Environmental Impact Assessment

Project Number: 41924
July 2014
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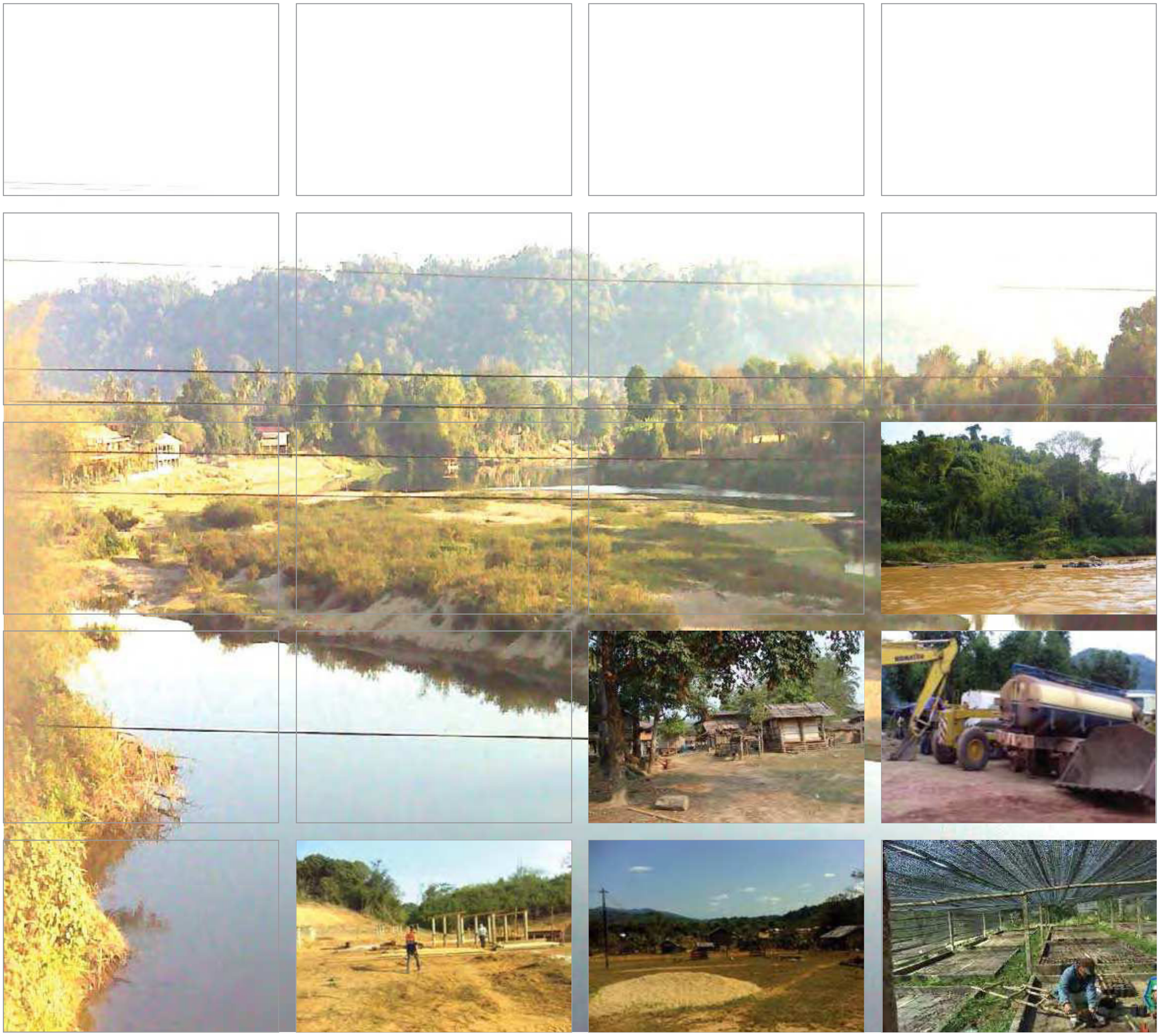
Nam Ngiep 1 Hydropower Project
(Lao People's Democratic Republic)

Main Report

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

Environmental Impact Assessment for Nam Ngiep 1 Hydropower Project

Updated Version - Revision 4

Main Report

July 2014

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FINAL REPORT

NAM NGIEP 1 POWER COMPANY LIMITED

Environmental Impact Assessment for Nam Ngiep 1 Hydropower Project: *Updated Version - Revision 4*

Prepared by	Environmental Research Institute, Chulalongkorn University (ERIC, March 2012)
Updated by	ERM-Siam Co., Ltd. (July 2014)
Reference	0229598

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

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Date: 23 July 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 the revised EIA following a request by the Nam Ngiep Power Company (the **Client**) in November 2013 and May 2014 (**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 revised to accommodate ADB comments in April to May 2014 and in June to July 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 the NNP1 Access Road	ERIC	ERM
Appendix F: IEE for 230 kV Transmission Line	ERIC	ERM
Appendix G1: Results of Soil Analysis	ERIC	N/A
Appendix G2: Water Quality Modelling Assumption and Results	ERIC	NNP1PC
Appendix G3: Public Consultation Results	ERIC	N/A
Appendix H: EMP Sub-Plans	ERIC	ERM
Appendix I: Agreement on National Environmental Standards of Lao PDR	Public Documents	Public Documents
Appendix J Houay Ngua Provincial Protected Area (PPA) Official Documents	N/A	NNP1PC
Appendix K Preliminary Archaeology and Cultural Heritage Survey Report	N/A	NNP1PC
Appendix L Emergency Response Procedure	N/A	NNP1PC

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

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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
AM	ADB Accountability Mechanism
AOF	Aggregate Offset Fund
APs	Affected Peoples
ARI	Acute Respiratory Infection
ASL	Above Sea Level
B	"Ban" Village in Laotian Language
B/C	Benefit – Cost, Economic efficiency
BAP	Biodiversity Action Plan
BAT	Best Available Techniques
BOD	Biological Oxygen Demand
BOT	Built-Operate-Transfer
CA	Concession Agreement
CC	Combined Cycle Power Plant
CCGT	Combined Cycle Gas Turbine
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 Rockfill Dam
CITES	Convention on International Trade in Endangered Species of Wild Fauna and Flora
COD	Commercial Operation Date
CPS-NSC, 2002	CPS-National Statistical Center, 2002
CPC	Committee for Planning and Cooperation
CRO	Complaint Receiving Officer
CRP	Compliance Review Panel
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
DEB	Department of Energy Business
DESIA	Development of Environmental and Social Impact Assessment
DFRM	Department of Forest and Resource Management
DHO	District Health Office

DLF	Department of Livestock and Fisheries
DMD	Deputy Managing Director
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
DONRE	District Office of Natural Resource and Environmental
DRWG	District Resettlement Working Groups
DSCR	Debt Service Cover Ratio
DSRP	Dam Safety Review Panel
EAC	Environmental Assessment Committee
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
FSL	Full Supply Level of Reservoir
FTA	Federal Transit Administration
FSL	Full Supply Level
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
IMA	Independent Monitoring Agency
IMR	Infant Mortality Rate
IPDP	Indigenous Peoples Development Plan
IPP	Independent Power Producer
IRR	Internal Rates of Return
ISO	International Organization for Standardization
IUCN	International Union of Conservation of Nature - World Conservation Union (Switzerland)
JBIC	Japan Bank for International Cooperation (JBIC)
JI	Joint Implementation
JBIC	Japan Bank for International Cooperation

ABBREVIATIONS

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
LFNC	Lao Front for National Construction
LWU	Lao Women Union
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 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
NAP	National Adaptation Plans
NC	Non-Compliance
NCC	National Consulting Company
NCR	Non-Compliance Report
NDVI	Normalised Difference Vegetation Index
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
NUL	National University of Laos
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
OM	Organic Matter
PAFO	Provincial Agriculture and Forestry Office
PAPs	Project Affected Persons
PCR	Physical Cultural Resources
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
PKK	Phou Khao Khoay
PM 10	Particulate Matter 10

ABBREVIATIONS

PMF	Probable Maximum Flood
PMO	Prime Minister's Office
PMP	Probable Maximum Precipitation
PONRE	Provincial Office of Natural Resource and Environmental
PPA	Provincial Protected Area
PPE	Personal Protective Equipment
PPV	Peak Particle Velocities
PRC	People's Public of China
PRLRC	Provincial Resettlement and Living Restoration Committee
PRP	Preliminary Resettlement Plan
RAP	Resettlement Action Plan
RC	Resettlement Committee
RCC	Roller Compacted Concrete Dam
RMU	Resettlement Management Unit
REDP	Resettlement and Ethic Minority Development Plans
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
SDP	Social Development Plan
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
SPF	Special Project Facilitator
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
UNCCD	United Nations Convention to Combat Desertification
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
USD	US Dollar
USBM	United States Bureau of Mines
UXO	Unexploded Ordinance
VDCs	The Village Development Coordination Committees
VECs	Valued Environmental and Social Components
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

0 EXECUTIVE SUMMARY

0.1 INTRODUCTION

The Nam Ngiep 1 Hydropower Project (NNP1) involves the construction of an access road, hydropower dam, re-regulation dam, powerhouse, transmission line and other required components by the Nam Ngiep 1 Power Company (NNP1PC). NNP1 is situated on the Nam Ngiep River in Lao People's Democratic Republic (Lao PDR), which is on a left bank tributary of the Mekong River. The project covers parts of the provinces of Bolikhamxay, Xaysomboun, Xieng Khouang and Vientiane.

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 Pakxan. The gorge is the location for the construction of the proposed dams. Average annual rainfall throughout the watershed area is estimated to be 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 watershed area at the dam site is estimated to be 3,700 km^2, with average inflow of 148.4 m^3/s or 4.68 billion m^3/year.

NNP1PC plans to construct a 148 m high concrete gravity dam on the Nam Ngiep River, serving as a main power station of 272 MW and annual power generation of 1,546 GWh at the substation. Once in operation, the main dam will utilize 66.9 km^2 of reservoir area. An effective storage of 1,192 million m^3 from the reservoir is designed to drop around 130 m to a power station downstream from the main dam. A re-regulation power station, located downstream of the main power station, will have 18 MW and annual power generation of 105 GWh.

The electricity generated at the main power station will be delivered to the Electricity Generating Authority of Thailand (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 230kV 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 115kV 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 population density in the Nam Ngiep watershed is low. Settlements are nearly all limited to the river valleys, with the main exceptions being the large expanse of fairly flat land towards the Mekong River and larger valleys toward the north and northeast of the watershed. These are also some of the most populated areas in the watershed. The major settlements relative to the

Nam Ngiep watershed are: Phonsavan, the capital of Xieng Khouang Province is just outside the watershed boundary to the north and Pakxan, the capital of Bolikhamxay Province downstream of the proposed dam near the Nam Ngiep confluence with the Mekong River. Other settlements in the north of the Nam Ngiep watershed include Muang Khoun and Phaxai.

NNP1PC sought and was granted approval by the Government of Lao PDR. This approval was granted in April 2013 and a subsequent Concession Agreement (CA) issued by the Government of Lao PDR (GOL). This approval was granted according to GOL regulations mandated in 2001, project developers must acquire environmental permits before undertaking an electricity projects. This can only be done after adequate environmental assessment (EA) has been completed.

NNP1 will be funded predominantly by the private sector. The owners of Nam Ngiep Power Co. Ltd. include The Kansai Electric Power Co. Inc. (Kansai Electric) from Japan, EGAT International Co. Ltd. (EGATi) from Thailand, and Lao Holding State Enterprise (LHSE) from the Lao PDR.

ERM Siam Co Ltd (ERM) has been engaged by 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 2014.

This Revised EIA Report presents an assessment of the potential environmental impacts associated with the proposed Nam Ngiep 1 Hydropower Project ('the Project') in Bolikhamxay, Xaysomboun, Xieng Khouang and Vientiane, Lao PDR to specifically respond to the ADB Safeguard Policy Statement (July 2009).

0.2 METHODOLOGY

0.2.1 *Approach*

The study approaches for the EIA are organized into two main categories according to their general environmental aspects – physical and biological. Additional assessments were undertaken for environmental flows, cumulative impacts and biodiversity offsets. A summary of the methodologies used for physical and biological aspects is shown in ***Table 0.1.***

0.2.2 *Physical Environmental Aspects*

Physical environmental aspects refer to the water, land, atmosphere and other environmental aspects that are likely to be impacted by the project. This differs from the biological environment that includes all living aspects, including biodiversity and the ecosystem services that are provided by the environment to enable human populations to function.

The methodologies used for collection of baseline information, assessment of impacts, and recommendation of mitigation measures for physical environmental aspects was developed by ERIC in the original EIA (2012) and has been refined by ERM.

Baseline information was based both on desktop review (secondary data) and field survey results (primary data). For each aspect, potential impacts due to the Project were assessed, and mitigation measures were recommended.

0.2.3 *Biological Aspects*

The specific methodology used for collection of baseline information, assessment of impacts, and recommendation of mitigation measures for biological aspects was developed and implemented by ERM and sub-contractors in the revised EIA (undertaken in 2013 and 2014).

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 (including by specialist sub consultants, including experts in botany, fisheries and terrestrial mammals);
- Desktop sources (published and grey literature, available reports, geospatial datasets and species profiles);
- Geospatial datasets; and
- Detailed flora survey of the access road corridor.

Specialist surveys and peer review was undertaken in conjunction with:

- Dr Will Duckworth – South East Asian Mammal Specialist

- Dr Maurice Kottelat – South East Asian Fish and Aquatic Habitat Expert
- Dr Phavainh Phiapalath – South East Asian Primate Specialist
- Dr Sinthavong Viravong - Living Aquatic Resources Research Centre, (LARReC) Lao PDR
- Dr Pheng Phengsintham – Lao Botanical Specialist
- Mr Terry Warren- Mekong River Fisheries Specialist

0.2.4 *Environmental Flow Assessment*

An environmental flow assessment (EFA) was undertaken by Kansai Electric Power Co. (Kansai) in August 2012. ERM undertook a review and update of the EFA based on original modelling undertaken by Kansai. The EFA models the likely downstream impacts on water flows and quality on the biodiversity and ecosystem services downstream of the re-regulation dam.

0.2.5 *Cumulative Impact Assessment*

ERM undertook a cumulative impact assessment (CIA) based on the principles outlined in the following documents:

- the U.S. Council on Environmental Quality (CEQ) implementing the National Environmental Policy Act (NEPA) (US EPA 1999);
- International Finance Corporation Performance Standards 1 and 6 (IFC 2012);
- IFC's Draft (External Peer Review) – Cumulative Impact Assessment Guidance Note for Private Sector in Emerging Markets (ESSA & IFC 2012); and
- ADB Safeguard Policy Statement (2009).

Impacts from this project and each of the RFFAs were considered on the valued environmental and social components VECs identified, including: terrestrial biodiversity and habitats; aquatic biodiversity and habitats; ecosystem services; and water quality and river flows.

0.2.6 *Biodiversity Offset Assessment*

ERM undertook a biodiversity offset assessment using the frameworks contained in the following Business and Biodiversity Offset Program (BBOP) resource documents: *Biodiversity Offset Design Handbook* (BBOP 2012a); and *Resource Paper: No Net Loss and Loss-Gain Calculations in Biodiversity Offsets* (BBOP 2012b). ERM has applied the methodology as described by BBOP in designing the biodiversity offset for the NNP1 Project.

Table 0.1 Summary of Methodology of Environmental Aspects

Environmental Aspects	Methodology for Collection Baseline Information	Methodology for Impact Assessment and Mitigation Measures
1. Physical Environment (by ERIC)		
Topography	• 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.	• Maps have been prepared, depicting the modified topography and recommended mitigation measure to minimize negative impacts.
Meteorology	• 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.	
Geology, Landforms, Seismology	• 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.	• Where potential problems were identified, appropriate mitigation measures were developed to minimize the impacts.
Soils	• 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. • Soils analyzed for: 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) and physical properties: soil texture (particle size distribution).	• Project activities were assessed for their potential impacts on soil fertility. • Mitigation measures were determined wherever necessary.
Erosion and Sedimentation	• 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.	• Project activities were assessed for their potential impacts on soil erosion and sedimentation. • Mitigation measures were determined wherever necessary.

Environmental Aspects	Methodology for Collection Baseline Information	Methodology for Impact Assessment and Mitigation Measures
Surface Water and Groundwater Quality	• 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. • Sampling was carried out in April 2007 and October 2007. Groundwater quality was observed in October 2007 at Ban Xomxeun and Ban Hat Gniun; however, only the well-water of Ban Xomxeun was collected. • Further water quality sampling was undertaken in March 2013 by ERM along the Nam Ngiep and Nam Xan Rivers. • Temperature, pH, conductivity, salinity, turbidity, and DO were measured at the field sites, whereas other characteristics were analyzed at the National University of Lao. • Results of surface water quality of the collected water samples were compared to Ambient Water Standards for Lao PDR. In addition, results were also compared to the Surface Water Quality Standards of Thailand.	• 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: o Construction Phase - Effects of water diversion; effects of the construction camp and other construction activities. o Operation Phase - Short-term impact due to degradation and settling in water impoundment. o Long-term impact caused by operation. • Suggested mitigation measures and monitoring plans for impacts expected from Project construction and operation.
Mineral Resources	• 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.	
Noise and Vibration	• 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 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.	• 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

Environmental Aspects	Methodology for Collection Baseline Information	Methodology for Impact Assessment and Mitigation Measures
		• Proposed appropriate mitigation measures and monitoring programs for the construction phase.
Air Quality	• 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 and comparison between ambient air qualities found for similar land uses.	• 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.
Potential Contaminated Sites	• Through observations and secondary data, acquired information to evaluate present conditions and use of hazardous substances.	• 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.
Hydrology	• 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.	• Evaluated potential hydrological changes due to the Project regarding existing natural condition & resources, people, and their living circumstances and recommended mitigation measures.
2. Biological Environment (by ERM, ERIC, TISTR and other sub consultants)		
Forest and Vegetation Cover;	• Rapideye imagery assessment of vegetation cover to determine the NDVI index for vegetation type and condition	• Applied the mitigation hierarchy to avoid, mitigate and identify residual biodiversity values requiring offsetting.
Terrestrial Ecology/Wildlife	• Targeted IUCN listed primate species survey and critical habitat assessment* • Targeted botanical survey in Houay Ngua PPA and along the access road* • 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, ** • 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 ***	• Applied the mitigation hierarchy to avoid, mitigate and identify residual biodiversity values requiring offsetting. • Assessment against Critical Habitat criteria according to ADB SPS

Environmental Aspects	Methodology for Collection Baseline Information	Methodology for Impact Assessment and Mitigation Measures
Aquatic Biodiversity Values	• Fish sampling using netting techniques ** • Targeted endemic, CR and EN fish survey*	• Applied the mitigation hierarchy to avoid, mitigate and identify residual biodiversity values requiring offsetting. • Assessment against Critical Habitat criteria according to ADB SPS
* ERM (including other specialist sub-consultants); ** ERIC; ***TISTR		

Source: Environmental Impact Assessment Report, ERIC 2012 and developed by ERM, 2014.

0.3 *ADMINISTRATIVE FRAMEWORK*

The project will conform to the legal and administrative requirements of Lao PDR. 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) (2009) and to the Equator Principles. The International Finance Corporation (IFC) Performance Standards have been used as a reference where required, and in particular, IFC Performance Standard 6 (2012).

Where there are legal gaps in terms of standards, the ADB or other international standards will be used.

0.3.1 *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."

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).

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.

0.3.2 *Equator Principles*

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 IFC'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.

As with the ADB, projects deemed to have potentially significant 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.

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

0.4 *PROJECT DESCRIPTION*

0.4.1 *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 0.1***.

The main facility of the Project will be located in Xaysomboun, Bolikhamxay Province, although the reservoir will also cover parts of, Vientiane and Xieng Khouang provinces. The reservoir will have a surface area of 66.9 km^2 when at full supply level of EL 320 m. The reservoir will have an effective storage capacity of 1,192 million m^3, 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 some 5km downstream, then be discharged downstream daily through the 20 m high re-regulation dam.

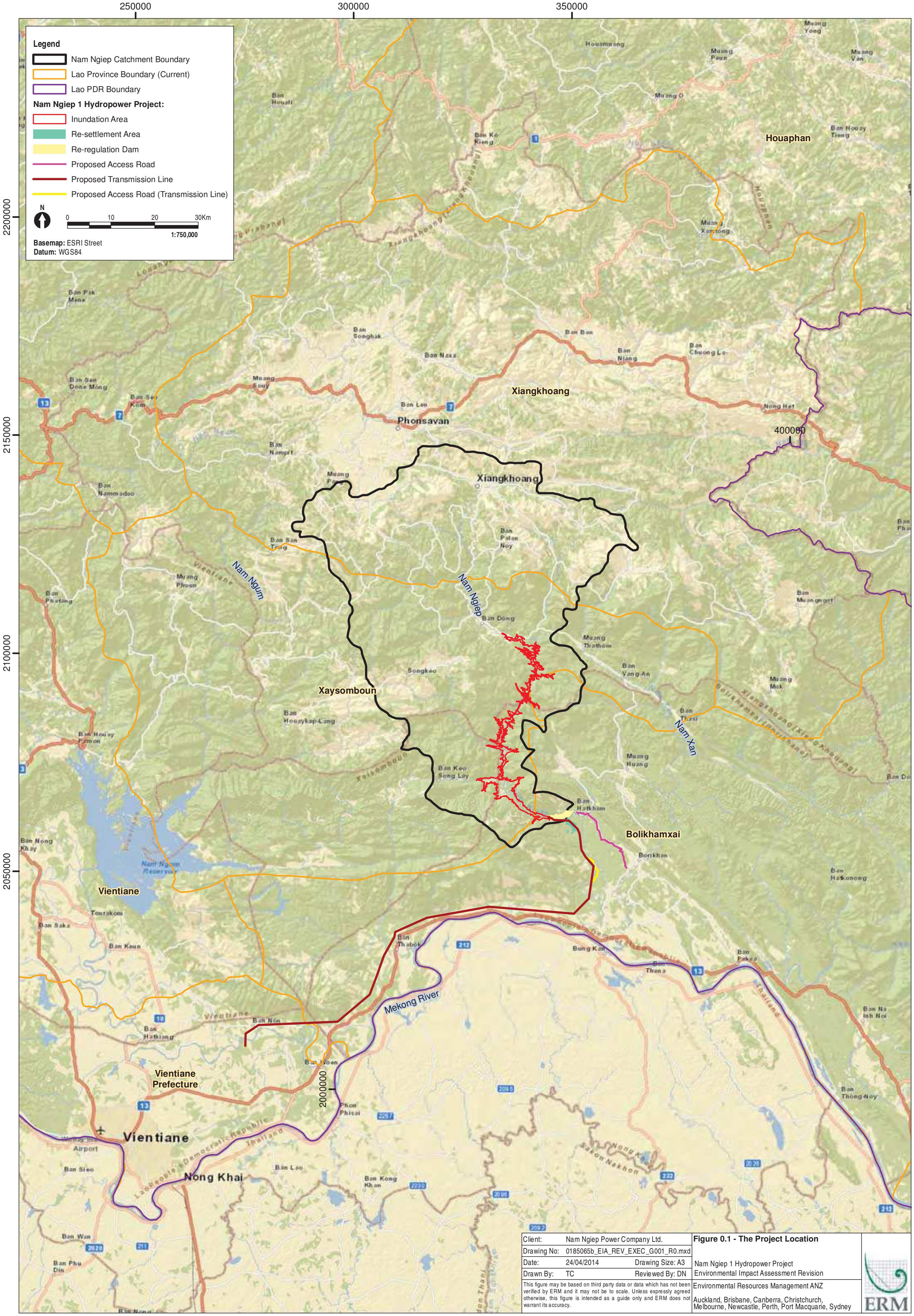


Figure 0.1 - The Project Location

0.4.2 *General Layout and Infrastructure*

Full details on the main dam and all associated facilities are provided in Chapter 4 of this EIA Report. ***Table 0.2*** provides a summary of the technical specifications.

The main features of the Project are presented in ***Table 0.2*** and ***Figure 0.2***.

Table 0.2 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
	Watershed 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 x 2
	Rated output	MW	272 (at Substation)
	Annual power generation	GWh	1,546 (at Substation)
	Peak operation hour	hrs	16 (Monday to Saturday)

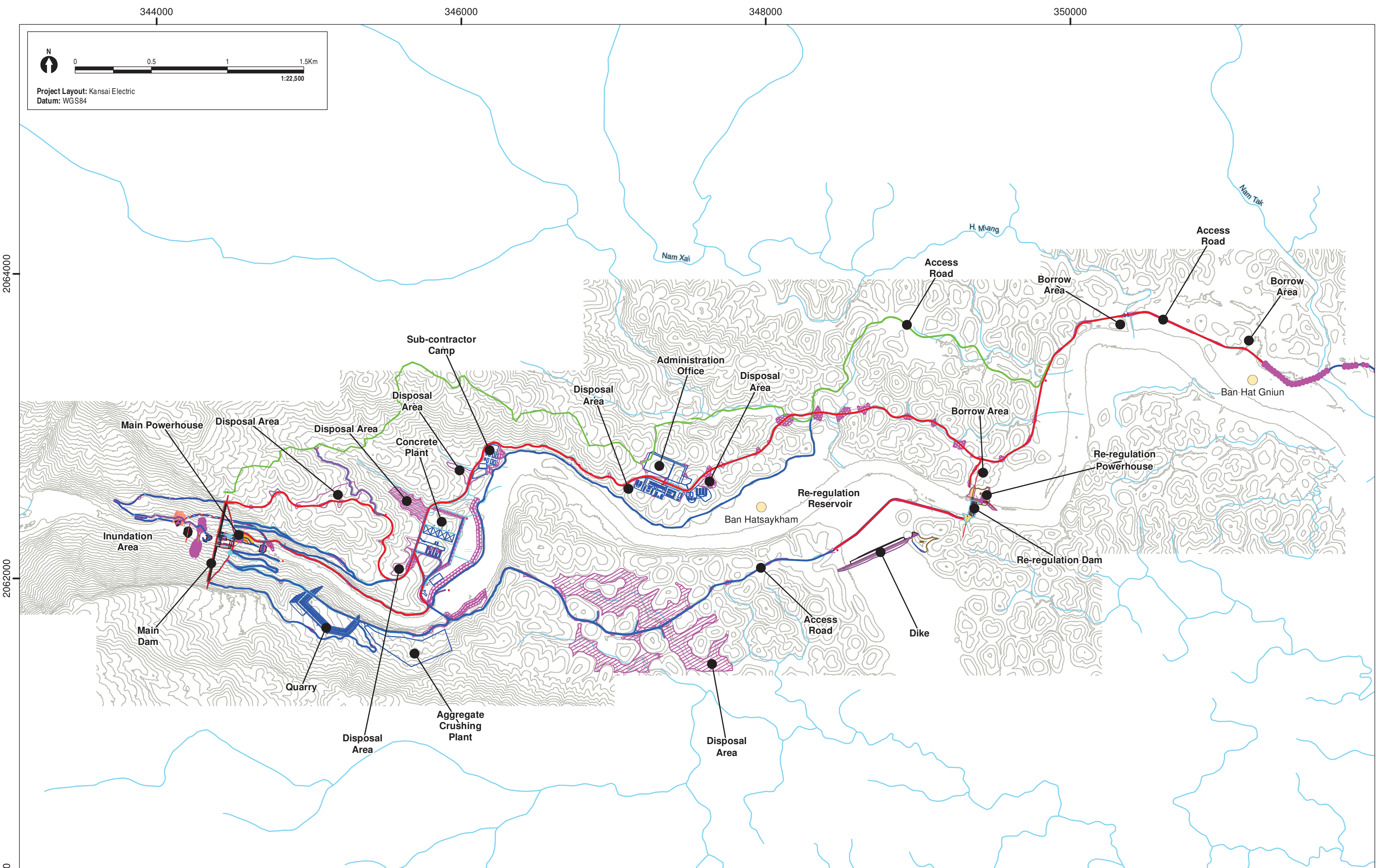
Facility	Items	Unit	Specifications
Transmission Line	Voltage	kV	230
	Distance	km	125
	Connecting point	-	Nabong S/S
	Width of right of way	m	80 (40 m each side of CL)
	Number of towers	-	262
Re-Regulation Power Station			
Re-Regulation Reservoir	Flood water level	EL. m	185.9
	Normal water level	EL. m	179.0
	Rated water level	EL. m	179.0
	Minimum operating level	EL. m	174.0
	Available depth	m	5.0
	Reservoir surface area	km^2	1.27 at NWL
	Effective storage capacity	$10^6 m^3$	4.6
	Watershed 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 x 2
	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

Facility	Items	Unit	Specifications
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
	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.

* 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.

Source: Kansai, 2013



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Date:	24/04/2014	Drawing Size: A3
Drawn By:	TC	Reviewed By: DN

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Figure 0.2 - Location of Main Features of Nam Ngiep 1 Hydropower Project (NNP1PC 2013)

Nam Ngiep 1 Hydropower Project
Environmental Impact Assessment Revision

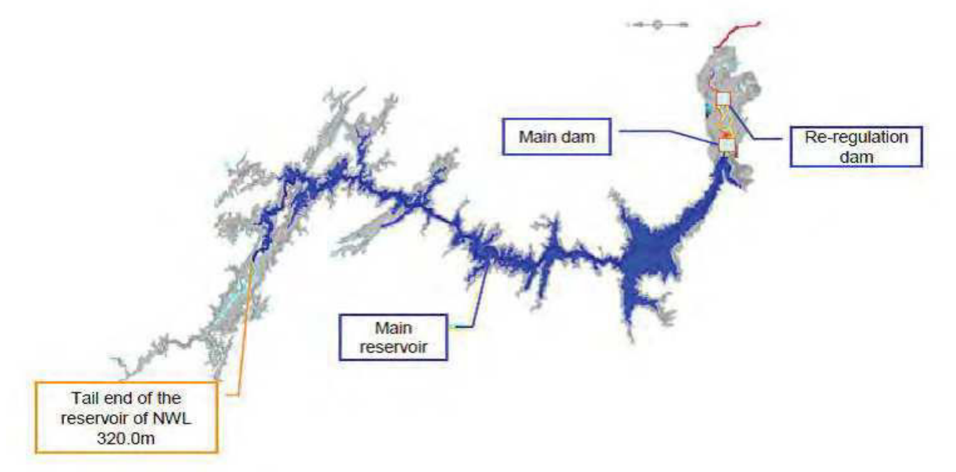
Environmental Resources Management ANZ

Auckland, Brisbane, Canberra, Christchurch, Melbourne, Newcastle, Perth, Port Macquarie, Sydney

0.4.3 *Summary of Main Dam and Reservoir Specifications*

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 0.3***.

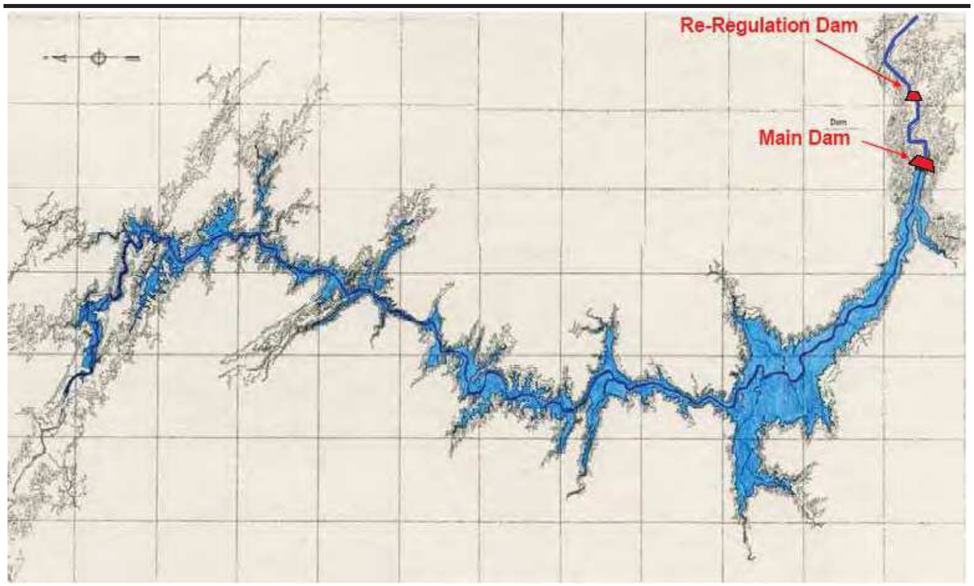
Figure 0.3 Main Dam Reservoir



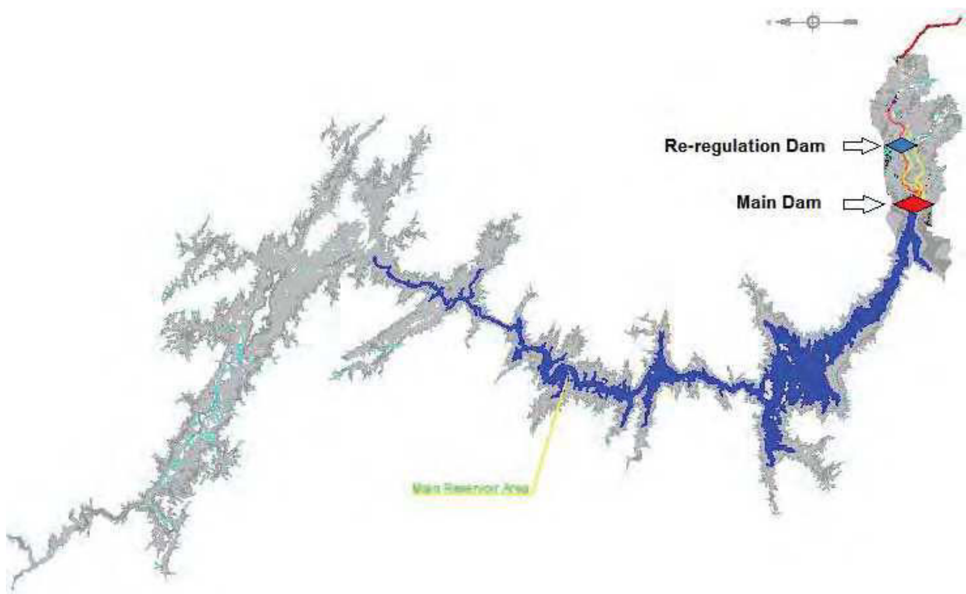
Source: Kansai, 2013

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 km². Most of the inundation (36.8 km², 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 km². The inundation areas for normal water level (NWL) and minimum operational level (MOL) are illustrated in ***Figure 0.4***.

Figure 0.4 Inundated Area of Main Reservoir



(a) Normal Water Level (EL 320 m)

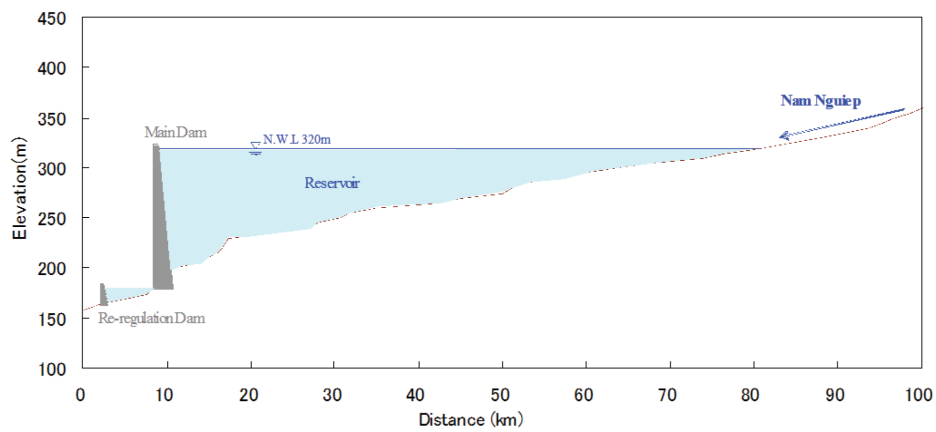


(b) Minimum Operation Level (EL 296 m)

Source: (a) Technical Report, 2011 and (b) Kansai, 2013.

As shown in the longitudinal profile (***Figure 0.5***), 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 0.5 Longitudinal Profile of Main Reservoir



Source: Technical Report, 2011.

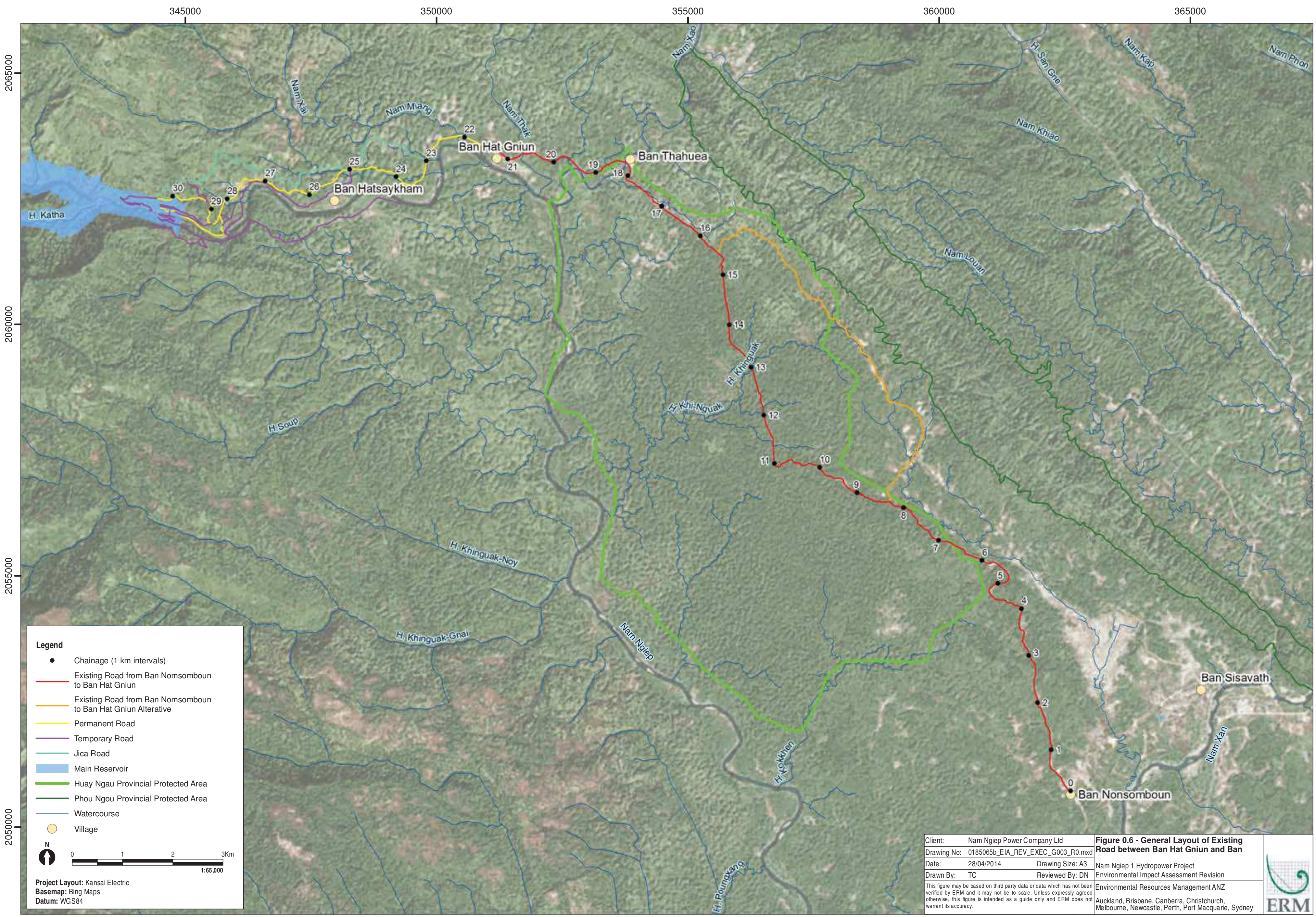
0.4.4 *Improvement of Existing Access Road*

The transportation distance and road conditions for each section of the route between Vientiane and Ban Hat Gniun are shown in ***Table 0.3***. The access road uses the same alignment as the existing road in the Houay Ngua Provincial Protected area. All equipment and materials will be transported during the construction period through the route. 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. The location of the access road is shown in ***Figure 0.6***.

Table 0.3 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 Gniun	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, 2014



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Date:	28/04/2014 — Drawing Size: A3
Drawn By:	TC — Reviewed By: DN

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Figure 0.6 - General Layout of Existing Road between Ban Hat Gniun and Ban

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0.4.5 Transmission Lines

For the Project, there are two transmission lines; 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 kilometres 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 Electricite Du Laos (EDL), is proposed to run 40 kilometres, starting at the re-regulation dam and ending at the Pakxan substation, providing domestic power supply. The 115 kV line is considered as a separate associated facility of the Project, and an IEE will be prepared for this line by EDL. Transmission Line Route for the 230kV line is shown in ***Figure 0.7***.

0.4.6 Resettlement Site

There are four affected villages in Zone 2LR: from north to southwest Ban Houaypamom, Ban Sopphuane, Ban, Sopyouak and Ban Namyouak. They are all located in Hom District of Xaysomboun Province about 12 to 25 km upstream from the dam site, which is located in Bolikhan District of Bolikhamxay Province. Through the inundation of the reservoir, all four (4) villages will require resettlement. A total of 384 households and 2,735 affected people will be resettled.

The Houaysoup resettlement site is around 6000 hectares in size and includes area for relocated houses, agriculture and NTFP collection. The resettlement site is located downstream of the re-regulation dam on the Southern Bank of the Nam Ngiep River.

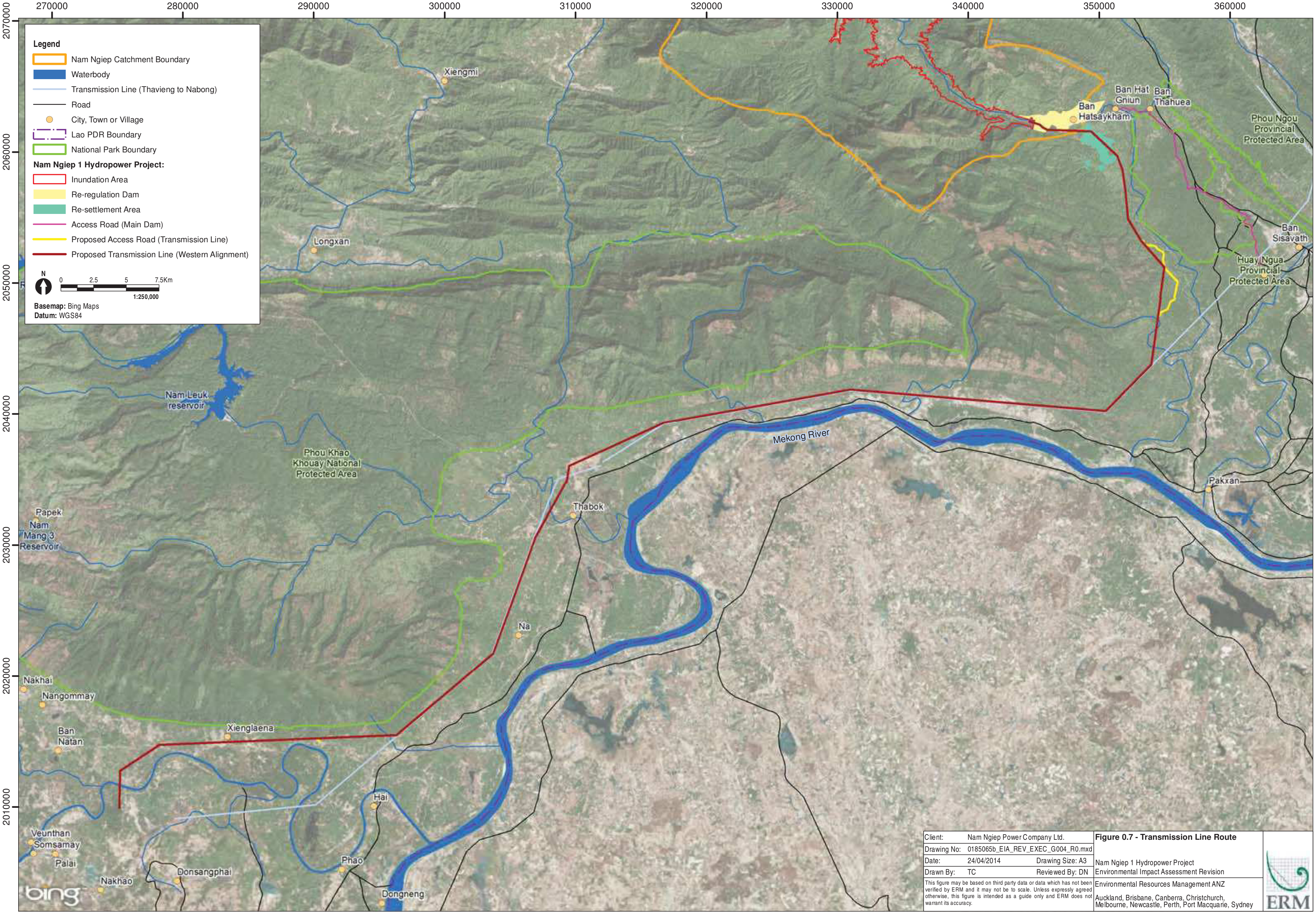


Figure 0.7 - Transmission Line Route

0.4.7 *Project Stages and Activities*

0.4.7.1 *Construction*

Construction procedures of the main power facility will 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.

The size of the various functional areas during the construction phase is detailed in ***Table 0.4***.

