and fallow land vegetation (modified habitat). The deciduous forest land cover dominates the Project area, representing approximately 36 per cent of the footprint. Young and old fallow land is also highly represented with 16 and 21 per cent respectively. Condition assessment of the Project area indicated that over 80 per cent of the Project area is classified as moderate or high NDVI (or photosynthetic capacity).

Flora and fauna species diversity was recorded to be high in comparison to other areas in the region. A total of thirteen flora and thirty-five fauna species listed as critically endangered, endangered or vulnerable on the IUCN Red List of Threatened Species were reported (by interview, secondary data or direct observation) as known or may occur within the Project area. This includes the critically endangered flora species *Dipterocarpus turbinatus* and the Northern white-cheeked gibbon (*Nomascus leucogenys*).

Aquatic ecology surveys were also undertaken in 2007 and 2013. In general, river habitats were fast flowing with greater water depth and flows during the wet season. Dry season river habitats exhibited riffle zones which were flooded during the wet season. The river bed was generally dominated by sand and gravel. Villagers use the river environment for fishing and other activities and cattle were observed in the waterbody.

The fish community of the Mekong River is one of the largest in the world with most of the production based on migratory river species (Poulsen *et al.*, 2004). Fish migration is an important component for many fish species life cycle. The EIA (ERI, 2009) noted that the fish community detected in 2007 contains species common to the Mekong tributaries and was dominated by Cyprinid species. Cyprinid family species were reported to adapt to different environments in various sections of the river, and this family was also the dominant group detected during 2013 survey. The EIA assessment noted that of the larger species detected, many are migratory species of the lower Mekong basin that move upstream during the wet season spawning activities (EIA citing Poulsen *et al.,* 2004). These larger species, such as mud carp (*Cirrhinus molitorella*) and Asian red tailed catfish *(Hemibagrus wyckioides*) were detected in 2007 and 2013 surveys. The surveys noted a number of juvenile individuals of the migratory species suggesting that the Nam Ngiep River plays a role in providing habitat for these species' reproductive cycle (EIA citing Lowe-McConnell, 1995).

It is evident that villagers in the Project area regularly use local terrestrial and aquatic biodiversity – e.g. as a food source. However, the dependence on natural resources varies by village and is largely associated with accessibility. For example, remote villages tend to rely more heavily on medicinal plants as access to pharmaceuticals is limited. The biodiversity values of the area provide ecosystem services such as hunting and gathering, medicinal plants and materials, timber products, fishing and cultural services.

IFC Habitat Categories

Land cover mapping for the Project area identified a number of vegetated cover classes. The grassland, old fallow land, young fallow land, rice paddy, slash and burn land, and urban classes are considered to be modified habitats while bamboo, deciduous forest and evergreen forest areas are considered to be natural habitats in accordance with the IFC habitat categories assessment.

Assessment for critical habitat within the Project area was undertaken for species considered to be candidates based on desktop and field survey review. Using baseline data and consultation with species experts the species were screened against the determination criteria and quantitative thresholds. No flora species or terrestrial fauna species were determine likely to have critical habitat within the Project area. Additional assessment is being undertaken to further understand the significance of the aquatic environment for candidate fish species.

15.1.3 *Results of Environmental Impact Assessment – Environmental Aspects*

15.1.3.1 *During Construction Period*

(1) Water Quality

Suspended solids are expected to have an impact on water quality downstream during construction activities, such as cutting into the hillsides to build the new access road, which could lead to more sediment and landslides. The bare topsoil and excavated debris and rocks caused by the construction activities at the construction site could also contribute to high sediment levels downstream. Uncovered soil will be a major source of sediment, which would be carried by runoff. Soil erosion during the rainy season could occur during the five to six years of the construction period.