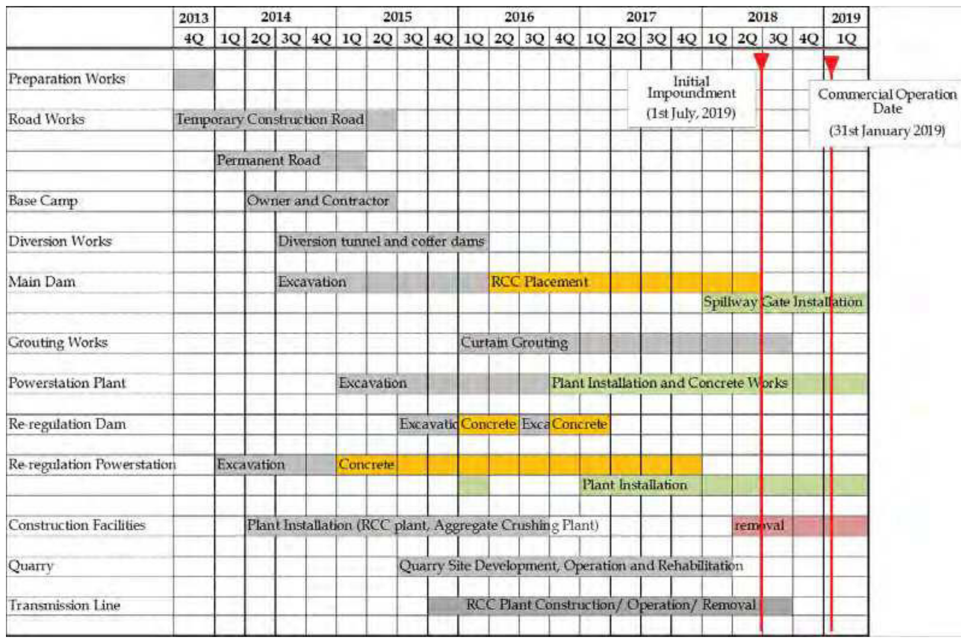
Table 0.4 Sizes of Functional Areas during Construction Phase

Functional area	Size		Length (km)	Permanent Use
	(ha)	(m^2)		
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, 2007 DWG # NNP1-C-03 and Technical Report, 2007.

A tentative schedule for the construction is presented in ***Table 0.5*** Construction is planned to take a total of 70 months.

Table 0.5 Schedule for Construction



Source: Kansai, 2013.

0.4.8 *Main Dam Operational Characteristics*

0.4.8.1 *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 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.

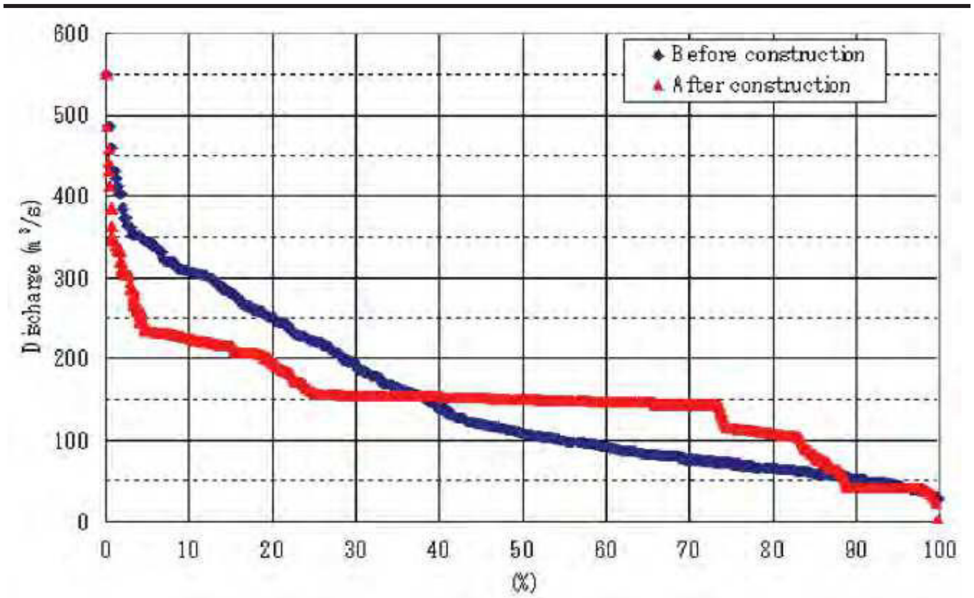
0.4.8.2 *Hydro Peaking Management and Environmental Releases*

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 – known as hydro peaking. The re-regulation dam is planned 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.

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 0.8***. 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.

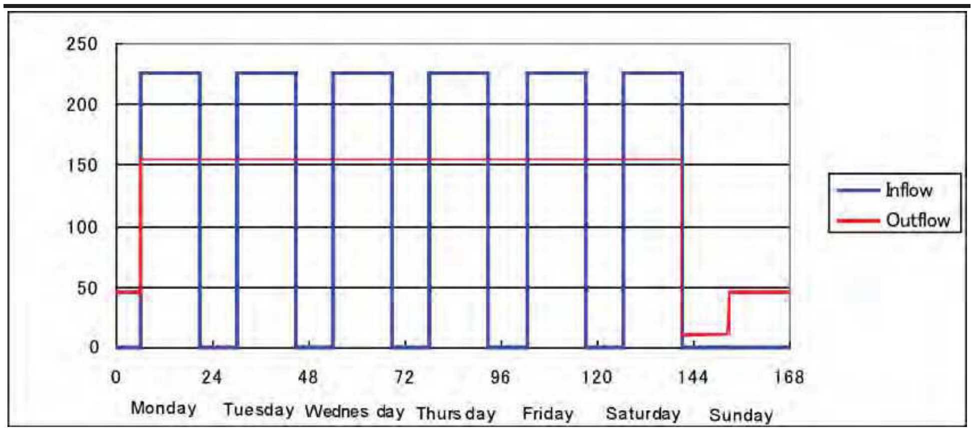
Figure 0.8 Change in River Flow Before and After Construction of Project



Source: Environmental Impact Assessment Report, ERIC 2012.

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 0.9***. The discharge from the main dam will be temporarily stored in the re-regulation reservoir.

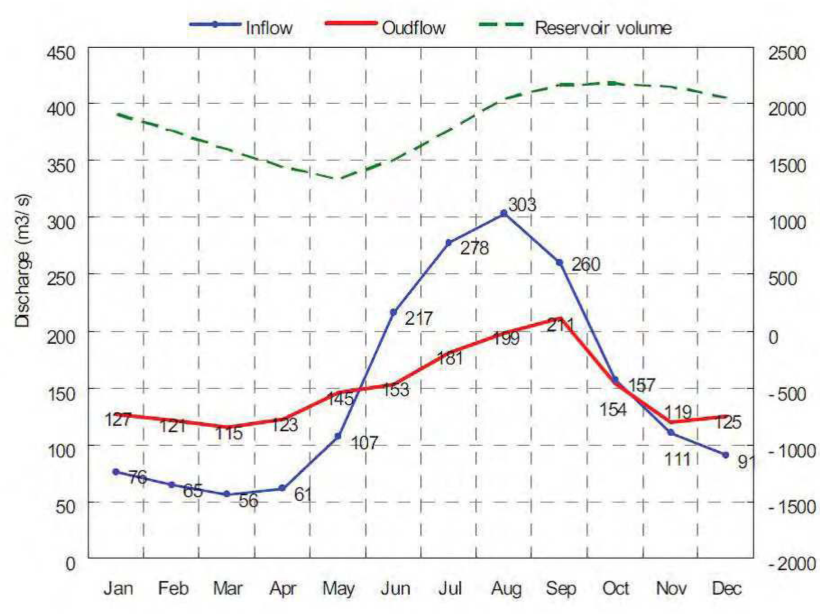
Figure 0.9 Typical Operation of Main Dam



Source: Environmental Impact Assessment Report, ERIC, 2012.
Note: Typical operation case of 230 m^3/s 16-hour peak generation

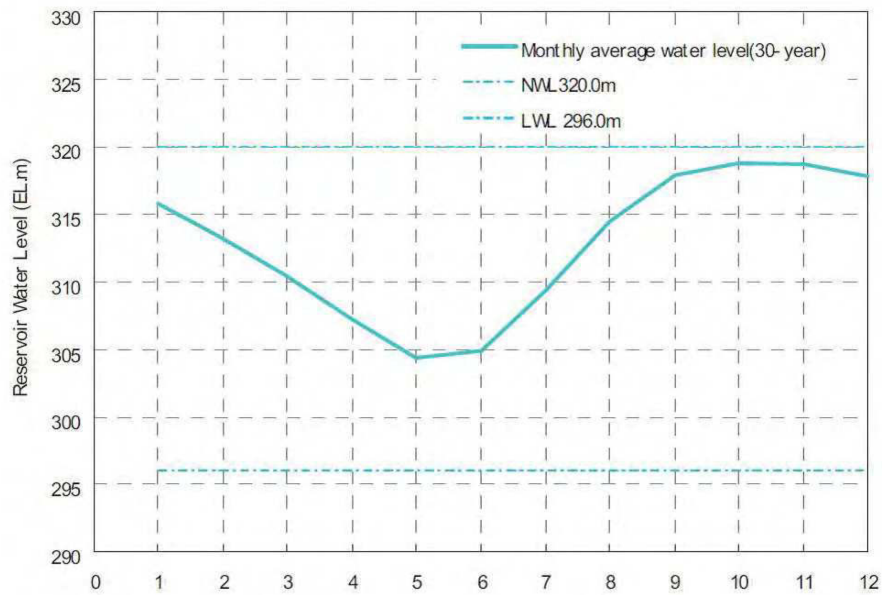
Operation of the main dam would intentionally release water downstream during emergency events such as drought or flooding, when both turbines would be unable to release water. Spillway gates would be operated during flooding in accordance with the spillway gates operation rules, to minimize downstream 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.

Figure 0.10 Seasonal Inflow and Outflow of Main Reservoir and Changes in Reservoir Volume



Source: Environmental Impact Assessment Report, ERIC, 2012.

Figure 0.11 Seasonal Water Level of Reservoir



Source: Environmental Impact Assessment Report, ERIC, 2012.

Spillway Discharge from Main Dam

The spillway gates will be operated under the following scenarios: 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, including environmental flow releases (discussed in the following section).

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.

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.

0.5 *EXISTING ENVIRONMENT*

This section of the Executive Summary presents a brief summary of the existing environment for each environmental aspect.

0.5.1 *Physical Environment*

0.5.1.1 Topography

Relief along the Nam Ngiep 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.

Upstream of Main Dam - High Mountains (EL. 180 m. MSL.) 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. Upstream of the dam is a deeply incised gorge with small fluvial deposits from major confluences. About the FSL, the Nam Ngiep flows from various tributaries with upstream deep pools and adjoining rapids. Immediately above FSL, the river flows through a mainly through a depositional landscape.

Downstream of Main Dam - Most of the river downstream from the main dam has an elevation of less than 180 meters. The downstream section of the river is characterized by gently meandering river stretches and large open floodplains as the river flows into the Mekong River some 47.9km away. A re-regulation dam will divide the downstream into two parts, one between the two dams about 5km apart and the other downstream of the re-regulation dam.

0.5.1.2 Climate

The Nam Ngiep1 Hydropower Project is located in the Xaysomboun, Vientiane, Xeing khoung and Bolikhamxay Provinces, 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 EIA study found that for the months of March to the end of May, temperatures ranged from 17^{o}C to 38^{o}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^{o}C to 36^{o}C, and from December to February (considered to be the dry season) temperatures ranged from about 11^{o}C to 29^{o}C.

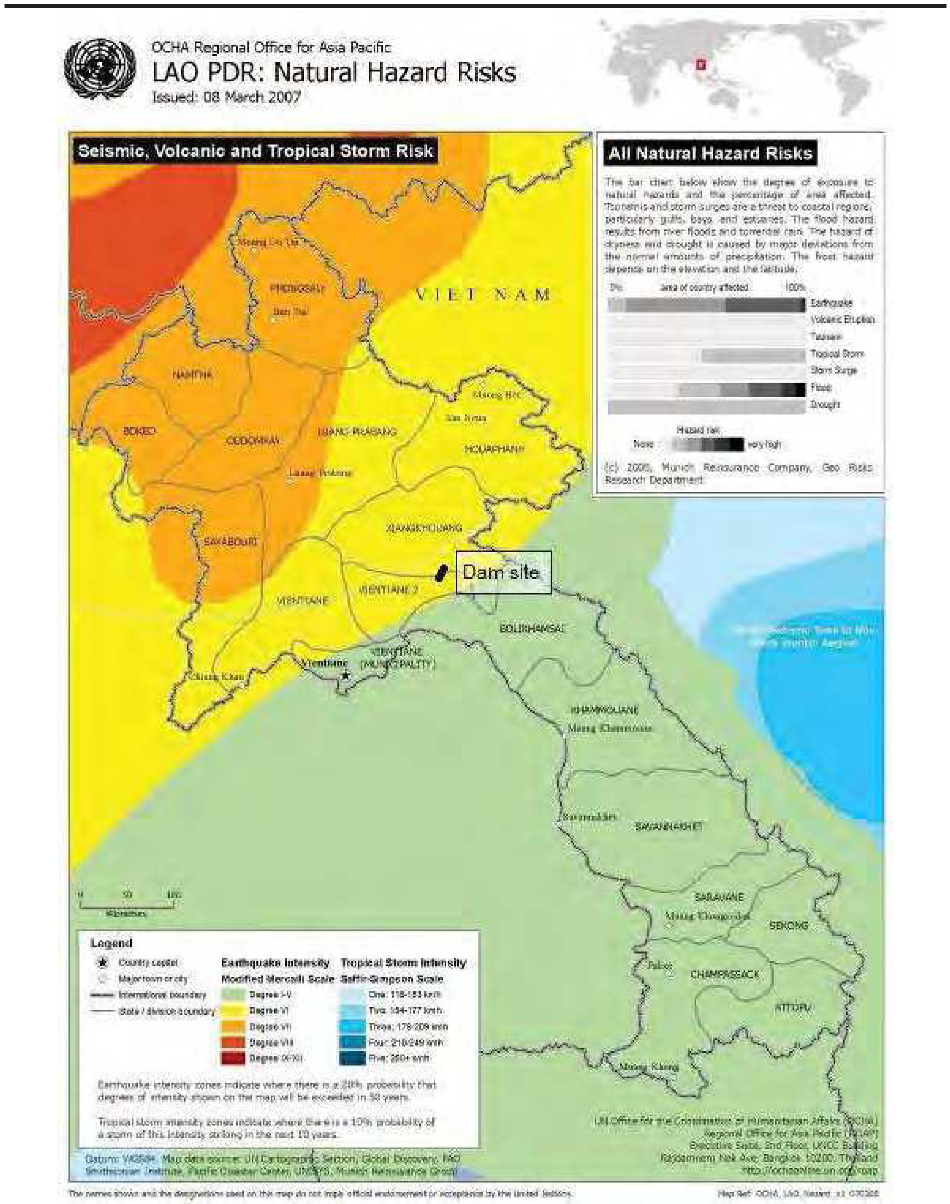
According to the meteorological data of Pakxan District (DMH, 2005), the seasonal variation of monthly rainfall follows the general pattern of the

Southeast Asia monsoon, with about 90% of rainfall during the six month wet season from May to October.

0.5.1.3 *Geology, Landforms and Seismology*

Seismic events in the Project area have been historically rare. 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 (***Figure 0.12***). 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 (Kansai Electric, 2007).

Figure 0.12 Map of Natural Hazard Risks in the Lao PDR, 2007



Source: Environmental Impact Assessment Report, ERIC, 2012.

0.5.1.4 *Soils*

Soil surveys found that the soils around the proposed construction sites and camps are 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.

0.5.1.5 *Erosion and Sedimentation*

The Western and Northern edges of the basin form a vast cirque with very steep sides due to headword erosion, while only outliners remain of the eastern rim which separates this basin from that of the Nam Xan 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 watershed area.

Some spoil erosion from surrounding landuses exists within the watershed, particularly from forestry and agriculture.

0.5.1.6 *Surface Water and Groundwater 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. The quality of water was noted to be poor in locations where there are more human activities. There is evidence that water quality is deteriorating, 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.

The EIA 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 within acceptable range for surface quality water quality standards freshwater and less disturbed forest found in the upper watershed. Turbidity values were low in the dry season, but became higher in the rainy season. Average concentration of suspended sediments was about 17 ppm in the dry season and 83 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 but was less than the acceptable standard for surface waters (<5mg/L). 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. These Standards are used as they provide a more comprehensive analysis for water quality benchmarks for surface waters. This is defined as very clean fresh surface water resources that 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.

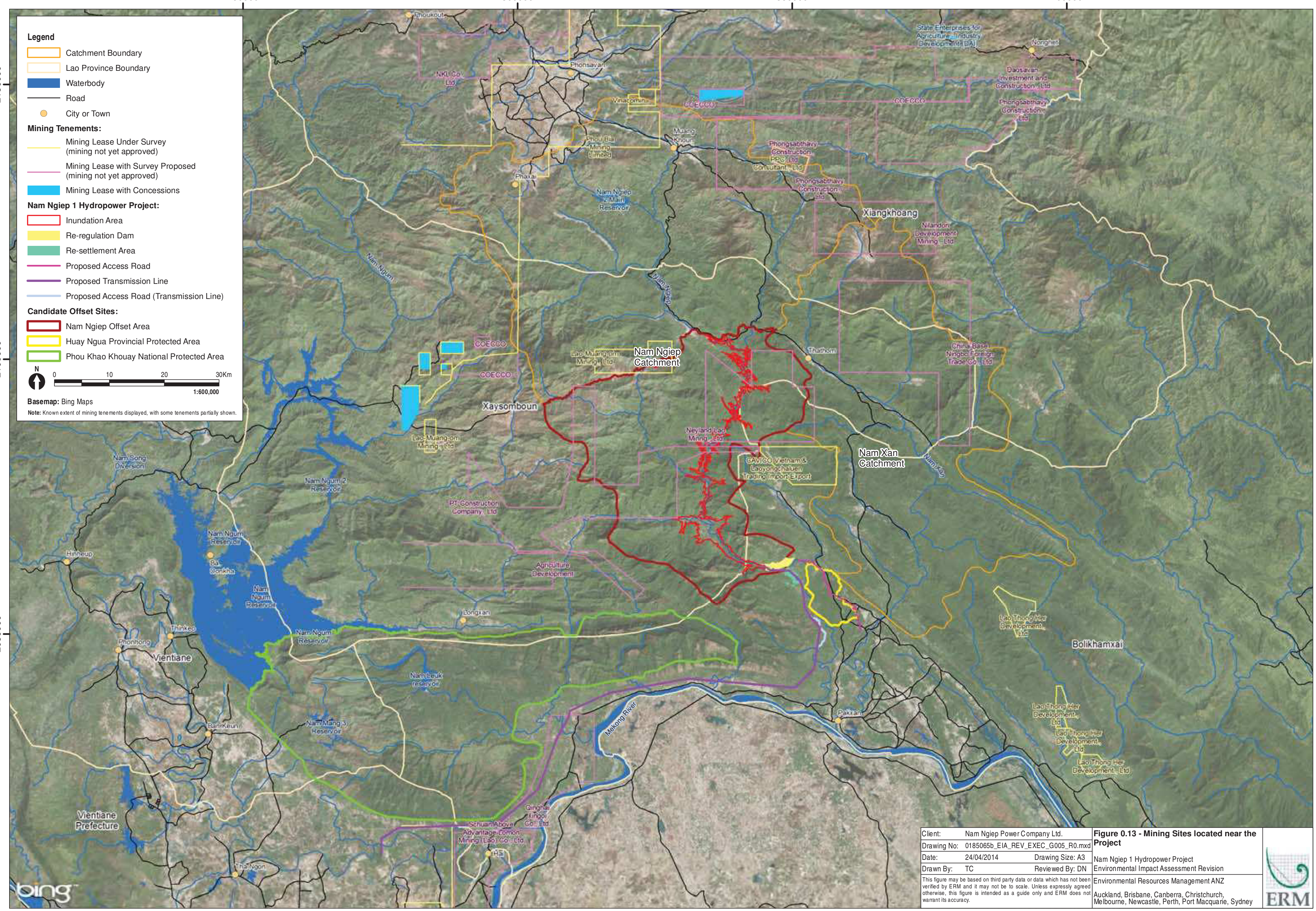
Groundwater quality of the sample collected from the well at Ban Xomxeun was within acceptable limits for most parameters according to Groundwater Quality Standard for Drinking Purpose as notified in the Lao National Environmental Standard. However, the water was slightly acidic (pH of 6), and was found 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.

0.5.1.7 Mineral Resources

Geological surveys around the reservoir area and construction area 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 the advice provided through the course of EIA indicates that no valuable minerals would be quarantined because of the project.

Most potential mining sites and existing mining near the Project are located more than 100 km away in adjacent watersheds. Only a few mining operations exist within 100 km of the Project, at Vientiane, Khammouane and Xaysomboun Provinces, as shown in ***Figure 0.13***.



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Date:	24/04/2014	Drawing Size: A3
Drawn By:	TC	Reviewed By: DN

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Figure 0.13 - Mining Sites located near the Project

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0.5.1.8 *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 noise and vibration during the construction or operation phases. 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 vibration levels were not measured; instead references to other Projects and activities similar to the NNP1 Project were compared and applied in 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 two-wheel tractors and the natural acoustic environment, so sound levels would likely be between 40 to 60 dB.

0.5.1.9 *Air Quality*

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 was anticipated to be good. In addition, the EIA 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 good. Air quality monitoring points have now been established around sensitive receptors throughout the project area.

0.5.1.10 *Potential Contaminated Sites*

Potential contaminated 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 were 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.

0.5.1.11 Hydrology, Hydrogeology and Environmental Flows

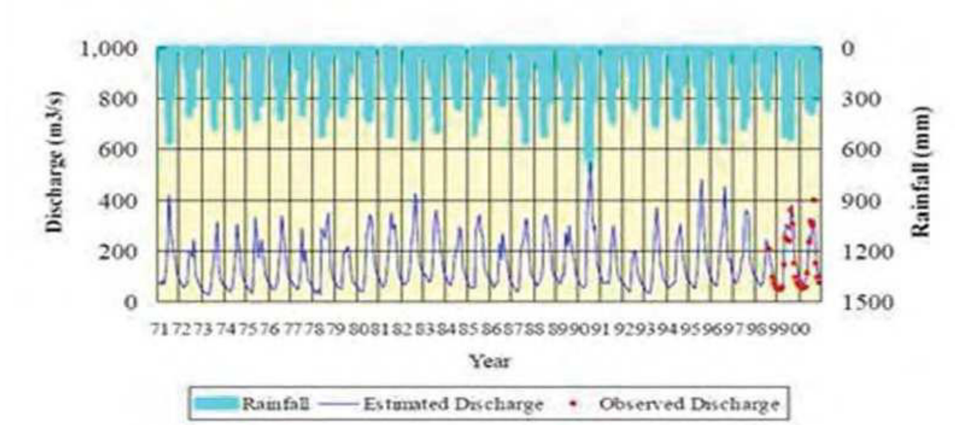
Nam Ngiep basin has a watershed area of about 4,533 sq. km., and is divided into 33 sub-basins. Most of the sub-basins are rather small, and only 3 sub-basins have a watershed area of more than 10% of the total watershed area.

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.

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 0.14**)*. The model was calibrated and verified against the actual results of river flow discharges over a two year period – wet and dry season 1998-2000. Actual river discharge data is plotted – in red dots – over the model for calibration. The results show that actual river discharge are closely aligned with the model, indicative of the accuracy

Figure 0.14 Result of Low Flow Analysis by Tank Model Method



Source: Technical Report, 2011.

Based on a mathematical model (Tank Model), the long-term inflow at the main dam site is estimated as tabulated in ***Table 0.6*** and ***Table 0.15***. The average inflow is about 148.4 m^3/s, with an annual runoff of around 4,680 mcm. The seasonal variation (***Figure 0.16***) is significant, with 74% of total runoff occurring 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.

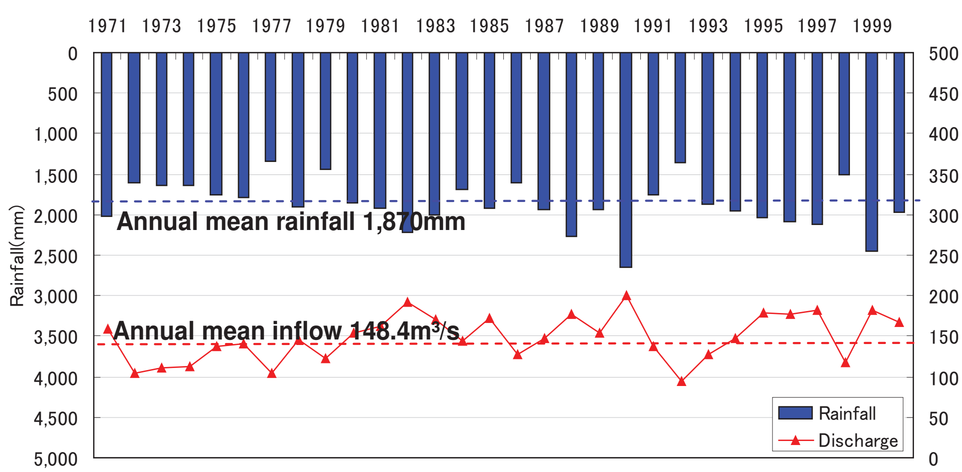
Figure 0.17 shows the duration curve of the inflow at the main dam site, with the flow at probability of being equalled or exceeded. Based on the minimum flow of 26.4 m^3/s (April 1973), it is equivalent to 99.58% probability.

Table 0.6 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	255.0
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	74.0

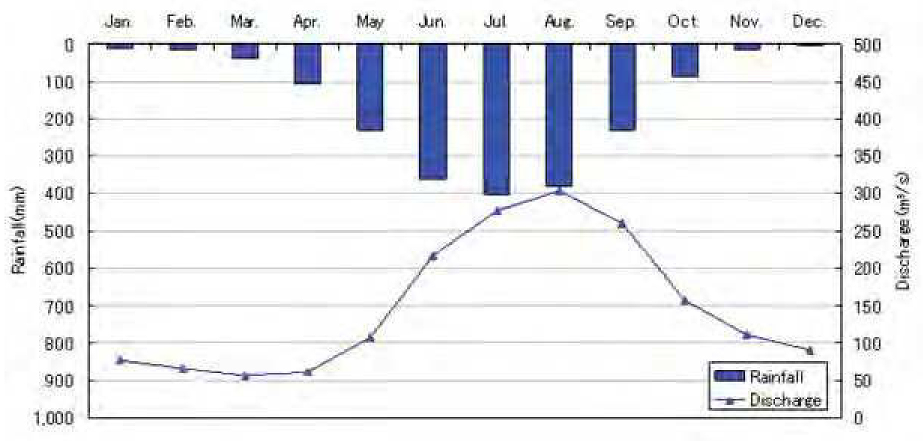
Source: Kansai, 2013.

Figure 0.15 Basin Annual Mean Rainfall and Discharge (Inflow) at Nam Ngiep Dam Site

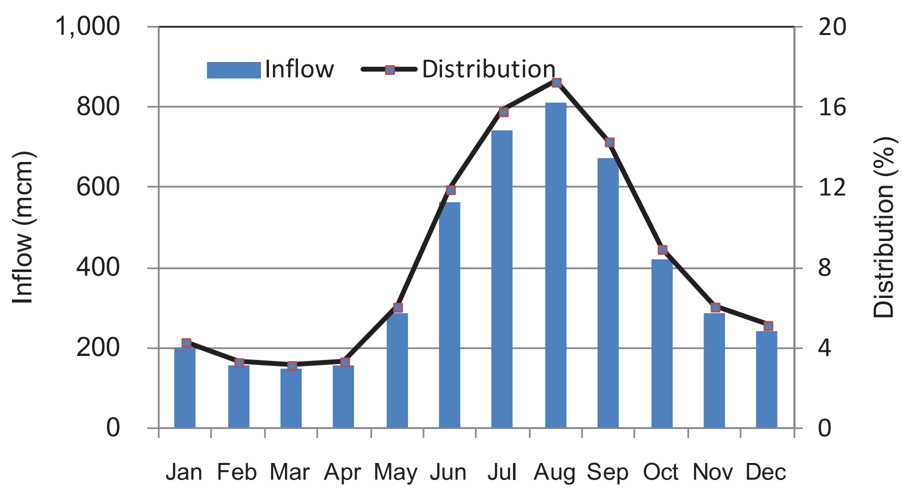


Source: Kansai, 2013.

Figure 0.16 Seasonal Charge of Inflow at Nam Ngiep Dam Site



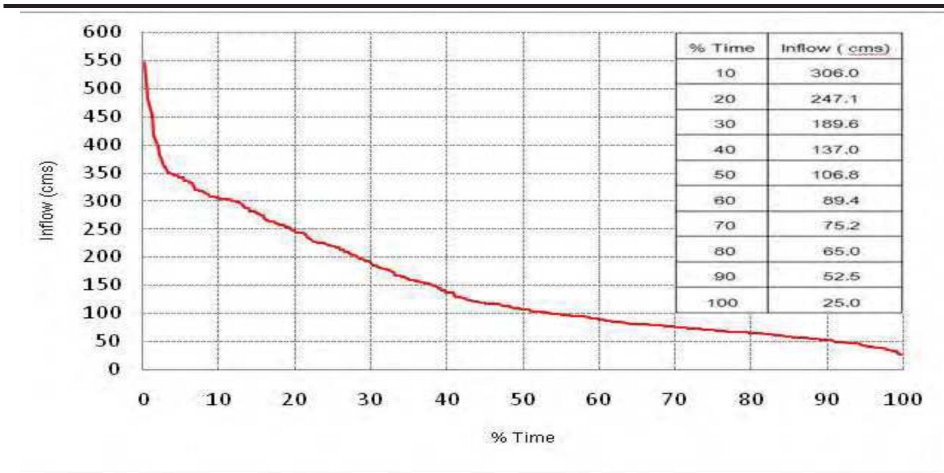
(a) Flow Rate



(b) Runoff

Source: Kansai, 2013.

Figure 0.17 Flow Duration Curve at Nam Ngiep Dam



Source: Kansai, 2013.

0.5.2 *Environment Flow Assessment*

The downstream aquatic environment below the proposed re-regulation dam consists of a riverine environment downstream to the confluence with the Mekong River. It is characterised as a meandering river with a large floodplain that is partially inundated during the wet season. The predominant land use of the flood plain is agriculture for seasonal cropping. Market gardens line the banks of the river near settlements. The river is also used for transportation by local villagers, both for personal travel between settlements and Pakxan in the South as well as for transport of produce. In addition to this navigation/transportation service, the river also supports other important ecosystem services, including fisheries, and provides water that is used for limited household consumption, washing, bathing, occasionally drinking and irrigation. The river is also used by villagers along the Nam Ngiep River to dump their waste.

With regards to drinking water, villagers mainly 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 NNP River and tributaries as a supplemental source of domestic water rather than the principle one. With regards to irrigation, nearly all the agricultural fields are on lands above the river and the main agriculture production (vegetables, lowland rice, upland crops, and forestry) depend upon rainfall rather than river water. A few are irrigated, but these use water from streams flowing down toward the Nam Ngiep from the mountains. Farmers use river and/ or local stream water only for some small plots near the embankments. Those 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. No irrigation systems were observed during surveys. Villagers typically rely on rainfall or nearby local streams rather than the Nam Ngiep.

Species presence and abundance of phytoplankton and benthic organism densities were determined at 10 locations (2008) impacted by NNP1. These organisms are vulnerable to large variations of sediment, hydrology and water quality. Groups of organisms were found to be affected to different degrees and at different trophic levels, with those directly feeding on planktonic groups, such as fish, being the most affected.

Sediment through the Nam Ngiep is largely of suspended nature and so is predicted to pass through the dams to the lower reaches. Anoxic conditions from dam stratification will be ameliorated by increased DO created by the re-regulation dam, and by the placement of drawdown from the main dam being taken from above the hypolinmion.

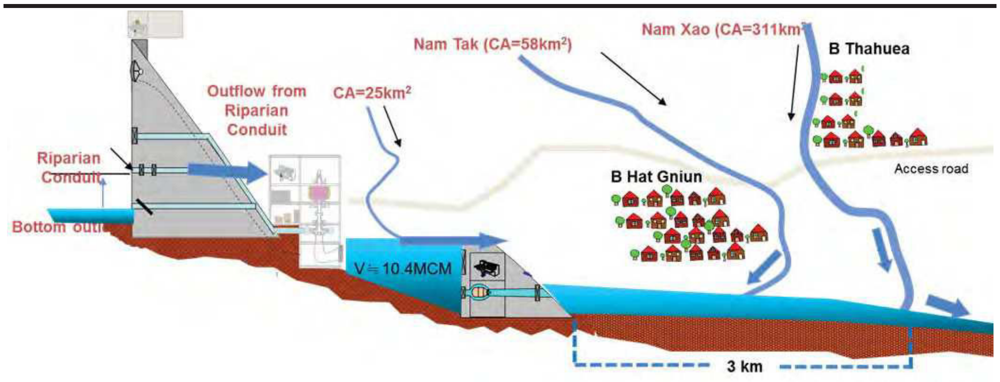
A dam will necessarily change the downstream hydrology of a river by increasing dry season flows and reducing wet season flows – reducing overall flow variability. Inevitably, some environments, particularly the current littoral zones and their invertebrate community structure, will be affected along with changes to vegetation communities, geomorphic units and habitat distributions. However, measures will be taken to minimize any adverse impacts from changes caused by the dam, particularly on phytoplankton and benthic communities. The construction of a re-regulation dam is planned for the purpose of reducing the fluctuation of the water released downstream from the main dam power house to maintain more constant environmental flow rates. This design takes into account that electricity generation from the main dam power house, and hence water releases, will not be constant during a 24 -hour period but the re-regulation dam will discharge water downstream to augment the downstream river flow and maintain a minimum environmental flow. The re-regulation dam will discharge water downstream on a 24-hour basis, re-using it for power generation when water levels in the re-regulation dam are sufficiently high or simply releasing the water in dryer periods in order to augment the downstream river flow and maintain an environmental flow that supports productive base food chain.

0.5.2.1 *Environmental Flows during Initial Impoundment*

An environmental flow of 5.5 m^3/s is adopted for the NNP1 Project during the initial impounding. This proposed environmental flow rate during the initial impounding also takes into account the restrictions of the designed capacity of the re-regulation reservoir and designed capacity of the outlet conduit.

The section of river with reduced water (minimum 5.5 m^3/s environmental flow) is limited to between the re-regulation dam and to a point 3 km downstream where it reaches the confluence of the Nam Xao River ('Reduced Water 3 km Section'). At this confluence point the minimum flow will increase to more than 18.6 m^3/s (Figure 0.18) with the inflows from the Nam Tak and Nam Xao Rivers. For this reason, the discussion following is focused on the 'Reduced Water 3 km Section'.

Figure 0.18 Minimum Recovered Discharge 3 km Downstream of the NNP1 Re-regulation Dam during Initial Impounding in July 2018



Source: Environmental Flow Assessment Report, 2014

It is noted that the initial impounding is scheduled to take place at the beginning of the rainy season in July with an increasing natural inflow to the main reservoir in order to reduce the impacts of low flows on the downstream riverine system. The filling of the main reservoir will take one wet season to complete. The reductions in water depth and flow rates are expected to be less severe by undertaking the initial impounding during the wet season and restricting it to just one wet season.

Non-uniform river flow analysis was performed, based on river sectional surveys and their river flows, to investigate the effects on the river downstream of the re-regulation dam during the initial impounding when the environmental flow is 5.5 m^3/s. The predicted minimum water depth and river surface width occurring between the re-regulation dam and B. Hat Gniun (located in the 'Reduced Water 3 km Section') are 0.5 m and 16.1 m respectively. Taking into account the in-stream flow contribution from groundwater seepage and delayed subsurface flow in the wet season, however, the flow regime is likely to be larger than these predicted minimum conditions.

These conditions of the river from the environmental flow during initial impoundment are predicted to be sufficient to the support usual navigation/ transportation (where a minimum 0.5 m water depth is considered sufficient) and domestic household use of the river. Downstream of the 'Reduced Water 3 km Section' with the combination of minimum 5.5 m^3/s environmental flow and confluence with the Nam Xao River, river conditions to the confluence with the Mekong are also predicted to be sufficient to maintain similar ecosystem services as currently provided. With respect to fisheries and aquatic fauna, potential impacts are confined principally to the local area of 'Reduced Water 3 km Section'. It was only considered necessary to assess one aquatic fauna species for the possible presence of critical habitat within the Project area, *Luciocyprinus striolatus* but this species' spawning sites were all recorded above the main dam site and only limited, seemingly non-migrating individuals were recorded below the re-regulation dam site, far from the confluence with the Mekong and only at the end of the rainy season when the discharge is highest. Overall the downstream NNP river is considered relatively less sensitive with the absence of critical habitats and with the temporal impact of the changes considered to be short-term (i.e. one wet season compared to the entire construction and operation duration) and the affected length of river relatively short compared to the total distance of the downstream reach from the re-regulation dam to the confluence with the Mekong River, any potential impacts during initial impoundment are unlikely to be significant.

0.5.2.2 Environmental Flows during Operation

During week days the outflow from the re-regulation dam will be maintained at 160 m^3/s. On weekends, the outflow from the re-regulation reservoir will be reduced over a 4-hour ramp down period to 27 m^3/s for 17 hrs (10pm on Sat to 2pm on Sun) and then increased to 48 m^3/s for a period of 15 hrs (2pm on Sun to 6 am Mon). This normal operation procedure is predicted to take place for over 97% of the time.

Environmental flow during operation in all weather conditions (i.e. including extreme drought) is set to a minimum of 27.0 m^3/s. Even during years of extreme drought when there is insufficient water in the main reservoir for normal operation, the minimum environmental flow of 27.0 m^3/s will be released and, taking into consideration the tributary contribution and groundwater seepage, the minimum flow occurring in the reach downstream of the confluence with the Nam Xao River will correspond to 38.0 m^3/s. This would be higher than the minimum flow rates that would occur naturally without dam regulations in these periods of extreme drought.

In the worst case scenario of 27.0 m^3/s environmental flow, the predicted minimum water depth occurring in the 'Reduced Water 3 km Section' is 1.0 m. When the release flow drops from 160.0 to 27.0 m^3/s over the 17-hour period once a week, the river width will change considerably, with the water surface width reducing by a maximum of 160.0 m near the B. Hatkham village. Water temperature in the main reservoir would be about 4°C higher than that before the construction. Water then flows into the re-regulation reservoir and when released through the re-regulation dam gate, surface water can still be up to 4°C higher. The predicted range of the DO in the main reservoir outflow discharge varies from 3.5 mg/L to 7.9 mg/L through the year. Due to oxygenation and dilution the DO concentration increases as the water flows downstream to the re-regulation dam and DO concentration of discharged water from the re-regulating dam is over 6 mg/L almost all the year.

As stated above, these conditions of the river from the environmental flow are predicted to be sufficient to support usual navigation/ transportation and domestic household use of the river. With regards to fisheries, as noted above, the lower NNP river stretch is regarded a relatively less sensitive compared to the reaches above the dam site. While any reduced flow and water depth of the river may affect the abundance and richness of fish and benthic fauna (also considered as a food source for fish species) in the long term, with the provision of a 27.0 m^3/s minimum environmental flow from the re-regulation dam, any potential impacts are likely to be mainly to the relatively short 'Reduced Water 3 km Section'. With the increased water temperatures, there is potential for some shifts in the macroinvertebrate community but DO levels are maintained above a level that supports aquatic life almost year round. In addition, the re-regulation dam and operating process have the advantage of securing environmental flow improving aquatic conditions in dry periods.

0.5.2.3 Sedimentation within the Reservoir

Sedimentation is not likely to be a significant issue for the NNP1 reservoir. Sediment trapping in the upstream Nam Ngiep 2 dam (NNP2) is likely to trap sediment from the upper watershed. During sediment modelling, the effect of NNP2 was not accounted for in the estimation of sediment for NNP1. No other mining projects in the upstream watershed were aware by the time when the project was conducted. Assuming future deforestation of the basin of the NNP1 Project, the specific sediment yield of the Project is conservatively set at 248 ton/ km^2/ year same level as that of the Project, which is more than estimated annual sediment yield of the Project, 178 ton/ km^2/ year. The volume for 50 years is approximately 35 million m^3 and sediment level in the reservoir for 50 years is estimated at EL.233 m, which is much lower than the minimum operation level, which is set at EL.296 m. The estimated volume during life of the NNP1 reservoir is quite small compared to the reservoir storage capacity; therefore sediment flushing and dredging is not required.

0.5.3 Fisheries

Specialist assessments were undertaken on fisheries in the Nam Ngiep River above and below the proposed reservoir. Information on actual income of local villagers indicates that fishing is more important in the lower reaches of the Nam Ngiep. According to the census data, fisheries is generally less important for household income than other income generating activities, especially agriculture/livestock tends to be important as well as small business and daily labour in some villages. Fisheries are comparable in importance to collection of NTFPs. The assessment suggests that daily catches are quite low and that the importance of the fisheries lies in food security and supplemental income to local villages. Village catch estimates for downstream villages (x3) indicate that on a weekly basis 3.5kg of wild fishery is consumed per household – dry season catch. Wet season catch statistics are not yet available.

The data collected suggests that currently almost all households are involved in fishing on a part-time basis. Most fishing is done close to the settlement areas. Fishing is foremost conducted for consumption of fresh fish with occasional processing and fish trading when large quantities or large fish are caught. Catches tend to be low mainly with gillnet and mainly catch small indigenous cyprinids. There is little evidence of neither an established trade network nor any form of management or fishermen organization.

0.5.4 *Biological Environment*

The Project area is located in the north-central Lao PDR ecoregion, Luang Prabang Montane Rainforest, which is characterized 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).

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).

0.5.4.1 *Study methods to characterize local conditions*

The description of the biological environment for this assessment focused on developing an understanding of the aquatic and terrestrial biodiversity directly and indirectly relevant to the Project and its activities.

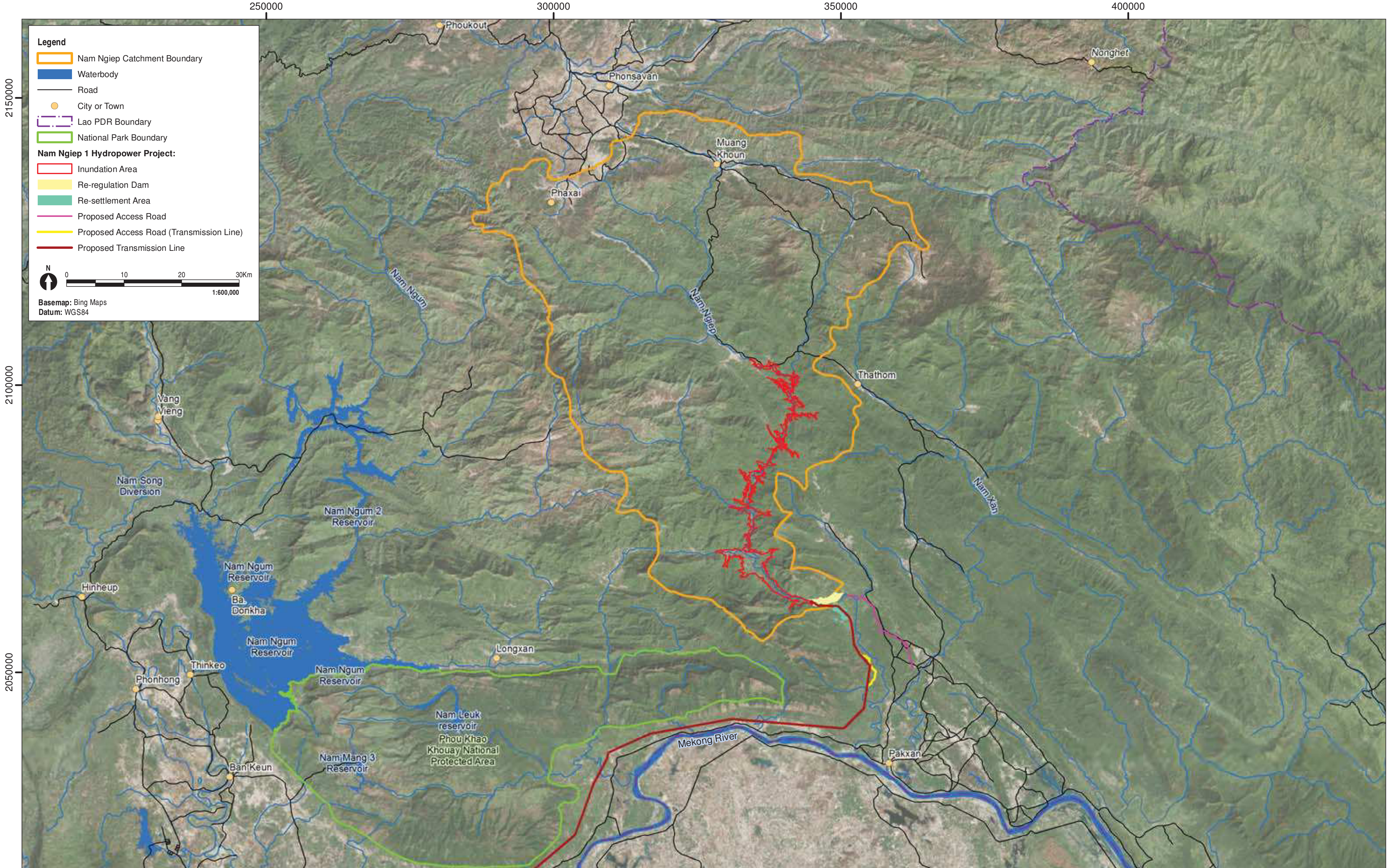
The following terminology is used in the Biological Environment section:

- Project area includes all project components assessed for the extent of direct and potentially indirect impacts; and
- Study area - encompassed all areas assessed including the Project area and candidate offset sites including the Upper Nam Ngiep River, Houay Ngua Provincial Protected Area and the Phou Khao Kouay (PKK) National Protected Area (NPA)

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 and candidate offset sites. Preliminary field sampling was undertaken in 2007 and in the wet and dry seasons of 2013. Additional targeted surveys were undertaken in 2013/2014 specific to threatened primate species and fast water aquatic habitats

Aspects of the study included forests and vegetation cover; protected areas; aquatic habitats; flora species; terrestrial fauna species, aquatic fauna, and fish species.

The assessed areas for the biodiversity assessment are shown in ***Figure 0.19.***



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This figure may be based on third party data or data which has not been verified by ERM and it may not be to scale. Unless expressly agreed otherwise, this figure is intended as a guide only and ERM does not warrant its accuracy.

Figure 0.19 - Biodiversity Study Area

Nam Ngiep 1 Hydropower Project
Environmental Impact Assessment Revision

Environmental Resources Management ANZ

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ERM

0.5.4.2 *Forests and Vegetation Cover*

Central Highlands, where the Project is located, were predominantly dry evergreen and mixed deciduous forests. Shifting cultivation however has removed much of the original forest and large areas of grassland, bamboo and other secondary vegetation are now present.

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" as defined by ADB SPS 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.

Over 80 per cent of the Project Area is classified as moderate or high NDVI (vegetation density and condition index). Only 5 per cent of the Project Area is classified as impacted NDVI.

The Project Area contains a number of 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. 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.

NTFPs were also noted and collected during field surveys. 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.

0.5.4.3 *Protected areas*

The closest protected areas to the Project are the Phou Khao Kouay (PKK) National Protected Area (NPA) to the South and the Houay Ngua "Provincial Protected Area" to the East.

The PKK NPA is an IUCN Category II reserve and is some 50 kilometers to the south of the Project area and is almost 2000 hectares in size. The reserve is an important sanctuary for IUCN listed plant and animal species. It is currently managed by the Lao military given its strategic location to Thailand. The Reserve does not currently receive sufficient funds for management and is threatened by agricultural development, mining and hydro power.

The Houay Ngua Provincial Protected Area is located along the project access road route to the south east of the main dam site. This area however is considered to be of low conservation value and does not meet IUCN reserve category classifications. The management plan for the area indicates that the area is a "reserve" forest for the primary purposes of education and multi-use management. The area is currently in a degraded state, however it does play host to threatened plant and animal species. The area is isolated in the landscape bordered by the Nam Ngiep River and farming, hence it does not play a role as a wildlife corridor. The area also drains into the Nam Ngiep River forming a remnant patch of forest along the river.

0.5.4.4 Aquatic Habitats

The flow regimes characteristics of an aquatic ecosystem play a determining role in the health and productivity of the river system and for some species. Flows can trigger movement during some periods. The Nam Ngiep River has a watershed 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 m^3/s) occur between June and September with lowest discharge volumes (50-75 m^3/s) in February to April.

Aquatic riverine and tributary habitats were assessed during TISTR 2012 site surveys. Seasonal variation to habitats was as observed in terms of water depth, clarity, flow and wetted width.

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 Forest Resource Management (DFRM) (2012), 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 degraded their ecological function as a wetland. These wetlands within the watershed are not classified as Ramsar sites and they do not have the potential in their current disturbed states to be classified in the future as Ramsar sites.

0.5.4.5 Flora 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 0.7***).

Table 0.7 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

Source: ERM, 2013.

0.5.4.6 *Terrestrial Fauna Species*

The diversity of terrestrial fauna in the main dam inundation area (upper Nam Ngiep) was high in comparison to other Project areas (Access Road, resettlement area) sampled in 2013 by TISTR. Habitats varied in condition with human disturbance evident in areas downstream of the main dam.

Table 0.8 Fauna Habitat (vegetation cover) in the Project area

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.
Upper Nam Ngiep	The Upper Nam Ngiep River is dominated by primary forest. The fauna habitat in this area is in good condition in comparison to other areas surveyed. The diversity of fauna is expected to be high given the large intact area of habitat and the results obtained from surveys of the Project area. The land cover mapping shows similar vegetation covers across the watershed area and, as such, it is likely that species recorded during surveys (2013) within the Main Dam site will also occur within the wider Upper Nam Ngiep area.
Access Road	The access passes through the Houay Ngua PPA in the Bolikhamxay

Survey Location	Forest Type Description
	Province and traverses nearby the Phou Khao Kouay National Protected Area (NPA). The Houay 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 Houay Ngua PPA in the Bolikhamxay Province, crosses the Nam Ngiep River and traverses nearby the Phou Khao Khoay National Protected Area (NPA). The Houay 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.

Source: ERM, 2013.

0.5.4.7 *Fauna Species*

The fauna species have been classified by the IUCN (2012) according to their species extinction risk status. 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.

Overall, the direct and indirect records identified through fauna surveys and literature reviews 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.

0.5.4.8 *Aquatic Fauna 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 0.9***). Species listed as critically endangered or endangered are considered candidates for critical habitat and these species records have been queried below. Species listed a Restricted under the Regulation of the Ministry of Agriculture and Forestry No. 0360/MAF is 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 0.9 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	Houay Ngua	Resettlement Site	
Giant barb	*Catlocarpio siamensis*					x		CR
	Luciocyprinus striolatus			x				EN
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
	Hemimyzon confluens							VU
	Labeo pierrei				x			VU
	Rhinogobius albimaculatus							VU
Bandan sharp-mouth barb	*Scaphognathops bandanensis*					3		VU
Jaguar loach	*Yasuhikotakia splendida*				1	4		VU

Source: ERM, 2013.

Note: IUCN Status: CR – Critically Endangered; EN – Endangered; VU – Vulnerable; counts = Direct record; x = Indirect record; blue x = noted within Houay Ngua PPA Area Management Plan

0.5.4.9 *Critical Habitat Assessment Summary*

The ADB SPS describes critical habitat as "*areas with high biodiversity value, including habitat required for the survival of critically endangered or endangered species; areas having species significance for endemic or restricted-range species; sites that are critical for the survival of migratory species; areas supporting globally significant concentrations or numbers of individuals of congregatory species*"

The assessment of the biological environment identified a number habitat types and IUCN species that may be impacted by the Project.

No habitats for species were deemed as critical habitat as defined by the ADB SPS.

Overall the biological aspects of the Project Area demonstrating high biodiversity values include:

- Natural habitats within the Project Area (being areas impacted by project components) and the forested areas of the watershed below FSL level;
- Aquatic habitats along the Nam Ngiep River and its tributaries from the Mekong River to upstream of the FSL;

- All CR, EN listed species and endemic aquatic and terrestrial species identified within the Project Area.

The species listed under the IUCN list and Lao PDR listed species that may be impacted by the Project (as outlined in ***Table 0.14*** and ***Table 0.17***) were assessed. Using baseline data and consultation with species experts each species assessed for critical habitat.

In order to undertake a structured assessment for each species, the assessment drew upon the critical habitat criteria thresholds defined by IFC PS6.

Further analysis of the impacts on species and their habitats can be found in *Section 0.6 Environmental Impacts and Mitigation Measures.*

0.6 *ENVIRONMENTAL IMPACTS AND MITIGATION MEASURES*

0.6.1 *Impacts to Physical Environment*

The approach to identifying impacts and subsequent mitigation measures was based on the original EIA undertaken by ERIC. This process included a screening process and identification of mitigation measures to reduce impacts on the environment.

In general, many of the direct and indirect impacts to physical environmental values, such as impacts to water quality and hydrology during construction and operation, can be minimised through the implementation of mitigation measures.

An outline of the key impact assessment components for the construction and operational phases for the project for water quality, hydrology, noise and air impacts are outlined below.

The summary of anticipated impacts on the physical environment from the Project and proposed mitigation measures during construction and operation phase are present in ***Table 0.14***. This table has been screened to only contain all "high" and "medium" risks to the physical environment from the project.

0.6.1.1 Water quality

Water quality impacts during construction are likely to arise through the exposure of soil surfaces to erosion and associated sediment laden runoff. The primary areas of concern for soil erosion and sedimentation will be from construction of the access road, construction of the main dam, re-regulation dam, transmission line, workers camps and quarries. Possible faecal contamination from latrines and runoff from vehicle maintenance areas pose also pose a risk to the aquatic environment.

Sources of sediment that can impact on water quality during construction near important environmental receptors will be from the main dam and re-regulation dam construction; spoil management stockpiles; access road construction within Huoay Nua Provincial Protected Area; transmission lines routes adjacent to Nam Ngiep River and quarries used during construction for the main dam, re-regulation dam and access road.

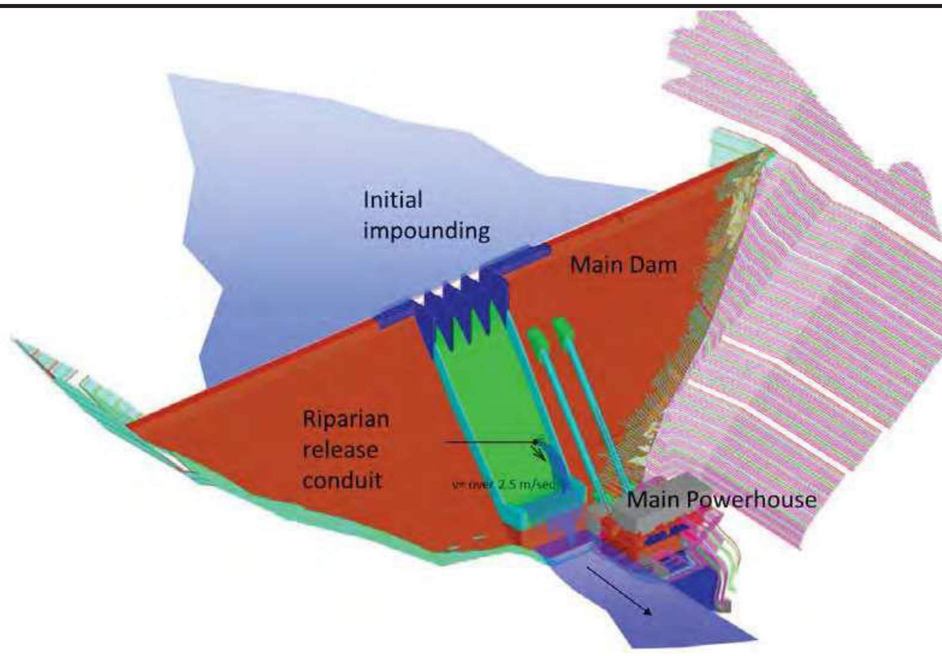
To mitigate against these impacts, an *Erosion and Sediment Control Sub-Plan (as part of Site Specific Environmental and Social Monitoring and Management Plans)* will be incorporated into the construction activities for all project components. The measures to be utilised include: limiting land clearing activities to the dry period only; use of best practices for excavation and working within the riverbed when constructing the main dam and re-regulation dam; using appropriate drainage along all access roads, quarry site, soil stockpiles and other construction sites; and use of standards for drainage works, sediment traps, diversion, culverts and other structures, including treating water before discharge into natural and/or constructed watercourses. Latrines and vehicle maintenance areas will also be subject to water treatment facilities.

During operation, sediment and erosion control is likely to be adequately controlled as land and river systems stbilise.

Maintaining discharges of water of sufficient quality for downstream uses will be the primary concern during operation. Downstream water quality concerns include discharging anaerobic water; discharge of water containing sediment contaminants from the bottom of the reservoir; and discharging water contaminated by algal blooms. These quality impacts could impact on domestic and agricultural uses of water and downstream biodiversity.

The main reservoir depth is between 180 – 320 masl (NWL). To manage potential water quality impacts, the main dam intakes (twin vertical positioned bell mouths) are located at ~274 masl –which is estimated to be above the hypolimnion where anoxic conditions will persist. This intake location will provide better quality water for discharge downstream. Modelling results indicate that DO levels from the main dam, will be at times low (varying between 3.5 – 8.0 mg/L). During standard operations release from main dam is via tailrace located below Re-regulation dam water level as such, no aeration at this point is expected. However, DO levels will increase along the intermediate reach (re-regulation pond) and regulation dam spillway to 5.9-8.6 mg/L.

Figure 0.20 NNP1 Man Dam Outlet Facilities and Power Station



Source: Kansai, 2013

Radial gates (x4) release to a ski-jump spillway, designed to dissipate energy while simultaneously aerating water. The riparian release valve (244 masl) will discharge 5.5m^3/s during initial impounding that will fall ~one-third down the full length of the spillway, and then additional ~25m to the river bed below the dam, thus providing opportunities for aeration during this time.

Maintaining watershed management activities will also be paramount in ensuring that the water quality in the reservoir is maintained during the life of the dam. Modelling has indicated that sediment and nutrient from water inflows can be maintained to within suitable levels to maintain water quality within the reservoir.

0.6.1.2 *Sedimentation and Dredging.*

Estimations of sediment yield have been modelled for the catchment to be 178t/km^2/year. Over a 50 year period, including consideration given to changes to land use but not the trapping capacity of the five other dams in the catchment, sediment plumes are expected to reach 233 masl. This level is well below minimum operation level of 296 masl, and also well below the main dam intake (274 masl). As such, periodic dredging or bottom discharge releases (sediment flushing) is not anticipated.

0.6.1.3 *Hydrology*

River flows into and from the dam will be a major environmental impact during construction and operation from the dam. At the NNP1 main dam the calculated annual average discharge (inflow), minimum monthly inflow and minimum daily flow is 148.4 m^3/s, 26.4 m^3/s (in April 1973) and 23.5 m^3/s (on 4 May 1973), respectively.

With the construction of the dam, the dam-reservoir systems regulate the flood discharge during the wet seasons and increase the flow rates during the dry seasons, so that the seasonal flow regime shows less fluctuation over the year. Averaged daily and monthly flow fluctuations are also likely to be less evident after the regulation. At the weekly and hourly operation levels, flow hydrologic regime will be established as follows.

At the start of the initial impounding, the elevation of the riparian release conduit is set at EL 244.0 m so that the river water cannot be discharged through the riparian outlet until the reservoir water level reaches EL 244.0 m, which is predicted to take approximately two weeks.

According to the tentative programme the initial impounding starts on 1st July 2018. Initially the stored water in the re-regulation reservoir will be discharged with natural inflow to the re-regulation reservoir to secure an environmental flow of 5.5 m^3/s below the re-regulation dam, and within about two weeks the main reservoir water level would reach the sill elevation. It will take about one wet season to fill the main reservoir at the first impoundment but it could vary depending on climate conditions according to the past 30 year inflow data. After that, the discharge from the riparian release conduit in the main reservoir takes place and increases gradually as the reservoir water level increases. After the construction of the NNP1 main dam and the re-regulation dam, stable outflow downstream of the re-regulating powerhouse can be secured. The discharge from the normal operation of the main power station is designed at 16-hour peak generation on weekdays and Saturday. The main power station would not operate on Sunday. The discharge from the main dam would be stored in the re-regulation reservoir and then discharged downstream.

The re-regulation reservoir will be operated between NWL of EL179.0 m and MOL of EL 174.0 m. From Monday to Saturday, the re-regulation reservoir will store part of the discharge from the main dam as it operates for 16-hours and release it downstream evenly over the 24-hour period in order to augment the downstream river flow for the remaining 8-hours when the main dam is not discharging, thus flattening the peak discharge from Monday to Saturday. During week days the outflow from the re-regulation dam will be maintained at 160 m^3/s. On the weekend, the outflow from the re-regulation reservoir will be reduced to 48 m^3/s for a period of 15 hrs (14pm on Sun to 6 am Mon). An environmental flow of 27 m^3/s at minimum will be maintained for the remaining 17 hrs (10pm on Sat to 14pm on Sun), during which time the flow will be released through the re-regulation dam gate. This typical operation accounts for over 97% of the reservoir simulation period of 30 years.

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. The construction of a re-regulation dam is planned for the purpose of "smoothing out" the fluctuation of the water released downstream from the main dam power house to maintain more constant environmental flow rates. This design takes into account that electricity generation from the main dam power house, and hence water releases, will not be constant during a 24 - hour period. The re-regulation dam will discharge water downstream augment the downstream river flow and maintain a minimum environmental flow. In this way, the re-regulation dam and environmental flow regime will help mitigate potential environmental impacts of the Project and help maintain the human use and ecosystem services normally provided by the river by creating 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.

0.6.1.4 Fisheries

Impacts to fisheries can be divided into those impacts downstream and upstream of the reservoir.

Upstream impacts on fisheries will be determined by the ability of the reservoir to support fisheries biomass and the ability of those fish to be caught. The species mix also will change, meaning different fish may be caught. Technologies used in the fishery will also need to change to enable the changed resource to be accessed.

Downstream impacts on fisheries will be influenced by the quality and quantity of water discharged. As outlined in the environmental flows assessment, it has been determined that sufficient water quality and quantity will be provided to maintain fisheries in the medium to long term. Short term impacts are likely during impoundment before the environmental flow regime is initiated. There will also be higher dry season flows which will influence fisheries.

There is uncertainty on the exact impacts as a result of the impoundment and it is realistic to implement an adaptive management framework to respond to changes in fisheries. This monitoring framework will respond by offering solutions to reductions in catch, technologies used and to supplement fisheries resources where they are shown to be lost.

Management of the fisheries should be initiated to manage impacts and changes in the fishery. The following measures will be adopted:

- Fishery dependency survey will be undertaken for communities that will be resettled;
- Socio-economic livelihood survey for all villages in the project area;
- Recurring food consumption survey (including fish consumption) covering multiple seasons;
- Routine Fish Catch Monitoring for downstream villages (including resettled households);
- Routine Fish Catch Monitoring for Nam Ngiep Reservoir; and
- Regular (monthly) food consumption monitoring.
- Aquaculture programs

0.6.1.5 Watershed Management

The management of the watershed to protect water quality and quantity is an important mitigation measure during construction and operation of the dam. Impacts from activities in the watershed are an important consideration, and although may not be under direct control of the Project, these issues should be considered.

As outlined in the cumulative impact assessment six (6) hydro power schemes are planned for the Nam Ngiep watershed. Currently, Nam Ngiep 2 Hydro power scheme is being constructed approximately 120 km upstream from the Project on the Nam Siam and Nam Ngiow rivers (2 co-joining dams). Another single large hydropower dam – tentatively named NN3- is under construction at 1061m, above the NN2 Nam Ngiow facility (elevation 844m). The operator, name and technical specifications of NN3 are not yet known. Two other hydropower projects are under construction on the Nam Xan - HPP A and B. The Nam Xan is a right bank tributary of the upper Nam Ngiep, and should not be confused with the Nam Xan River (watershed) to the south east of the Nam Ngiep watershed.

Forestry and agriculture within the watershed are also important to the district government and local people as income sources. Impacts from these activities have the potential to increase sediment and nutrient flows into the main reservoir.

Mitigation of impacts from these activities is not the primary responsibility of the Project. However, to ensure that the water quality and quantity is maintained at an acceptable standard and to manage the biodiversity values within the watershed, a *Watershed Management Framework* will be prepared in conjunction with the GOL. The purpose of this framework will be to commence a collaborative approach to watershed management with other land users. The approach will identify key sensitive receptors, sources of water pollution and land use planning. A management framework will be prepared to mitigate against impacts and to manage land use activities (such as forestry and agriculture) that may cause significant downstream impacts.

0.6.1.6 Noise and Vibration

Noise and vibration during construction will likely have an impact on local residents, workers and any fauna that frequent the construction of the Project main components.

The main sources of noise will be from construction activities impacts to surrounding area from tunnelling, main and re-regulation dam construction; construction machinery; quarrying activities; passing traffic through local villages along the access road; blasting works for quarries, main and reregulation dam site

Sensitive receptors will include the residences along the main road and access road from Pakxan to Ban Hat Gniun and the fauna within the Houay Ngua Provincial Protected area. On site workers will also likely to be exposed to noise that will need to be managed to protect amenity and possible hearing loss.

The key mitigation measures to be used include: limiting construction activities and transport of materials that may generate harmful noise to only to day time between 6 am to 7 pm; and the use of appropriate and sufficient Personal Protection Equipment (PPE) for noise protection for all workers. Sound-control devices on equipment will be maintained on vehicles and equipment. All residents and workers will be warned in advance regarding blasting works. Trespassing to the blasting area shall also be strictly controlled. The location of the workers camp will also be located away from the main construction site.

These measures are considered adequate to mitigate against potential noise impacts on humans and the environment.

It is not anticipated that noise impacts will be significant during operation.

0.6.1.7 *Air Quality*

The main impacts on air quality during construction will be increased dust particles and fugitive dust emissions into atmosphere from construction works and increased dust particles and fugitive dust into the atmosphere along the access road.

The primary sources of air emissions near sensitive receptors will include emissions from 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 through Houay Ngua PPA and Ban Hat Gniun village. Underground activities are also likely to impact on ambient air quality during tunnelling activities.

Air emissions will be minimised during construction by minimizing dust generating activities; keeping stockpiles for the shortest possible time; dust suppression systems to minimize dust from construction activities and transportation should be implemented and the location of machinery and dust generating activities away from sensitive receptors. All vehicles will be maintained in clear and good working to reduce diesel emissions.

It is not anticipated that significant air emissions will occur during operation of the dam.

0.6.2 *Impacts to Biological Environment*

In relation to the biological environment, the mitigation hierarchy was applied to the biological features identified. Mitigation and management approaches have been considered to avoid, minimise and mitigate potential impacts to biodiversity as a result of Project activities.

Residual impacts on biodiversity values have been determined based on requirements of IFC PS6 and ADB SPS. These residual values are impacts that cannot be mitigated against and therefore must be considered to be offset to achieve a no-net-loss of biodiversity values.

A biodiversity offset design 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 and is described in Section.

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 "high" and "medium" impacts to aquatic and terrestrial biological environments and proposed mitigation measures are outlined in ***Table 0.14***.

An outline of the key impact assessment for habitats, primates, flora and fish species are described below.

0.6.2.1 *Habitats*

The impact assessment 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.

No flora species or terrestrial fauna species were determine likely to have critical habitat within the Project area. For most species, the Project area was not considered of significant importance to the species. For a number of species the Project has potential to pose a threat and as such recommendations to manage key threats to the species identified along the access road and main dam inundation area.

0.6.2.2 *Primates*

Surveys undertaken by TISTR in 2013 recorded vocalisation assumed to be White-cheeked gibbon (*Nomascus leucogenys*) in the vicinity of the main dam and consultation with experts identified there may be potential for other primate species to occur. Targeted surveys were undertaken specific to primate species within the watershed in order to confirm the presence of populations and suitability of habitat. Key habitat areas were identified for the White-cheeked gibbon outside the FSL, mineral licks for Phayre's leaf monkey (*Trachypithecus phayrei*) were detected within the FSL and no signs of the Red shanked douc langur (*Pygathrix nemaeus*) were detected. These findings informed an assessment for critical habitat. The targeted survey indicated that the Project area does not contain key habitat areas for primate species, with areas outside the Project area, which will not be directly impacted, more likely to support populations. Specific management measures will be employed for managing indirect impacts to species habitats and mitigate the loss of mineral licks for Phayre's leaf monkey.

0.6.2.3 *Fish species*

One fish species, *Luciocyprinus striolatus*, was assessed specifically against the ADB SPS critical habitat definition and it was determined to not have critical habitat within the main dam inundation area as the species is not considered to be a regionally significant concentration when compared to other populations across the species range.

Two migratory fish species were identified within the project footprint. Expert surveys and advice indicated that migratory fish identified were unlikely to travel upstream to above the dam wall, preferring the meandering riverine environment of the lower watershed. Sufficient environmental flows and inflows from other tributaries of the Nam Ngiep below the dam wall will sustain habitat for these species

Nine endemic fish species (two new-to-science) were identified in the tributaries of the Nam Ngiep above the dam and below FSL. Expert survey and advice indicated that sufficient habitat would remain for these species following inundation within the tributaries above FSL. Management of habitat for these species will focus on protecting the forested watershed to maintain water quality in these tributaries.

0.6.3 *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. 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.

The residual impacts on biodiversity values are quantified as follows.

0.6.3.1 *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.

Approximately 73 km of riverine and associated riparian habitats of the Nam Ngiep River and its tributaries will be inundated following dam construction. This impact will include the permanent transition of lotic (flowing water) aquatic habitat to lentic (still water) aquatic habitat.

Table 0.10 summarises the breakdown of land cover types that will be permanently removed or altered.

Table 0.10 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
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

Source: ERM, 2013

0.6.3.2 *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 0.11*** outlines the terrestrial species that have been identified that have residual impacts remaining after mitigation. ***Table 0.12*** outlines the fish species that have residual impacts on their habitats following mitigation. Management of the residual impacts on the aquatic environment is contained in the biodiversity offset and watershed management recommended measures.

Table 0.11 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
	Golden jackal	Himalayan black bear
Birds	Wreathed hornbill	Red-breasted parakeet
	Great hornbill	Lesser fish-eagle
	Green peafowl	Siamese fireback
	White winged duck	Silver pheasant

	Species	
	Greater coucal	Grey peacock pheasant
Reptiles	Reticulated python	Elongated tortoise
	King cobra	Big-headed turtle

Source: Source: ERM, 2013.

Table 0.12 Aquatic Species with Residual Impacts following Mitigation

Species name	Common name
Catlocarpio siamensis	Giant barb
Laubuca caeruleostigmata	Leaping barb
Luciocyprinus striolatus	
Pangasianodon hypothalamus	Striped catfish
Probarbus labeamajor	Thicklipped barb
Cirrhinus cirrhosus	Mrigal carp
Scaphognathops bandanensis	Bandan sharp-mouth barb
Yasuhikotakia splendida	Jaguar loach
Labeo pierrei	
Rhinogobius albimaculatus	
Hemimyzon confluens	

Source: Source: ERM, 2013

0.6.3.3 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.

0.6.3.4 Biodiversity Offsets

A *Biodiversity Offset framework* has been developed based on the analysis of the options undertaken by ERM contained in the *Biodiversity Offset Design Report* *for the Nam Ngiep Power 1 Project* (NNP1 Project) (ERM 2014). This offset framework was designed using the Business and Biodiversity Offset Program (BBOP). In principal agreement has been reached for this framework with GOL.

The loss of biodiversity values caused by other projects upstream (such as the Nam Ngiep 2 Hydro Scheme) as well as impacts from activities in the watershed (forestry and agriculture) has a cumulative detrimental impact on biodiversity values. Offsets designed for the Project will not directly offset the impacts of these other projects, but will provide a basis for arresting further degradation and have positive contributions to conservation within the watershed.

The offsets are designed to mitigate against residual impacts identified for the Project in relation to species and habitats and to achieve a no-net-loss of biodiversity values.

In relation to specific offsets for the NNP1 Project, it is planned that the biodiversity offset framework includes:

1. Forested and riverine areas of the Nam Ngiep Watershed to manage biodiversity in terrestrial and aquatic habitats; and
2. Species specific offsets within the Nam Ngiep Watershed and other candidate offset sites (potentially PKK NPA).

The area contained in the watershed was analysed using the "Habitat Hectares" model that determines the type and condition of the habitats lost with the relative gain from management of candidate offsets site over a set management period (In this case, 27 years being the length of the concession agreement). Based on this approach, there is sufficient "like for like" habitat able to be managed to achieve a sufficient gain in biodiversity value over the life of the concession agreement to achieve a "no-net-loss" habitat values in the chosen offset areas.

The legal mechanism to secure the biodiversity offset area is recommended to be a "Provincial Government Decree" to secure the Protection Forests of the Nam Ngiep 1 watershed for the purposes of a biodiversity offset. This Decree is recommended to classify the protection forests as a "Total Protection Zone" under the Forestry Law, prohibiting all uses other than those that sustain the local community. Production forests will be managed for sustainable timber production by introducing techniques to protect habitats for species identified.

To administer and govern the identified offset areas, it is planned that an "NNP1 Offset Advisory Committee" be established. This Committee would be formed with membership from PONRE, DFRM and NNP1PC. This would be chaired by DFRM at representatives from MONRE, the community, NNP1PC (as an observer) and an independent technical advisor holding seats on the committee. Other representatives and stakeholders can be invited to sit on the Committee as required.

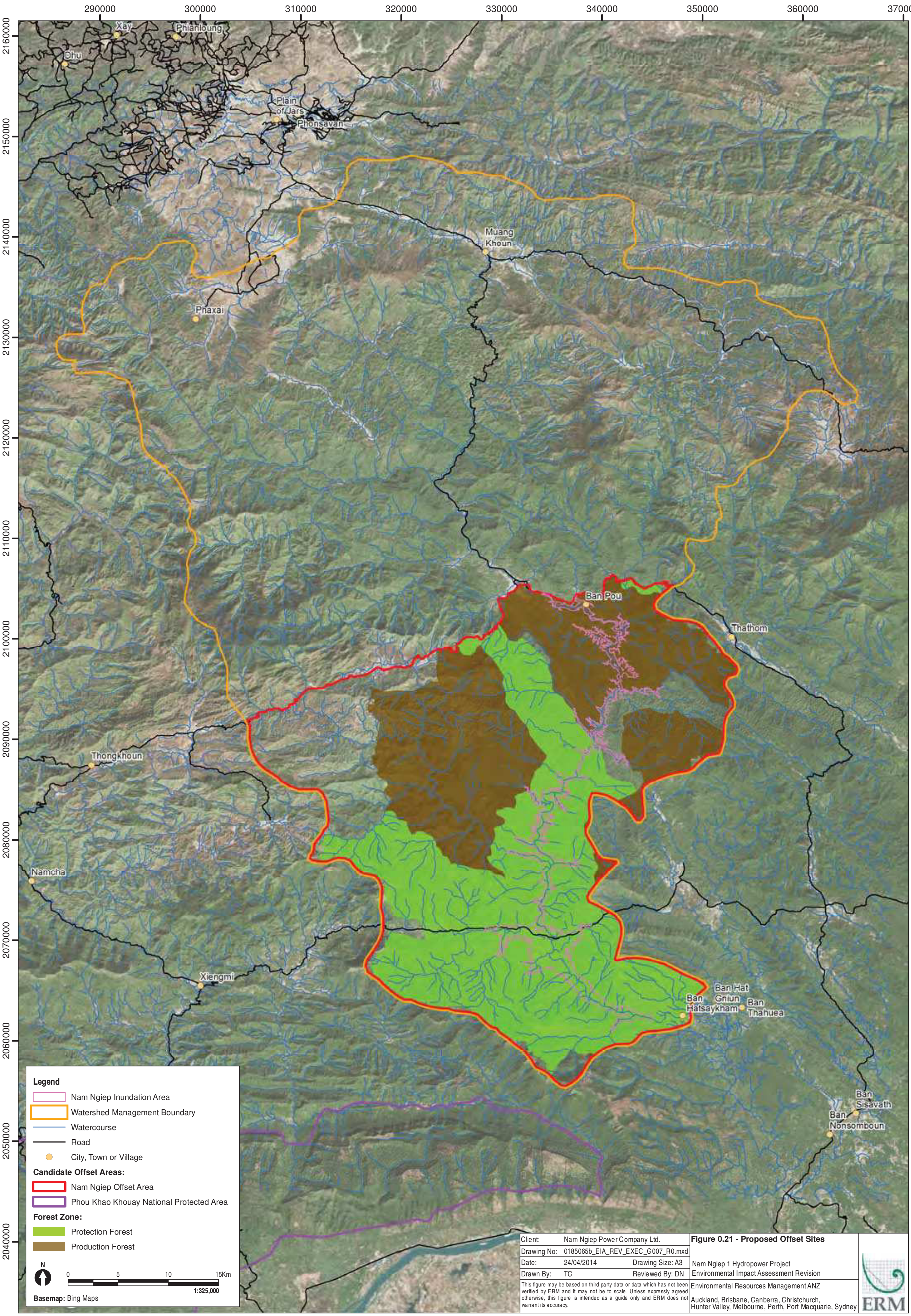
Management of habitats within the watershed will include the development of a management plan including the following key actions: monitoring and evaluation; management of hunting; sustainable forestry management in production forests; wildlife corridors; sustainable forest product use (NTFP); management of weeds and pests; fire management; sediment and erosion control; assisted natural regeneration; habitat installation (eg. nest boxes and salt licks); community engagement and development and education and awareness

Both the Nam Ngiep and PKK NPA are included in the offset package in order to increase the opportunities for identifying and protecting target species identified as having residual impacts on their habitats. These species will be subject to a survey to identify their location, either within the watershed or within PKK NPA. However, if these species are not identified or management is not successful in either location, additional offsets may be required elsewhere in Lao PDR.

In determining species offsets, the first step will be a comprehensive survey in the Nam Ngiep Watershed offset area to identify the target species. This would then be followed up with a comprehensive species survey in PKK or other areas within Lao PDR, if required, to identify presence of the target species. A *Species Offset Management Plan* will be prepared that outlines the management actions required for the target species once their presence has been confirmed.

Species specific offsets for management will be prepared. These will include survey and monitoring of species presence within offset areas; identification of core habitat and management of identified populations; species specific management actions identified to manage identified populations; targeted campaigns to manage key threats (eg. education and awareness activities for individual species); alignment of conservation priorities to national and international management plans and requirements and monitoring the effectiveness of offset management activities on species populations

The proposed offset sites are outlined in ***Figure 0.21*.**



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Drawing No:	0185065b_EIA_REV_EXEC_G007_R0.mxd		
Date:	24/04/2014	Drawing Size: A3	
Drawn By:	TC	Reviewed By: DN	

This figure may be based on third party data or data which has not been verified by ERM and it may not be to scale. Unless expressly agreed otherwise, this figure is intended as a guide only and ERM does not warrant its accuracy.

Figure 0.21 - Proposed Offset Sites

Nam Ngiep 1 Hydropower Project
Environmental Impact Assessment Revision

Environmental Resources Management ANZ

Auckland, Brisbane, Canberra, Christchurch, Hunter Valley, Melbourne, Perth, Port Macquarie, Sydney

ERM

Table 0.13 Summary of Priority Anticipated Impacts from the Project and Proposed Mitigation Measures

Environmental Aspects	Nature of Impact	Concerned Activities (that would cause impacts)	Priority Impact Area	Magnitude and Level of Impacts		Proposed Mitigation Measures
				Medium	High	
Physical Environment						
Erosion and Sedimentation	• Erosion of disturbed areas from construction of access road, main dam, re-regulation dam, transmission line, workers camps and quarries. • Increased sediment load discharged into aquatic systems adjacent to construction sites. • Management of spoil from excavation and tunneling.	• Main dam and re-regulation dam construction • Site clearing for construction • Excavation works • Slope stabilization • Underground works • Transmission line construction • Road construction • Quarrying	• Dam and re-regulation dam construction within the Nam Ngiep River • Spoil management stockpiles • Access Road Construction within Houay Nua Provincial Protected Area • Transmission Lines routes adjacent to Nam Ngiep River • Quarries used during construction for main dam, re-regulation dam and access road			• Development and implementation of an Erosion and Sediment Control Plan (via SS ESMMPs) to be incorporated into the construction environmental management plan for all project components. • Land clearing activities should be performed during the dry period only. • Best practices for excavation and working within the riverbed should be conducted when constructing the main dam and re-regulation dam. • Limitation of land disturbing activities to take place only in design construction boundary. • Appropriate drainage should be implemented along all access roads, quarry site, soil stockpiles and other construction sites. • Appropriate standards should be applied to project components including drainage works, sediment traps, diversion, culverts and other structures designed to treat water before discharge into natural and/or constructed watercourses should be conducted. • All soil stockpiles should be managed to prevent discharge of contaminated

Environmental Aspects	Nature of Impact	Concerned Activities (that would cause impacts)	Priority Impact Area	Magnitude and Level of Impacts: Medium	Magnitude and Level of Impacts: High	Proposed Mitigation Measures
					High	sediment into watercourses. • All quarries should be managed and prevent discharge of contaminated sediment into watercourses.
Upstream reservoir and river water quality	• Water pollution from increased sediment and erosion from project components increasing suspended solids and turbidity in the river and reservoir • Faecal coliform impacts from workers camps during construction and villages upstream of the main reservoir. • Nutrients entering the main reservoir from upstream sources.	• Discharge of wastewater from worker camps. • Water pollution from construction activities.	• All construction sites within the watershed of the river, including workers camps and quarries • Construction of the main dam and reregulation dam, including tunneling and coffer dam construction • Access Roads constructed upstream of the main dam and re-regulation dam.	Medium		• Prepare a watershed management framework in conjunction with GOL to manage land use planning, point and diffuse water pollution within the watershed. • To provide designated wastewater treatment facilities. • On-site toilets at working areas and toilet facilities at worker camps should be installed • Direct discharge of wastewater into natural receiving water is not allowed. • To provide designed contaminant treatment facilities for each significant construction site • 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.

Environmental Aspects	Nature of Impact	Concerned Activities (that would cause impacts)	Priority Impact Area	Magnitude and Level of Impacts: Medium	Magnitude and Level of Impacts: High	Proposed Mitigation Measures
Downstream river water quality	• Changes in water quality, including Dissolved Oxygen, Suspended Solids and Temperature from discharges downstream from the re-regulation dam • Water pollution from increased sediment and erosion from project components increasing suspended solids and turbidity in the river and reservoir • Faecal coliform impacts from workers camps during construction and villages upstream of the main reservoir.	• Changes in water quality from re-regulation dam discharges during high and low flow • Discharge of wastewater from worker camps. • Water pollution from construction activities. • Water pollution from road and quarry construction	• Riverine environments immediately downstream of the reregulation dam that are used for human use or provide aquatic habitats. • All construction sites within the downstream watershed of the river, including workers camps and quarries • Construction of the main dam and reregulation dam, including tunneling and coffer dam construction • Access Roads construction downstream of the main dam and re-regulation dam (through Houay Ngua PPA).			• Prepare and implement a construction environmental management plan for all project components. • Undertake discharges according to the environmental flows regime to ensure adequate downstream water flows (minimum of 5.5m³/sec) • Maintain a dry season flow to ensure adequate water depth. • Monitor water quality and flows downstream from the re-regulation dam. • Mitigation measures outline for "upstream reservoir water quality" outlined above.

Environmental Aspects	Nature of Impact	Concerned Activities (that would cause impacts)	Priority Impact Area	Magnitude and Level of Impacts		Proposed Mitigation Measures
				Medium	High	
Noise and Vibration	• Noise of construction activities impacts to surrounding area from tunneling, main and re-regulation dam construction • Noise from construction machinery • Noise from quarrying activities • Noise from passing traffic through local villages along the access road	• Use of machinery for cutting and land excavation • Moving of equipment to the site along the access road • Material transportation along the access road • Blasting works for quarries, main and reregulation dam site • Machinery operation during construction period for all construction sites • Workers camp	• Ban Hat Gniun village • Workers camps within the construction area • All construction sites that use heavy machinery or undertake blasting • Residences along the access road from Pakxan to B an 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. • Construction activities that may generate harmful noise should be limited only to day time, e.g. 6 am to 7 pm. • People shall be warned in advance regarding blasting works. • Trespassing to the blasting area shall be strictly controlled. • Location of the workers camp away from the main construction sites.
Air Quality	• Increased dust particles and fugitive dust into atmosphere from construction works • Increased dust particles and fugitive dust into the atmosphere along the access road	• 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	• All quarry sites for dam and access road construction • Crushing and Batching plants for dam construction • Road construction areas especially through Houay Ngua Provincial Protected Area • Embankment and channel construction for the main dam and re-			• 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 machinery

Environmental Aspects	Nature of Impact	Concerned Activities (that would cause impacts)	Priority Impact Area	Magnitude and Level of Impacts: Medium	Magnitude and Level of Impacts: High	Proposed Mitigation Measures
			regulation dam • Haulage of materials along the access road • Construction of worker camps • Communities around main construction and communities along the access road			
Potential Contaminated Sites	• Contamination from chemical and hazardous wastes into environment from construction sites and machinery maintenance sites	• Chemical storage areas • Drum reconditioning or recycling • Electric transformers • Explosive product and storage • Landfill operation • Pest control • Petroleum product and oil storage • Machinery maintenance areas	• Concrete batching plant near the main and reregulation dam construction • Quarries and associated infrastructure for the storage of hazardous materials • All vehicle storage and maintenance sites			• 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. • Appropriate training should be conducted for all workers responsible for handling hazardous waste. • Best practice and emergency response procedure will be developed 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 downstream during construction of the re-regulation and main dams	• Construction of the main dam and re-regulation dam and Diversion tunnel	• Riverine environments immediately downstream of the reregulation dam that			• River diversion works shall be constructed during low flow season. • In case of floods, the construction contractor must prepare emergency plans

Environmental Aspects	Nature of Impact	Concerned Activities (that would cause impacts)	Priority Impact Area	Magnitude and Level of Impacts: Medium	Magnitude and Level of Impacts: High	Proposed Mitigation Measures
			are used for human use or provide aquatic habitats.			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. • Undertake discharges according to the environmental flows regime to ensure adequate downstream water flows (minimum of 27m^3/sec) • Maintain a dry season flow to ensure adequate water depth. • Monitor water quality and flows downstream from the re-regulation dam.
	• Reservoir impoundment upstream from the re-regulation dam	• Reservoir impoundment	• Upstream riverine environments up to FSL, including tributaries.			• Complete the resettlement activities according to Resettlement Action Plan and national standards. • Public consultation with local residents must be conducted frequently.
			• Riverine environments immediately downstream of the reregulation dam that are used for human use or provide aquatic habitats.			• 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.

Environmental Aspects	Nature of Impact	Concerned Activities (that would cause impacts)	Priority Impact Area	Magnitude and Level of Impacts		Proposed Mitigation Measures
				Medium	High	
	• Change in flow downstream during operation of the re-regulation and main dams (operational discharges)	• Operation of environmental flow regime	• Riverine environments immediately downstream of the reregulation dam that are used for human use or provide aquatic habitats.			• Undertake discharges according to the environmental flows regime to ensure adequate downstream water flows (minimum of 5.5m³/sec) • Maintain a dry season flow to ensure adequate water depth. • Monitor water quality and flows downstream from the re-regulation dam.
Biological Environment						
Biodiversity Values	• Permanent loss of habitat	• Permanent loss of 8359 ha habitat within inundation and footprint area from all project components. • Approximately 5180 ha of Protection Forest will be inundated	• Inundation area for the main Dam and re-regulation dam			• Develop and implement a Biodiversity Action Plan (BAP) and manage residual impact through a Biodiversity Offset Plan (BOP) • Minimize the extent of disturbance where possible (logging and hunting rules, design and layout consideration, clear demarcation, forest guard • Develop Biological Resources management program and management plan • Rehabilitation of temporarily disturbed areas
	• Alteration of 73 km stretch of lotic aquatic habitat to lentic aquatic habitat	• Transition of habitat will occur as the main dam and re-regulation dam fill to supply level • Impact to habitat for endemic fish species in the lower reaches of tributaries of the	• Inundation area for the Dam and re-regulation dam • Lower reaches of tributaries of the Nam Ngiep River			• Develop and implement a BAP and manage residual impact through BOP focusing on watershed management and riparian protection. • Specific management for endemic fish species identified in tributaries of the Nam Ngiep River

Environmental Aspects	Nature of Impact	Concerned Activities (that would cause impacts)	Priority Impact Area	Magnitude and Level of Impacts: Medium	Magnitude and Level of Impacts: High	Proposed Mitigation Measures
		Nam Ngiep			High	
	• Loss of habitat for IUCN terrestrial CE and E species	• The project footprint intersects habitat suitable for these species	• All project components, but in particular the inundation area for the main dam and re-regulation dam		High	• Develop and implement a BAP and manage residual impact through BOP • Establish wildlife protection team • Rehabilitation of temporarily disturbed areas • Minimise extent of disturbance where possible (logging and hunting rules, design and layout consideration, clear demarcation, forest guard
	• Loss of habitat for IUCN listed aquatic species and endemic species	• The inundation area impacts species below the dam wall and above FSL in tributaries and upstream	• Flows discharges from the main dam and re-regulation dam • Inundation area flowing habitats in tributaries		High	• Develop and implement a BAP and manage residual impact through BOP focusing on watershed management and riparian protection. • Specific management for endemic fish species identified in tributaries of the Nam Ngiep River • Additional management measures for the species *Luciocyprinus striolatus* (See separate section for mitigation for this species)
	• Degradation habitat adjacent to project areas	• Increased access to the area through access roads	• Houay Ngua Provincial Protected Area • Perimeter of the main	Medium		• Develop and implement a BAP and manage residual impact through BOP • Elephant exclusion fencing where

Environmental Aspects	Nature of Impact	Concerned Activities (that would cause impacts)	Priority Impact Area	Magnitude and Level of Impacts: Medium	Magnitude and Level of Impacts: High	Proposed Mitigation Measures
		increases poaching and hunting	dam and re-regulation dam			appropriate • Raise awareness to discourage poaching and hunting • Watershed management activities (including erosion and sediment control)
	• Impacts on Houay Ngua Provincial Protected area from road re-construction activities	• Indirect impacts on habitats along the access road route • Impacts on threatened plants removed because of the access road re-construction	• Houay Ngua Provincial Protected Area			• Develop and implement a BAP and manage residual impact through BOP • Minimise extent of disturbance where possible (logging and hunting rules, design and layout consideration, clear demarcation, forest guard • Check points to manage illegal poaching along access road • Rehabilitation of temporarily disturbed area • Replanting of trees to compensate for those lost through construction • Raise awareness to discourage poaching and hunting • Watershed management activities (including erosion and sediment control
	• Alteration of flows downstream of the re-regulation dam in the Nam Ngiep River	• Alteration of flows may alter habitat values downstream • Installation of the dam will restrict movement of aquatic species up- and down-stream of the dam walls • Filling of the dams	• Dam and re-regulation dam • Downstream of the re-regulation dam			• Develop and implement a BAP and manage residual impact through BOP • Natural flows maintained during construction using a diversion • Water quality monitoring • See hydrology mitigation measures above

Environmental Aspects	Nature of Impact	Concerned Activities (that would cause impacts)	Priority Impact Area	Magnitude and Level of Impacts		Proposed Mitigation Measures
				Medium	High	
		will result on greater restriction of movement for species that cross the Nam Ngiep or aquatic fauna moving up- and downstream				

Source: Environmental Impact Assessment Report, ERIC 2012 and developed by ERM, 2013.

0.7 STUDY OF ALTERNATIVES

Several project alternatives were considered in order to decide the optimal design and operational modes to minimize the possible impacts to the environment from the Project.

0.7.1 *No-Project Alternative*

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.

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.

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.

0.7.2 *Project Design Alternatives*

The study of alternative project designs analyzed 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.

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 0.15.***

Table 0.14 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, 2011

0.7.2.1 *Normal Water Level (NWL) of the main reservoir*

Analysis of the normal water level in the main dam considered inundation of villages outlined in ***Table 0.16***. The analysis aimed to limit inundation of villagers and hence the level of resettlement required.

Table 0.15 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, 2011.