Activities related to the construction of the dam and other construction activities, such as the worker camps, offices, access roads, concrete mixing plants, stockyards, quarry, and disposal sites, are potential sources of water pollutants. Treated wastewater with remaining BOD_5 of less than 20 mg/L will be discharged from an on-site wastewater treatment facility or settling pond. The maximum number of workers expected on site is 1,800 workers, during which time, with estimated wastewater generation of 50 L/day/person, the Project could produce a total of 90,000 L/day or 1.0×10^{-3} m^3/s^2 of wastewater. Given the average annual flow of 148.4 m^3/s of the river, the release of the treated water with low BOD at a rate of 1.0×10^{-3} m^3/s will not have a significant impact on water quality.

(2) Noise and Vibration

During the construction phase, activities that could cause noise impacts to the surrounding area include cutting and land excavation, and moving equipment and materials for construction. Typically, construction-site noise levels are about 80 - 90 dBA, measured 50 feet (15.24 m) from the activity. Ban Hat Gniun lies about 3 km, or nearly 9,900 feet, from the construction site, so the noise level would be less than 50 dBA.

Noise impacts can occur throughout the construction phase. The Project will involve the use of many different types of equipment and activities. Raw materials for construction will be transported from the Thai border by trucks along the newly constructed access road. The noise impacts from this transportation will be low, because there are few residential areas along the new road. However, where the road does pass near a community or a house, the contractor should take measures to mitigate the impacts of noise on those residences during transportation.

(3) Air Quality

At the construction site, dust particles and fugitive dust from the construction activities, the emissions from on-road vehicles associated with the construction site and on-site machinery (off-road emissions) need to be controlled. In addition, the land clearing and surface excavation activities, construction of water conveyance systems, tunnels, and distribution systems also represent potential sources of air emissions from point sources. Increased traffic on unsealed gravel road surfaces will contribute to air pollution by the generation and release of fugitive dust. All of these activities can lead to considerable negative impacts on the ambient air quality at the Project site. However, the impacts can be limited through good construction management practices. The contractor should implement an emission and dust control plan within their environmental protection and mitigation framework. The emission and dust control plan should include methods for dust suppression resulting from quarry sites, crushing and batching plans, including road construction, embankment and channel construction, haulage of materials and construction of work camps.

(4) Potential Contaminated Sites

For hazardous sources, the possible sites of contamination were determined by reviewing plans of transport, storage, and use of hazardous substances during Project construction. The chemicals that must be used for the Project during construction were reviewed to predict the potential site contamination. The Project materials that would be stored in the construction site and could cause hazardous contamination to the environment were determined to be explosive materials, fuel (diesel, LPG), lubricant oils, pesticides and paints. The activities that involve hazardous materials are: used chemical and storage, drum reconditioning or recycling, electric transformers, used explosive and storage, landfills, pest control, used petroleum product and oil storage, and scrap yards. Hazardous materials used for the Roller-Compacted Concrete, RCC, were also considered. Since the functional units during construction are projected to be close to the river, the risk enhanced by high slope surfaces would be increased. The cut-and-fill technique that is planned for application for the high slope can only retain the contamination. Stringent management of hazardous materials to prevent spills must be applied to the construction sites.

For non-hazardous contamination, sources of waste and potential contamination sites were determined based on plans for construction. Human waste and wastewater of the workers could also be a source of land and water contamination. It is estimated that 1,000 to 1,800 persons will work for the Project on a daily basis for six years; thus 2,000 to 3,600 kg/day of solid waste is expected to be generated. Seepage from the landfill for this waste would be another potential source of pollution. Turbidity and hardness caused by runoff from the quarry site near the riverbank are also potential problems. The contractor camp yard, the disposal site for solid waste, the stockpile, the potential quarry site near the river, are sites where Project activities will be carried out that could run the risk of contamination.