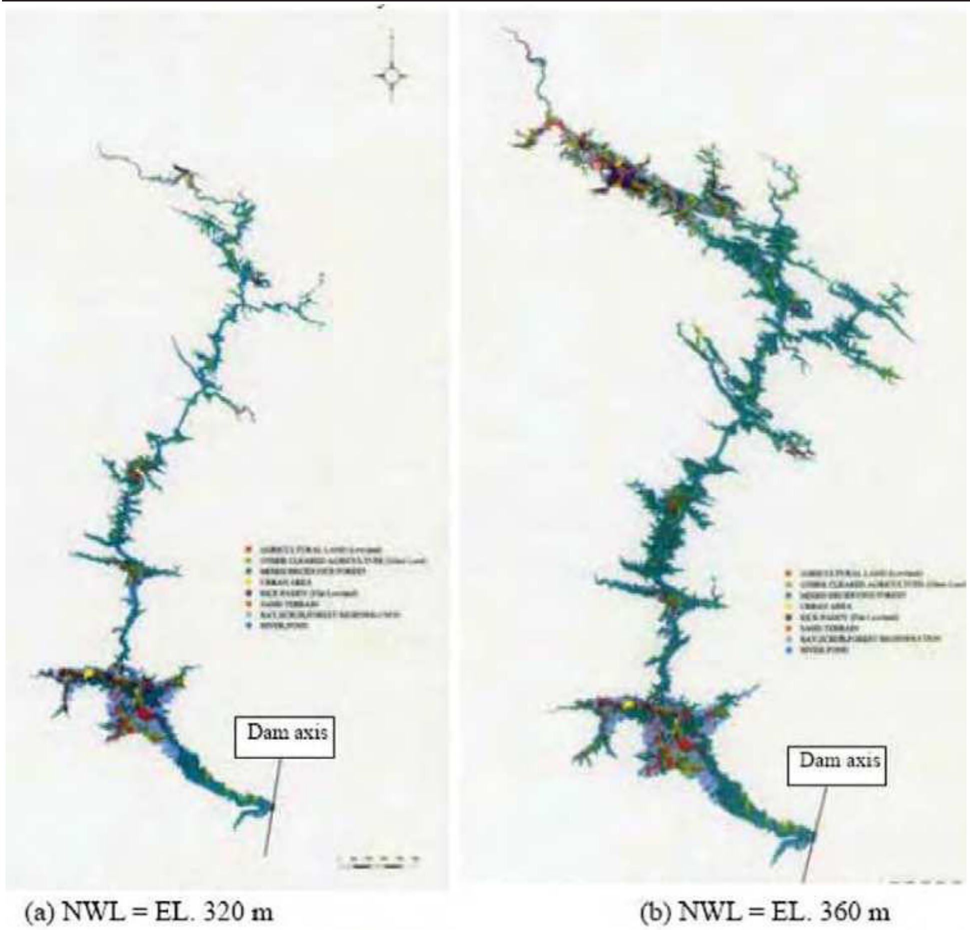
0.7.2.2 Flood Water Level (FWL) of the main reservoir

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.

0.7.2.3 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 0.22 **Land Utilization of Areas to be Inundated at NWL 320 and 360 m of the Main Reservoir***



Source: JICA-F/S, 2002

0.7.2.4 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, with the least environmental and social impacts.

0.7.2.5 Alternative comparison of Main Dam design

Table 0.17 outlines an analysis of the alternatives for main dam design.

Table 0.16 Alternatives for Main Dam Design

Case No.	Design Options	No. of Villages Impacted	Inundation Area	Power generation capacity	Evaluation (or ranking)
1	320m	2	~7,500ha	272MW	1
2	360m	9	~ 12,000ha	~300MW	2

Source: ERM, 2014.

0.7.3 Facilities Design Alternatives

0.7.3.1 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 the Houay Ngua Provincial Protected Area.

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.

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 Houay Ngua PPA

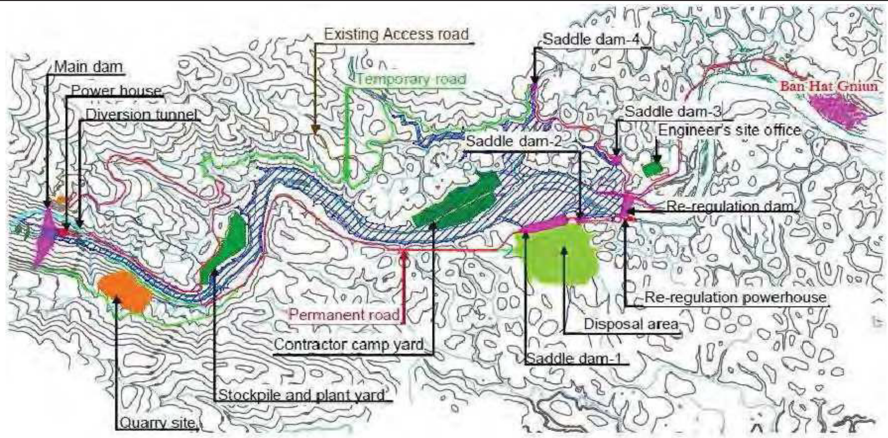
The Alternative Road would also cause significant increase of construction cost for the Access Road. Considering additional time needed for re-survey, topographic and geological survey, UXO survey, land use survey, re-design, ESMMP-CP and re-approval process by GOL, the Alternative Road may cause delay of commencement of construction works and impacts to project feasibility. Thus the Proposed Road is preferred.

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.

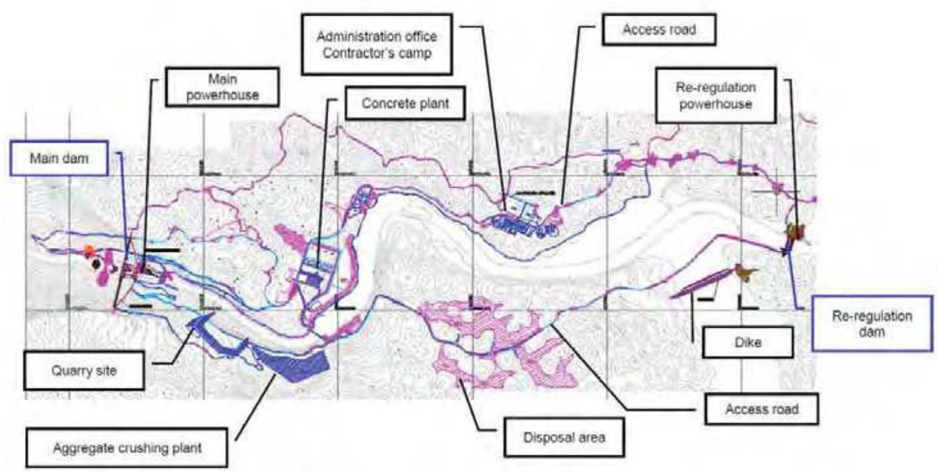
There have been two alternatives of access road alignments adopted in NNP1, as shown in ***Figure 0.23*** and ***Figure 0.24.***

Figure 0.23 Previous Proposed Alignment (2008)



Source: Environmental Assessment for NNP1 Access Road from Ban Nonsomboun to the Main Dam, 2014.

Figure 0.24 Current Alignments (2013)



Source: Environmental Assessment for NNP1 Access Road from Ban Nonsomboun to the Main Dam, 2014.

0.7.3.2 *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.

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.

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.

The original route alignment was designed prior to the official announcement of the creation of Houay 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 final chosen route will avoid the Houay Ngua PPA and pass along the opposite bank of the Nam Ngiep River, avoiding areas of high biodiversity value.

0.8 *CUMULATIVE IMPACT ASSESSMENT*

A Cumulative Impact Assessment (RCIA) was undertaken the NNP1 Project. The purpose of the assessment is to better understand the impacts of past and future actions on the Nam Ngiep River and watershed.

There is currently very little quantitative data available for other projects upon which to make an informed RCIA for the Nam Ngiep watershed. Nonetheless, some other Reasonably Foreseeable Future Actions (RFFA) for which impact assessments have been completed contains qualitative discussion of impacts.

An analysis of available information on seven other proposed hydro-electric power (HEP) projects in the area and various other reasonably foreseeable future actions (RFFA) was undertaken for this RCIA. Impacts from this project and each of the RFFAs were considered on the Valued Environmental and Social Components (VEC) identified for the project:

- VEC 1: Terrestrial biodiversity and habitats
- VEC 2: Aquatic biodiversity and habitats
- VEC 3: Water quality and flows
- VEC 4: Ecosystem services

The following are descriptions of current and RFFAs proposed for the Nam Ngiep Watershed.

0.8.1 *Descriptions of Current and Future RFFAs*

0.8.1.1 *Hydro Power Projects*

Seven hydropower projects are proposed within the Nam Ngiep watershed (See ***Table 0.18***). The total installed capacity known from proposed HEPs 585 MW. NNP1 will have a capacity of 290 MW, the four other projects for which the total installed capacity is known have a combined total installed capacity of 295 MW. In this regard, NNP1 is the largest development on the Nam Ngiep River, accounting for 49.6% of the 585 MW of development that is reasonably foreseeable within the next 25 years. Four projects other than NNP1 have data available on size of the reservoirs. The two dams for NNP1 will be approximately 7497 ha in size with the sum of the other three where data are available being 1313 ha. In that regard, the reservoirs of NNP1 will be approximately 85.1 per cent of the known size of proposed hydro power reservoirs in the watershed.

Table 0.17 Hydro Schemes Proposed in the Nam Ngiep Watershed

Hydro Scheme	Province	Electricity Generating Capacity	Status
Nam Ngiep 1 (this project)	Vientiane/ Bolikhamxay	290 MW	Planning and Approvals Stage
Nam Ngiep 2	Xiengkhouang	180 MW	Under construction
Nam Ngiep 3A	Xiengkhouang	Unknown	Unknown
Nam Pot	Xiengkhouang/ Vientiane	20-25 MW	Approved – construction planned 2015
Nam Chain	Xiengkhouang	Unknown	Unknown
Nam Phouan	Vientiane	52 MW	Approved – construction date unknown
Nam Ngiep (Mouang Mai)	Bolikhamxay	38 MW	Feasibility Stage

0.8.1.2 *Forestry & Agriculture*

Consultation with DFRM identified that currently, the Provincial government auctions timber allocations to companies on a rotational basis. These allocations are located in two types of areas: 1) in designated production forest, and 2) from land in proposed development footprints (e.g. new dams, roads or other infrastructure) prior to that development, essentially making use of the timber that is to be cleared for that development. This process is unlikely to change with changes in land use or development of NNP1, other hydro power or other RFFAs. Currently the middle reaches of the Nam Ngiep watershed are designated as production forest.

Agriculture is widespread with agricultural land cover types accounting for the majority of land cover types in the Project Area. Rubber plantations, rice cropping (non-irrigated), cassava, timber plantations (eucalyptus), cropping and market gardens are extensively spread across arable land in the Nam Ngiep Watershed. These generally occur beside the river on the floodplain.

0.8.1.3 *Mining*

Three mining leases under survey coincide with the Nam Ngiep watershed. One is near the centre of the watershed with two others partly within the upper reaches of the watershed near the headwaters in the north. Two leases where survey is proposed are located in the lower parts of the watershed near the Project Area with four more partly within the upper reaches of the watershed in the north and east.

0.8.1.4 *Roads*

The main road through the watershed is National Road 1D, which was until recently a dirt road with some sections covered in gravel. It connects Phonsavan (the capital of Xieng Khouang Province) with Pakxan (the capital of Bolikhamxay Province). It runs north from Pakxan through the Nam Xan watershed and then turns west to go through the northern part of the Nam

Ngiep watershed. A rudimentary road network exists throughout the watershed with few major, all-weather roads. During consultation with the MPI, they identified that road upgrades/development has recently occurred. A new road was built in the Nam Xan watershed from Pakxan to Khonsana in 2012 and another road was resurfaced to bitumen to service the Nam Ngiep 2 project in the upper Nam Ngiep in 2010. However, the new road in the Nam Xan watershed was severely damaged in the 2013 wet season and has yet to be reconstructed.

Both of these roads have been used to transport construction materials for the NNP2 project and it would appear that the heavy construction traffic has compounded the damage. It should be noted that the terrain of both watersheds make road construction difficult and expensive. This is compounded by poor road construction techniques, traffic and the wet season. It is envisaged that these factors will continue to hamper overland transport in the short to medium term.

0.9 PUBLIC CONSULTATION AND INFORMATION DISCLOSURE

0.9.1 Methodology

Methodology to elicit the stakeholders' perceptions and concerns was carefully designed by taking into account the stakeholders' understanding and expectations toward the Project. The consultation methodology emphasizes the following areas:

- The Project's objectives and composition are understood;
- The presented information including the Project description, potential impacts and related mitigations measure are transparent and easily understood by the stakeholders;
- The presented information does not attempt to mislead or cause any misunderstandings, false reputation upon the Project.
- The environmental and social information of the Project shall be disclosed by posted on the Project's web site and engagement activities shall be arranged on stakeholders continuously.

0.9.1.1 *Consultation Activities*

Extensive public consultation occurred with GOL, affected peoples and other relevant parties since 2007 until 2014. These consultative meetings have included over 30 meetings and focus groups during this period. The meetings have provided an opportunity to:

- Present up to date Project information and raise awareness about the Project; and
- Receive feedback from stakeholders. This feedback has been used to inform key Project decisions, such as the height of the reservoir.

The initial consultation meetings focused on collecting and disseminating information regarding the Project design. This included the collection of social and environmental data in order to provide a baseline for predicting the potential Project impacts.

The next phase of consultation meetings sought to gain feedback from stakeholders regarding design alternatives and proposed management measures.

Table 0.20 outlines the stakeholders consulted to date.

Table 0.18 Stakeholders Consulted to Date

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 and April 2012	Consultation and discussion at Bolikhamxay, Xieng Khouang and Vientiane Provinces
District Level: Bolikhan, Pakxan, Hom, and Thathom District representatives	January 2008	Public consultation at Bolikhan District 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
	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, Ban Hatsamkhone & Ban Piengta
	December 2012	Focus group discussions at Ban Pou, Ban Hatsamkhone & Ban Piengta
	August 2013	Village consultation meeting at Ban Pou, Ban Hatsamkhone & 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 Houaypamom & Ban Sopyouak
	November 2007	Consultation meeting at Ban Sopphuane, Ban Namyouak & 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

Stakeholder Group	Date	Consultation Activity
	September 2011	Consultation meeting at Ban Namyouak, Ban Sopyouak, Ban Sopphuane and 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
	September 2013	Consultation meeting at Ban Sopphuane, Ban Houaypamom, Ban Sopyouak & 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 Thaheua
	June 2008	Consultation meeting in the Bolikhan District
	September 2011	Consultation meeting in the Pakxan District, Pakxan District & Ban Hatsaykham
	November 2013	Focus group discussions at Ban Hatsaykham
	July 2013	Consultation meeting with Ban Hat Gniun and Ban Hatsaykham & representatives of four villages of 2LR, and Ban Hat Gniun and Ban Hatsaykham
	July 2013	
Zone 5 villages, including villagers and village authorities	October 2007	Consultation meeting at Ban Hat Gniun
	November 2008	Consultation meeting at Ban Pha-Ane, Ban Phukatha & Hom District
	September 2011	Consultation meeting at Ban Hat Gniun & Ban Thahuea
	November 2013	Focus group discussions at Ban Hat Gniun and Ban Thahuea
Other resettlement areas	November 2008	Consultation Meeting at Ban Pha-Aen and Ban Phukakatha

Source: Social Impact Assessment, 2014.

0.9.1.2 Future Consultation Activities

Consultation will continue throughout the life of the Project. This will include engagement during implementation during construction and operation.

These documents will be available for 120 day review period before the ADB board commences its review of the Project. A translation of the Project documents will be provided to the GOL

0.9.1.3 Grievance Redress Mechanism

The Project has the potential to affect the interests of thousands of people, which may result in differences in perception and expectations regarding environmental matters. These differences may lead to conflicts between potentially affected person (PAPs), including individuals, households or groups in the communities surrounding the Project, 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 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.

0.9.1.4 Grievance Redress Process

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.

Stages 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.

- 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 to the District Grievance 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.

- 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.

- 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.

0.9.2 ADB Accountability Mechanism

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 components of the safeguard policies are presented in the volume on "Social Impact Assessment Report- Nam Ngiep 1 Hydropower Project" and "Social Development Plan Report – Nam Ngiep 1 Hydropower Project", completed in 2012. These reports identify key social matters and provide corresponding management measures. This includes potential impacts on vulnerable groups and gender related issues, the location and sensitivity of cultural heritage values, and potential community health and safety related impacts. In addition, the reports address the ADB's safeguard relating to involuntary resettlement by providing a framework through which resettlement will occur; this includes relevant livelihood restoration measures. Where appropriate these social matters are captured in the EIA.

0.10 DEVELOPMENT OF AN EMP

An Environmental Management Plan will be developed for all components of the Projects construction and operation. The EMP presents the various preventative and/or mitigation measures proposed for the different types of impacts, the responsible agencies cover to pre-construction phase (1 year), construction phase (6 years) and operation phase (27 years).

The EMP will also be supplemented by 21 EMP-Sub Plans, which have been developed as guidelines for minimizing environmental impacts from specific activities of the Project.

The EMP will be continually revised throughout both of construction phase and operation phase of the Project according to the available of additional mitigation measures.

An Environmental and Social Management and Monitoring Plan (ESMMP) and Site Specific Environmental and Social Monitoring and Management Plan (SSESMMP) will be also developed by the Project and Project's Contractor to strictly prevent and decrease the impacts or to mitigate their effects.

A project wide Environmental Management System (EMS) will be developed for the project.

0.11 *RECOMMENDATIONS*

Recommendations for the Project are as follows:

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.

Environmental Flow Regime

Management of the environmental flows downstream of the dam should be implemented and monitored to determine their effectiveness at protecting biodiversity and ecosystem service values downstream. An evaluation and management framework should be prepared to complement the environmental flow regime. An adaptive management framework should also be utilized to amend flow strategies based on water quality and biological data on downstream effects.

Watershed Management

Management of the watershed is a critical component for managing the aquatic habitat and ecosystem services values of the Nam Ngiep River. Threats from upstream hydroelectric schemes, forestry, mining, increasing urbanization and agriculture all pose a threat to the sustainable management of the watershed and hence the management of good quality water inflows into the dam.

A comprehensive watershed management framework is required that has the ability to manage identified risks, propose collaborative efforts with other stakeholder interests and actively engages GOL in administering and managing the values of the watershed. This framework should be developed as the overarching approach to achieving sustainable development in the watershed. NNP1PC should actively engage with GOL to promote a watershed management framework.

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.

Biodiversity Mitigation and Offsetting

Managing biodiversity values to achieve a no-net-loss of biodiversity is required to demonstrate compliance with ADB safeguards policies and to ensure the long-term sustainability of habitats and species populations. Implementation, management and monitoring of the biodiversity offsets recommended will require close collaboration with GOL, third party capacity builders and NNP1PC to deliver on this commitment. The approach taken should ensure positive engagement of the local community and GOL in management, be adequately funded and resourced and be responsive to changing ecological information.

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.

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.

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.

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.

1 INTRODUCTION

1.1 PURPOSE

The Nam Ngiep 1 Hydropower Project (NNP1) involves the construction of an access road, hydropower dam, re-regulation dam, powerhouse, transmission line and other required components by the Nam Ngiep 1 Power Company (NNP1PC). NNP1 is situated on the Nam Ngiep River in Lao People's Democratic Republic (Lao PDR), which is on a left bank tributary of the Mekong River. The project covers parts of the provinces of Bolikhamxay, Xaysomboun, Xieng Khouang and Vientiane.

NNP1PC sought and was granted approval by the Government of Lao PDR (GOL) in 2013. The Concession Agreement (CA) for the Project was issued in August 20133. Annex C of the CA includes obligations for environmental and social components of the project and was granted in April 2013 by Ministry of Natural Resources and Environment (MORNE). This approval was granted according to GOL regulations mandated in 2001, which states that project developers must acquire environmental permits before undertaking electricity projects. This can only be done after adequate environmental assessment (EA) has been completed.

NNP1 will be funded predominantly by the private sector. The shareholders of the Nam Ngiep Power Co. Ltd. include KPIC Netherlands B.V. which is a subsidiary of Kansai Electric Power Co. Inc. (Kansai Electric) from Japan, EGAT International Co. Ltd. (EGATi) from Thailand, and Lao Holding State Enterprise (LHSE) from the Lao PDR.

ERM Siam Co Ltd (ERM) has been engaged by NNP1PC to provide a revision of the Environmental Impact Assessment Report (March 2012), which was prepared by the 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 to April 2014.

This Revised EIA Report presents an assessment of the potential environmental impacts associated with the proposed Nam Ngiep 1 Hydropower Project ('the Project') in Bolikhamxay, Xaysomboun, Xieng Khouang and Vientiane, Lao PDR to specifically respond to the ADB Safeguard Policy Statement (July 2009)

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.

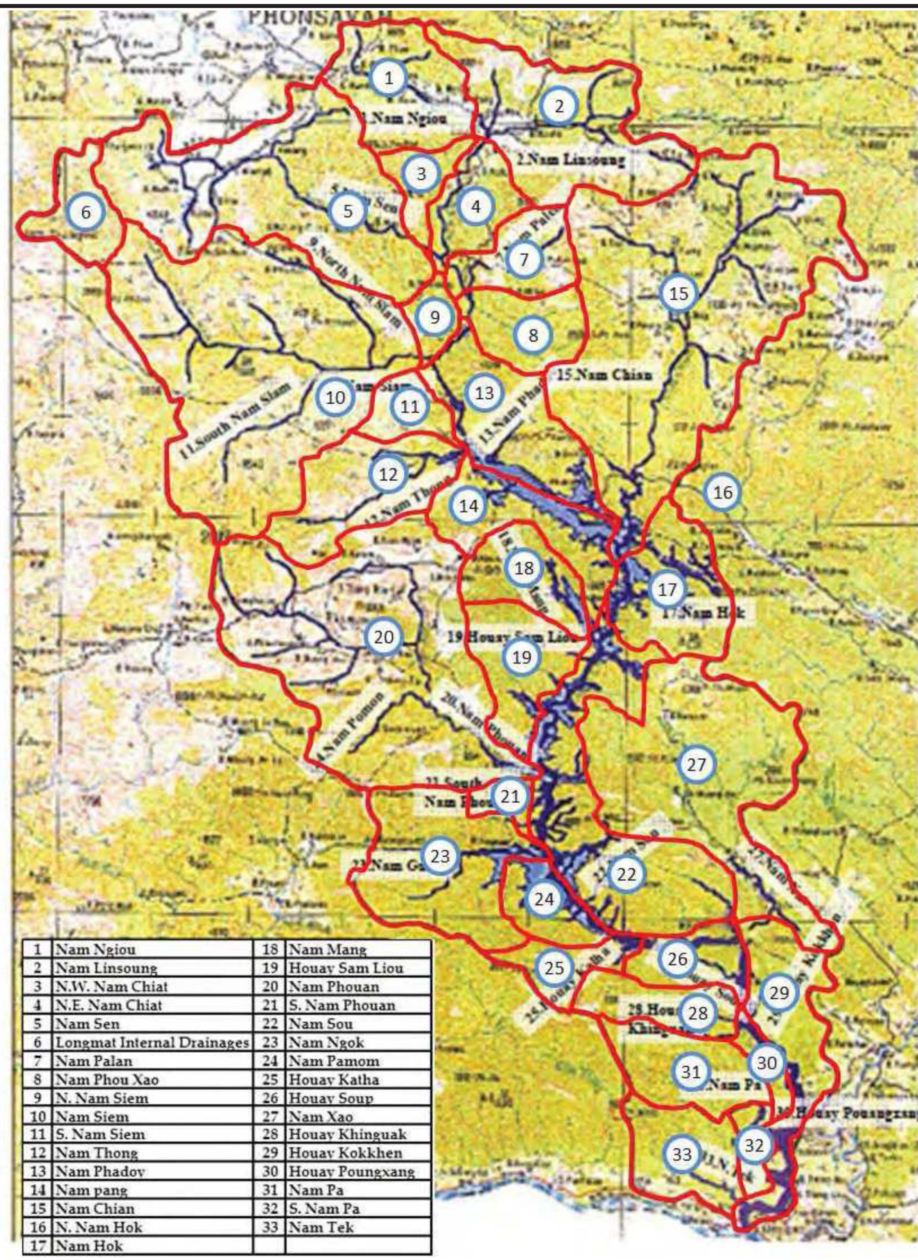
The government-owned Electricite du Laos (EDL) currently owns and operates a number of hydropower projects. With its policy of domestic and rural electrification, EDL's primary objective is to supply power within the country, but it also exports excess power to Thailand and other neighboring countries 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 (now located in the newly created Xaysomboun 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 watershed 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 watershed area of 4,494.7 km^2, and is composed of 33 tributaries (sub-watersheds), 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



Source: Environmental Impact Assessment Report, ERIC 2012 and Adapted by ERM, 2013.

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) Analyse 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 analyse 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.

Additional studies conducted in conjunction with the EIA Report include the following:

- Biodiversity Baseline Assessment Report
- Biodiversity Offset Design Report
- Cumulative Impact Assessment Report
- Environmental Flow Assessment Report
- EA for Access Road
- IEE for Transmission Line from the Main dam to Vientiane
- Preliminary Archaeology and cultural heritage Survey Report

1.5 *PROJECT AREA OF INFLUENCE, STUDY AREA BAND METHODOLOGY*

1.5.1 *Project Area of Influence*

According to the ADB Safeguard Policy Statement, the Project area of influence, which represents the boundary for identifying and analysing the Project potential impacts and risks, encompasses the following:

- Main dam and reservoir
- Re-regulation dam and reservoir
- Resettlement site
- Access road alignment
- 230 kV Transmission line alignment from main dam (main powerhouse) to the Nabong substation
- Area and communities potentially affected by cumulative impacts (Nam Ngiep watershed); and
- Downstream of the re-regulation dam

Details of the Project area of influence and components are present in *Chapter 4*.

1.5.2 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)

In addition, the candidate biodiversity offset sites form part of the Study Area, as follows:

- Upper Nam Ngiep watershed
- Nam Xan watershed
- Houay Ngua Provincial Protected Area (PPA)
- Phou Khao Kouay National Protected Area (NPA)

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 RCIA report focused on the identified Valued Environmental and social Components (VECs) (ESSA&IFC 2012)[2].

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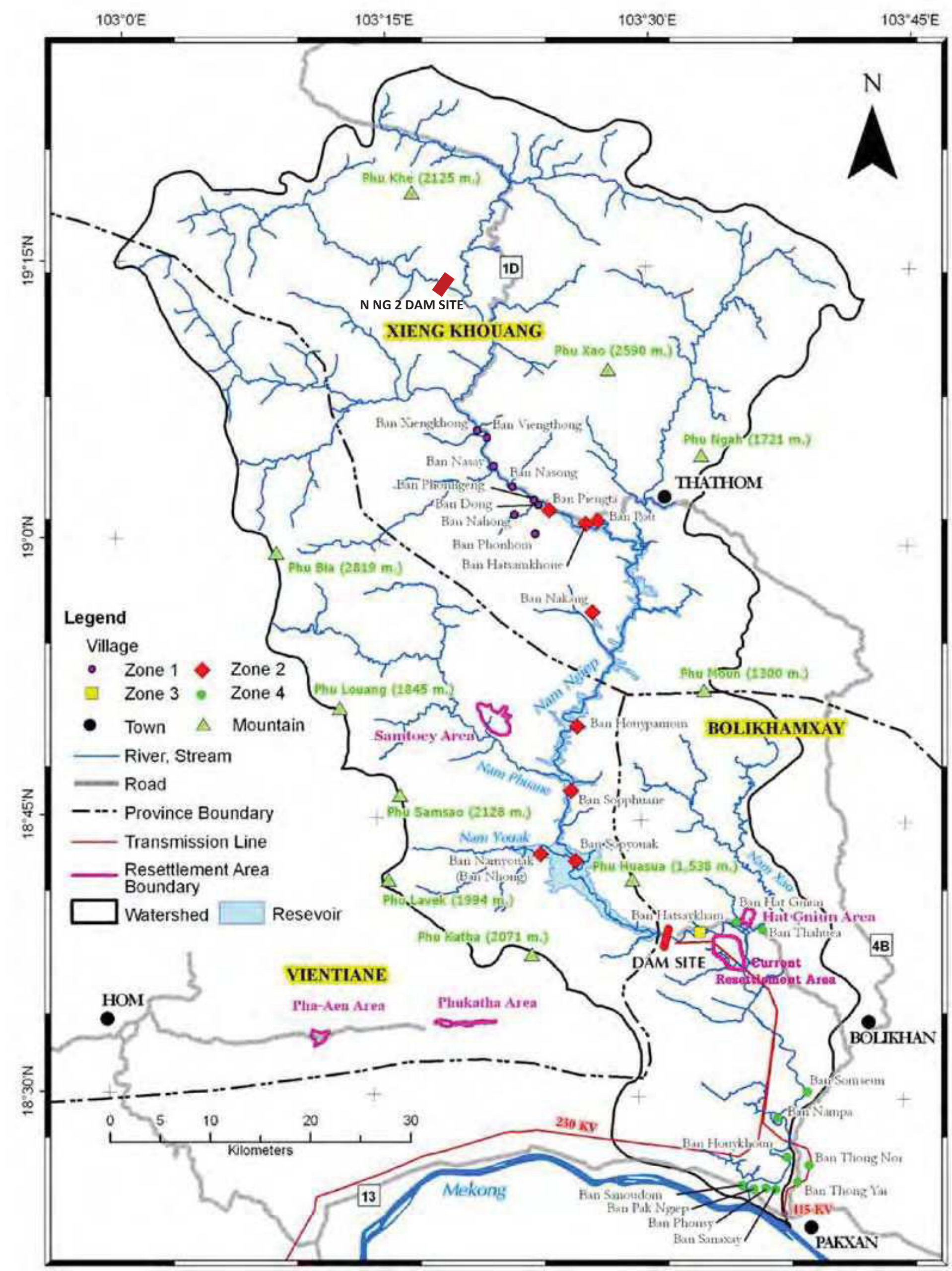
[2] Valued Environmental and Social Components (VECs) are environmental and social attributes that are considered important in assessing risk. The VECs identified as a result of the literature review are:
- VEC 1: Terrestrial biodiversity and habitats
- VEC 2: Aquatic biodiversity and habitats
- VEC 3: Ecosystem services
- VEC 4: Water quality and flows

Figure 1.2 Zones in the Study Area



Source: Environmental Impact Assessment Report, ERIC 2012 and Adapted by ERM, 2013.

1.5.3 *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.*

1.5.4 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 April 2014. Specialist surveys and peer review was undertaken in conjunction with:

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- Dr Maurice Kottelat – South East Asian Fish and Aquatic Habitat Expert
- Dr Phavainh Phiapalath – South East Asian Primate Specialist
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Source: Environmental Impact Assessment Report, ERIC, 2012.

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1.6 *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, Policy and Administrative 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. Appendices are as follows:

Appendix A – Biodiversity Baseline Assessment Report – This report provides an assessment of the biodiversity values in accordance with the requirements of ADB Environmental Safeguard Policy and guided by the IFC Performance Standard 6. In term of vegetation, flora and fauna species diversity, aquatic ecology surveys, the fish community of Mekong River and critical habitat of Project Areas.

Appendix B – Biodiversity Offset Design Report – This report analyses the residual biodiversity values that will be lost and identifies areas to offset these impacts for terrestrial and aquatic habitats and species.

Appendix C – Cumulative Impact Assessment Report – The report provides the assessment of cumulative impacts from the direct and indirect impacts assessed. The results of the direct/indirect assessments are considered in the combination with other past, present and reasonably foreseeable future actions, potential resources and receptors.

Appendix D - Environmental Flow Assessment Report – This report provides the result of the assessment of environmental flows required to maintain biodiversity and ecosystem services in the Nam Ngiep River system downstream of the main dam.

Appendix E – Environmental Assessment for the NNP1 Access Road – This Appendix is updating the original assessment of the access road upgrading prepared by ERIC. The report provides an initial examination of the potential environmental impacts and also provides a series of managements and mitigation measures that to be implemented along the access road of the Project.

Appendix F – NNP1 Transmission Line from the Main dam to Vientiane Initial Environment Examination – This Appendix incorporates the result of assessment for transmission line of the Project. The original one was prepared by ERIC in January 2012 and the updated report was amended by ERM in May 2014.

The report provides the assessment of potential impacts on social, physical and biological environment for the design, construction and operation phases and the mitigation measures had identified to decrease the impacts likely to occur along the 230 kV transmission line from main dam to Nabong substation.

Appendix G – NNP1 Results of Analysis – This Appendix consists of the analysis of data collected by ERIC. The data and analysis include all data collected from site survey, including the results from data analysis and public consultation.

Appendix H – EMP Sub- Plans – The Environmental Management Plan (EMP) Sub-Plans include the guidelines for Project implementation for minimizing the environmental impacts and will be used to develop the related Environmental and Social Mitigation and Management Plan (ESMMP) for the Project.

Appendix I - Agreement on National Environmental Standards of Lao PDR, 2009 – These applicable standards outline the Project sampling results and the relevant standards contained in the Agreement on National Environmental Standards of Lao PDR launched in December 2009 and relevant international standards.

Appendix J – Houay Ngua Provincial Protected Area (PPA) Official Documents – This appendix provides the communication letters for the Houay Ngua PPA between the GOL's authorities and the Project and the PPA's Site Management Guideline that the Project shall implement according to the guideline when the Project's activities related to the PPA

Appendix K - Preliminary Archaeology and Cultural Heritage Survey Report – This appendix provides the results of the assessment of present archaeological and cultural heritage sites of significance located within the Project area including proposed the mitigation measures for appropriate management.

Appendix L – Emergency Response Procedure – This appendix provides measures and guidance for the establishment and implementation of emergency preparedness plan for NNP1.

2 METHODOLOGY

2.1 APPROACH

The study approach for the EIA is organized into two main categories according to their general environmental aspects – physical and biological, as follows:

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.
   - Cultural Resources
2. **Biological Environment**
   - Forest and Vegetation Cover
   - Terrestrial
   - Ecology/Wildlife
   - Aquatic Biodiversity Values

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).

2.2 PHYSICAL ENVIRONMENT

The physical environmental aspects refer to the water, land, atmosphere and other environmental aspects that are likely to be impacted by the project. This differs from the biological environment that includes all living aspects, including biodiversity and the ecosystem services that are provided by the environment to enable human populations to function.

The methodologies used for collection of baseline information, assessment of impacts, and recommendation of mitigation measures for physical environmental aspects was developed by ERIC in the original EIA (2012) and has been refined by ERM.

2.2.1 *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.

2.2.1.1 *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.

2.2.1.2 *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.

2.2.1.3 *Methodology for Impact Assessment and Mitigation Measures*

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

2.2.2 *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 conditions 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.

2.2.2.1 *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.

2.2.2.2 *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.

2.2.3 ***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.

2.2.3.1 *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.

2.2.3.2 *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.

2.2.3.3 *Methodology for Impact Assessment and Mitigation Measures*

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

2.2.4 *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.

2.2.4.1 *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.

2.2.4.2 *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).

2.2.4.3 *Methodology for Impact Assessment and Mitigation Measures*

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

2.2.5 *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.

2.2.5.1 *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.

2.2.5.2 *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.

2.2.5.3 *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.

2.2.6 ***Surface Water and Groundwater Quality***

A range of impacts on water quality may occur in different stages of the 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.

2.2.6.1 *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.

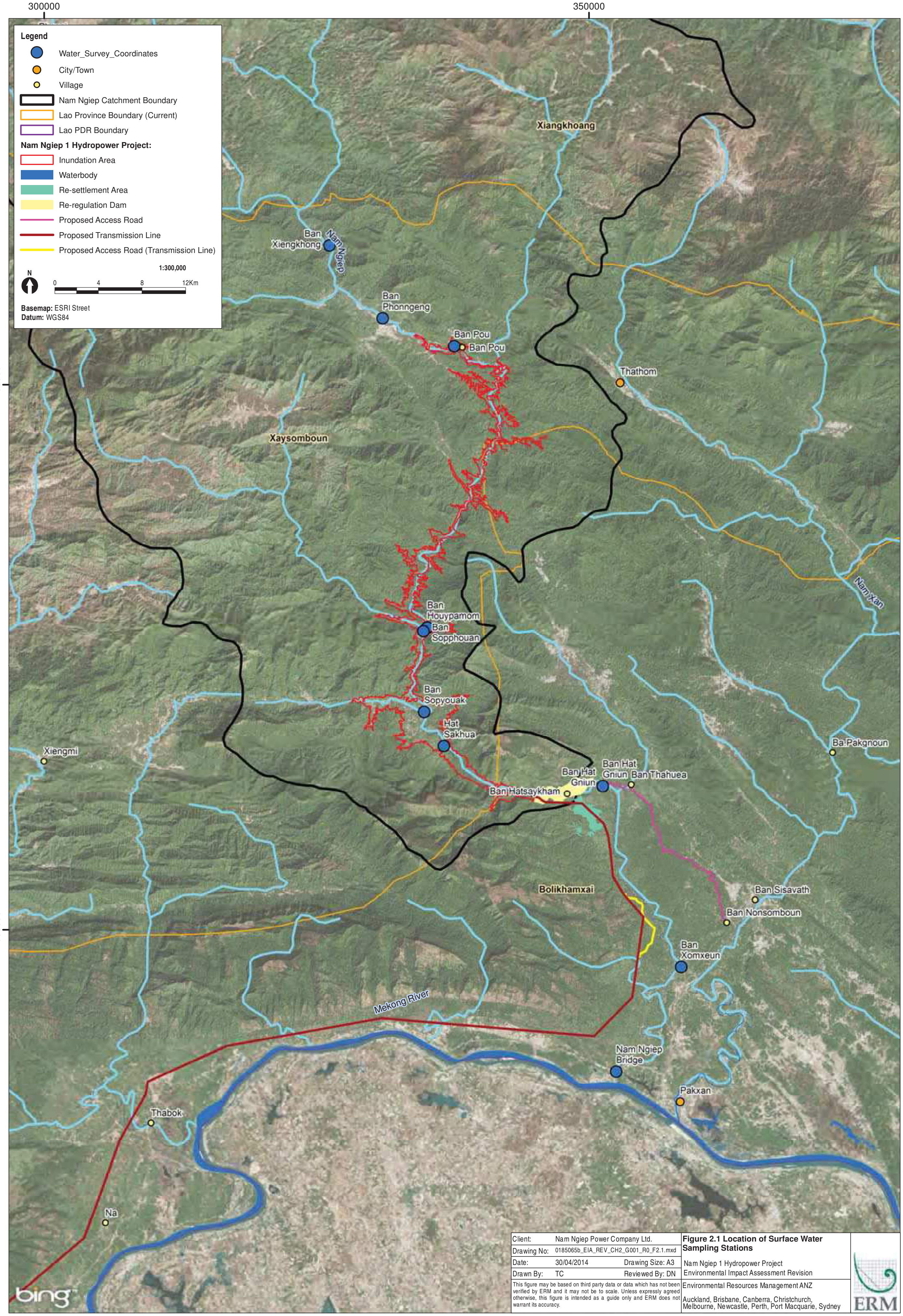
2.2.6.2 *Methodology for Collection of Baseline Information*

- 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***). Where appropriate, results are also compared to relevant international standards (i.e. EPA or WHO).

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′′

Source: ERIC, 2012.



Client:	Nam Ngiep Power Company Ltd.	**Figure 2.1 Location of Surface Water Sampling Stations**
Drawing No:	0185065b_EIA_REV_CH2_G001_R0_F2.1.mxd	Nam Ngiep 1 Hydropower Project
Date: 30/04/2014	Drawing Size: A3	Environmental Impact Assessment Revision
Drawn By: TC	Reviewed By: DN	Environmental Resources Management ANZ
This figure may be based on third party data or data which has not been verified by ERM and it may not be to scale. Unless expressly agreed otherwise, this figure is intended as a guide only and ERM does not warrant its accuracy.		Auckland, Brisbane, Canberra, Christchurch, Melbourne, Newcastle, Perth, Port Macquarie, Sydney

ERM

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 °C
TDS	mg/L	at 105 °C
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

Source:
[1] Agreement on the National Environmental Standards, MONRE 2009.
[2] Refer to National Recommended Water Quality Criteria – Correction, EPA 822-Z-99-001, 1999.

Table 2.3 Surface Water Quality Standards of Lao PDR

Parameter	Unit	Standard[1]	EPA[2] (Freshwater CCC)
pH		5-9	6.5-9
Dissolved Oxygen	mg/L	>6.0	-
BOD_5	mg/L	1.5	-
COD	mg/L	5.0	-
Nitrogen as nitrate (N-NO_3)	mg/L	5.0	-
Nitrogen as ammonia (N-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	0.15
Cadmium (Cd) $CaCO_3 \leq 100$ mg/l	mg/L	0.005	0.00025
Cadmium (Cd) $CaCO_3 \geq 100$ mg/l	mg/L	0.05	-
Chromium (VI) (Cr^{6+})	mg/L	0.05	0.011

Parameter	Unit	Standard[1]	EPA[2] (Freshwater CCC)
Copper (Cu)	mg/L	0.1	0.009
Cyanide	mg/L	0.005	0.0052
Lead (Pb)	mg/L	0.05	0.0025
Mercury (Hg)	mg/L	0.002	0.00077
Nickel (Ni)	mg/L	0.1	0.052
Zinc (Zn)	mg/L	1.0	0.12
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	0.000001
Alpha-BHC	mg/L	0.02	-
Dieldrin	mg/L	0.1	0.000056
Aldrin	mg/L	0.1	-
Heptachlor and Heptachlor Epoxide	mg/L	0.2	0.0000038
Endrin	mg/L	0	0.000036

Source:
[1] Agreement on the National Environmental Standards, MONRE 2009.
[2] Refer to National Recommended Water Quality Criteria – Correction, EPA 822-Z-99-001, 1999.

Lao PDR's national environmental standards were implemented in 2009, and are comparable to those shown in Appendix 2: Standards in *Annex C of Concession Agreement.*

The Project's monitoring program shall include compliance with the surface water quality standards of Lao's national environmental standards and the ambient surface water quality standards addressed in *Annex C of Concession Agreement,* which is the Project's commitment to MONRE and 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
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

Parameter	Units	Statistics	Standard Value for Class					Methods for Examination
			Class 1	Class 2	Class 3	Class 4	Class 5	
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[1]		WEPA Standard[2]	
				Suitable	Maximum	Suitable Allowance	Maximum Allowance
Physical	1. Colour	-	Platinum-Cobalt (Pt-Co)	5	15	5	15
	2. Turbidity	-	JTU	5	20	5	20
	14. Total solids	TS	mg/l	≤600	1,200	≤600	1,200
Chemical	3. Acidity	pH	-	7.0-8.5	6.5-9.2	6.5-8.5	6.5-9.2
	4. Iron	Fe	mg/L	≤0.5	1	≤0.5	1
	5. Manganese	Mn^{2+}	mg/L	≤0.3	0.5	≤0.3	0.5
	6. Copper	Cu^{2+}	mg/L	≤1.0	1.5	≤1.0	1.5
	7. Zinc	Zn^{2+}	mg/L	≤5.0	15	≤5.0	15.0
	8. Sulphate	SO_4^{2-}	mg/L	≤200	250	≤200	250
	9. Chloride	Cl^-	mg/L	≤250	600	≤250	600
	10. Fluoride	F^-	mg/L	≤0.7	1	≤0.7	1.0
	11.Nitrate	NO_3^-	mg/L	≤15	45	≤45	45
	12. Total Hardness as $CaCO_3$	Total $CaCO_3$	mg/L	≤300	500	≤300	500
	13.Non-carbonate hardness as $CaCO_3$	Non $CaCO_3$	mg/L	≤200	250	≤200	250
	15. Arsenic	As^{3+}, As^{5+}	mg/L	None	0.05	None	0.05
	16. Cyanide	CN^-	mg/L	None	0.1	None	0.1
	17. Lead	Pb^{2+}	mg/L	None	0.05	None	0.05
	18. Mercury	Hg	mg/L	None	0.001	None	0.001
	19. Cadmium	Cd^{3+}	mg/L	None	0.01	None	0.01
	20. Selenium	Se	mg/L	None	0.01	None	0.01
Bacteria	21. Coliform bacteria	Coliform	MPN/100 mL	<2.2	<2.2	<2.2	-
	22. E. coli bacteria	E. coli	MPN/100 mL	None	None	None	-
	23. Standard plate count	-	Colonies/mL	≤500	-	≤500	-

Source: [1] Agreement on the National Environmental Standards, MONRE 2009.

[2] Refer to Ground water Quality Standards for Drinking Purposes, WEPA
URL: http://www.wepa-db.net/policies/law/thailand/std_gw_for_drinking.htm

2.2.6.3 *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.

2.2.7 *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.

2.2.7.1 *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.

2.2.7.2 *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.

2.2.8 *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.

2.2.8.1 *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.

2.2.8.2 *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.

2.2.8.3 *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.

2.2.9 *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. Specifically, the required permission (from Lao and Thai authorities) for importing the necessary equipment was not granted during the period of field assessment.

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.

2.2.9.1 *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 μg/m^3, while those of Thailand are 0.50 μg/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 $\mu g/m^3$.

2.2.9.2 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.

2.2.9.3 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.

2.2.10 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.

2.2.10.1 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.

2.2.10.2 *Methodology for Collection of Baseline Information*

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

2.2.10.3 *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.

2.2.11 *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].

2.2.11.1 *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.

2.2.11.2 *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.

2.2.11.3 *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.

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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.

2.2.12 *Cultural Resources*

Evidence of archaeological and cultural resources were sought through archaeological surveys, and the potential direct and indirect impacts from the Project area were assessed in 2007.

The results of the archaeological survey were reviewed by the Department of Museums and Archaeology on October 2007.

2.2.12.1 *Objective of Study*

- Identify and assess the presence of archaeological and cultural heritage sites of significance located within the vicinity of the proposed Nam Ngiep 1 Hydropower Project.
- Assess the risk of direct or indirect impacts from the proposed Project on identified archaeological and cultural heritage sites.
- Identify appropriate management and mitigation measures.

2.2.12.2 *Methodology for Collection of Baseline Information*

- **Literature Review:** included review of the following: old publications of Lao archaeology, recent reports on archaeological survey conducted at several construction projects, and recent publications on the prehistory of Vietnam, Cambodia and Thailand.
- **Methods in the Field**: A village consultation took place to try to locate any objects with prehistoric, archaeological, historical or cultural value. Field observation, toponymic study and documentation of sites and artefacts were also conducted.

  The survey team was composed of;

  - Department of Museum and Archaeology (DMA) Professional Staff,
  - Office of Information and Culture of Hom District, Vientiane Province: Mr. Buaphet, Chief, and
  - Office of Information and Culture of Bolikhan District, Bolikhamxay Province: Mr. Viengnakhone, Deputy Chief.

- **Assessment of Sites**: Three main criteria were established to assess the archaeological/cultural sites, as follows:
  - Site contents: on the basis of artefact finds, to determine if the site was significant by the quantity and quality of those artefacts;
  - Site condition: to determine if the site still was intact or has it undergone any disturbance; and
  - Representativeness: based on its material culture to determine if the site was representative of a particular period of human evolution or cultural development.

2.2.12.3 *Methodology for Impact Assessment and Mitigation Measures*

Both direct and indirect impacts were assessed according to the archaeological survey evidence, and mitigation measures were provided to decrease the magnitude of potential impacts from the Project.

2.3 BIOLOGICAL ENVIRONMENT

The specific methodology used for collection of baseline information, assessment of impacts, and recommendation of mitigation measures for biological aspects was developed and implemented by ERM and sub-contractors in the revised EIA (undertaken in 2013 and 2014).

2.3.1 *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;
- Species expert consultation;
- Detailed flora survey of the access road corridor; and
- Targeted threatened species survey.

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.
- *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.

2.3.2 *Direct Biodiversity Data Sources*

2.3.2.1 *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).