15.1.3.2 During Operation Period

(1) Water Quality

After reservoir impoundment, the main water pollutants will be from degradation of organic material under anaerobic conditions and sedimentation. The reservoir may also become stratified into thermocline and hypolimnion zones, and the water from these zones could be released according to the engineering design. It will take several months for the reservoir to fill to EL 320 m, its normal operating level. Water from EL 280 m will be discharged downstream. During the early phase of water impoundment, organic matter in the soil and remaining plants will degrade anaerobically, while some chemical components can be expected to leach. This leaching and degradation can be expected to occur under anaerobic conditions for at least five years. For the next five years, the rate of leaching and degradation would become much lower, depending on the amount of organic matter remaining in the reservoir, the depth of the impounded water and the effect of the thermocline. Regular monitoring of water quality will help to indicate the quality of the water in the Project reservoir. After about ten years of water impoundment, the discharge quality may recover to Class 2 or Class 3 standard for surface water. Even so, water quality monitoring programs must be continued on a regular basis, because many external factors can affect water quality.

The direct impacts on the water body also include the load of sediment in the reservoir and the change in downstream water quality caused by altered flow patterns. The sedimentation would also cause reduced levels of dissolved phosphorus (P-PO_4) concentrations, total phosphorus (TP) concentrations, nitrate (N-NO_3) and ammonium (N-NH_4) downstream during normal operation. However, during the early stage of inundation, the nutrients trapped in the reservoir could be a source for algal bloom, which would lead to oxygen depletion at night. High phytoplankton productivity was predicted to occur frequently during the initial several years.

In addition, after the water has filled to the designed level, the stored water will inundate a large variety of terrestrial and riparian habitats, including natural plants and strips of crops along the shore. Water can continue to deteriorate from the dissolved components of these plants flowing into the reservoir, with runoff containing soil nutrients and sediment from the catchment settling in the reservoir.

Computer models were run to determine the quality of water expected at EL 280 m, the level of water discharge. The predicted change of temperature, DO, and SS varied monthly and at different distances downstream. Other computerized output, focusing on DO, showed a major impact during the operational phase because of degradation of organic material under anaerobic conditions and sedimentation. These were evaluated at different periods of inundation during operation.

(2) Noise and Vibration

The operation phase does not have any major activities that are anticipated to create noise and vibration impacts.

(3) Ambient Air Quality

The operation phase does not have any major activities that are anticipated to create dust; hence, adverse impacts from dust are not likely after the operation phase begins.

(4) Potential Contaminated Sites

For hazardous sources, the possible sites of contamination were determined by reviewing plans of transport, storage, and use of hazardous substances during Project operation. The possibility of site contamination during Project operation will be low, since only few hazardous materials, such as flammable fuels and pesticides, will be used. In the operation phase, there will be very few vehicular movements related to the operational and maintenance works of the dam within the Project area, thus only small amounts of fuels and petroleum products will be required. Some pesticides and fertilizers may be used for landscape control and maintenance. These chemicals may be contaminated if they are over used or improperly stored. This contamination would be limited only to the areas where hazardous materials are used.

For non-hazardous contamination, sources of waste, and potential contamination sites, were determined as very low during operation period.

15.1.4 Results of Environmental Impact Assessment – Biological Aspects

Disturbance to habitat in modified and natural habitat areas during construction has potential to impact the local and downstream biodiversity as well as impacts to priority biodiversity values. Mitigation measures can be implemented to manage the disturbance during construction such that biodiversity values are not significantly impacted or impacts are reduced by the application of the mitigation hierarchy (avoid, minimise, mitigate and compensate through offsets).

In accordance with the hierarchy, avoidance measures were initially investigated with a number of route options assessed for both the access road and transmission line. For the access road an alternative alignment located outside the boundary of the Huay Ngua PPA was developed and through assessment of biodiversity values, the original route (as presented in *Section 5.2*) was deemed preferred due to a lower disturbance of natural habitat and other engineering considerations. For the transmission line an alternative to avoid alignment through the Huay Ngua PPA was developed and through assessment of biodiversity values was deemed preferred due to a lower disturbance to natural habitat and avoidance of disturbance within the PPA. This option has been depicted in *Section 5.2*. Detailed analysis of alternatives is documented in each of the respective EA and IEE documentation (*Appendix E* and *Appendix F*).

To further mitigate potential impacts to biodiversity values, the remainder of the mitigation hierarchy principle was applied. The impact assessment (***Table 15.1***) identified potential impacts to both modified and natural habitats, and habitats for conservation significant species. Modified habitat types were not identified to play a significant role in habitat suitability for priority biodiversity values.

Management measures specific to managing the natural environment will be incorporated into the Project Construction Management Plans and these will include (but not be limited to) those identified in ***Table 15.1***. These general environmental management measures will assist in reducing the potential for degradation of habitat, behaviour disturbance, fauna mortality and habitat fragmentation for native species.

Table 15.1 Mitigation and Management Measures, Construction Phase

Nature of Impact	Overview of Measures
Loss of habitat	• Strict rules against logging outside the approved construction areas and against wildlife hunting and poaching will be imposed on Project staff, workers, and all contractors and personnel engaged in or associated with the Project, with penalties levied for anyone caught carrying and using fire arms, or using animal snares and traps, including fines and dismissal, and prosecution under the laws of the Lao PDR; • The design and layout plan will be prepared to minimise tree cutting and protected area disturbance where possible. The Project owner shall be directly responsible for dissemination to its staff and workers of all rules, regulations and information concerning these restrictions, as well as the punishment that can expected if any staff or worker or other person associated with the Project violate rules and regulations; • The planned clearance area for the construction works shall be clearly identified and marked to avoid accidental clearing; • Construction Contractor, in association with the Forest Guard, will schedule and implement routine inspection program throughout construction period to monitor clearing extent; • Construction Contractor will establish biological resource management program and management plan to manage the construction activities to be conducted and monitor compliance with relevant permits and environmental regulations in order to prevent potential impacts to terrestrial ecology, in particular, vegetation and wildlife; • Project will utilise or upgrade existing roads where possible to minimise unnecessary clearing requirements; • In natural habitat areas to be cleared, microhabitat features such as hollow logs will be relocated to adjacent natural habitat areas rather than being destroyed where possible.
Disturbance to fauna behaviour	• A wildlife protection team will be established to protect and rescue remaining wildlife in the proposed reservoir area; • Construction vehicles and machinery will be maintained in accordance with industry standard to minimise unnecessary noise generation; • Arrangement of transportation schedules will aim to avoid peak hours of road usage to minimise heavy traffic through habitat areas;

Nature of Impact	Overview of Measures
	• Traffic signs will be installed on all roads throughout construction areas depicting speed limits; • For construction areas requiring night-time lighting, lights will be used only where necessary and will be directed toward the subject area and away from habitat areas where possible; and • Commitment will be made to raise awareness of values of natural habitat areas to construction work force and make arrangements for restriction of poaching.
Barrier to movement and habitat fragmentation	• The Project shall implement landscaping and re-vegetation after completion of construction in suitable areas, including margins of the reservoir to establish a suitable riparian corridor; • In-stream works will be carried out in low-flow conditions where possible; and • The transmission line will not be fenced.
Edge effects	• Dust suppression techniques will be utilised during construction, to control the dispersion of dust created by clearing lands at the construction sites; • The Project shall implement landscaping and re-vegetation after completion of construction using native species where possible; • To avoid/minimize releasing sediment load into the river, erosion control measures will be implemented and maintained e.g. using silt fence and temporary re-vegetation to minimize sediment transport from steep slope releasing to the river and smaller waterways; and • Weed and pest management measures should be implemented in accordance with a Project weed and pest management plan to avoid introduction of weeds to natural and modified habitat areas.
Hydrology changes	• During construction, at least the normal flow in the river will be maintained through diversion. In case of flood period, the construction contractor must prepare the emergency programs such as increased waterway capacity in order to release the excess volume of water if required; • Flash floods during the rainy season should be including in safety plans provided for the construction site; • In-stream works for water crossings will be carried out in low-flow conditions where possible. Stabilisation measures will be used as appropriate (e.g. matting, sheet piles); • The local people will be made aware of changes to the river which could affect water transport and navigation locally; and • Water quality monitoring will be undertaken to inform adaptive management approaches such as altering the regulated release program.
Degradation of habitat	• Construction and domestic waste will be appropriately stored and disposed of to avoid attracting native and alien species to the construction areas; • For areas in direct runoff path to a watercourse, sediment and erosion control devices will be installed and maintained until vegetation replanting can occur to stabilise disturbed surfaces; • Oil, chemical and solid waste will be stored, and handled and disposed of by appropriately licenced waste management contractors; • Weed and pest management measures should be implemented in accordance with a Project weed and pest management plan to avoid introduction of weeds to natural and modified habitat areas; • Speed limits to maximum of 40 km/hr for construction vehicles will be enforced to limit noise and dust generation; • Construction materials and chemicals will be appropriately secured and locked down during flood season to avoid accidental release to the