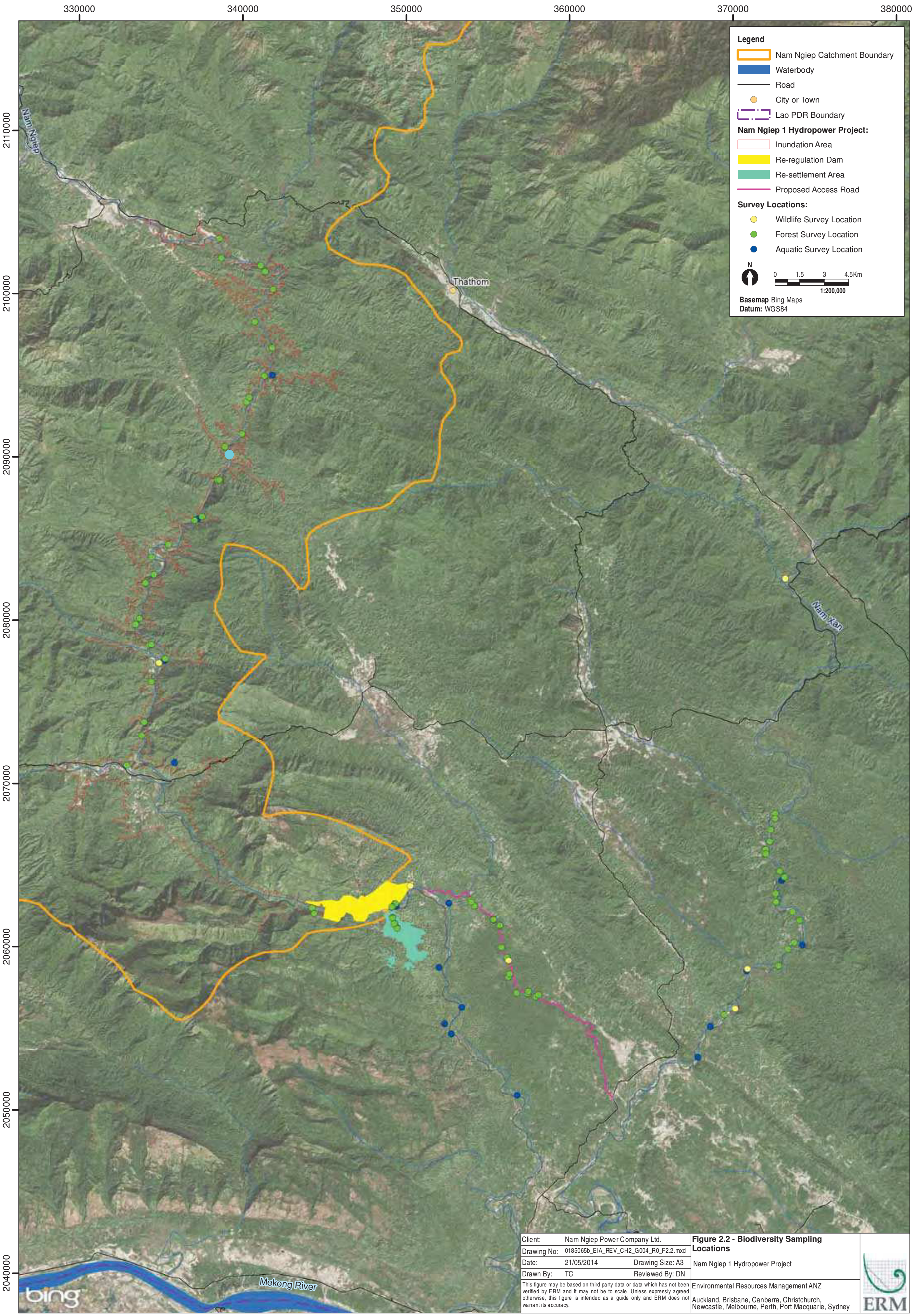
2.3.2.2 *Thailand Institute of Scientific and Technological Research Biodiversity Survey 2013*

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. The biodiversity sampling locations are shown in ***Figure 2.2.***

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
- Houay Ngua Provincial Preserved Area.



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Drawing No:	0185065b_EIA_REV_CH2_G004_R0_F2.2.mxd
Date:	21/05/2014 — Drawing Size: A3
Drawn By:	TC — Reviewed By: DN

This figure may be based on third party data or data which has not been verified by ERM and it may not be to scale. Unless expressly agreed otherwise, this figure is intended as a guide only and ERM does not warrant its accuracy.

Figure 2.2 - Biodiversity Sampling Locations

Nam Ngiep 1 Hydropower Project

Environmental Resources Management ANZ

Auckland, Brisbane, Canberra, Christchurch, Newcastle, Melbourne, Perth, Port Macquarie, Sydney

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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, geo-referenced 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, Pathum 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, Houay 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.

2.3.2.3 *National University of Laos Ground-truth of Natural Habitat Survey (Access Road Corridor) 2013*

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.

2.3.2.4 *Dr Phaivanh Phiapalath Endangered Primate Survey 2013*

Targeted survey of the inundation area, in particular potential habitat areas for the Northern White-cheeked Gibbon (*Nomascus leucogenys*, Critically

Endangered), Red-shanked Douc Langur (*Pygathrix nemaeus*, Endangered) and Phayre's Leaf Monkey (*Trachypithecus phayri*, Endangered) were undertaken in December 2013. The survey aimed to identify habitats for the species, confirm if the species is present and assess the significance of the area for these primate species. The survey area included the inundation area with four survey clusters established and surveyed by five sub-survey teams.

The survey was conducted by establishing listening posts for gibbons and reconnaissance surveys for non-vocal primate species. Additional data was captured from village interviews with boat men, hunters and elders of Ban Pou, Ban Sop Phouan and Ban Sop Youak.

2.3.2.5 *Dr Kottelat Fast Water Habitat Survey 2014*

Aquatic survey targeting fast water habitats was undertaken in February 2014 to meet a knowledge gap in fish species data recognised for this habitat type. Most sampling was undertaken using a battery-powered electric fish shocker or using ichtyocides. Other methods used included push-net and seine, as well as inspection of villager catches and restaurant kitchens.

Fish were sampled or observed at 21 sites in the Nam Ngiep draninge upstream of the dam site, 14 of them in fast water habitats in the inundation area of the main dam. Eight locations were sampled in the Nam Xan drainage, one in the Nam Mang and six in the Nam Xao.

2.3.2.6 *Mr Terry Warren Critically Endangered Fish Species Habitat Assessment 2014*

To further understand the extent of habitat and distribution of *Luciocyprinus striolatus* in the Nam Ngiep catchment and other catchments, a team led by Mr Terry Warren undertook field survey during April-June 2014. The assessments aimed to collected information to regarding the habitats, distribution and threats to the species in order to identify the importance of Nam Ngiep River concentration in the context of the survival of the species.

Villages and accessible river stretches were visited by the team and anecdotal information collected specific to the species.

Investigations were undertaken in 3 distinct phases (as undertaken by Mr Terry Warren):

1. Investigation into the likely species distribution within the Nam Ngiep watershed through villager interviews;
2. Assessment of the distribution of habitat features that support important lifecycle components for the species (spawning and dry season refugia) and an assessment of risks and threats to the persistence of the species within the Nam Ngiep watershed; and
3. Assessment of the distribution of the species across its range (Lao PDR and Southern China) and a ranking of the conservation significance of known populations.

2.3.3 *Indirect Biodiversity Data Sources*

2.3.3.1 *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:

- Houay 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.

2.3.3.2 *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

Source: Technical Report, 2007.

Limitations

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.

2.3.3.3 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, Dr M Kottelat, Dr P Phiapalath and Mr T Warren. Comments was provided on some species texts however it is acknowledged that the final content remains the responsibility of the report compilers.

2.3.3.4 *A number of the specialists were engaged to undertake targeted surveys as described in Sections 2.3.2.4, 2.3.2.5, and 2.3.2.6 above. The information has been considered in the biodiversity baseline assessment and analysis of critical habitat. 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.

A summary of methodology for collection of baseline information and assessment and mitigation of impacts for physical and biological environment aspects is shown in ***Table 2.7.***

Table 2.7 Summary of Methodology of Environmental Aspects

Environmental Aspects	Methodology for Collection Baseline Information	Methodology for Impact Assessment and Mitigation Measures
1. Physical Environment (by ERIC)		
Topography	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.	Maps have been prepared, depicting the modified topography and recommended mitigation measure to minimize negative impacts.
Meteorology	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.	
Geology, Landforms, Seismology	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.	Where potential problems were identified, appropriate mitigation measures were developed to minimize the impacts.
Soils	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. Soils analyzed for: 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) and physical properties: soil texture (particle size distribution).	Project activities were assessed for their potential impacts on soil fertility. Mitigation measures were determined wherever necessary.

Environmental Aspects	Methodology for Collection Baseline Information	Methodology for Impact Assessment and Mitigation Measures
Erosion and Sedimentation	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.	Project activities were assessed for their potential impacts on soil erosion and sedimentation. Mitigation measures were determined wherever necessary.
Surface Water and Groundwater Quality	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. Sampling was carried out in April 2007 and October 2007. Groundwater quality was observed in October 2007 at Ban Xomxeun and Ban Hat Gniun; however, only the well-water of Ban Xomxeun was collected. Further water quality sampling was undertaken in March 2013 by ERM along the Nam Ngiep and Nam Xan Rivers. Temperature, pH, conductivity, salinity, turbidity, and DO were measured at the field sites, whereas other characteristics were analyzed at the National University of Lao. Results of surface water quality of the collected water samples were compared to Ambient Water Standards for Lao PDR. In addition, results were also compared to the Surface Water Quality Standards of Thailand.	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.
Mineral Resources	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.	

Environmental Aspects	Methodology for Collection Baseline Information	Methodology for Impact Assessment and Mitigation Measures
	Conducted field interviews to verify secondary data and resolve any problematic or conflicting information.	
Noise and Vibration	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 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.	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.
Air Quality	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.	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.
Potential Contaminated Sites	Through observations and secondary data, acquired information to evaluate present conditions and use of hazardous substances.	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

Environmental Aspects	Methodology for Collection Baseline Information	Methodology for Impact Assessment and Mitigation Measures
		monitoring plans.
Hydrology	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.	Evaluated potential hydrological changes due to the Project regarding existing natural condition & resources, people, and their living circumstances and recommended mitigation measures.
2. Biological Environment (by ERM, ERIC, TISTR and other sub consultants)		
Forest and Vegetation Cover;	Rapideye imagery assessment of vegetation cover to determine the NDVI index for vegetation type and condition	Applied the mitigation hierarchy to avoid, mitigate and identify residual biodiversity values requiring offsetting.
Terrestrial Ecology/Wildlife	Targeted IUCN listed primate species survey and critical habitat assessment* Targeted botanical survey in Houay Ngua PPA and along the access road* 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, ** 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 ***	Applied the mitigation hierarchy to avoid, mitigate and identify residual biodiversity values requiring offsetting. Assessment against Critical Habitat criteria according to ADB SPS
Aquatic Biodiversity Values	Fish sampling using netting techniques ** Targeted endemic, CR and EN fish survey* Targeted CR fish species habitat assessment*	Applied the mitigation hierarchy to avoid, mitigate and identify residual biodiversity values requiring offsetting. Assessment against Critical Habitat criteria according to ADB SPS
* ERM (including other sub-consultants); ** ERIC; ***TISTR		

Source: Draft Environmental Impact Assessment Report, ERIC 2012 and Adapted by ERM, 2014.

3 *POLICY, LEGAL AND 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 conform to the legal and administrative requirements of Lao PDR. 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) (2009) and to the Equator Principles. The International Finance Corporation (IFC) Performance Standards have been used as a reference where required, and in particular, IFC Performance Standard 6 (2012).

Where there are legal gaps in terms of standards, the ADB or other international standards or other relevant local standards will be used,.

3.1 *OUTLINE OF ANNEX C OF THE CONCESSION AGREEMENT*

In addition, the Annex C Environmental and Social Obligations of Concession Agreement approved by MONRE dated on 18 April 2013 is the commitment between the Project (NNP1PC and Sub- Contractor), MONRE and GOL to oblige the activity implementation of the Project complied with the environmental and social obligations.

The 3 main parts of this Annex C including its Appendices consist of;

Part I - General Applicability

- Context and Rationale
- Core Commitments
- Relationship of the company and GOL
- Records, Data and Information
- Confidentiality and the Public's Right to Information
- Standards
- Permits
- Monitoring
- Penalties
- Rehabilitation, Decommissioning and Post-Handover

Part II- Environmental & Social (Non-Resettlement/ Non- Compensation) Matters	- Introduction - Measures - Water Management - Environmental Management System - Additional Obligation, Data, Reporting and Instructions - Pre-Construction and Construction Phase - Operational Phase - Environmental Monitoring - Funding
Part III- Social Matters- Resettlement & Compensation	- Introduction - Social Measures - Resettlement
Appendix	- Definitions - Standards - Budgets - Penalties - GOL Organizations on Social Matters - Resettlement and Compensation Activities, Budgets and Timelines - Entitlement Matrix - Grievance Redress Mechanism

3.2 *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 Decree on the Implementation of the Land Law (2008);
7) The Electricity Law (2008);
8) The Road Law (1999);
9) The Decree on Environmental Impact Assessment (2010);
10) The Decree on State Land Lease or Concession (2009);
11) The Decree on Compensation and Resettlement of People Affected by Development Projects (2006);

12) The Technical Guidelines on Compensation and Resettlement of People Affected by Development Projects (2005);
13) The Regulation on EIA for Road Projects (2004);
14) The Decree on the Environmental Protection Fund (2005);
15) The Constitution of the Lao People's Democratic Republic (1991), amended 2003;
16) The Law on Investment Promotion (2009);
17) The Executive Decree on State Land Lease and Concession Fees Rate (2009);
18) The Ministerial Instruction on the Environmental and Social Impact Assessment for the Investment Projects and Activities (2013);
19) Decision on the Management of Quality Standards for Drinking Water and Household Water Supply (2005);
20) Agreement on National Environmental Standards (2009); and
21) Regulation on Logging and Clearance after Logging for a Hydropower Project Reservoir Area (2008).
22) Prime Minister's Decree No. 164/1993 for National Conservation Forests.
23) Decree No. 03/PR of June 20, 1997, on the Preservation of Cultural, Historical and Natural Heritage

3.2.1 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 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

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

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.

3.2.2 *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.

3.2.3 *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).

3.2.4 *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.

3.2.5 *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.

3.2.6 *Decree on the Implementation of the Land Law (2008)*

This Decree on the Implementation of the Land Law No.88/PM, dated on 3 June 2008, issued for the purpose of implementing the Land Law relating to the management, protection, use and development of land in an efficient, peaceful, and fair manner as well as ensuring the compliance with the set-targets and the uniformity of practice throughout the country.

3.2.7 *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.

3.2.8 *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.

3.2.9 *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.

3.2.10 *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.

3.2.11 *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.

3.2.12 *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.

3.2.13 *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.

3.2.14 *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.

3.2.15 *Constitution of the Lao People's Democratic Republic (1991), amended 2003*

The Lao PDR Constitution (1991) and other legislation recognize the unity and equality of ethnic groups in the political process and protect their rights to preserve and improve their unique traditions and culture (Articles 1, 2, 3, 8 and 22). All ethnic minorities are Lao citizens, possess family books and identify cards, have the right to use native languages and to practice traditional customs and religion (Const., Articles 8 and 9). The Constitution prohibits any act that discriminates against or divides ethnic groups (Article 8). Ethnic groups maintain land tenure user rights equal to all Lao citizens with certain specifications (see Section 3.1.5.1) and even preferential access and customary user rights to certain forest products (Forestry Law, Article 30; MAF Regulation 535; MAF Orders 54 and 377).

As the primary legal document in Lao PDR, the Constitution provides a framework and minimum rights to be implemented in legislation. However, since the court system remains underutilized, it is difficult to enforce such rights or resolve conflicts between ethnic groups and the government or other stakeholders. Legislation in Lao PDR recognizes primary land tenure and resource user rights for ethnic groups, but most of them remain unaware of these rights under national legislation due to the inability of the government to provide extension to remote ethnic villages such as e.g. those within the NNT NPA. Thus any project within the Watershed Management Area should focus on providing extension of legislation and rights to the ethnic groups and assist in establishing village based rules, zoning and management.

The National Assembly has a special Committee on Ethnic Affairs to draft and evaluate proposed legislation to ensure that the concerns of ethnic minorities are incorporated and not infringed upon. The lead institution for ethnic affairs in Lao PDR is the Lao Front for National Construction (LFNC), which has an Ethnic Affairs Department. Research on ethnic groups is the responsibility of the Institute for Cultural Research under the Ministry of Information and Culture.

The country's new constitution, enacted in August 1991, ensures equal rights for both sexes in the political, economic, cultural, social fields, and family affairs. The role of the Lao Women's Union (LWU) is also recognized in the constitution with an information gathering and service delivery role. Among the 21 other laws which have been enacted since January 1992, some are related to gender issues. Among these are Property Law, Inheritance Law, Insurance Law, Labor Law, Family Law and Election Law.

3.2.16 Law on Investment Promotion (2009)

The Law on Investment Promotion, No. 02/NA dated on 8 July, 2009. The law stipulates principles, regulations and measures regarding the promotion and management of domestic and foreign investments aiming at ensuring investment with convenience; speediness; accuracy; being protected by the Government; and ensuring the rights and benefits of investors, of the state and of the people. The Law aims to enhance the roles and benefits of investments contributed to the national socio-economic growth in a continuous and sustainable manner; and significantly to the national protection and development.

3.2.17 Decision on the Management of Quality Standards for Drinking Water and Household Water Supply (2005)

No 1371/MoH defines standards for drinking and household water supply, including bacteriological, physical-chemical (aesthetic), and health-significant chemical parameters. The Decision defines "drinking water" as "water obtained from the water supply or other sources and cleaned through the process of boiling, filtering and disinfecting in accordance with the correct technical principles and standards" (Art. 2). The microbiological parameter for water quality conforms with the WHO Guidelines for Drinking Water Quality: zero faecal coliforms and zero total coliforms in 100 ml samples.

3.2.18 Agreement on National Environmental Standards (2009)

Agreement on National Environment standards No. 2734/PMO.MONRE, dated on 7 December, was issued for definition of the National Environmental Standards as the basis for environmental monitoring and pollution control on water, soil, air and noise. This agreement applies to any relevant person, enterprise and organization in order to protect the environment and tot control pollution in Lao PDR.

3.2.19 *Regulation on Logging and Clearance after Logging for a Hydropower Project Reservoir Area (2008)*

The regulation No. 0112/MAF dated on 25 November 2008, is related to the principles on logging and clearing of forest products in term of planning, preparation and logging and final clearing for logging and forest product clearing, responsible agencies, information dissemination and evaluation and prohibition.

3.2.20 *Prime Minister's Decree No. 164/1993 for National Conservation Forests*

This decree established eighteen protected areas and required that the Government develop management plans for each area. A summary of key provisions of the decree are as follows:

Article 1 names and defines the 18 areas, and refers boundary details to a map (at scale 1: 500 000).

Article 2 states that various other forest reservations remain in force.

Article 3 specifies three main objectives: (I) protect natural resources, including forest, wild animals and water, (iii) maintain the abundance of nature and environmental stability (iii) protect natural beauty for purposes of leisure and research

Article 4 prohibits within reserved forests the cutting of timber, collection of non-timber forest produce, including all wildlife hunting, mining or reservoirs, ownership of land, destruction of cultural or historical sites, use of explosives, burning.

Article 5 states that anyone failing to observe these injunctions commits an offense and may be tried and punished.

Article 6 states that MAF and the provincial authorities are responsible for providing further regulations, planning, budget provision and field implementation.

Article 7 requires all other ministries to cooperate with MAF and publicize the provisions of the act.

Article 8 nullifies any orders, rules and regulations contrary to this Decree.

Two additional protected areas, referred to as National Biodiversity Conservation Areas (NBCAs), have since been added. The current area totals 3.4 million ha or 14.3% of the country's area. In addition, provinces and districts have also designated their own conservation areas and protection forests, bringing the overall national coverage total to 5.3 million ha or 22.6% of the total land area.

3.2.21 *Decree No. 03/PR of June 20, 1997, on the Preservation of Cultural, Historical and Natural Heritage*

This decree outlines the regulations and measures for the management, conservation and use of the national heritage, including for upgrading of movable and immovable assets with historical or cultural or natural value into national heritage with the view of raising the spirit of patriotism, people's democracy, awareness and ownership of the fine national and ethnic cultures.

This decree requires that in order to prevent exploitation of relics and antiquities, any person who discovers archaeological relics or a cultural site must inform the provincial and district offices within three days.

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

Table 3.1 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.
	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

Law or Decree	Article	Relating To	Content
	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 forest zones	Stipulates the preservation of water resources in forest zones for those areas where waterways originate and flow, including strict management and regulations to control logging, shifting cultivation, and destructive forest uses
	Article 70	Conversion of	Stipulates that forestland can be

Law or Decree	Article	Relating To	Content
		forestland	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 Impact Assessment	Requires an environmental impact assessment and indicates the contents to 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

Law or Decree	Article	Relating To	Content
			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

Source: Draft Environmental Impact Assessment Report, ERIC 2012 and Adapted by ERM, 2013

3.3 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:

1) The Convention on Biological Diversity (1996);
2) The Convention on Climate Change (1995);
3) The Agreement on the Cooperation for Sustainable Development of the Mekong River Basin (1995);
4) The Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) (2004);
5) The Inter-Governmental Agreement on Regional Power Trade in the Greater Mekong Sub-Region;
6) The Convention Concerning the Protection of the World Cultural and Natural Heritage (World Heritage Convention, 1972) (1987); and
7) The United Nations Convention to Combat Desertification (1996).

3.3.1 *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.[2]

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.[3]

3.3.2 *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

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

3 Ibid

renewable sources of energy, and the promotion of sustainable forms of agriculture.

3.3.3 *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 PDR, Thailand and Vietnam, established the Mekong River Commission and formed the basis for the joint 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)

3.3.4 *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.

3.3.5 *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)

3.3.6 *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.

3.3.7 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[4] and specifically address the following issues:

[4] 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

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.

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.

3.4 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."[5]

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

[5] ADB, Environment Policy of the Asian Development Bank, 2002, p. 9.

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).[6]

As with the ADB SPS, projects deemed to be categorized as 'Highly Complex' projects which normally have potentially greater environmental impact, such as dams. Therefore, this proposed hydropower development is classified as Category A project with provisions for 'Highly Complex' project. 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.

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.

3.5 *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 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:

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6 Ibid, p.18.

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.[7]

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

3.6 DETERMINATION OF HOUAY NGUA PROTECTED AREA AS PROTECTED AREA OF BOLIKHAMXAY PROVINCE

Regarding the determination of definition and function of Houay Ngua Protected Area (PPA) and its responsible agencies, it was found that Houay Ngua PPA is a provincial protected area under supervision of the Provincial Agriculture and Forestry Division, Bolikhamxay Province. It was also found that the area is still being utilized by villagers and private companies for illegal logging and poaching within the area, despite its protected status, especially near the edge of the protected area. However, the improvement and recovery of invasion and encroachment of the natural forest is ongoing. The purpose of the PPA is for education and scientific research purposes of the Province. The PPA does not meet any IUCN reserve categories given its mixed use and degraded state.

The revised boundary of Houay Ngua PPA has recently been announced. It shall also be highlighted that the Right of Way (30 m) was excluded from Houay Ngua PPA.

The road corridor can be used for the construction activities for the access road within the Right of Way area. The road corridor concept will be developed further in details in terms of implementation and action plan.

A series of letters between the NNP1PC and Bolikhamxay Province communications are sequenced in the following paragraphs.

[7] 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.

13th Mar 2009	**Minutes of Meeting: The Discussion Meeting for Solution on Houay Ngua Protected Area invasion**
	The meeting discussed possible solutions to the invasion/encroachment of Houay Ngua Protected Area, as well as the determination of the scope of the improved forest area along the edge.
4th Feb 2010	**Report on Determination of Houay Ngua Protected Area as Protected Area of Bolikhamxay Province**
	Houay Ngua has been designated as a Protected Area of Bolikhan district since 1998. Houay Ngua Protected Area is very important for Bolikhan district, particularly for the livelihood of 5 villages around the protected area.
	The area has been seriously threatened from poaching, timber extraction and non-timber forest products, and illegal land use. This has taken place primarily due to lack of commitment to protection of the area, lack of public awareness, incapacity of the relevant organisations, and financial constraints in the implementation.
	In 2009, the Provincial Agriculture and Forestry Department announced to all relevant sectors, including villages, alerting them to the status of Houay Ngua Protected Area, with details of following key subjects: • Objectives; • Target groups; • Geographic location, the area of Houay Ngua Protected Area; • Restrictions; and • Implementation measures.
10th June 2010	**Proposal for Determination of Houay Ngua Protected Area as the Provincial Protected Area**
	NNP1 proposed for the Houay Ngua Protected Area (area of 4,595 hectares) to be under the management of the province.

24th June 2010	**Agreement of the Bolikhamxay Governor**
	Boilikhamxay governor agrees to adopt the forest area of 4,595 hectares to be the Provincial Protected Area, which is assigned for provincial agriculture and forestry division, related sectors and Bolikhan district authority to effectively implement the agreement.
3rd April 2013	**Notification of NNP1 Access Road Construction**
	Agreement from Office of Bolikhamxay Province to permit NNP1 access road construction to pass Houay Ngua Provincial Reservation Forest from Ban Nonsomboun to NNP1 Dam site.
14th Feb 2014	**MoM for Houay Ngua PPA Consultation Meeting for Environmental Management**
	Provincial of Natural Resource and Environment of Bolikhamxay province (PONRE) require monitoring points at 2 locations along the Houay Ngua PPA. A patrol team was assigned for inspection. Inspection to take place at least 15 times/month, and inspection report shall be submitted according to regulation.
	Public relations shall be provided to local community around 5 villages and to district officer, by appropriate methods.
	Each activity shall comply with PPA's Site Management Guideline that was attached in this MoM.

The PPA's Site Management Guideline was developed in accordance to the agreement between the Project Owner and the relevant Authorities (MONRE and PONRE) during the meeting dated 14th February 2014 and the framework has been approved by PONRE of Bolikhamxay province. The minute of meeting mentioned that PONRE and EMO manager of NNP1PC should coordinate directly for any issue related to Houay Ngua PPA including the necessary budget for work implementation and monitoring programs.

The Contractor and Subcontractor in Houay Ngua PPA should implement all mitigation measures/ activities according to the PPA's Site Management Guidelines to avoid disturbing of flora and fauna and reach the ADB's requirement. The site specific ESMMP-CPs around the Houay Ngua PPA shall include monitoring methods, monitoring programmes, responsible parties and location of activities to comply with the Sub plans as stated in this document.

Appendix J1 presents the relevant letters between the NNP1PC and Bolikhamxay Province, and communications related to Houay Ngua Protected Area determination.

According to the meeting between PONRE and NNP1PC on 14th February 2014, the objective of the PPA's Site Management Guideline and its Conservation Action Plans have been set to enforce the Project Owner, Contractor and Subcontractor to be responsible for the management of access road construction activities and implementation of the proposed Conservation Action Plans within Houay Ngua PPA.

The Project Owner is responsible for developing the detailed Conservation Action Plans in order to minimise the impacts to Houay Ngua PPA and to protect the existing flora and fauna species within Houay Ngua PPA. The Houay Ngua Provincial Protected Area: Conservation Action Plans - Access Road 'A' Upgrade approved by the PONRE of Bolikhamxay province is presented in ***Appendix J2***.

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***.

Originally the main facilities of the Project were to be located in Bolikhamxay Province, with the reservoir covering parts of Vientiane (Hom district) and Xieng Khouang (Thathom district) Provinces.

However, the GOL recently announced the establishment of a new province, Xaysomboon Province. The amended boundaries of Vientiane, Xieng Khouang and Xaysomboon provinces were not officially announced at the time of preparing this report.

Initial available information indicates that the Project area will now be only located in Bolikhamxay Province and Xaysomboon Province. This is because the Thathom district and Hom district have now been re-allocated from Xieng Khouang Province and Vientiane Province to Xaysomboon Province respectively.

The reservoir will have a surface area of 66.9 km^2 when at full supply level of EL 320 m. The reservoir will have an effective storage capacity of 1,192 million m^3, 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 or re-regulation power station.

The location coordinates of main dam axis and re-regulation dam axis are as following;

Main Dam Axis -	Left Bank	N 2062524, E 344453
	Right Bank	N 2062019, E 344342
Re-Regulation Dam Axis -	Left Bank	N 2062562, E 349329
	Right Bank	N 2062451, E 349310

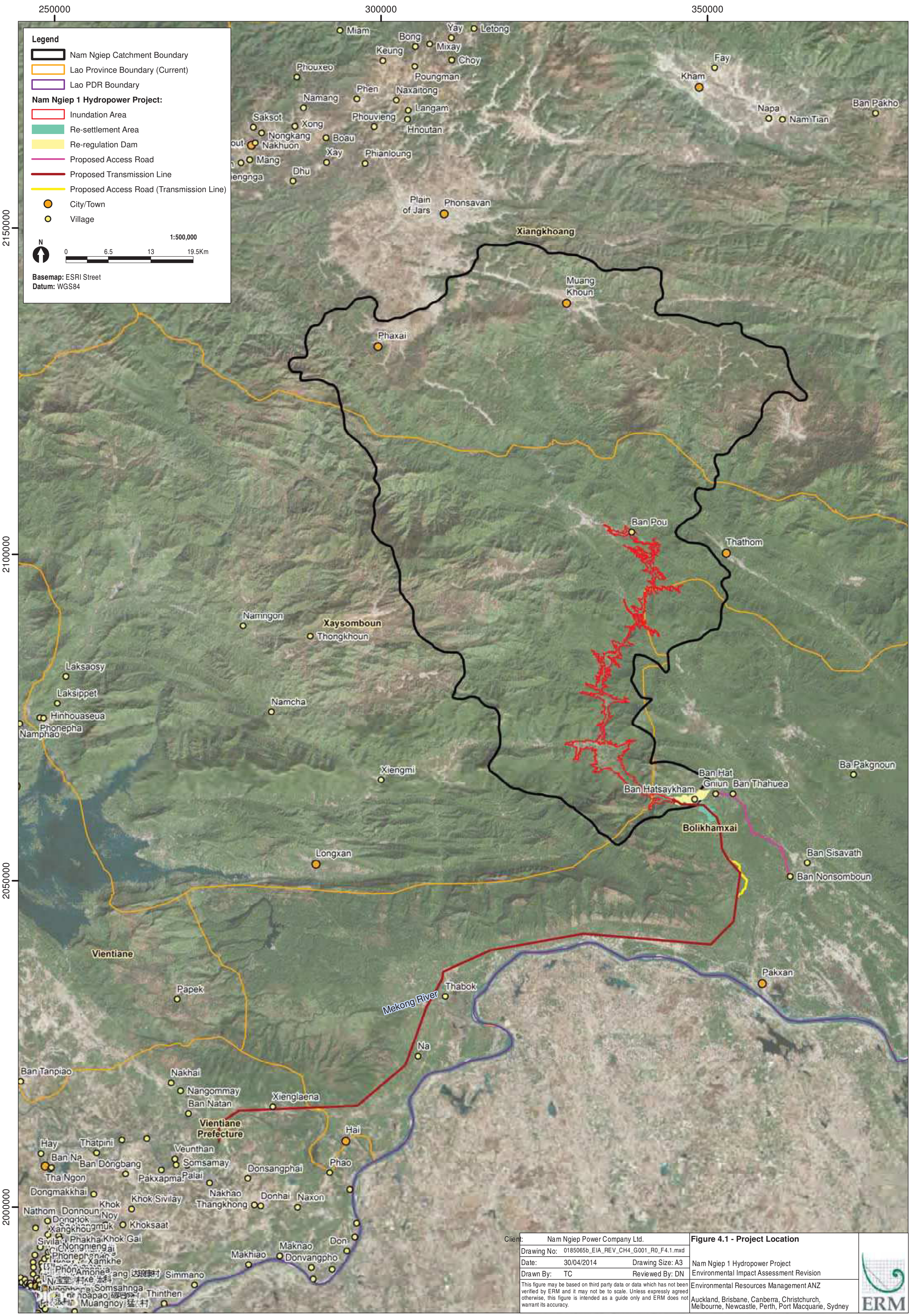


Figure 4.1 - Project Location

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 km^2, with average inflow of 148.4 m^3/s or 4.68 billion m^3/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

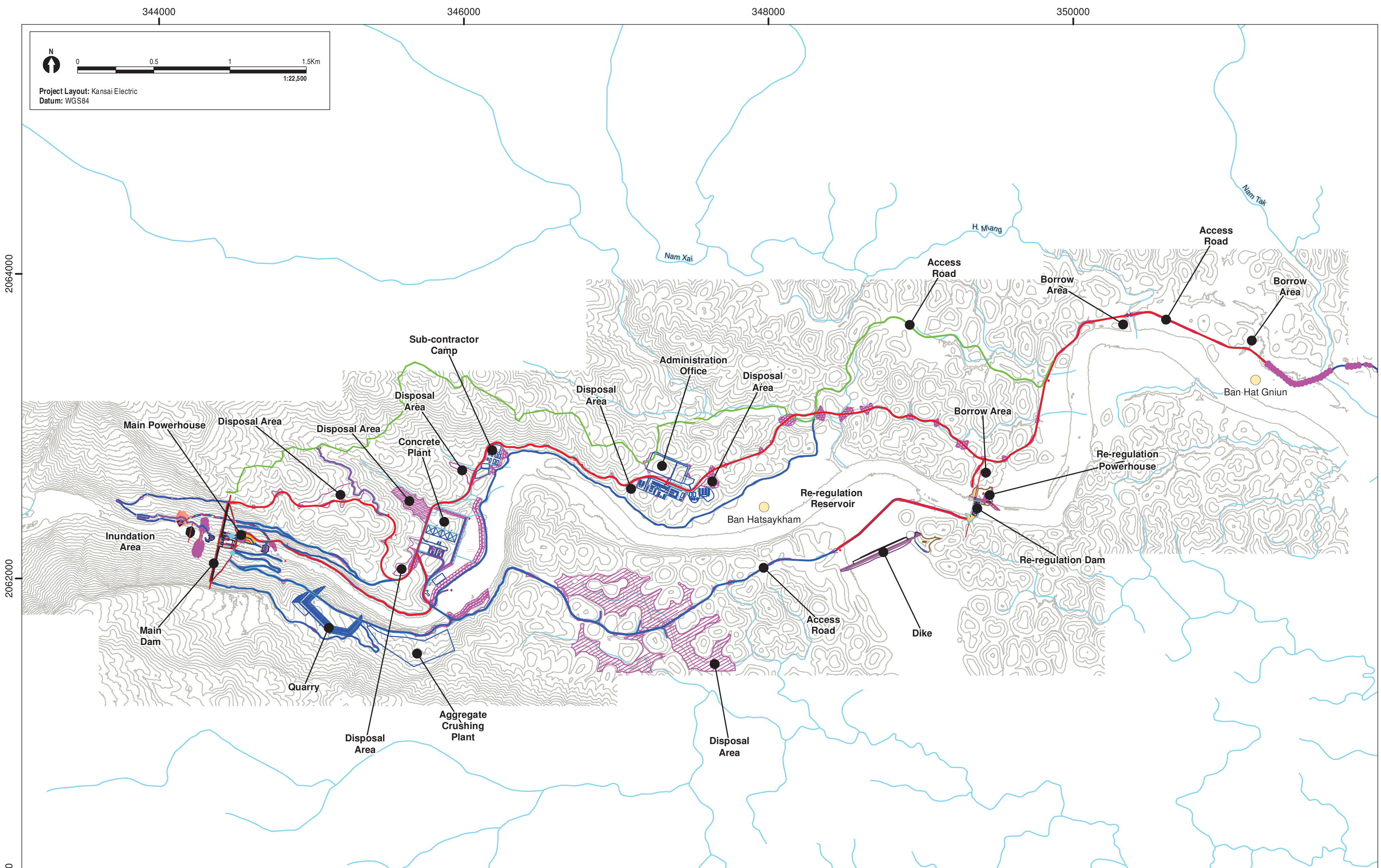
Facility	Items	Unit	Specifications
Main Power Station			
Main Reservoir	Flood water level	EL. m	320.0
	Normal water level	EL. m	320.0
	Rated water level	EL. m	312.0
	Minimum operating level	EL. m	296.0
	Available depth	m	24.0
	Reservoir surface area	km^2	66.9
	Effective storage capacity	10^6 m^3	1,192
	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)
	Spillway level	EL. m	206.4
Intake	Type	-	Bell-mouth
	Number	-	2
	Discharge capacity	m^3/s	230.0
	Sill level	EL. m	276
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	m^3/s	34.5

Facility	Items	Unit	Specifications
	(for simulation)		
	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)
Conduit	Release level (sill gate of chamber)	EL. m	244.6
	Velocity in pipe	m^3/s	20 m/s
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
	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)
	Spillway level	EL. m	187
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)

Facility	Items	Unit	Specifications
Transmission Line*	Peak operation hour	hrs	24 (Monday to Sunday)
	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
	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	m^3	12,000
	Expected disposal volume	m^3	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

* 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

Source: Kansai, 2013..



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Drawn By:	TC	Reviewed By: DN	

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Figure 4.2 - Location of Main Features of Nam Ngiep 1 Hydropower Project (NNP1PC 2013)

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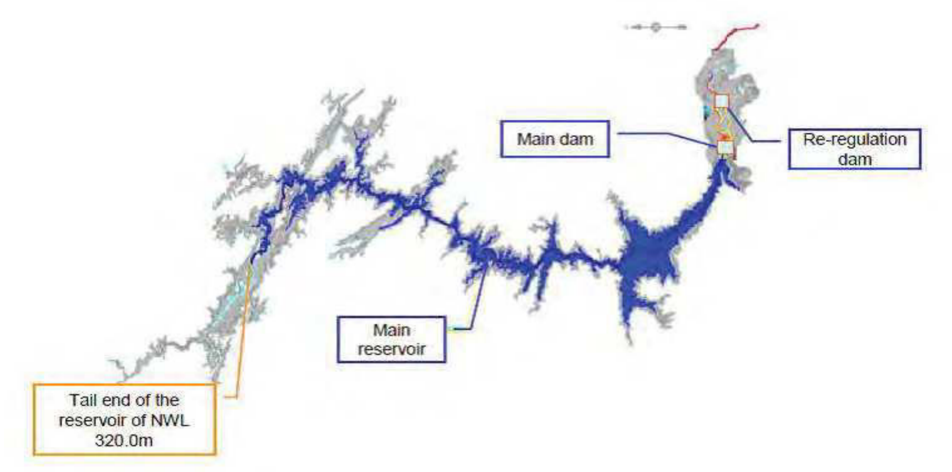
4.4 MAIN DAM AND RELATED FACILITIES

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***.

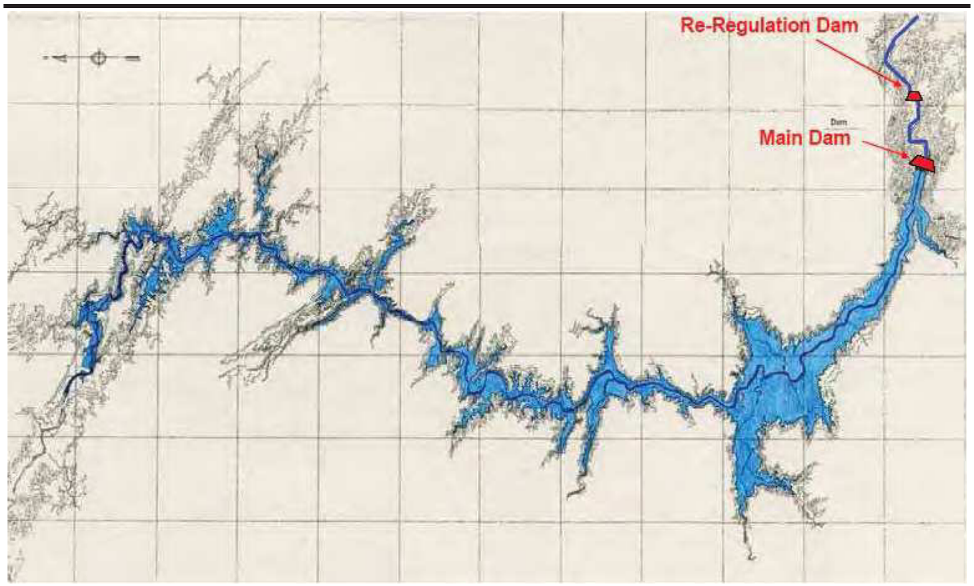
Figure 4.3 ***Main Dam Reservoir***



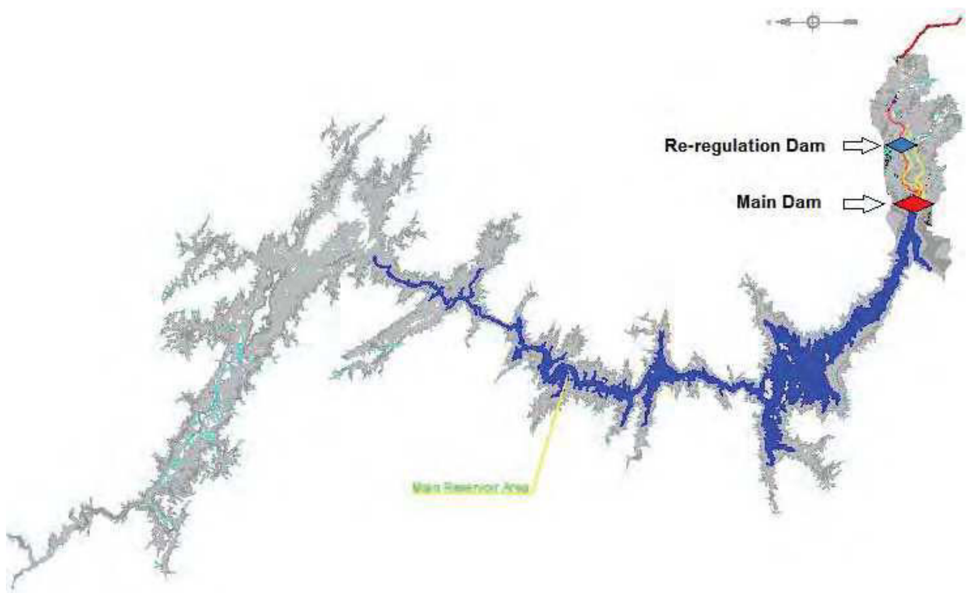
Source: Kansai, 2013.

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)

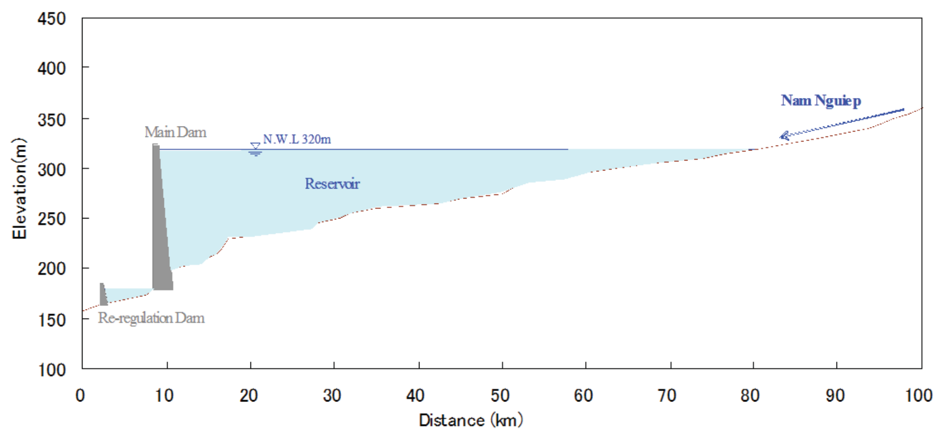


(b) Minimum Operation Level (EL 296 m)

Source: (a) Technical Report, 2011 and (b) Kansai, 2013.

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 174 m. The reservoir depth at the deepest point, directly behind the dam, will be equal to the dam height, which is about 148 m. The average depth of the reservoir would be about 74 m, ranging from a maximum of 148 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



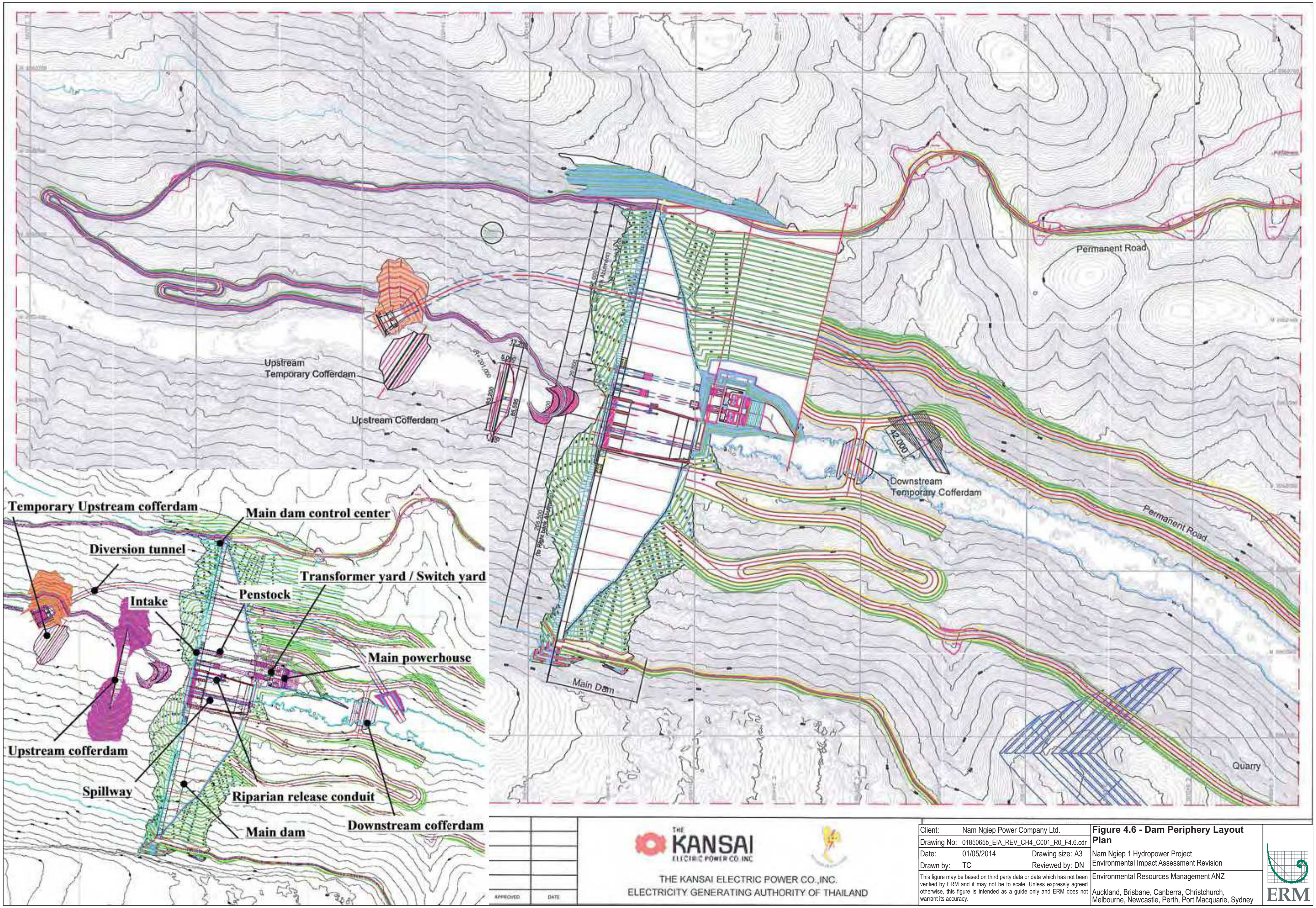
Source: Technical Report, 2011.