Nature of Impact	Overview of Measures
	natural environment; • Engineering works will be designed to comply with the agreed water quality standards; • Water quality monitoring will begin as soon as possible after the Project begins, in order to control the quality of discharge of water to the Nam Ngiep River; and • Emergency response plan and procedures will be prepared and implemented for the construction activities of the Project. This will include emergency drills and education of Project workers.
Fauna mortality	• Speed limits to maximum of 40 km/hr for construction vehicles will be enforced to minimise potential for fauna strike; • Commitment will be made to raise awareness of values of natural habitat areas to construction work force and arrangements will be made for restriction of poaching and forest product collection; • Hunting wild animals will be strictly prohibited to apply for all staff; • Fishing and using of illegal fishing gear anywhere along the river will be prohibited; • UXO clearance and certification will be implemented for the whole construction area; and • Construction activities will only be commenced within the UXO clearance boundary.

In addition to the general measures for the management of potential impacts to the natural environment, measures specific to managing potential impacts to conservation significant values are also considered. Throughout the baseline assessment, priority biodiversity values have been identified in order to assess candidates for critical habitat in accordance with IFC PS6. Following assessment of each of the candidate species against the threshold criteria it was determined that no terrestrial species are likely to have critical habitat within the Project area. Ongoing investigation is being undertaken specific to aquatic species given the complexity of issues associated with migratory fish movement and potential changes to downstream environmental flows.

Although the Project area is not considered to be critical habitat for terrestrial species, it is acknowledged that potential habitat does occur within the Project area that will be permanently lost and that indirect impacts to these species may occur. As such, measures specific to these species have been considered and will be included and developed further for inclusion in a Project Biodiversity Action Plan (BAP) and appropriate management in biodiversity offset areas.

A BAP will be developed to document a strategy for refining the mitigation and management approach to conservation of biodiversity values, including key objectives, specific measures for the IUCN listed threatened species with potential to occur in the Project area, performance indicators and responsible parties.

Specific management actions will be required for biodiversity offset areas for species.

15.1.4.1 Residual Impacts on Biodiversity Values

The residual biodiversity values impacted following the application of the avoidance and mitigation steps of the following mitigation hierarchy have been determined.

Mitigation and management approaches have been considered to avoid, minimise and mitigate potential impacts to biodiversity as a result of Project activities. In general, many of the indirect impacts to biodiversity values can be minimised, such as behavioural disturbances, degradation of habitats, edge effects and barriers to terrestrial fauna movement.

The residual impacts identified relate to unavoidable loss of 4050 ha of natural habitat. Direct disturbance to habitats will be minimised where possible however this impact assessment has identified an unavoidable loss and as such compensatory measures must be considered. The next step of the mitigation hierarchy necessitates consideration biodiversity offsets for residual impacts.

A Biodiversity Offset Design Report has been developed to provide an analysis of the approach to offset identified residual biodiversity values in accordance with the Business and Biodiversity Offset Program documents.

The residual impacts are quantified below.

15.1.4.2 Residual Impacts on Habitats

The residual impacts identified for the NNP1 Project relate to unavoidable habitat loss within the operational footprint of the Project (including habitat for IUCN listed species) and barrier to aquatic fauna movement as a result of the dam wall. Direct disturbance to habitats will be minimised where possible however this impact assessment has identified an unavoidable loss of approximately 4050 ha of natural habitat and 3549 ha of modified habitat. ***Table 15.2*** summarises the breakdown of land cover types that will be permanently removed or altered.

Table 15.2 Impacted Land Cover Areas within the Project Area

Land Cover	IFC Habitat Class	Code	Area (ha)			Total (ha)
			Main dam	Re-regulation dam	Resettle-ment	
Deciduous Forest	Natural	DF	2721	132	56	2909
Evergreen Forest	Natural	EF	508	27	0	535
Old Fallow Land	Modified	OF	1321	194	163	1678
Young Fallow Land	Modified	YF	1036	143	82	1261
Bamboo	Natural	B	241	127	132	500
Slash and Burn	Modified	SB	328	27	19	374

Land Cover	IFC Habitat Class	Code	Area (ha)			Total (ha)
			Main dam	Re-regulation dam	Resettle-ment	
Rice Paddy	Modified	RP	107	5	15	127
Water	-	W	368	42	0	410
Grassland	Modified	G	108	0	0	108
Urban Area	Modified	U	38	3	0	41
Rock	Natural	R	1	0	0	1
Cloud	-	CL	4	0	0	4
Shadow	-	SH	16	0	0	16
			6797	700	467	7964

15.1.4.3 *Residual Impacts on Species*

ERM has applied a risk based assessment of species values to determine the significance of impacts on biodiversity values following mitigation. This risk assessment approach is outlined in the revised EIA for the NNP1 Project (ERM 2013). ***Table 15.3*** outlines the terrestrial species that have been identified that have residual impacts remaining after mitigation. ***Table 15.3*** outlines the fish species that have residual impacts on their habitats following mitigation[1].

Table 15.3 Terrestrial Species with Residual Impacts following Mitigation

	Species	
Flora	Dipterocarpus turbinatus	Afzelia xylocarpa
	Shorea roxburghii	
Mammals	Asian small clawed otter	Southwest China serow
	Asian elephant	Dhole
	Smooth coated otter	Sun bear
	Sunda pangolin	Bengal slow loris
	Leopard	Pygmy slow loris
	Tiger	Asiatic golden cat
	Fishing cat	Leopard cat
	Phayre's leaf monkey	Sambar
	White-cheeked gibbon	Himalayan black bear
	Golden jackal	
Birds	Wreathed hornbill	Red-breasted parakeet
	Great hornbill	Darter
	Green peafowl	Rufous necked hornbill
	White winged duck	Crested argus
	Greater coucal	Spot-bellied eagle owl
	Siamese fireback	Red-collared woodpecker
	Silver pheasant	Hoopoe
	Grey peacock pheasant	
Reptiles	Reticulated python	Elongated tortoise
	King cobra	Big-headed turtle

1 It should be noted that further assessment of the aquatic values are currently being undertaken to determine the presence of fish species in the Nam Ngiep River and the impacts of the proposal from the development.

Table 15.4 Aquatic Species with Residual Impacts following Mitigation

Species name	Common name
Poropuntius deauratus	Yellow tail brook barb
Cirrhinus cirrhosus	Mrigal carp
Cyprinus carpio	Wild common carp
Scaphognathops bandanensis	Bandan sharp-mouth barb
Yasuhikotakia splendida	Jaguar loach
Cirrhinus molitorella	Mud carp
Mekongina erythrospila	
Hemibagrus wyckioides	Redtail catfish
Luciosoma bleekeri	Apollo shark minnow

15.1.4.4 *Residual Impacts on Human Use Values*

From a human use perspective the impacts relate to ecosystem services values lost from the direct use of biodiversity values. It is evident that villagers in the Project area regularly use local terrestrial and aquatic biodiversity – e.g. as a food source – largely for subsistence purposes. However, the dependence on natural resources varies by village and is primarily associated with accessibility. For example, remote villages tend to rely more heavily on biodiversity (e.g. medicinal plants as access to pharmaceuticals is limited).