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.

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.***



Permanent Road
Upstream Temporary Cofferdam
Upstream Cofferdam
Downstream Temporary Cofferdam
Permanent Road
Main Dam
Quarry
Temporary Upstream cofferdam
Main dam control center
Diversion tunnel
Transformer yard / Switch yard
Penstock
Intake
Main powerhouse
Upstream cofferdam
Spillway
Riparian release conduit
Main dam
Downstream cofferdam
THE KANSAI ELECTRIC POWER CO.,INC.
THE KANSAI ELECTRIC POWER CO.,INC.
ELECTRICITY GENERATING AUTHORITY OF THAILAND
APPROVED
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Figure 4.6 - Dam Periphery Layout Plan
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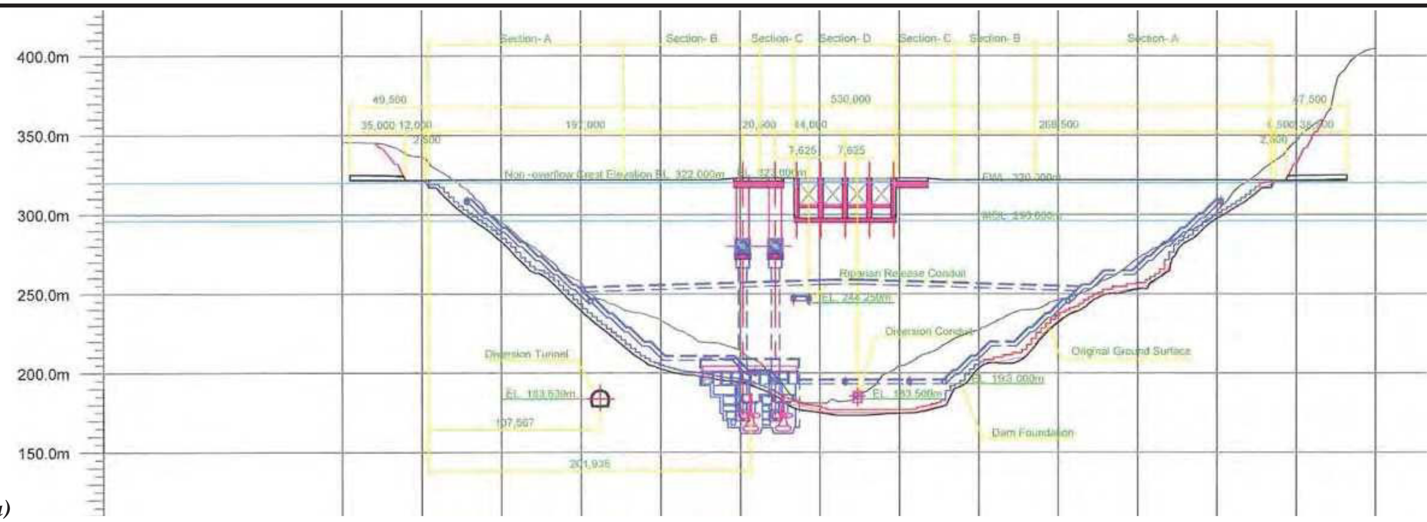
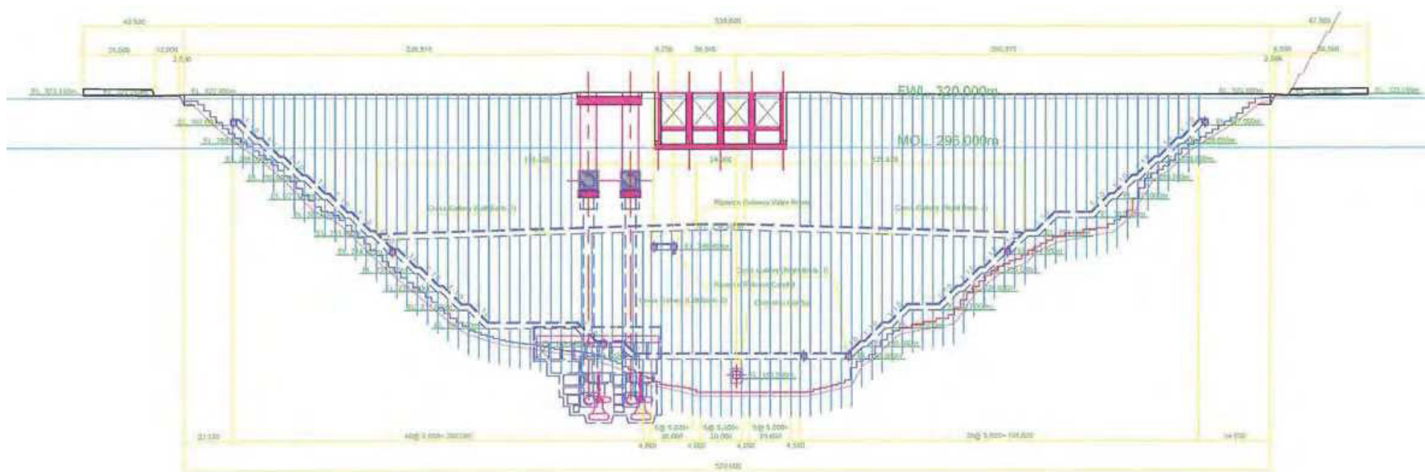
Figure 4.7 Upstream Cross-Section of Main Dam



(a)



(b)

Source: (a) Technical Report, 2011 and (b) Kansai, 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.

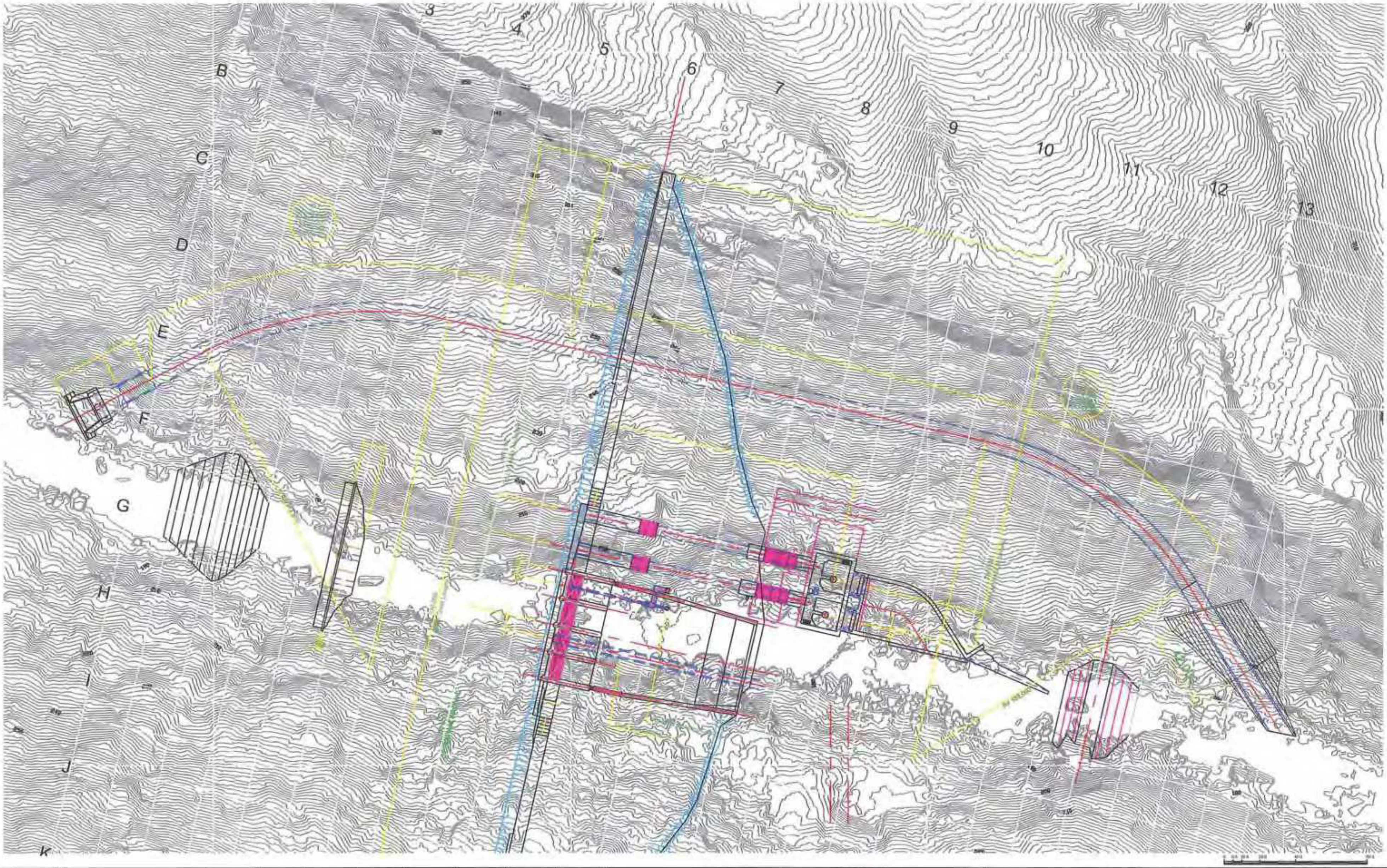
The reservoir water level has been set at EL 320.0 m. Although higher water levels would be more economical, the EL 320.0 water level was selected in order to reduce the impacts on the environment and on residents around the reservoir. There exist many villages (at least 14) in Thaviang area (around EL. 320 m) upstream of the main dam. If NWL is set at a higher elevation than EL. 320 m to improve the project economy, many villages will be submerged under the reservoir, which will require large scale resettlement. The NWL beyond EL 320.0m would also cause adverse impact the utilized land.

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***).



THE KANSAI ELECTRIC POWER CO., INC.
EGAT International Co.,Ltd.
LAO HOLDING STATE ENTERPRIZE

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Figure 4.8 - River Diversion Tunnel Layout

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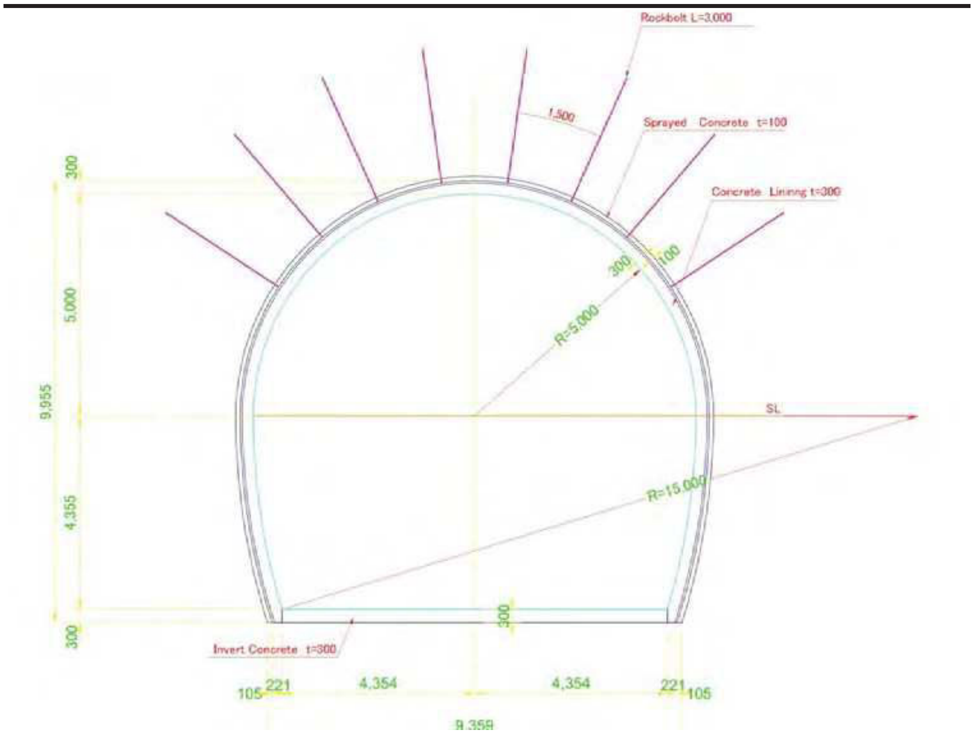
The river diversion will be carried out via a single-row water pressure tunnel with inner diameter of 10.0 m, length of 653 m, consisting of a horseshoe cross-section, and structurally capable of passing a 1.5-year probable flood discharge of 1,000 m^3/s. The tunnel will be concrete-lined; the thickness 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



Source: Kansai, 2013.

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. For the purposes of this report, "riparian release" is defined as the discharge from the NNP1 main reservoir and re-regulation reservoir that will maintain normal functions of the river downstream of the re-regulation dam, including from a biodiversity perspective concerning the terrestrial/ riparian habitats and aquatic biota, as well as from a utilization perspective (ecosystem services) such as through fisheries, navigation, etc.

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. Additional information on maintaining reservoir water level through operational controls is presented in *Section 4.7.3*.

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

Source: Environmental Impact Assessment Report, ERIC, 2012.

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.

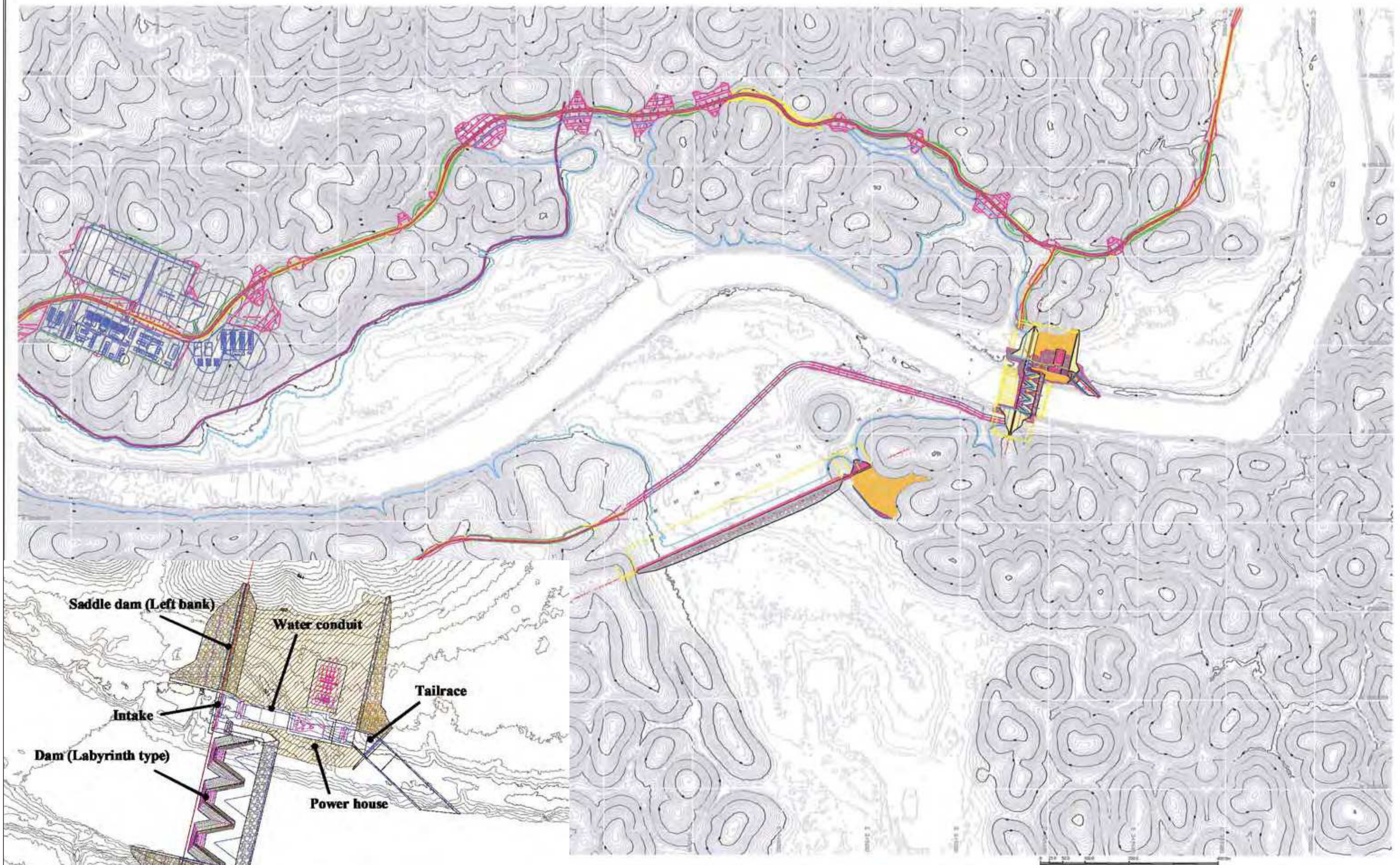
A Supervisory Control and Data Acquisition (SCADA) system will enable monitoring, supervision and control of the power stations and substations. This system will also enable analysis of power station conditions. All relevant information will be transmitted to EGAT's national and regional control centers.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



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EGAT International Co.,Ltd.
LAO HOLDING STATE ENTERPRIZE

Client:	Nam Ngiep Power Company Ltd.
Drawing No:	0185065b_EIA_REV_CH4_C003_R0_F4.10.cdr
Date: 01/05/2014	Drawing size: A3
Drawn by: TC	Reviewed by: DN

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Figure 4.10 - Re-regulation Dam Layout

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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) and have an inundation area 1.27 km^2 (surface area at the NWL of the re-regulation dam). 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

Source: Technical Report, 2011.

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. A saddle dam is an auxiliary dam constructed to confine the reservoir created by a primary dam to permit a higher water elevation and storage. 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

Source: Kansai, 2013.

4.6 ANCILLARY WORKS

4.6.1 *Quarry Site*

The quarry site, used for obtaining aggregate for the Project, 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. Extracted rocks will be conveyed to the planned contractor's camp yard in front of the gorge on the left bank after crossing the Nam Ngiep River, and crushed at the crushing plant. Alkali-silica reaction was tested twice and it verifies that rocks obtained at the planned quarry are innocuous.

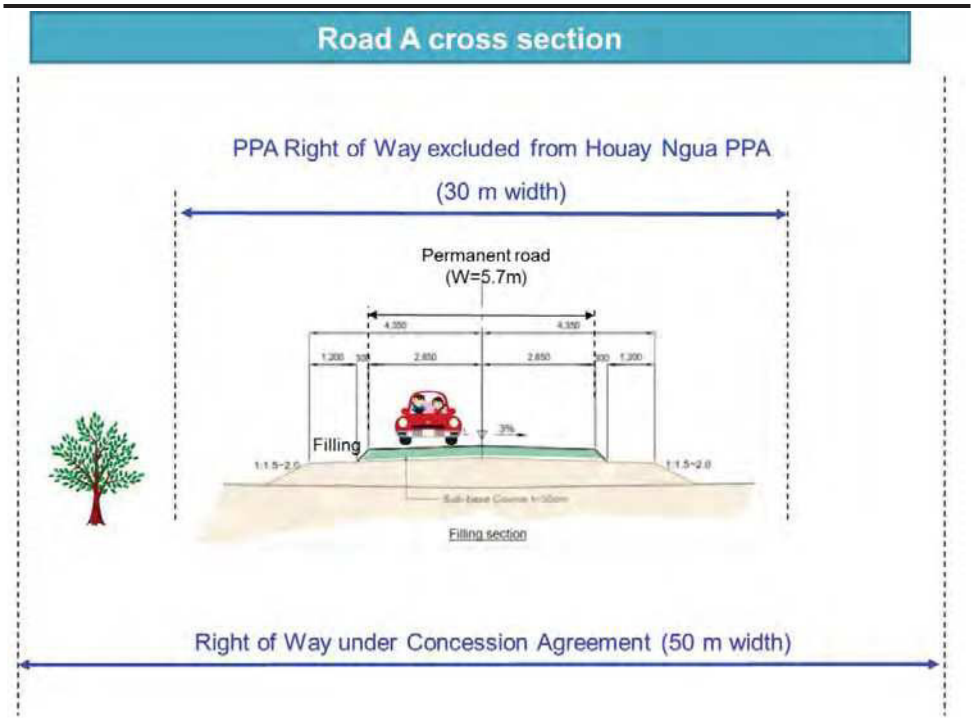
4.6.2 *Access Road*

The purpose of the access road is to provide infrastructure to facilitate the transport of construction materials and equipment from outside the NNP1 Project area. Construction materials include cement and steel bars used for concrete, gates and penstocks for metal-work, turbines and generators for the power station, and other equipment. Construction equipment and infrastructure will include earth transport and construction equipment, as well as an aggregate and concrete plant.

A majority of the equipment and materials will be imported from foreign countries. At present, it is expected that the cement and steel bars will be from Thailand, and that construction equipment, transformers, gates, penstocks, and other equipment will be imported mainly from other developed countries.

The most promising transportation route for these imported equipment and materials would be through Thailand. Equipment would first be discharged at either the Bangkok Port or the Laem Chabang Port in Thailand, and then be taken by road to Vientiane, Lao PDR via the Friendship Bridge. From Vientiane, the 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***). Typical access road outline in ***Figure 4.12***.

Figure 4.12 Typical Access Road A Cross Section



Source: Kansai, 2014.

4.6.2.1 *Improvement of Existing Access Road*

All equipment and materials will be transported during the construction period through the route outlined in ***Figure 4.13.*** For some sections of the route, improvement will be required, including widening the existing roads, structural overlays, constructing bridges or culverts at stream (marsh area) crossings, and stabilization work of the roadbed.

The existing roads from the Vientiane Friendship Bridge to Ban Nonsomboun are sealed asphalt roads. The asphalt-paved road from Vientiane to Pakxan, or Route 13 South, was developed and used to transport materials and equipment for several large-scale projects in the central and southern region from Vientiane. No upgrades to these roads are currently proposed, however future road improvements may be required.

The existing road from Ban Nonsomboun to Ban Hat Gniun is a dirt road, with a width of approximately five to ten metres. Areas of the road are prone to flooding or otherwise unsuitable following rain events. Currently, the road is not suitable to support NNP1 project activities, and improvement work will be required, including structural overlays, bridge/culvert rehabilitation and construction, and raising of road level in flood prone areas.

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, hence it is referred to as the "JICA Road".

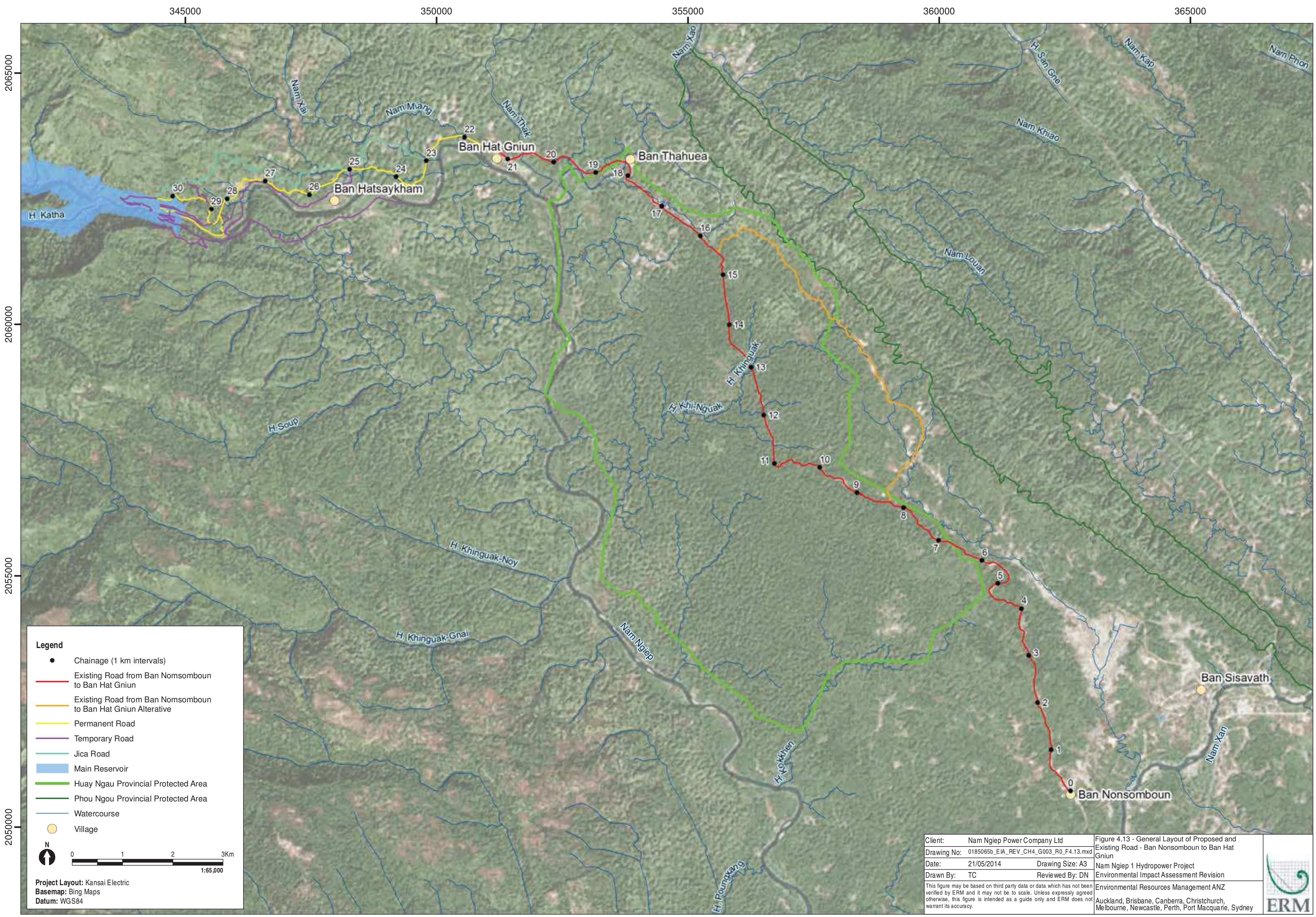
The condition of the road is poor, with pot holes, eroded areas, standing water and vegetative debris covering the road. For access to the left bank of the dam site, this temporary road will be upgraded and used as a construction road during the construction period. The current condition is not suitable to support the transport loads required for NNP1 project construction, and improvement work will be required.

Road conditions and transport distances for each section of the route between Vientiane and Ban Hat Gniun are shown in. ***Table 4.4***.

Table 4.4 Conditions of Existing Roads between Vientiane and Dam Site

Section	Dimensions	Condition	Photograph
Vientiane – "Friendship Bridge" to Pakxan	Length: 161.7 km Width: 6 m	Existing road. All asphalt paved, crossing 2 PC bridges on the way (Capacity: 80 tons)	
Pakxan to Ban Nonsomboun	Length: 19.9 km Width: 6 m	Existing road. Asphalt paved up to Ban Nonsomboun from Pakxan, crossing a PC bridge on the way (Capacity: 80 t, Width: 6 m, Length: 25 m)	
Ban Nonsomboun to Ban Hat Gniun	Length: 21.2 km Width: 5 – 10 m	Upgraded existing dirt road.	
Ban Hat Gniun to Dam Site (JICA Road)	Length: 9.25 Width: 4.5 – 13.5 m (Average 6.6 m)	Existing dirt road, with some potholes, erosion, fallen branches and trees, and areas with standing water.	

Source: NNP1 Access Road from Ban Nonsomboun to Main Dam Environmental Assessment, 2014.


345000
350000
355000
360000
365000
2065000
2060000
2055000
2050000
Ban Hat Gniun
Ban Thahuea
Ban Hatsaykham
Ban Nonsomboun
Ban Sisavath
H. Katha
Nam Xai
Nam Miang
Nam Thak
Nam Xao
H. San Gne
Nam Kap
Nam Phon
Nam Khiao
Nam Louan
H. Khinguak
H. Khi-Nguak
H. Soup
H. Khinguak-Noy
H. Khinguak-Gnai
Nam Ngiep
H. Kokkhen
H. Poungxang
Nam Xan
0
1
2
3
4
5
6
7
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28
29
30
Legend
Chainage (1 km intervals)
Existing Road from Ban Nomsomboun to Ban Hat Gniun
Existing Road from Ban Nomsomboun to Ban Hat Gniun Alterative
Permanent Road
Temporary Road
Jica Road
Main Reservoir
Huay Ngau Provincial Protected Area
Phou Ngou Provincial Protected Area
Watercourse
Village
N
0
1
2
3Km
1:65,000
Project Layout: Kansai Electric
Basemap: Bing Maps
Datum: WGS84
Client: Nam Ngiep Power Company Ltd
Drawing No: 0185065b_EIA_REV_CH4_G003_R0_F4.13.mxd
Date: 21/05/2014
Drawing Size: A3
Drawn By: TC
Reviewed By: DN
This figure may be based on third party data or data which has not been verified by ERM and it may not be to scale. Unless expressly agreed otherwise, this figure is intended as a guide only and ERM does not warrant its accuracy.
Figure 4.13 - General Layout of Proposed and Existing Road - Ban Nonsomboun to Ban Hat Gniun
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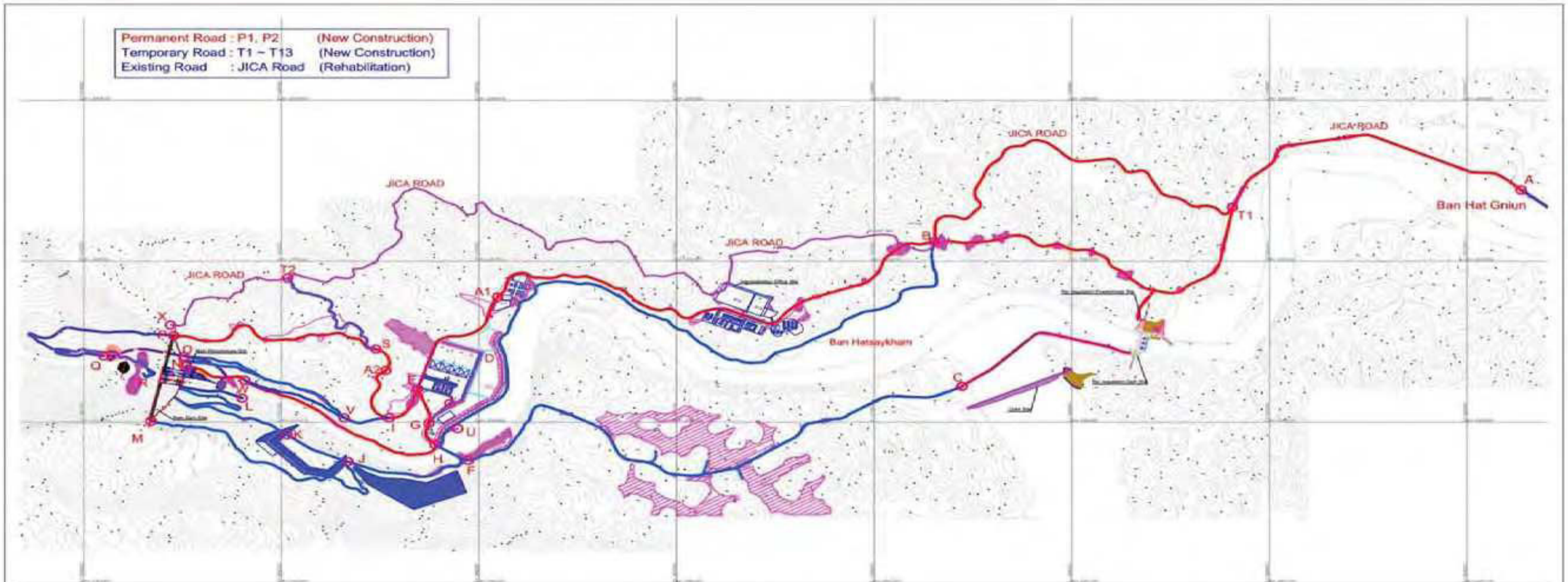
4.6.2.2 *Construction of Access Road*

For access to the left bank of the dam site, the JICA Road (described in previous section) 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, primarily due to the requirement of constructing an additional bridge, as well as substantial maintenance and repair costs to accommodate the complex topography. 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 Nonsomboun, to provide electricity during construction. The proposed road route plan is shown in ***Figure 4.14***.

Figure 4.14 New Access Road Route Plan



Road Name	Start point	Mid point	End point	Length
P1 (To Dam Top)	A	T1, B, A1, E, I, A2, S	P	9.32km
P2 (To Power house)	E	G, H, W	N	1.84km
T1, T2 (Haul road EL 230 and 250m)	I	V	O	1.58km
T3 (RCC & CVC plant road)	G	-	D	0.55km
T4 (Upstream uproach road)	P	-	Q, R	1.94km
T5 (Temporary access road)	B	-	H	3.88km

Road Name	Start point	Mid point	End point	Length
T6 (Jetty road)	H	-	U	0.20km
T7 (Haul road to dam top)	J	-	M	1.54km
T8 (Soil disposal road)	F	-	C	3.20km
T9 (Haul road to quarry)	F	-	K	1.00km
T10, T11 (Haul road EL 200 and 230m)	K	-	L	1.68km
T12 (Temporary Road)	S	-	T2	0.72km
T13 (Temporary Road)	V	-	W	0.52km
JICA Road	A	T1, B, T2	X	9.25km

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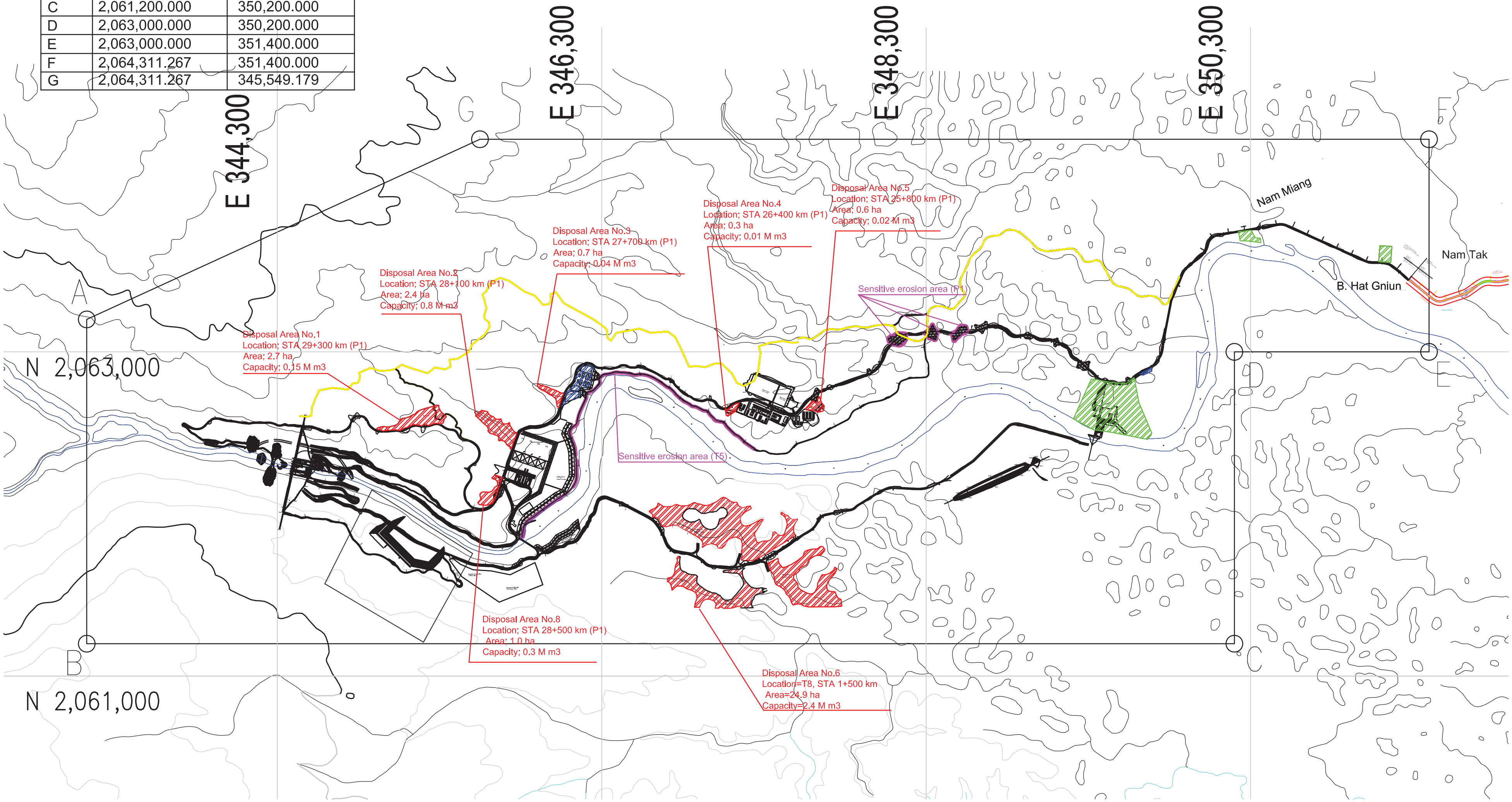
NAM NGIEP 1 HYDROPOWER PROJECT
Layout of Permanent Road and Temporary Road

Source: KANSAI, 2013.

Note: Access road = red line

Grid Coordinate Datum Lao-97-NEW

	North	East
A	2,063,200.000	343,125.074
B	2,061,200.000	343,125.074
C	2,061,200.000	350,200.000
D	2,063,000.000	350,200.000
E	2,063,000.000	351,400.000
F	2,064,311.267	351,400.000
G	2,064,311.267	345,549.179



Construction area (Total 2,224ha)

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Client:	Nam Ngiep Power Company Ltd.	**Figure 4.15 - Spoil Disposal Area Locations**
Drawing No:	0185065b_EIA_REV_CH4_C001_R0_F4.14.cdr	
Date: 01/05/2014	Drawing size: A3	Nam Ngiep 1 Hydropower Project Environmental Impact Assessment Revision
Drawn by: TC	Reviewed by: DN	
This figure may be based on third party data or data which has not been verified by ERM and it may not be to scale. Unless expressly agreed otherwise, this figure is intended as a guide only and ERM does not warrant its accuracy.		Environmental Resources Management ANZ Auckland, Brisbane, Canberra, Christchurch, Melbourne, Newcastle, Perth, Port Macquarie, Sydney

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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 4.15*** 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 11 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 4.5 Capacity of Spoil Disposal Areas

Description	Location	Area (ha)	Perimeter (m)	Capacity Volume (m^3)	Expected Disposal Volume (m^3)
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	

Source: Kansai, 2013.

4.6.4 *Transmission Lines*

There are two transmission lines related to 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 power station and ending at the Pakxan substation, providing domestic power supply. The 115 kV line is considered as a separate associated facility of the Project, and an IEE will be prepared for this line by EDL.Transmission Line Route is shown in ***Figure 4.17***.

The Government of Lao PDR, through EDL, upgraded the operating voltage of the 230kV substation to a 500kV substation within the existing 42 ha site in Nabong Village, Pakngum District, and acquired the existing 500 kV transmission line from NN2PC. The upgraded substation and transmission line will be used as a common transmission facility of the Nam Ngum 2, Nam Ngum 3, Nam Theun 1, and Nam Ngiep 1 hydropower projects.

A 230 kV capacity substation is already operational within the 42 ha land in Nabong. The expansion of the substation to 500 kV capacity will require the clearing of approximately 15,000 sq.m of land within the 42 ha substation site. The expansion project will involve the construction and installation of facilities for the switchyard and control room on the land adjacent to the existing 230 kV substation. Additional equipment such as power transformer, circuit breakers, disconnecting switches, current transformers, and voltage transformers will be acquired for installation at the 500 kV substation. It is planned that construction of the expansion of the substation will start in 2013 and will be completed by 2016.

The alignment of the existing 27-km 500 kV transmission line to be acquired by EDL crosses an existing National Road No. 13 South at Kilometer 34-35 to the west through Thinthaen Village and then crosses the Hatxayfong Road.

The transmission alignment crosses the Mekong River where it meets the EGAT transmission line in Udon-Thani at the Thailand border. Under supervision of the Department of Electricity (DOE), the project proponent is EDL, a state owned utility company responsible for transmission and distribution of electricity in Lao PDR.

Full details on the transmission lines are presented in "*NNP1 Transmission Line from the Main Dam to Vientiane Initial Environment Examination, 2014*" (***Appendix F***).

4.6.5 Resettlement Area

There are four affected villages in Zone 2LR: from north to southwest Ban Houaypamom, Ban Sopphuane, Ban, Sopyouak and Ban Namyouak. They are all located in Hom District of Xaysomboun Province about 12 to 25 km upstream from the dam site, which is located in Bolikhan District of Bolikhamxay Province. Through the inundation of the reservoir, all four (4) villages will require resettlement. A total of 384 households and 2,735 affected people will be resettled.

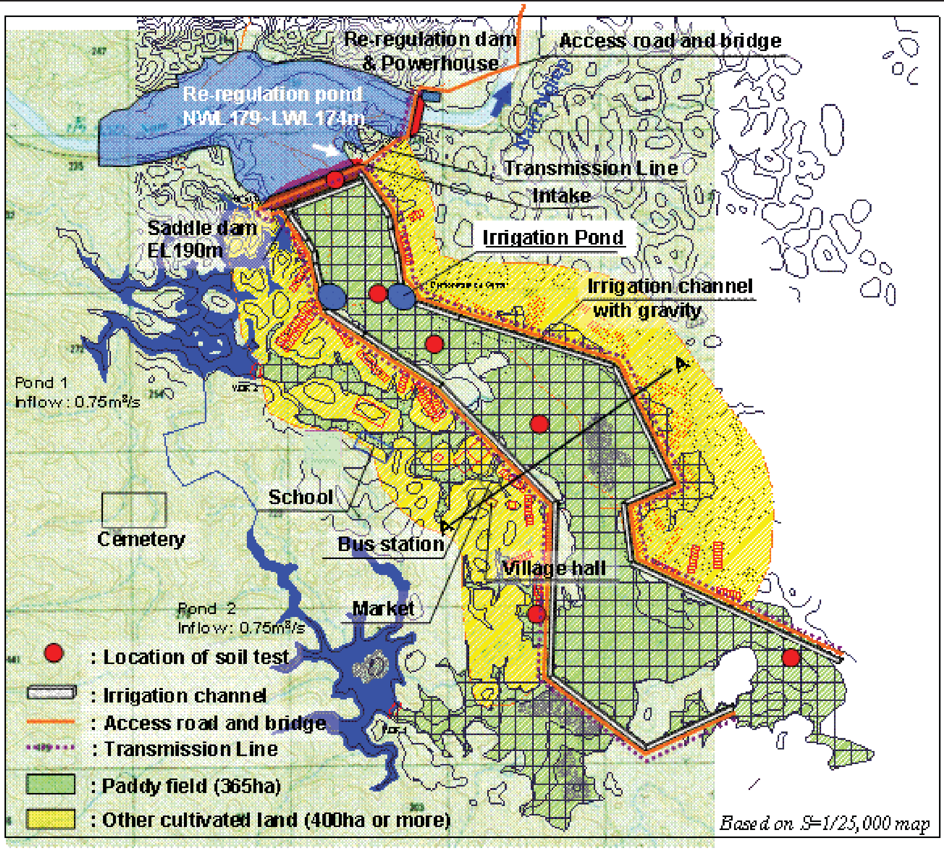
The Houaysoup resettlement site is around 6000 hectares in size and includes area for relocated houses, agriculture and NTFP collection. The resettlement site is located downstream of the re-regulation dam on the Southern Bank of the Nam Ngiep River.

Additionally, in sub-zone 2UR, there will be extensive infrastructure development almost identical to that being done in the resettlement areas, because of the extensive losses of productive lands and the need for 15 households to relocate. The socio-economic development program that will be implemented in this area is designed to assure good livelihoods for the affected people, enabling to live at a standard equal to if not better than their current conditions.