Development of the Project will likely impact the ability of villagers to access both tangible human use provisioning services and intangible cultural heritage values. This includes:

- Hunting, gathering and fishing. This typically includes small animals, such as squirrels and rats, and flora species, such as bamboo and mushrooms. The flora and fauna are primarily consumed within the household;
- Collection and use of medicinal plants;
- Cultural heritage, such as cemeteries. In most cases, villagers did not identify intangible cultural heritage values, which may be attributed to relatively recent settlement of the local villages; and
- Collection of timber products to be used as fuel or in construction.

15.1.4.5 *Biodiversity Offsetting*

The investigation for biodiversity offsets has been triggered by the Policy Principles of ADB Safeguard Policy Statement, Environmental Safeguards. (ADB 2009). This policy requires that impacts to Natural Habitats including the significant conversion or degradation of habitats are to be avoided or appropriately mitigated. The Project has been categorised under ADB's Safeguard Policy Statement (SPS) 2009 as an "A" for all of three safeguards categories; environment, involuntary resettlement (IR), and Indigenous People (IP).

To consider the required quantum of biodiversity offset, ERM has developed a biodiversity offset metric that captures the type (habitat and species), amount and condition of biodiversity. The biodiversity offset metric is based on the Habitat Hectare model (BBOP 2012a). This model captures the type, amount and condition of the biodiversity values present on the impacted site and candidate offset sites. The approach is designed to create a "balance sheet" to compare the biodiversity losses at the impact site with the gains available from candidate offset sites. The basis of the analysis is calculating the change in condition (loss) at the impact site compared to the change in condition (gains) at candidate offset sites over time from management. The application of the offset rules enables the most appropriate candidate offset sites to be chosen to achieve a no-net-loss of biodiversity values.

ERM has also undertaken consultation with Lao PDR government and NGO consultation to design implementation mechanisms for the biodiversity offset. The delivery of the biodiversity offset package will be through a combination of governance, legal and institutional arrangements to administer Projects designed to improve biodiversity values.

Land use activities in the Nam Ngiep and Nam Xan watershed that were likely to be a major threat to the long-term management of biodiversity offsets were identified. The exercise identified that the major threats to the biodiversity offset sites are mining leases and Production Forests. It was identified that this is of particular concern in the Nam Xan watershed where the majority of forested areas are Production Forests, limiting the ability to use these areas as primary conservation areas to protect terrestrial biodiversity values. Mining leases were also located across both watersheds.

Following discussions with the ADB and the IAP, it is recommended that currently available legal and administrative mechanisms be used to establish an Aggregate Offset Fund (AOF) in Lao PDR. This fund would be used to build capacity for ongoing offset management and conservation within Lao PDR. Further work (supported by the ADB) would be required to strengthen the capacity of the Lao PDR Government to enable appropriate governance and oversight of the AOF. Further policy work is also required to define an appropriate offset metric and a method to determine the value of trust fund deposits as well as the establishment of a Specialised Financial Window by the Environment Protection Fund.

In relation to specific offsets for the NNP1 Project, it is recommended that offset areas include: forested and riverine areas of the Phou Khoa Khoay NPA; and forested and riverine areas of the Nam Ngiep Watershed. It is anticipated that work on establishing offset sites for the NNP1 project would occur in parallel to setting up the AOF. This is necessary to ensure that appropriate offsets are established for the NNP1 project and are not delayed due to the time required to establish the AOF.