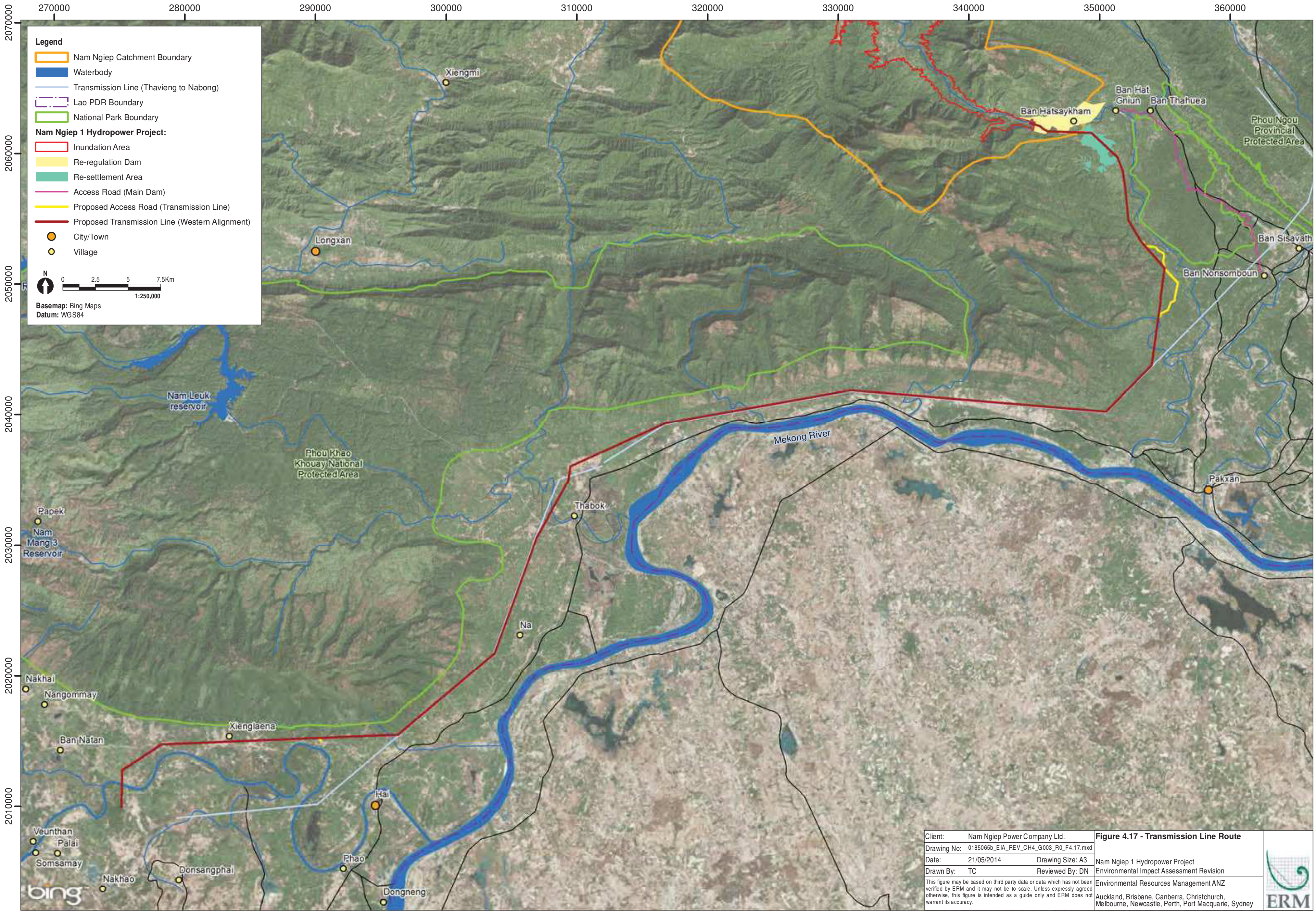
These activities – land acquisition, land survey and reallocation of all three resettlement sites – will be started around the first year of construction, so that the sites will be ready for people to move into as soon as possible. However, in case of the development required for Zone 2UR, these activities can be started at least by year 4 of the Project construction, because there is no resettlement in this area, and the experience in social and economic development programs from other areas can then be applied to this area.

Location and main facilities planned for the resettlement area is outlined in ***Figure 4.16***.

Figure 4.16 Facilities Planned for the Houay Soup Resettlement Area



Source: Environmental Impact Assessment Report, ERIC, 2012.



Legend
Nam Ngiep Catchment Boundary
Waterbody
Transmission Line (Thavieng to Nabong)
Lao PDR Boundary
National Park Boundary
Nam Ngiep 1 Hydropower Project:
Inundation Area
Re-regulation Dam
Re-settlement Area
Access Road (Main Dam)
Proposed Access Road (Transmission Line)
Proposed Transmission Line (Western Alignment)
City/Town
Village
N
0 2.5 5 7.5Km
1:250,000
Basemap: Bing Maps
Datum: WGS84
270000
280000
290000
300000
310000
320000
330000
340000
350000
360000
2070000
2060000
2050000
2040000
2030000
2020000
2010000
Xiengmi
Longxan
Ban Hat Gniun
Ban Thahuea
Ban Hatsaykham
Phou Ngou Provincial Protected Area
Ban Sisavath
Ban Nonsomboun
Nam Leuk reservoir
Mekong River
Phou Khao Khouay National Protected Area
Pakxan
Thabok
Papek
Nam Mang 3 Reservoir
Na
Nakhai
Nangommay
Xienglaena
Ban Natan
Hai
Veunthan
Palai
Somsamay
Phao
Donsangphai
Nakhao
Dongneng
bing
Client: Nam Ngiep Power Company Ltd.
Drawing No: 0185065b_EIA_REV_CH4_G003_R0_F4.17.mxd
Date: 21/05/2014
Drawing Size: A3
Drawn By: TC
Reviewed By: DN
This figure may be based on third party data or data which has not been verified by ERM and it may not be to scale. Unless expressly agreed otherwise, this figure is intended as a guide only and ERM does not warrant its accuracy.
Figure 4.17 - Transmission Line Route
Nam Ngiep 1 Hydropower Project
Environmental Impact Assessment Revision
Environmental Resources Management ANZ
Auckland, Brisbane, Canberra, Christchurch, Melbourne, Newcastle, Perth, Port Macquarie, Sydney
ERM

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. A summary of functional areas in each facility is presented in ***Table 4.6***.

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, rehabilitation/expansion of existing road, construction of labor camp, and administration facilities and lay-down area (to reach the outlet of the diversion tunnel and to construct dam, power station and other ancillary facilities).
2) Excavation of the diversion tunnel from the outlet toward inlet and construction of inlet and outlet structure of diversion tunnel. In parallel, dam foundation and abutment excavation to be started. Construction of batching plant and crushing plant.
3) Filling of gravel and soil to construct the primary cofferdam.
4) River flow diversion
5) Construction of cofferdam by placing CVC concrete with appropriate foundation treatment.
6) Excavation of dam foundation (riverbed).
7) Placing consolidation/curtain grouting for dam foundation.
8) Placing dam concrete. Clearing major trees in proposed reservoir area according to reservoir management plan and biomass removal plan.
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***

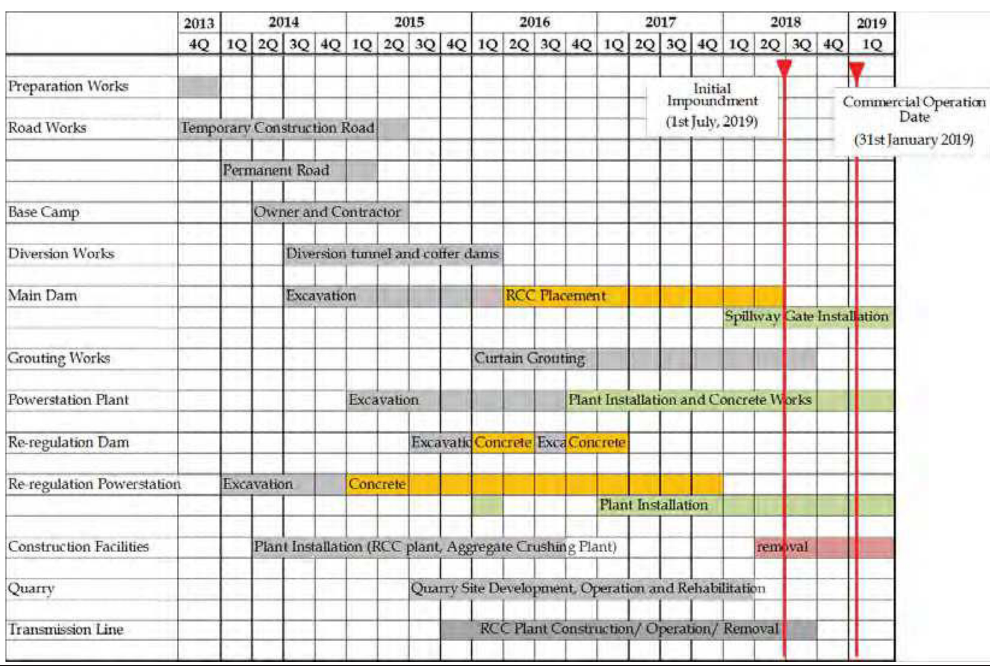
Functional area	Size (ha)	Size (m²)	Length (m)	Permanent Use
Main dam	4.32	43,200		Yes
Re-regulation dam	1.60	16,000		Yes
Cofferdams	0.67	6,700		Yes
Diversion tunnels	0.62	6,240		Yes
Main dam powerhouse	0.15	1,470		Yes
Re-regulation dam powerhouse	0.06	570		Yes
Quarry areas	46	460,000		No
Temporary yards	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, 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***



Source: Kansai, 2013.

4.7.2 *Impounding*

During reservoir impoundment, upstream inflow has to be collected in the main reservoir to meet water storage requirements before hydropower operations can commence. The re-regulation reservoir, which stores natural inflow that it receives from its side catchment (25 sq.km), will release stored water downstream during the impounding period to meet minimum flow requirements (5.5 m^3/s, as discussed in *Section 4.4.7*). Within 2 weeks, the reservoir water level at the main dam will reach the sill elevation of the riparian outlet, and the flow from the main dam can be released downstream.

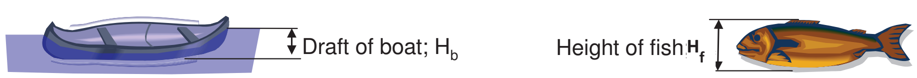
The required environmental flow and water depth has been determined as shown in ***Table 4.8***, which can be found in *Concession Agreement Annex C: Environmental and Social Obligation* between the GOL and NNP1PC.

Table 4.8 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

Source: Concession Agreement, Annex C Environmental and Social Obligations, 2013.

Required minimum water depth for navigation and fish has been considered. Based on previous experience with similar projects, the minimum required water depth for navigation is 0.5 m (Hb) and 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.



4.7.3 *Operation & Maintenance*

4.7.3.1 *Operation of Project Facilities*

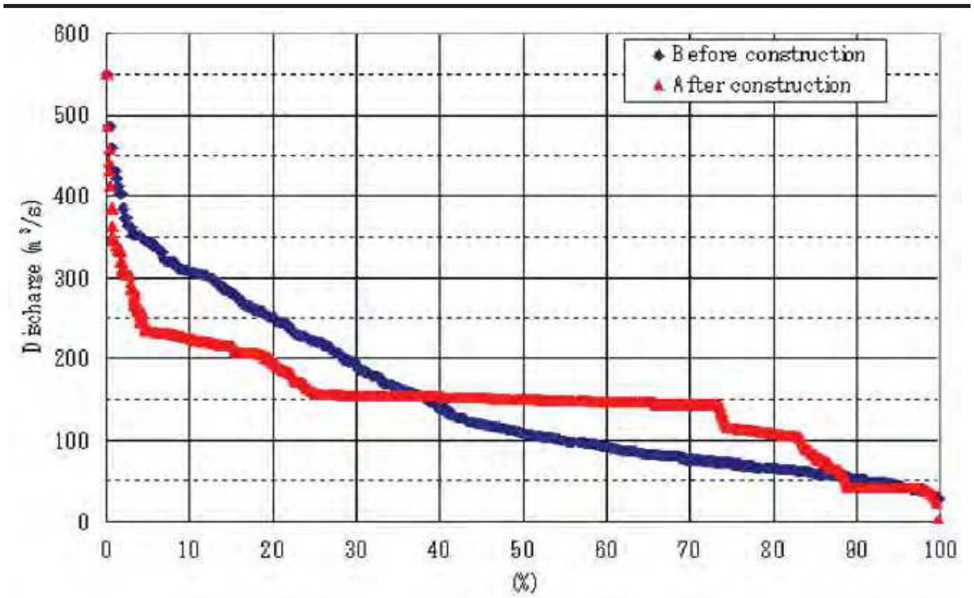
The main 272 MW power station will be operated in accordance with the "Operation and Maintenance Manual", which will be prepared before the initial filling of the reservoir. The maximum discharge through the turbines of the main power station will be 230 m^3/s. The re-regulation power station will provide 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 230 kV transmission line, owned by the Project owner, and via a 27 km long shared-ownership 500 kV transmission line beyond the substation at Ban Nabong (stepped up from 230 kV at the Ban Nabong substation). Ownership of the shared 500 kV 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 4.18***. 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.

It is not anticipated that dredging will be required within the main reservoir due to the low sediment inflows within the Nam Ngiep River.

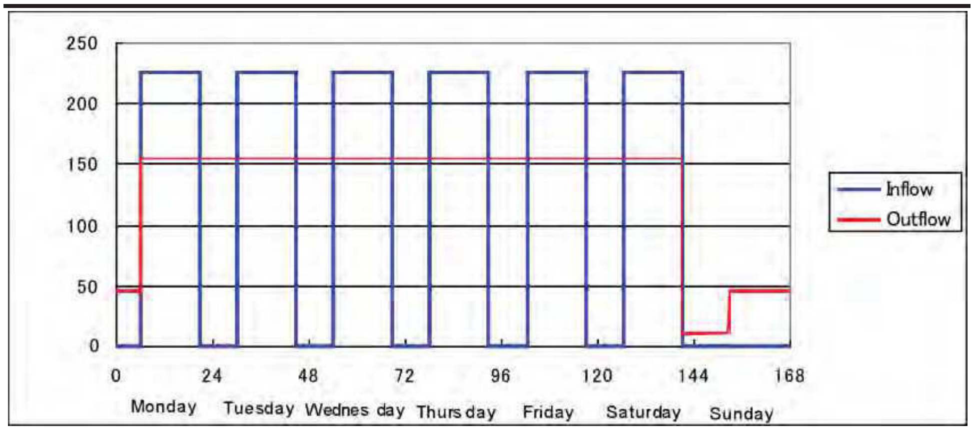
Figure 4.18 Change in River Flow Before and After Construction of Project



Source: Environmental Impact Assessment Report, ERIC, 2012.

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 4.19***. The discharge from the main dam will be stored in the re-regulation reservoir.

Figure 4.19 Typical Operation of Main Dam



Source: Environmental Impact Assessment Report, ERIC, 2012.
Note: Typical operation case of 230 m^3/s 16-hour peak generation

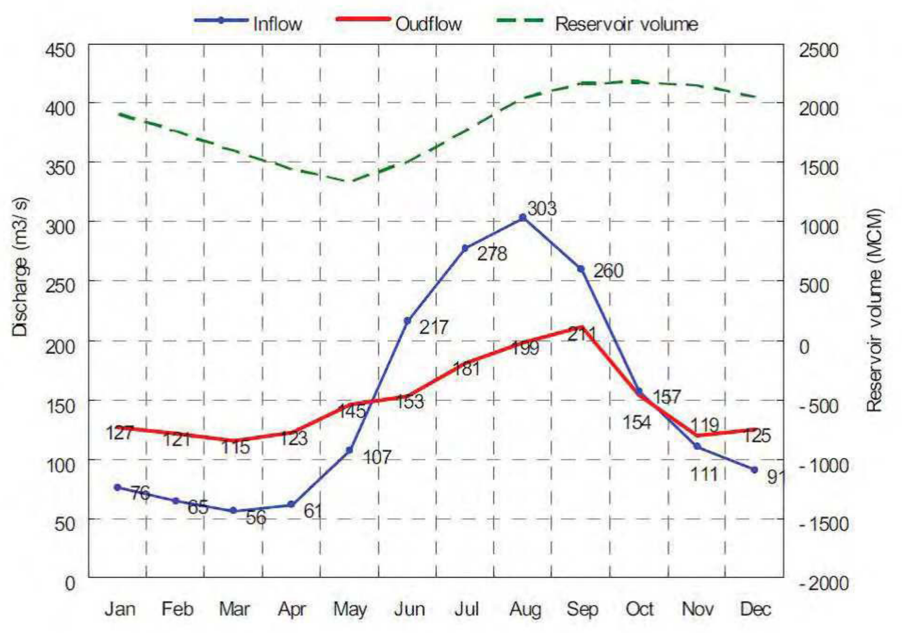
Operation of the main dam would intentionally release water downstream during emergency events such as drought or flooding, when both turbines would be unable to release water. Spillway gates would be operated during flooding in accordance with the spillway gates operation rules, to minimize downstream 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.

4.7.3.2 *Operation of Main Power Station*

(1) Plant Discharge

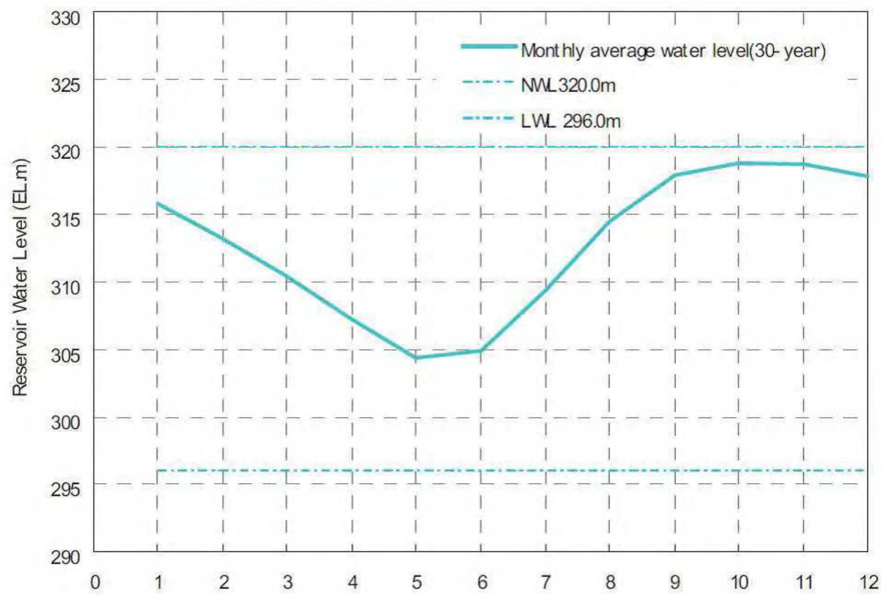
The NWL and MOL of the main dam will be EL 320.0 m and EL 296.0 m, respectively. Drawdown of the reservoir will normally occur during the dry season, with filling occurring during the rainy season as shown in ***Figure 4.20***. When the reservoir water level reaches NWL during floods, the spillway gates will be operated. Seasonal water level of the reservoir is presented in ***Figure 4.21.***

Figure 4.20 Seasonal Inflow and Outflow of Main Reservoir and Changes in Reservoir Volume



Source: Environmental Impact Assessment Report, ERIC, 2012.

Figure 4.21 Seasonal Water Level of Reservoir



Source: Environmental Impact Assessment Report, ERIC, 2012.
Note: The worst case of reservoir water level not lower than EL. 245 m. at sill level of gate chamber.

(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 4.9***.

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 4.9 Typical Operation Pattern of Spillway Gates of Main Dam

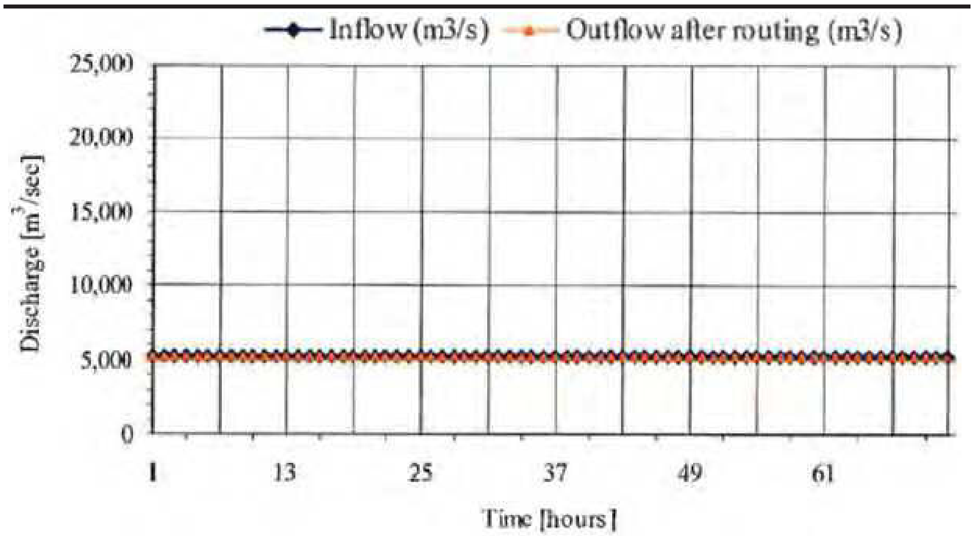
	Reservoir water level (WL)	River inflow (Q_{in}) into the main reservoir	Outflow (Q_{out}) from the spillway gates
Case 1	WL < NWL	Q_{in}	$Q_{out} = 0$ Note: the spillway gates will not be operated. River inflow will be stored in the main reservoir until the WL rises up to NWL.
Case 2	WL = NWL	Q_{in} < = 5,210 m³/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.

Source: Environmental Impact Assessment Report, ERIC, 2012.

Case 2:

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 4.22***.

Figure 4.22 Hydrograph at Dam Site



Source: Environmental Impact Assessment Report, ERIC, 2012.

Note: River inflow: 5,210 m^3/s, Reservoir water level: EL 320 m

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 as defined in the Emergency Response Procedure (see ***Appendix L*****).**

4.7.3.3 *Operation of Re-Regulation Power Station*

(1) Re-Regulation Function

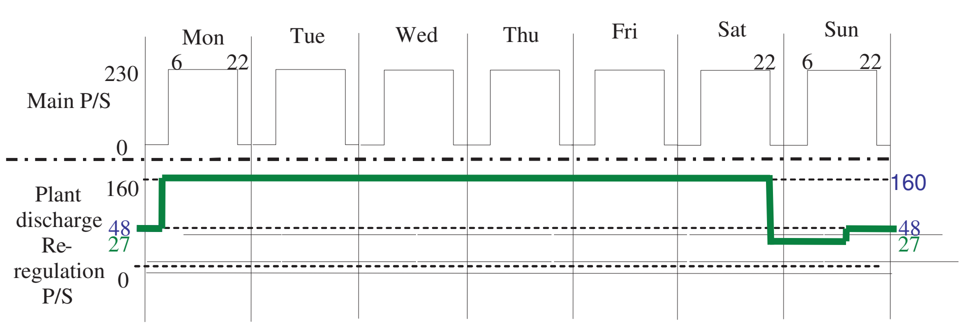
Large fluctuations in the river water level caused by the power generation of the main dam can be mitigated to a certain degree by the re-regulation dam.

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 4.23***.

Figure 4.23 Inflow and Plant Discharge Pattern in the Re-Regulation Reservoir



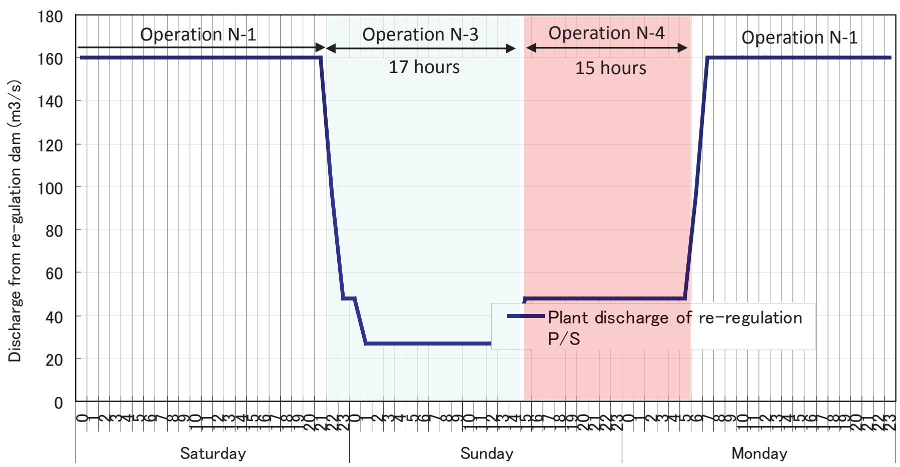
Source: Kansai, 2013.

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 15 hrs, and reduced further to 27 m^3/s for a period of 17 hours (during which time it is released from the re-regulation gate).

The flow pattern is illustrated in ***Table 4.10***, and the discharge pattern over the weekend is shown in ***Figure 4.24***. 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 years of extreme drought when there is insufficient water in the main reservoir for normal operation, a discharge of environmental flow of 27.0 m^3/s will be secured and released continuously downstream through the main powerhouse intake at EL 274.4 m.

Figure 4.24 Discharge Pattern from Re-Regulation Reservoir during Weekend



Source: Kansai, 2013.

Table 4.10 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)	10pm Sat - 3pm Sun	17 hrs/ week	0	27.0	Water release through spillway during off-peak
N-3		3pm Sun - 6am Mon	15 hrs/ week	0	48.0	Minimum plant discharge of re-regulation P/H during off-peak
E-1	Initial impounding	-	-	0	5.5	Riparian release during initial impounding

Source: Kansai, 2013.

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.

When the water level of the reservoir falls below the MOL due to inflow in dry season, the to the discharge from the reservoir will be released through the turbines. This discharge will be sufficient to maintain the environmental flow of 27 m3/s. This is based on the minimum monthly flow of 26.4 m^3/s as claclutated by the Tank Model, the long-term inflow at the main dam site is estimated (see Detailed in ***Section 5 Hydrology and Hydrogeology***).

4.7.3.4 Upper and Lower Rule Curves for Reservoir

In order to utilize water effectively, rule curves are established to control the reservoir water level. Daily operation is performed based on the relation between the reservoir water level and the rule curves. For this Project, there is a Lower Rule Curve (LRC), and an Upper Rule Curve (URC), as defined below:

(i) Lower Rule Curve (LRC)

When the water level of the reservoir is higher than the LRC, the water will be discharged from the reservoir for primary energy generation. In the case that the water level of the reservoir is lower than the LRC, there will be no water discharge from the reservoir.

(ii) Upper Rule Curve (URC)

When the water level of the reservoir is higher than the URC, the water will be discharged from the reservoir for primary and secondary energy generation.

By applying such operation above, the reservoir water level is always kept higher than the minimum water level, i.e. 296 m, as will be described below.

During Impounding

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 riparian conduit.

Instead, during this period, water will be released downstream primarily from the re-regulation reservoir, which stores natural inflow from its side watershed (25 sq.km). Within 2 weeks, the reservoir water level at the main dam will reach the sill elevation of the riparian conduit, 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 release in accordance with concession agreement) to 27 m^3/s for operation.

The 4 sources for downstream discharge during initial impounding consist of the following:

a. Natural inflow into re-regulation reservoir, 1.8 m^3/s.
b. Release of storage water from re-regulation reservoir, 10.4 $x10^6$ m^3.
c. Release from conduit at main dam, located at EL 245 m. This conduit is able to release water 5 days after start of impounding.
d. Water flow from 3 tributaries: Nam Xao, Nam Tak and Nam Miane.

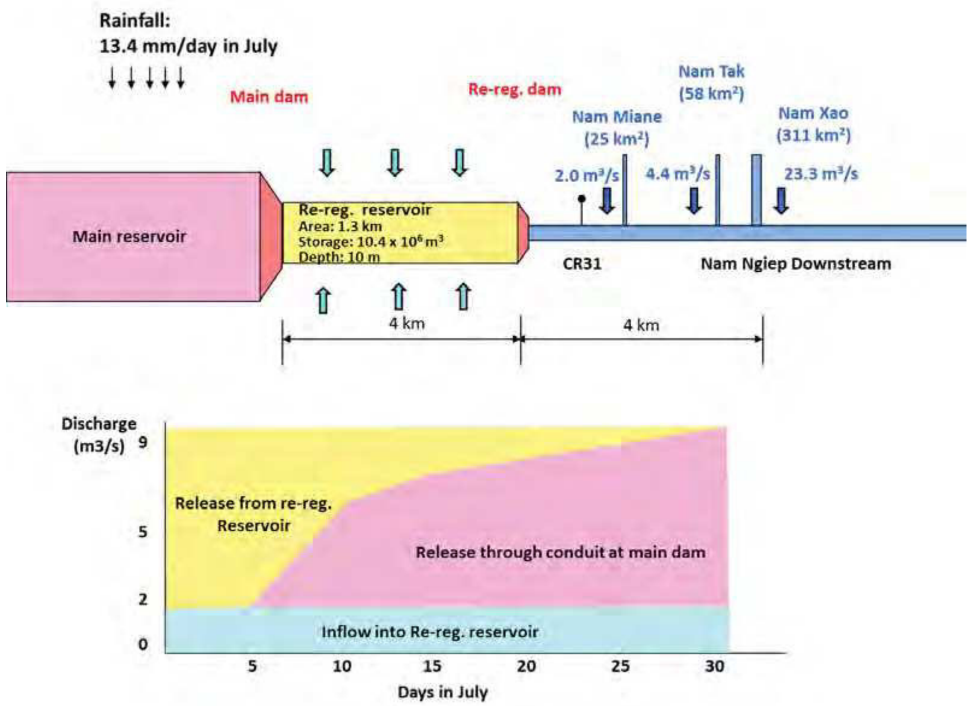
Discharge during impounding varies according to the water level, as shown in ***Table 4.11*** and ***Figure 4.25***.

Table 4.11 Discharge during Impounding

Time	Source of Discharge (see *Figure 4.25*)	Water Level of Main Reservoir
0 to 5 days	a+b+d	225 to 245 m. = sill level of conduit
0 to 30 days	a+b+c+d	245 to 285 m.
More than 30 days	a+c+d	296 m. after 45 days =MOL.

Source: NNP1PC, 2014.

Figure 4.25 Water Release Model Example in July



Source: NNP1PC, 2014.

During Operation

During the operation phase, the Project proposes to release a minimum flow of 27 m^3/s downstream for maintaining the existing functions of the river, such as the drinking water supply, navigation water depth, and irrigation of downstream villages. This is in alignment with flow requirements in Annex C of the CA during Operation Phase, and discussed further in *Section 6.2.2.10*.

The Project has incentive to maintain the reservoir water level higher than the LRC, in order to maximize generation of primary energy. In case the inflow is smaller than minimum operating discharge and more than environment flow requirement (27 m^3/s), the Project will release environmental flow through turbine or intermittent generation, so that the downstream discharge from the re-regulation dam will be more than the environmental flow requirement of 27 m^3/s.

In case the inflow is less than 27 m^3/s, the Project pass inflow downstream via turbine or intermittent generation, so that the discharge will be equal to the inflow.

Summary

With reference to ***Figure 4.10***, at the critical point downstream (CR31), a minimum water depth of 0.80 m is secured through the impounding period. The water level at CR31 and total discharge of 3 tributaries during impounding and operation are shown in ***Table 4.12.***

Table 4.12 *Water Level at Critical Point Downstream (CR31) of Nam Ngiep River*

Case	**Initial Impounding**	**During Operation**	
		Weekend	**Peak Operation**
Discharge (m^3/s)	9	27	160
Water Depth (m)	0.8	1.0	1.7
Total Discharge at 3 Tributaries			
	Nam Miane	Nam Tak	Nam Xao
Discharge (m^3/s)	11.0	15.4	38.7

Source: NNP1PC, 2014.

4.7.4 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

The Nam Ngiep watershed covers an area of about 4,533 square kilometers (453,300 ha). The Nam Ngiep River runs 160 kilometers in a generally south to southeastern 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° 39′ N and longitude 103° 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's location in Lao PDR 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 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. (°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. (°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*

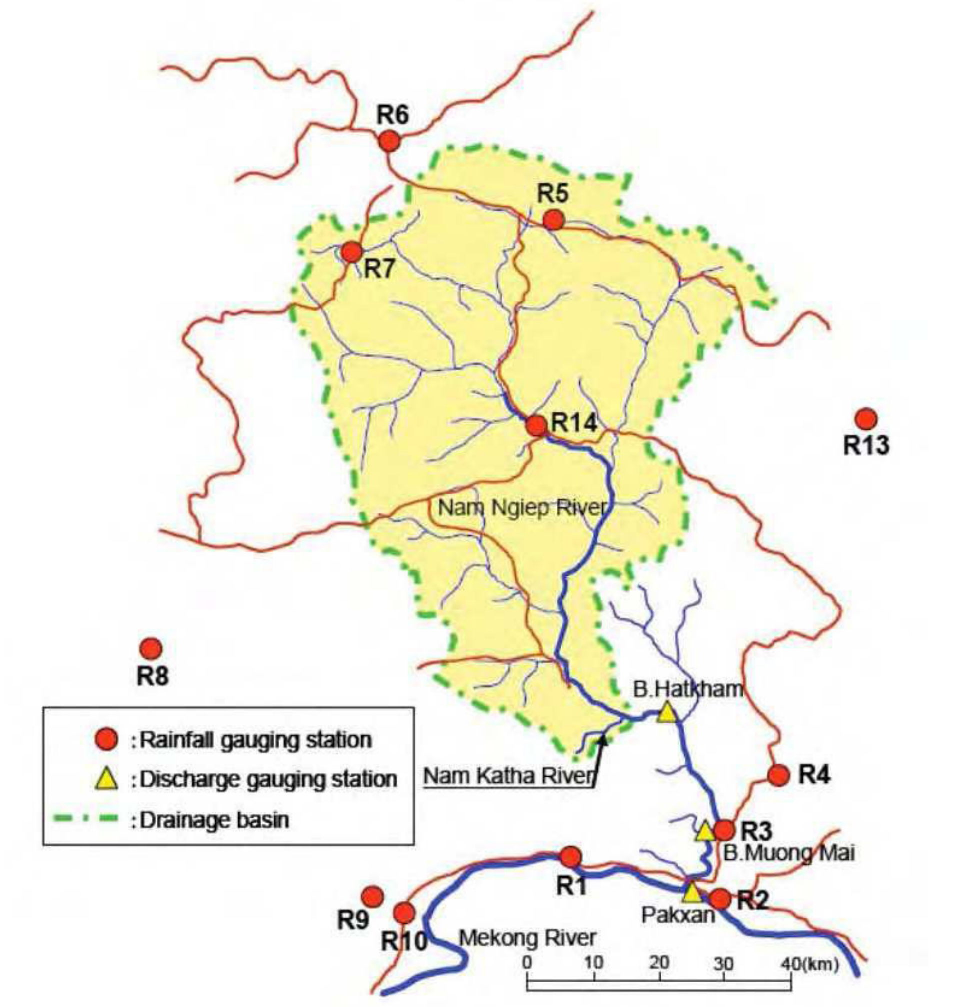
Rainfall records were reviewed for the hydrological study and dam designs. The records of hydrological gauging locations in areas peripheral to the planned basin were also evaluated.

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 5.1.12* on hydrology.

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



Source: Environmental Impact Assessment Report, ERIC, 2012.

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

Source: Environmental Impact Assessment Report, ERIC, 2012

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[1], the seasonal variation of monthly rainfall follows the general pattern of the Southeast Asia monsoon, with about 90% of rainfall occurring 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.[2] 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 DMH, 2005

2 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 times 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.

In addition to the existing geological data, the result from investigation on geological works of the Project area during detailed design and dam construction are available. The location map for drilling carried out during 3 geological surveys is shown in ***Figure 5.3***, as follows:

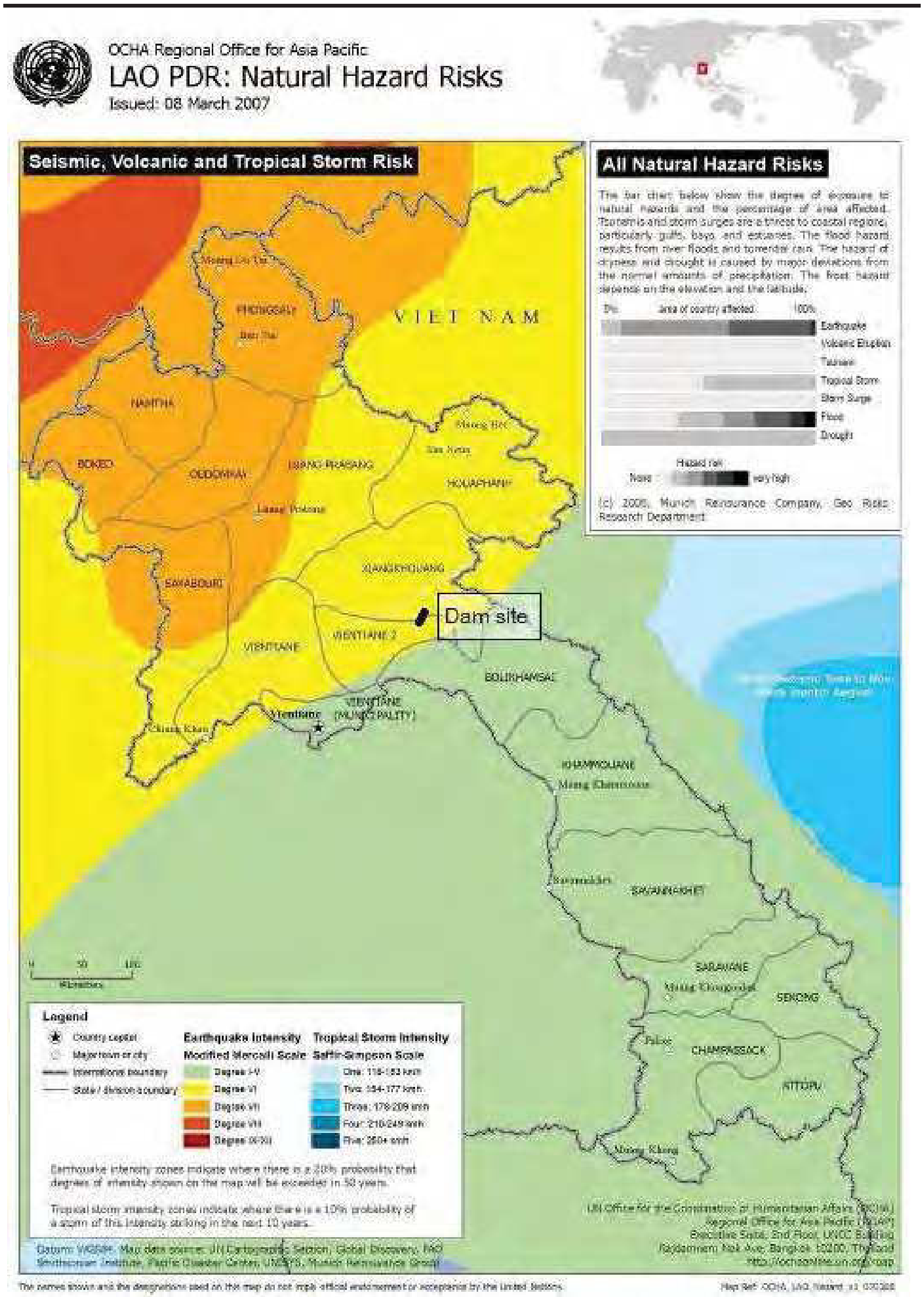
- Previous investigation works in 2002: 5 drilling holes around dam site are consist of ND—1, ND-2, ND-3, ND-4 and ND-5.
- Investigation works in 2007 and 2009: Total 24 numbers (D-1 to D-24) of drilling (1,532.9 m.) at main dam site.
- Investigation works in 2010 to 2011: 14 drilling holes (1,027.8 m) at the main dam site (D-25 to D-38).

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 5.4***).

In addition, the results of 5 lines of new seismic prospecting (2,500 m), which were completed at the main dam location for geological investigation works in 2007 and 2009, are shown in ***Figure 5.5***.

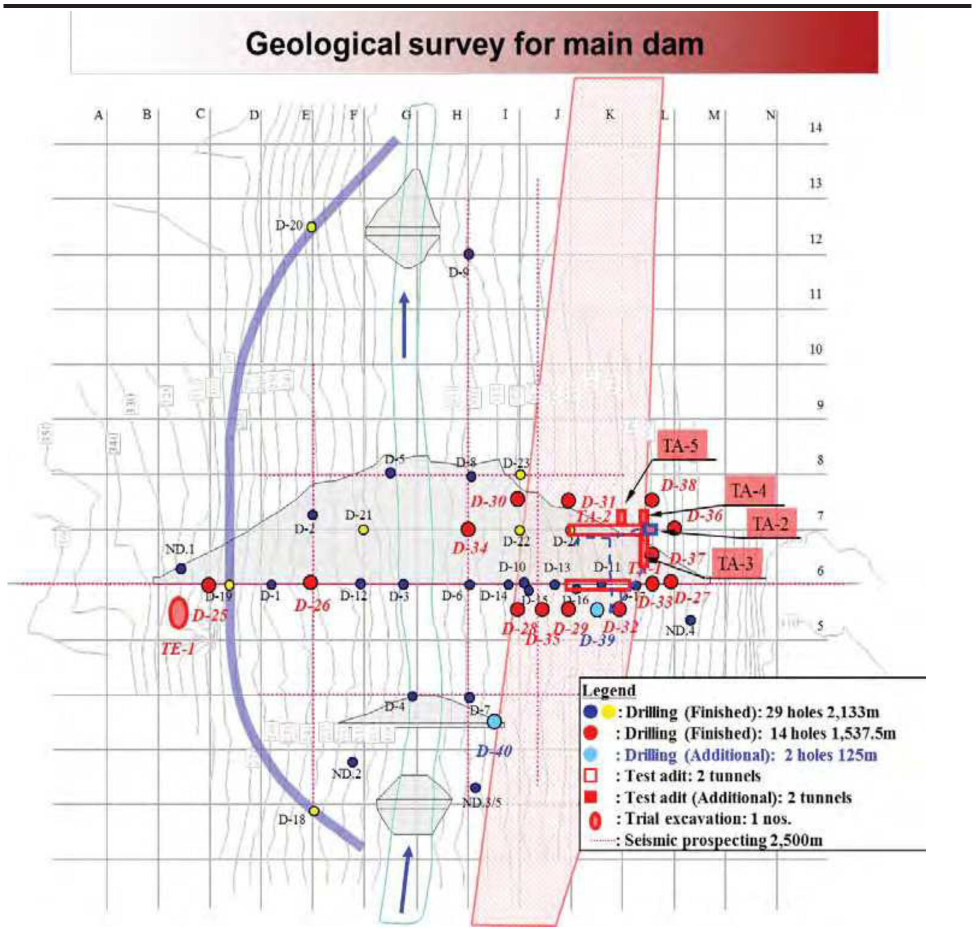
Rock formations found in the region can be divided into four main sedimentary sequences and one period of igneous activity as described below.

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



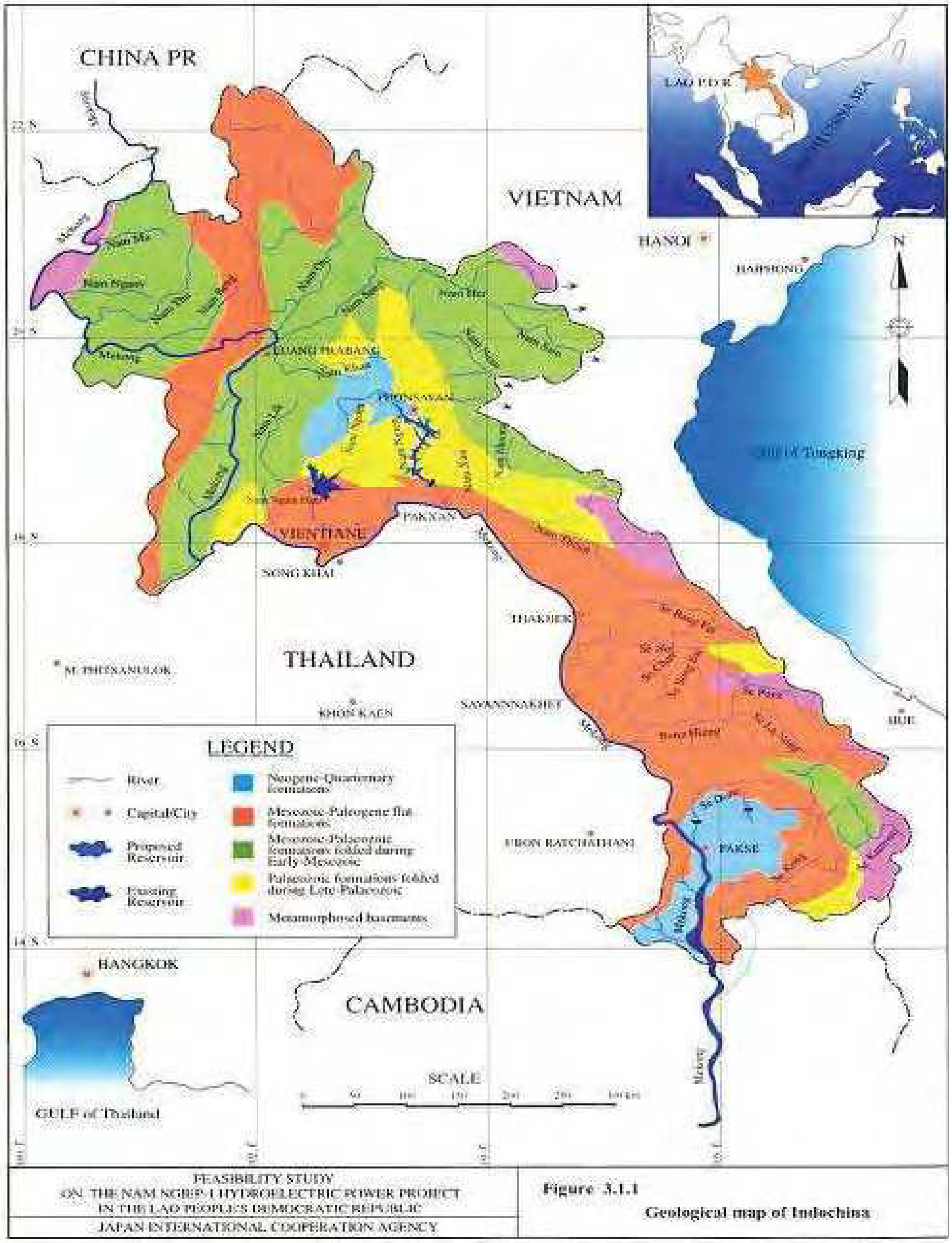
Source: Environmental Impact Assessment Report, ERIC, 2012.

Figure 5.3 Location Map of Drilling Tests



Source: Geotechnical Baseline Report on Nam Ngiep 1 Hydropower Project, 2011.