The offset balance sheet analysis indicates that sufficient habitat is available to offset the impacts from the Project on biodiversity values. Species specific management to manage residual impacts on species are also recommended.

Management costs for the biodiversity offsets would be covered by the funds allocated under the Concession Agreement for the NNP1 Project. This includes allocations of $13.7 Million for watershed and environmental management costs for the biodiversity offset package for the life of the concession agreement (27 years). It is recommended that this money is invested and the returns on that investment used to find offset management of the recommended candidate offset areas.

Management oversight for the offsets is recommended to occur through a management committee (NNP1 Offset Advisory Committee) formed to administer offset management and tender offset management services to relevant and qualified NGOs. The Provincial Office of Natural Resources and Environment of the Lao Government would be responsible for direct oversight of the implementation of the offset projects.

15.2 RECOMMENDATIONS

Recommendations for the Project are as follows:

15.2.1 Baseline Data

As permanent environmental quality monitoring stations do not exist around the Project area, as well as permission was not granted by local authority to allow monitoring during the study period, the baseline information for noise and vibration, and air quality, was unavailable. It is recommended to conduct environmental quality monitoring programs during the pre-construction period and construction period to provide essential baseline data. In addition, it will be of benefit to establish permanent water quality monitoring stations for Nam Ngiep Basin to regularly monitor the water quality along Nam Ngiep River prior to and after reservoir inundation.

15.2.2 Downstream Flood Analysis

To be able to predict downstream flood events, in particular at Pakxan District which is influenced by the Mekong River in flooding season, hydrological data in the Project area and vicinity should be gathered, along with the development of flood models. This is to assure and disseminate information to the public that water released from the dam during the wet season will not cause flooding at the downstream areas.

15.2.3 Waste Disposal Facility

According to the latest edition of the Decree on Environmental Impact Assessment dated 18 February 2010, it is required that, for all waste disposal facility development, an environmental impact assessment is performed for the new waste disposal facility. It is expected that it will require considerable time for the EIA preparation and approval process, which may affect the schedule and performance of waste management in the future. To avoid potential delays, conceptual design and initial Project information on waste disposal facilities should be provided as soon as possible so that the impact assessment can be carried out accordingly.

15.2.4 Reservoir Clearing

There are four options for reservoir clearing: (1) do nothing, (2) cutting trees without removal, (3) cutting trees with removal, and (4) clearing trees by burning. Cutting trees with removal and clearing trees by burning have been proposed for valuable tree species and for other non-valuable species, respectively. Both options can maximise income and minimize adverse impact of high initial oxygen demand after water filling.

The following are recommended effective practices for reservoir clearing:

- Removal of maximum commercially viable timber, except in some designated buffer zones.
- All remaining timber, after commercial and salvage logging operations have been completed, will be cut as necessary and burnt.
- Avoid removing stumps, as disturbed soil may release far more nutrients in water.

15.2.5 Seismological Information

As existing seismological data is only available at a regional scale, assessment at this stage is limited. A preliminary assessment of the geological structures in the region has shown that there are possible joints and fractures in the rock formations. However, judging from the available seismic records, the current design is resistant to seismic impacts, and has sufficient safety margin. Additional assessment of conditions will be carried out during detailed design.

15.2.6 Environmental Friendly Design and Equipment

In case there is indication of poor downstream water quality caused by water releasing from dam, the Project owner shall carry out all applicable design and equipment modifications in accordance with environmental protection concerns. Effective turbine design can be used to increase the amount of oxygen in discharging water downstream.

15.2.7 Contractors' Environmental Obligations

It is recommended to include all proposed mitigation measures, monitoring programs, as well as obligations and commitments in relation to environmental preservation and protection in all construction contracts. The involvement of Contractors, especially during the construction period, will help to achieve and maintain environmental preservation and protection. Based on environmental obligations, as addressed in the contract, contractors shall put the environmental management into practice through effective implementation, and manage risks to the environment arising from all construction activities during the construction phase.

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