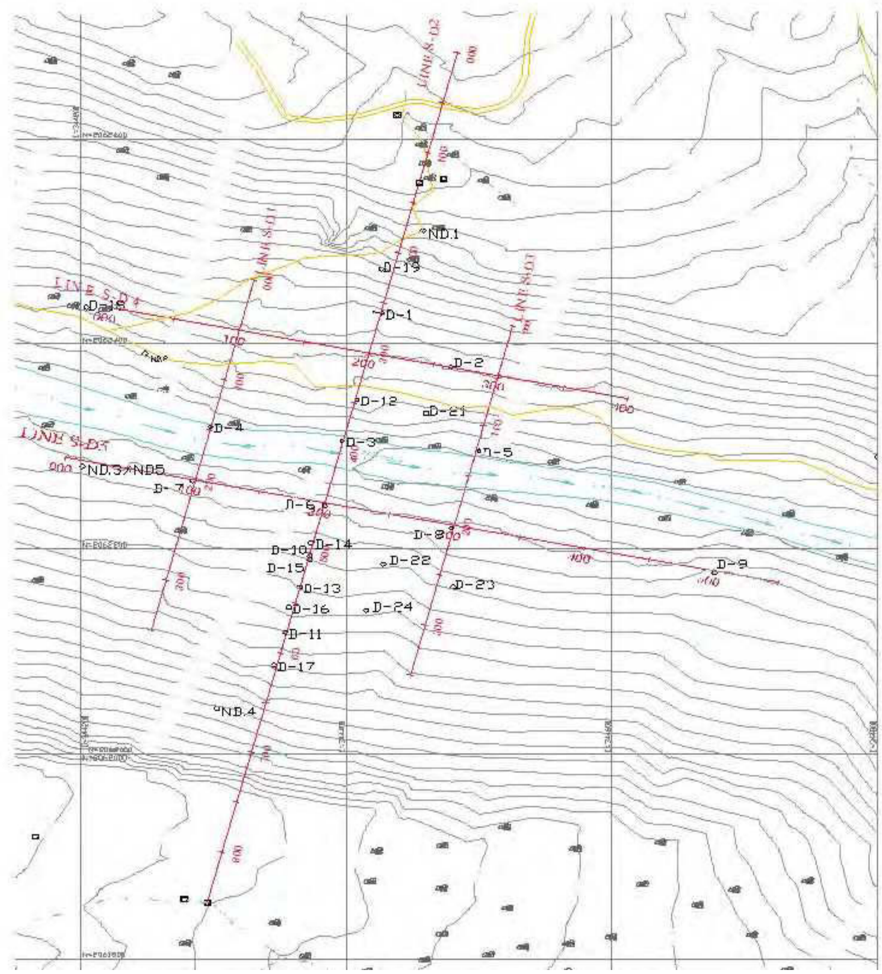
Figure 5.4   Geological Map of Lao PDR



Source: JICA-F/S, 2002.

Figure 5.5 Seismic Lines at Main Dam Location

Name of Line	Length (m)	Main purpose	Results
LINE S-D1	350	1) Excavation depth of the cofferdam 2) Rock conditions of the folded zone on right bank	1) Overburden seems rather thin 2) Folded zone was probably detected
LINE S-D2	850	1) River deposits and talus deposits 2) Rock conditions of the folded zone on right bank	1) Overburden is comparatively thick 2) Folded zone detected
LINE S-D3	350	Rock condition of the dam toe	Folded zone was probably detected
LINE S-D4	400	Depth of overburden beneath the middle portion of the dam	Overburden is seemingly thick at the middle portion of the slope
LINE S-D5	550	Depth of overburden beneath the lower portion of the dam	Overburden is seemingly thick
Total	2,500		



Source: Geotechnical Baseline Report on Nam Ngiep 1 Hydropower Project, 2011.

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, 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.

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 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[3] and shifting cultivation studies[4] 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[5]. 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[6]. 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.

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3 Lao-IRRI, 1995
4 UNDP, 1994
5 Lao-IRRI, 2000
6 Driessen and Dudal, 1991

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 (base aerial photograph used for topography analysis shown in ***Figure 5.6***) 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.

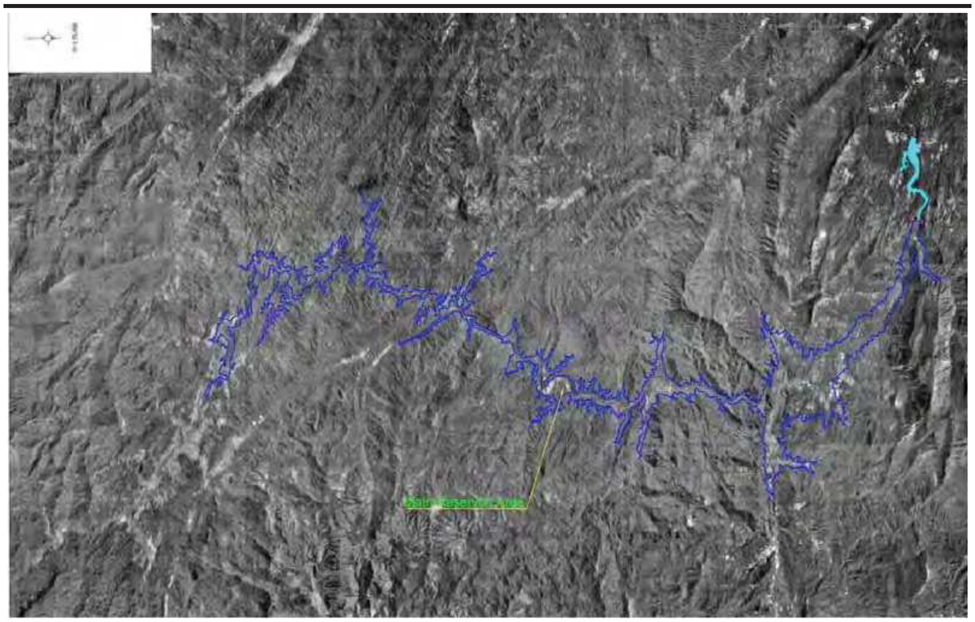
Some small localised landslide areas may occur, but these are not expected to be significant. The probability of landslides will be further evaluated by the survey of reservoir slopes, which will be carried out to make sure that possible slope instabilities will not impact the safety of the Project structures.

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[7]).

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

Figure 5.6 Aerial Photograph of the Project Reservoir Area



Source: Kansai, 2013.

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)"*.

For the purposes of comparison of rice yield of the surveyed soils, rice yield in Lao typically varies from 1.5 – 2.0 ton/ha in the rainfed lowland rice environment.[8] However the average yield of rice production in 2008 for all of Lao was 3.47 ton/ha.[9] However, the rice cropsat the proposed resettlement areas will also be irrigated, and therefore their yield would likely increase from the values presented in this section.

(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. ***Figure 5.7*** shows the location of sampling conducted in December 2007.

8 On-farmresidue effect on rainfed lowland rice productivity in Lao, Soil Survey and Land Classification Center, National Agriculture and Forestry Reserch Institute, Vientiane, Laos, Agust 2002.

9 World Rice Statistics, FAO 2008.

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

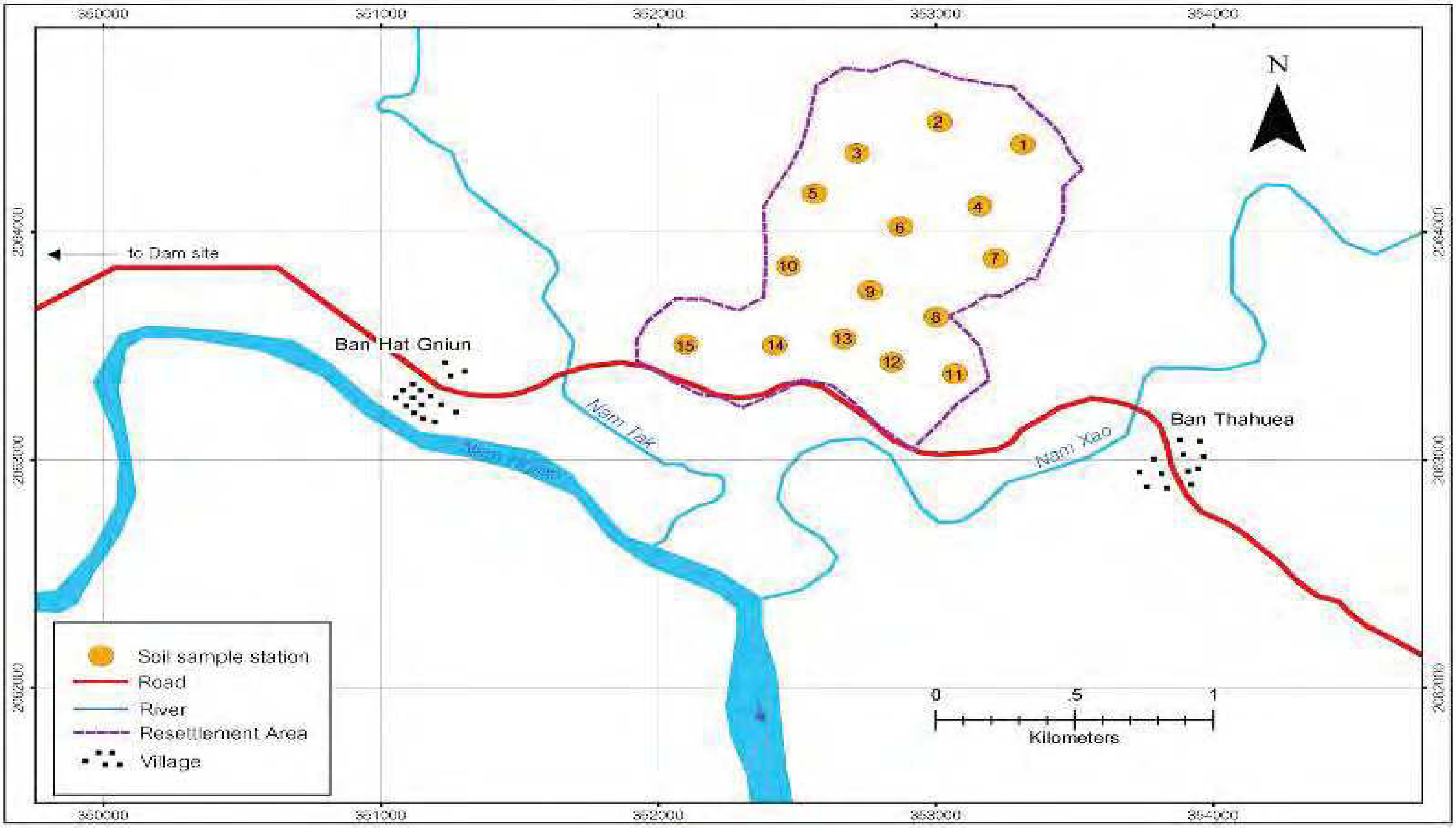
Source: Agriculture and Forestry Scientific Research Institute, Lao PDR, 2007.

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



Source: Environmental Impact Assessment Report, ERIC, 2012.

(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 are 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 5.8*** and ***Figure 5.9*** 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

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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

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Source: Environmental Impact Assessment Report, ERIC, 2012.

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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Agriculture and Forestry Land Use Research Center

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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	6.32	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	5.48	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	7.29	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	3.95	1.43	14.00	6.30	0.03	4.39	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	16.50	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	67.38
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	1.06	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	1.65	11.80	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	7.58	0.04	1.53	0.06	0.29	23.77

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Nam Ngiep 1 Soil Results (8 samples)

N/N	No Lab	Profile	Layer	Data	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	3.98	6.75	16.40	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	0.068	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

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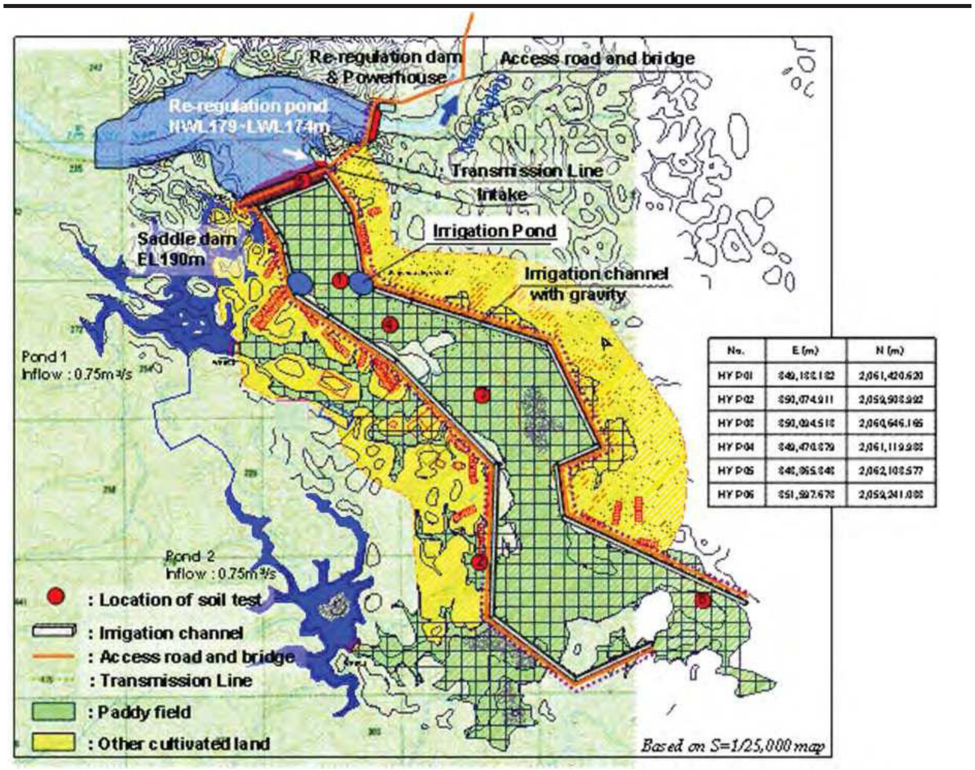
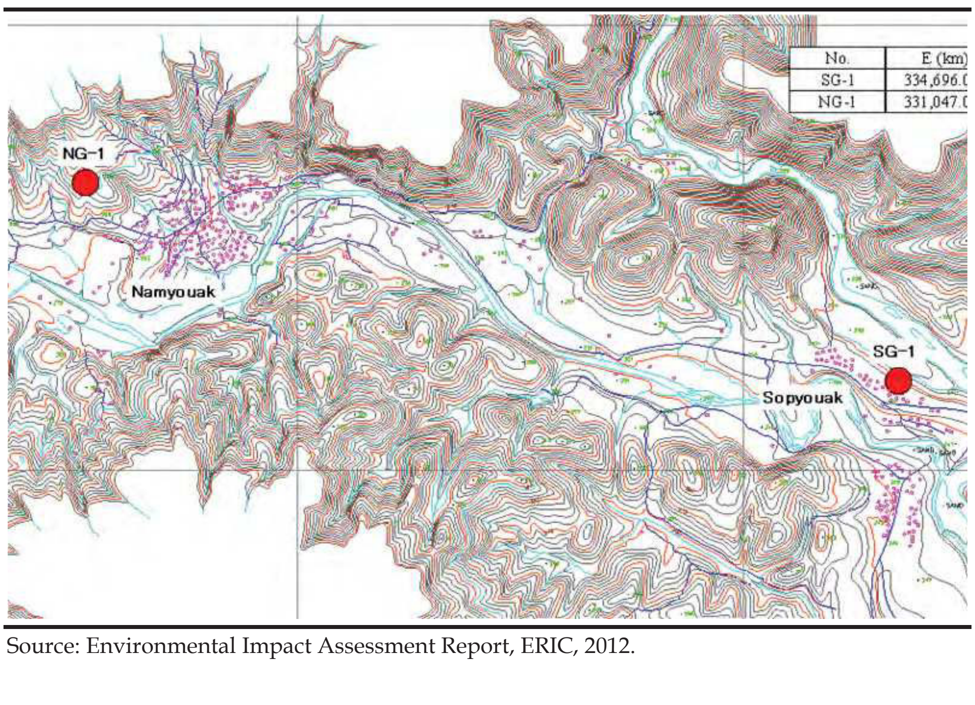
Source: Environmental Impact Assessment Report, ERIC, 2012.

Figure 5.8 Soil Sampling Locations at Proposed Area on the Right Bank of Re-Regulation Dam during the Final Resettlement Site Selection



Source: Environmental Impact Assessment Report, ERIC, 2012.

Figure 5.9 Soil Sampling Locations of Ban Sopyouak and Ban Namyouak



Source: Environmental Impact Assessment Report, ERIC, 2012.

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% too steep of 30 to 55%.

Table 5.7 and ***Table 5.8*** show the summary of soil erodibility and texture for humic ACRISOLS type from soil survey in Nam Ngiep watershed area.

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)	25-50 cm	16-30%	EE	< 25%
HC (Heavy clay)	<25 cm	30-55%	EEE	
LS (Loamy sand)		> 55%		
SA (Sand)				

Note: EEE: very serious potential erodibility
Source: Environmental Impact Assessment Report, ERIC, 2012.

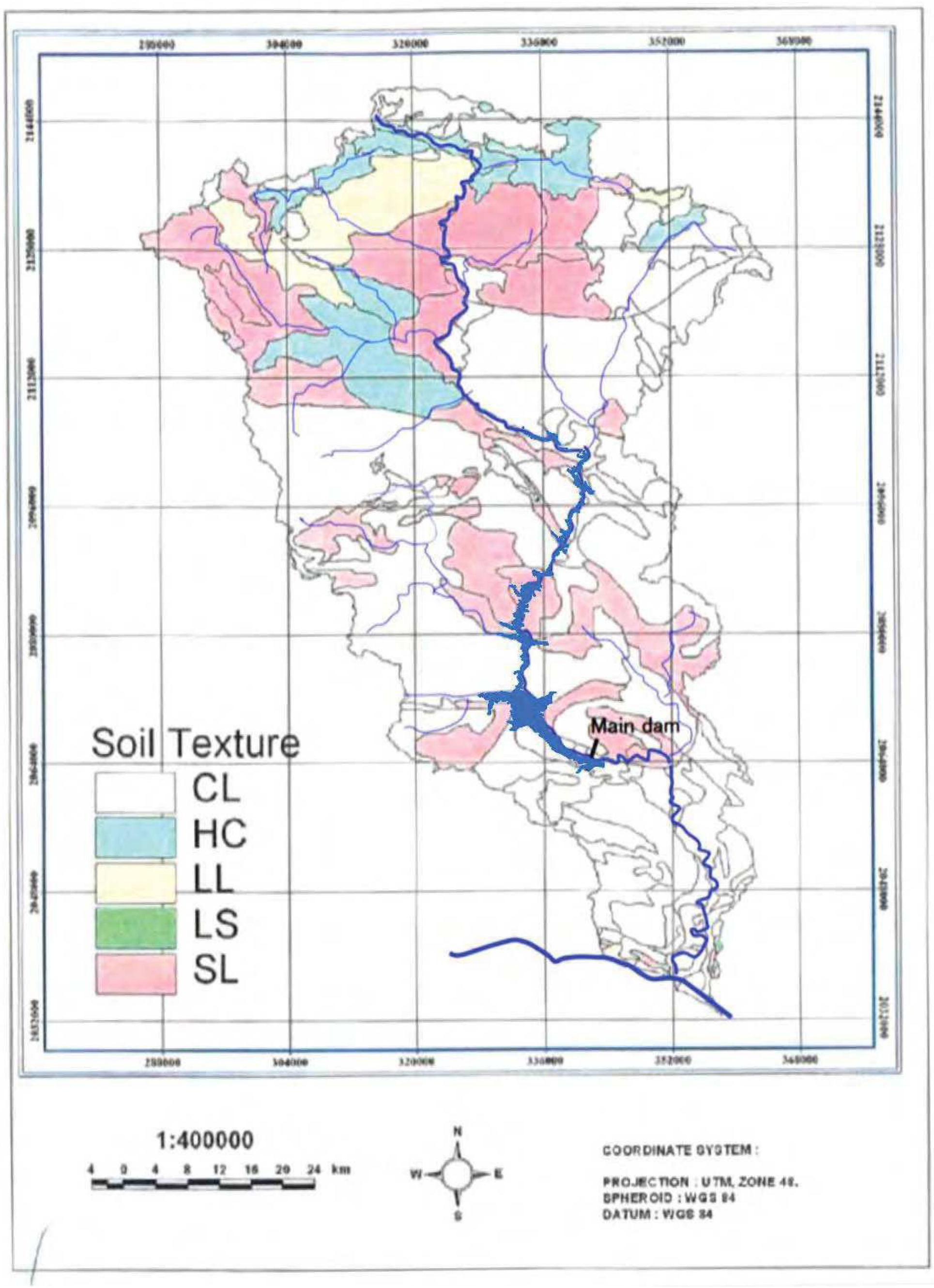
Table 5.8 Soil Texture

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

Source: Environmental Impact Assessment Report, ERIC, 2012.

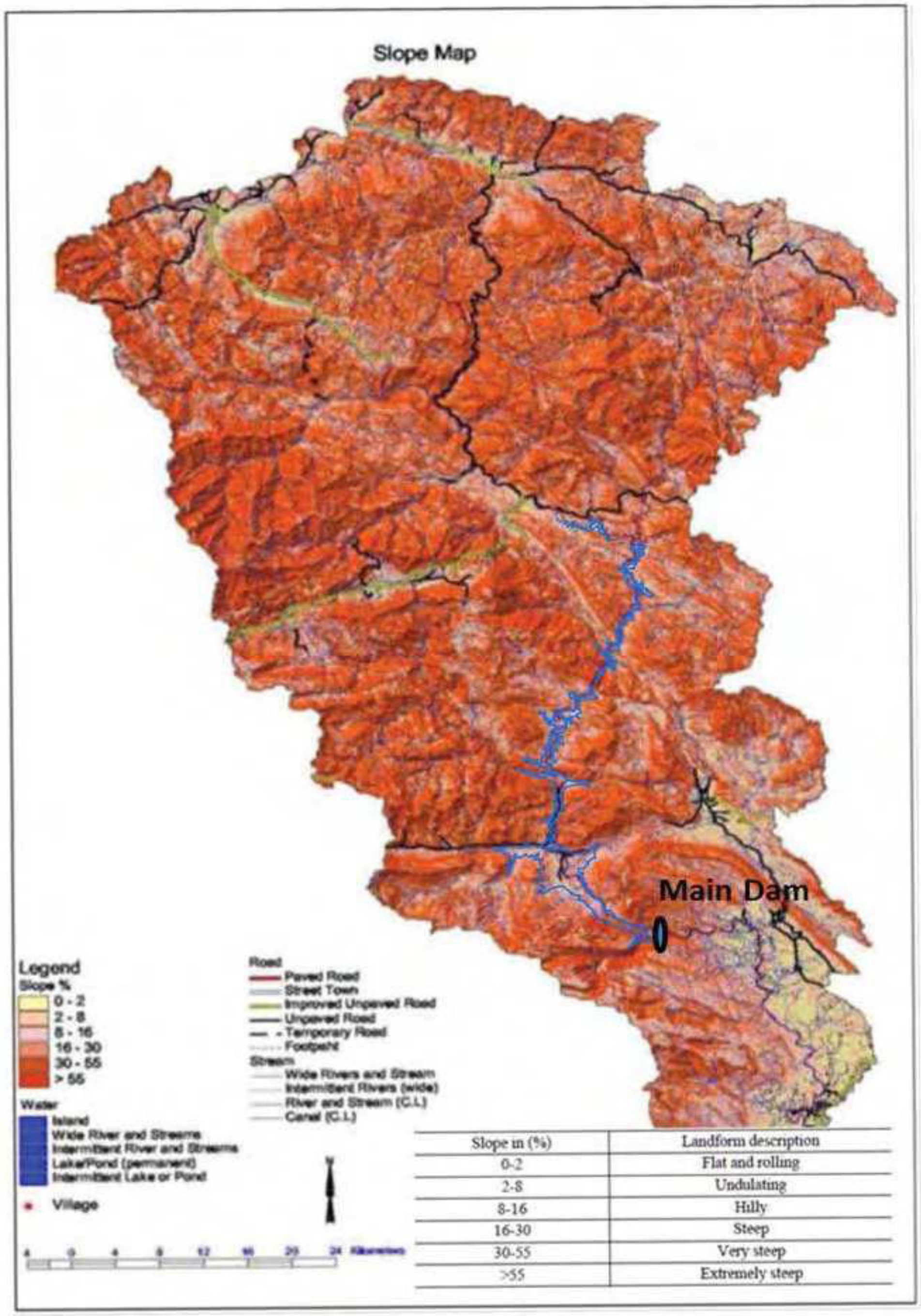
Figure 5.10 shows a soil texture map of the Nam Ngiep watershed. The figure shows that the reservoir area of the Project is classified in two soil textures: Sandy Loam (SL) and Clay Loam (CL). A comparison of Soil Erodibility for Humic ACRISOLS identified that the slope of SL and CL are 2-8% and 8-16% 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 5.11*** 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 5.10 Soil Texture Map of the Nam Ngiep Watershed



Source: ERM, 2013.

Figure 5.11 Slope Classification Map of the Nam Ngiep Watershed



Source: ERM, 2013.

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 headword 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) = $\frac{A_1 - B}{V} \times 10^6$ 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) = $\frac{A_2 - A_1}{V} \times 10^6$ 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	1 Oct 2010	-	1,000	42.5
Ban Hat Gniun	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

Source: Environmental Impact Assessment Report, ERIC, 2012.

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 1-3 m. 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	30 Apr 2010	-	1,000	14.1
Ban Hat Gniun	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

Source: Environmental Impact Assessment Report, ERIC, 2012.

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.

$$Qs = 7.063 \times 10^{-8} \times Q^{2.155}$$

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:

$$Vy = Vy_s + Vy_b$$

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

$$R = \text{Suspended load curve} \times D_h$$

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 are 178 ton/km²/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 (km²)	Sediment yield (ton/km²/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 Downstream Geomorphology

Downstream geomorphology of the Nam Ngiep River can be characterized as generally stable, as evidenced by observations of sandbars and other geomorphological characteristics upstream and downstream of the proposed dam.

A sandbar upstream of Ban Hat Gniun, shown in ***Figure 5.13***, consists mainly of gravels, and can be considered as stable due to the river gradient is steeper than downstream water level toward the mouth of Nam Ngiep River.

Figure 5.12 shows a topographic map (1:25,000) by JICA in 1995 to compare with the satellite image in 2014 and ***Figure 5.13*** shows the photos of sandbar location and its component at Ban Hat Gniun. Based on ***Figure 5.13*** and ***Figure 5.14***, it appears that there has been stable sand bars and islands in the Project area since the 1960's. The figures show that these geomorphological features have retained their form over time, indicating that the sediment throughput has remained in equilibrium. Also, based on observations of NNP1PC, the sand bars have remained the same size and location after the rainy season in the past several years.

The potential of sediment yield is also estimated to be quite small, because geology and topography consist of mainly sedimentary rocks distributed horizontally in the basin area are stable. Sediment yield and capacity of sediment transport is balanced so that minimal change of river regime have occurred over the long term. Riverbed materials consist primarily of fine suspended particles.

Figure 5.12 Comparison the Topographic Map (1:25,000) by JICA in 1995 and Satellite Image in 2014 at Ban Hat Gniun

(a) Sandbar location on topographic map 1:25,000 by JICA, 1995.

(b) Sandbar location on satellite image, 2014.

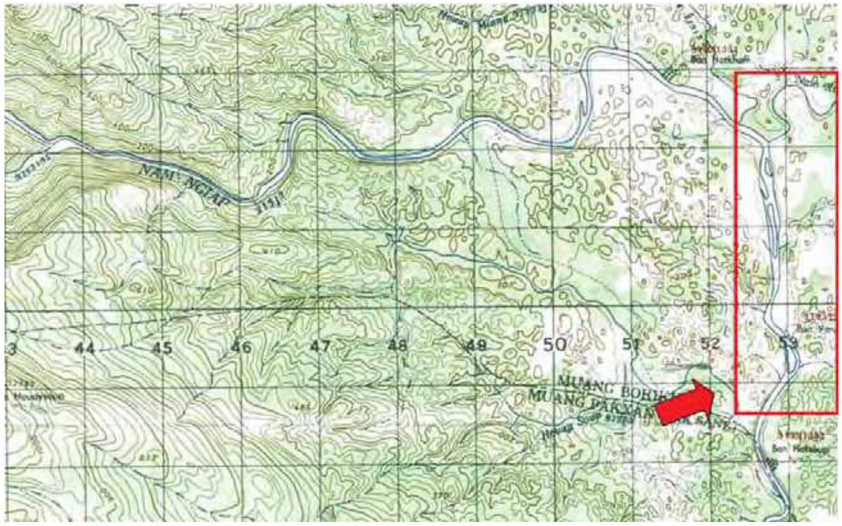
Figure 5.13 Photographs of Sandbar Location in Nam Ngiep River at Ban Hat Gniun

(a) Sandbar location, facing upstream

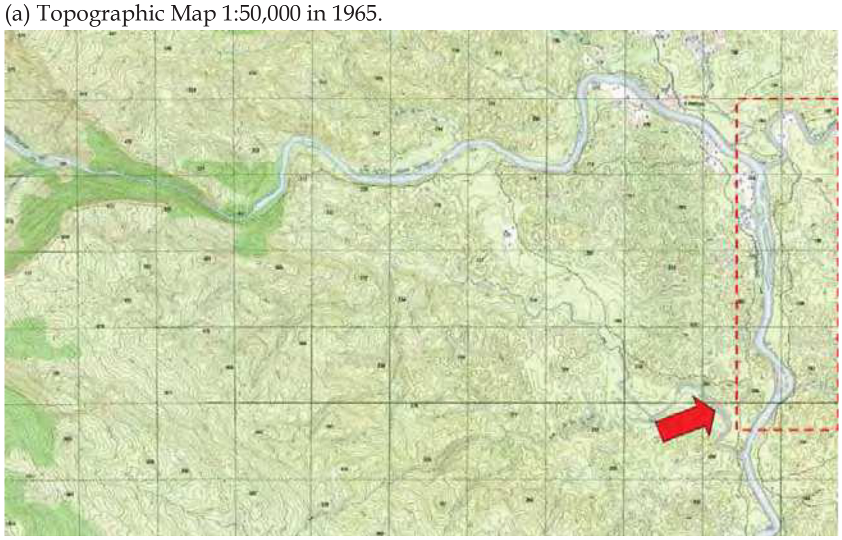
(b) Gravel sandbar

Source: NNP1PC, 2014.

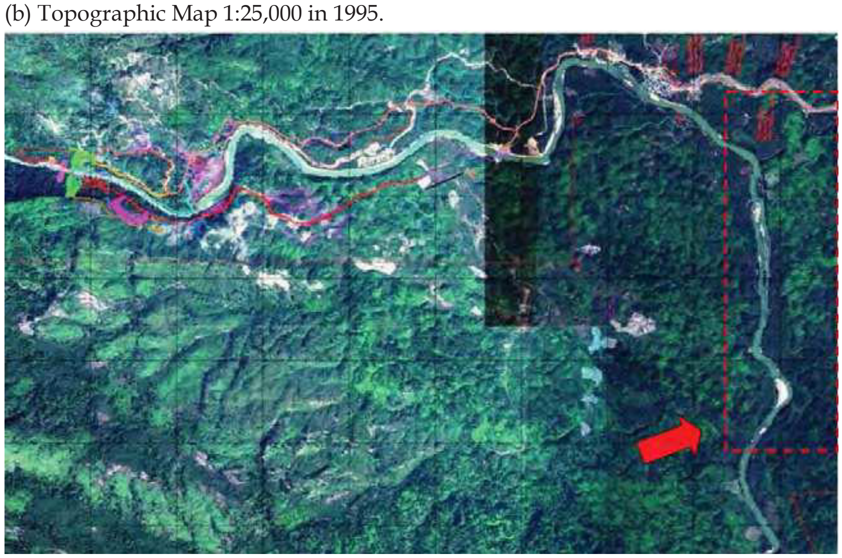
Figure 5.14 Comparison of Nam Ngiep Downstream River Regime



(a) Topographic Map 1:50,000 in 1965.



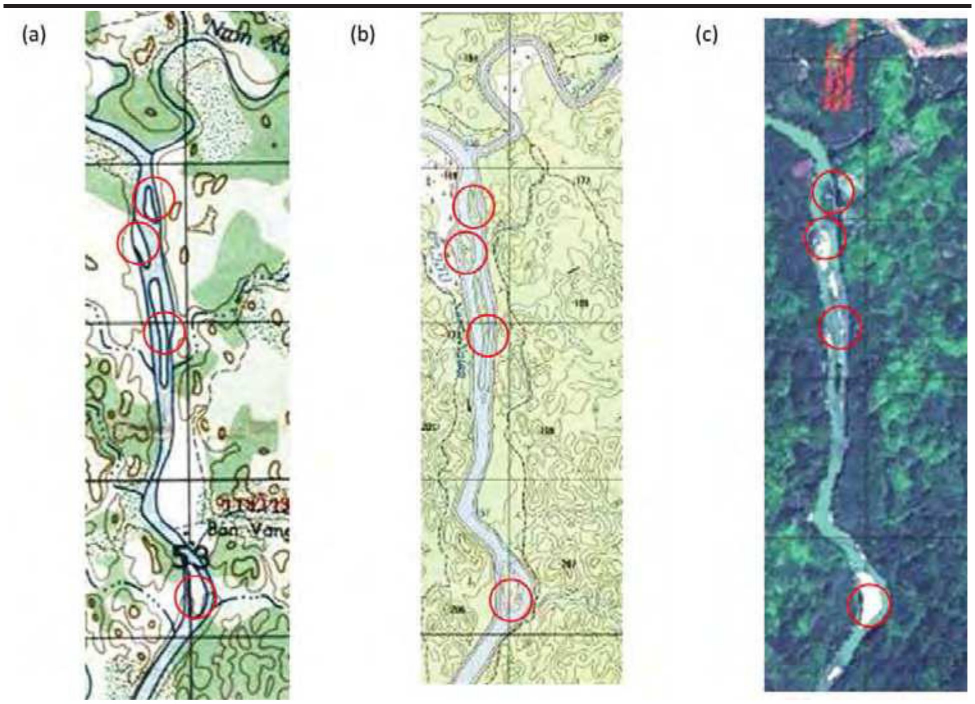
(b) Topographic Map 1:25,000 in 1995.



(c) Sattlelite image high resolution in 2013.

Source: NNP1PC, 2014.

Figure 5.15 Comparision of Nam Ngiep Downstream River Regime over Time



(a) Topographic Map 1:50,000 in 1965.
(b) Topographic Map 1:25,000 in 1995.
(c) Sattlelite image high resolution in 2013.

Source: NNP1PC, 2014.

5.1.7 *Surface Water and Groundwater Quality*

A World Bank[10] 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. The Social Impact Assessment of the Nam Ngiep 1 Hydropower Project (NNP1, May 2012) found that villages downstream of the Project obtained their drinking water primarily from underground water and streams, rather than the Nam Ngiep River. However, recently, some villagers in the area have been observed using the Nam Ngiep River for potable water consumption. This is likely due to the water use pressures from a temporary increase in population due to the influx of workers in the area.

5.1.7.1 *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[11]. However, water quality was found to be deteriorating. In urban areas, pollutants from roads, commercial and

10 World Bank. 2006. Lao PDR Environmental Monitoring Report.
11 ADB. 1998. Water Sector Study.

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 5.16***.

Figure 5.16 Open Dump of Solid Waste in a City

Source: Environmental Impact Assessment Report, ERIC, 2012.

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. 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 5.17*** to ***Figure 5.19***), 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 5.20***). 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 5.21***). Their waste can mix with runoff and flow through the riverbank down to the river.

Figure 5.17 Three-Canopy Forest Located near the Proposed Dam Site

Source: Environmental Impact Assessment Report, ERIC, 2012.

Figure 5.18 Stake Marking the Dam Site

Source: Environmental Impact Assessment Report, ERIC, 2012.

Figure 5.19 Forest at the Proposed Dam Site

Source: Environmental Impact Assessment Report, ERIC, 2012.

Figure 5.20 Disturbed Forest from Grazing near Ban Xomxeun

Source: Environmental Impact Assessment Report, ERIC, 2012.

Figure 5.21 Residential Areas Divided for Activities such as Washing, Waste Dumping and Animal Feeding

Source: Environmental Impact Assessment Report, ERIC, 2012.

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 5.22***. 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 results of surface water quality sampled at these sites in April and October 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′′

Source: Environmental Impact Assessment Report, ERIC, 2012.

Figure 5.22 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

Source: Environmental Impact Assessment Report, ERIC, 2012.

Table 5.14 Results 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
BOD5	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

Source: Environmental Impact Assessment Report, ERIC, 2012.

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 30ºC 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 22ºC in December to February and 20°C to 28ºC in March and even reached 31ºC 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 data 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. Based on this information, it is a reasonable assumption that most water bodies adjacent to rural settlements, such as the Nam Ngiep River, would contain some level of microbiological contamination, and would likely not be suitable to be used for drinking water.

Although Lao PDR has water quality standards, it does not yet have its own water classification standard; therefore 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 samples 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.

NNP River Water Quality Sampling during July/August 2012

Surface water quality data in July and August 2012 at Ban Hat Gniun and Houay Soup was provided by NNP1. Results are presented in ***Table 5.15.***

Table 5.15 Results of Water Quality Sampled in July/August 2012

	Unit	Drinking Water Standard	Ambient Surface Water Quality Standard	Ban Hat Gniun	Ban Hat Gniun	Houay Soup	Houay Soup
Date	dd/mm/yyyy	-		24.7.2012	25.7.2012	24.7.2012	10.8.2012
Time	hh:mm	-		9:45 AM	9:34 AM	13:30 PM	13:45 PM
Climate	Fine,Coudy,Rain			Cloudy , Rain	Cloudy , Rain	Cloudy	Rain
Air temperature	°C	-		28		29.8	31.1
Humidity	%	-		81%		80%	0.78
Water temperature	°C	-		25.4		25.4	24.8
pH	-	25 – 35	5~9	7.9		6.2	6.4
DO	mg/l	6.5 – 8.5	>6.0	9.7		8	8.8
Turbidity	FTU	-		192.3		153.84	153.84
BOD	mg/l	<10	2	3		2	2
COD	mg/l	-	5	4		2	4
Total coliform	MPN/100	-	5000		176	-	24
Nitrate-N	mg/l	<2.2	5		0.118		0.25
Ammonium (NH4-N)	mg/l	50	0		0.033		0.014
Conductivity	µS/cm	-			69.3		7.8
Orto-Phosphate (PO4-P)	mg/l	500 – 600			0.002		0.005
TDS	mg/l	-			36		3.8
Manganese (MN)	mg/l	500 – 600	1		<0.01		0.018
Total Iron	mg/l	0.1 – 0.5			0.109		<0.02
Sodium (Na)	mg/l	0.3 – 1			1.15		0.276
Calcium (Ca)	mg/l	200 – 250			9.3		0.9
Magnesium (Mg)	mg/l	-			1.9		0.18
Cupper (Cu)	mg/l	-	0		<0.01		<0.01
Mercury (Hg)	mg/l	1.0 – 2.0	0		<0.0005		<0.0005
Cyanide (CN)	mg/l	0.001	0		0.024		0.027
Arsenic (As)	mg/l	0.07	0		<0.005		<0.005
Cadmium (Cd)	mg/l	0.05	0		<0.002		<0.002
Chromium (Cr)	mg/l	0.003	0		<0.02		<0.02
Zinc (Zn)	mg/l	0.05	1		<0.005		<0.005

Source: Nam Ngiep 1 Power Company Limited, 2012.

The parameters were measured against the relevant water quality standard for drinking water and surface water listed in Lao PDR National Environmental Standard (Lao PDR 2009) and analysed. The results of water quality analysis indicate that Cyanide exceeds the water quality standard at both Hat Gniun and Houay Soup. BOD exceeds the BOD standard of 2 mg/L at B Hat Gniun. A higher average DO level of 8.8 mg/L is noticed than that in the dry season (***Figure 5.23***). In addition, total coliform was found to be above the drinking water standard (Lao PDR 2009) at both Ban Hat Gniun and Houay Soup. Based on the above results, water from the Nam Ngiep River is not suitable for drinking purposes.

NNP River Water Quality Sampling during March 2013

As part of the NNP1 Biodiversity Offset Assessment Study, ERM consultants conducted water quality monitoring along the NNP River and the Nam Xan River at strategic locations to assess water quality conditions and facilitate the biodiversity offset study. Water quality sampling results along the Nam Xan River were presented in the *NNP1 Biodiversity Offset Design Report* and the key findings are presented in *Annex A*. Surface water quality samples along the length of the surveyed NNP River were taken at six (6) stations (***Table 5.16***) every 1 km on 15 March 2013 (***Figure 5.24***)

Table 5.16 Locations for Surface Water Quality Sampling along the Surveyed Stretch of NNP River

Station	Location
SW-1	Upstream of main dam and powerhouse (PH)
SW-2	Downstream of main dam and PH, and upstream re-regulating dam and PH
SW-3	Downstream re-regulating dam and PH, and upstream of one tributary (Nam Xao)
SW-4	Downstream of Nam Xao
SW-5	Upstream of one tributary (Nam Pa)
SW-6	Downstream of Nam Pa

Source: Environmental Flow Assessment Report, 2014.

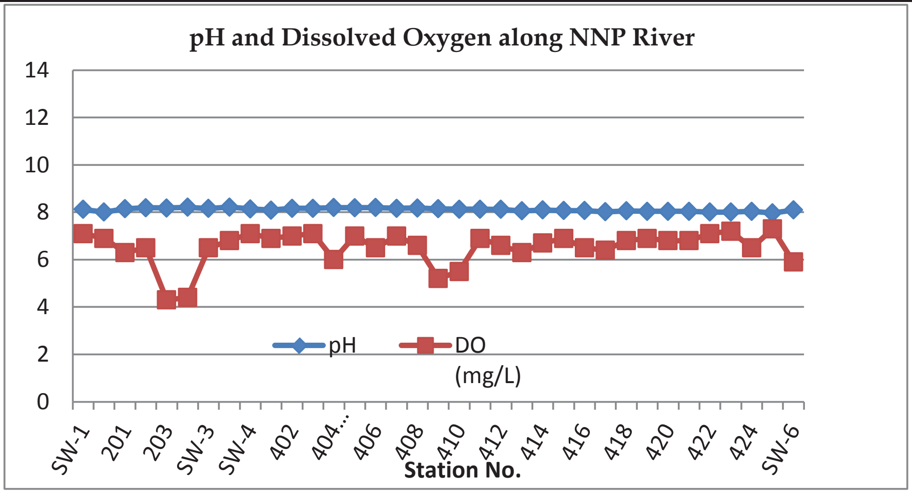
Figure 5.23 Water Quality Sampling Sites along the NNP River in March 2013

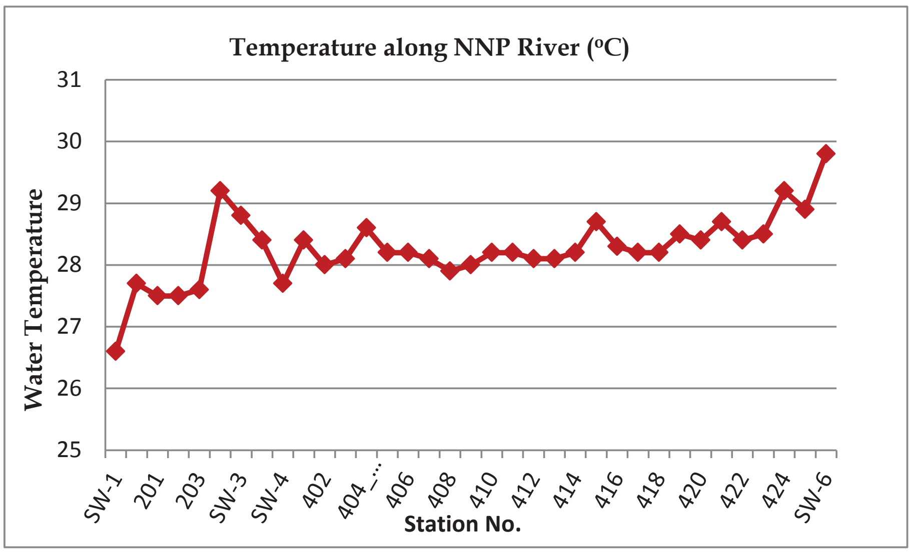
Source: Environmental Flow Assessment Report, 2014.

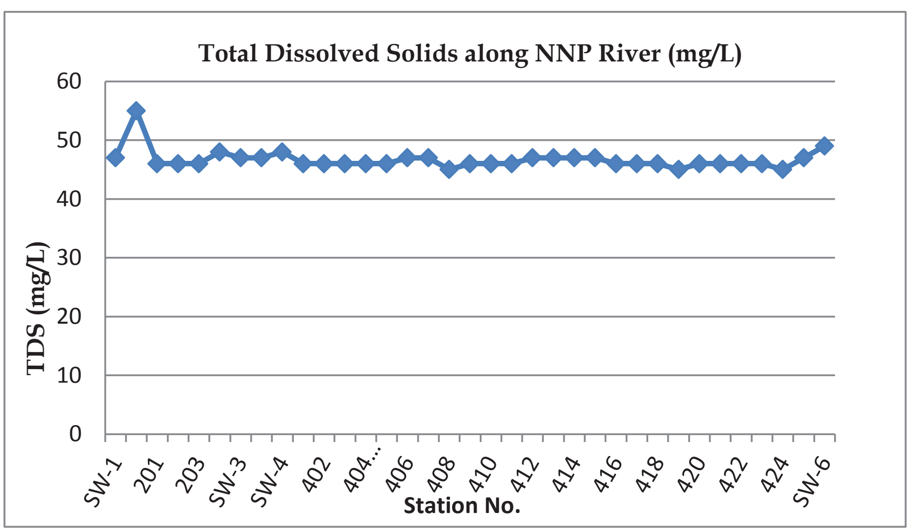
The parameters were measured against the relevant water quality standard for drinking water and surface water listed in Lao PDR National Environmental Standard (Lao PDR 2009) and analysed. All parameters were recorded as well as date and time, GPS UTM (Zone 48, based on WGS 84 datum), physical conditions such as weather, water colour, odour, visible oil and grease, floating solids and any activities near the sites that were considered useful for helping to interpret the water quality data.

The results of water quality analysis indicate that along the NNP River the average DO level of 6.5 mg/L complies with the Ambient Surface Water Quality Standard of Lao PDF. TDS was measured at the sites and shows an average level of 46.7 mg/L.

Figure 5.24 Results of Water Quality Monitoring, March 2013







Source: Environmental Flow Assessment Report, 2014.

5.1.7.2 *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 (see ***Figure 5.27***) 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 5.25***, ***Figure 5.26***). ***Table 5.17*** shows the results for groundwater quality at Ban Xomxeun.

Figure 5.25 Groundwater Sampling at Ban Xomxeun

Source: Environmental Impact Assessment Report, ERIC, 2012.

Figure 5.26 The Well at Ban Hat Gniun

Source: Environmental Impact Assessment Report, ERIC, 2012.

Figure 5.27 Spring Water Gravity Flow System in Ban Hat Gniun

Source: Environmental Impact Assessment Report, ERIC, 2012.

Table 5.17 Ground Water Quality of Ban Xomxeun Collected on 17 October 2007

Parameters	Unit	Xomxeun	STD value[1]	
			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
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

Source: Environmental Impact Assessment Report, ERIC, 2012.

Note: NA = Not Available , - = Not indicated

[1] Lao and WEPA Standard Value of each parameter are same.

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 Lao PDR (2009). 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.

5.1.8 Mineral Resources

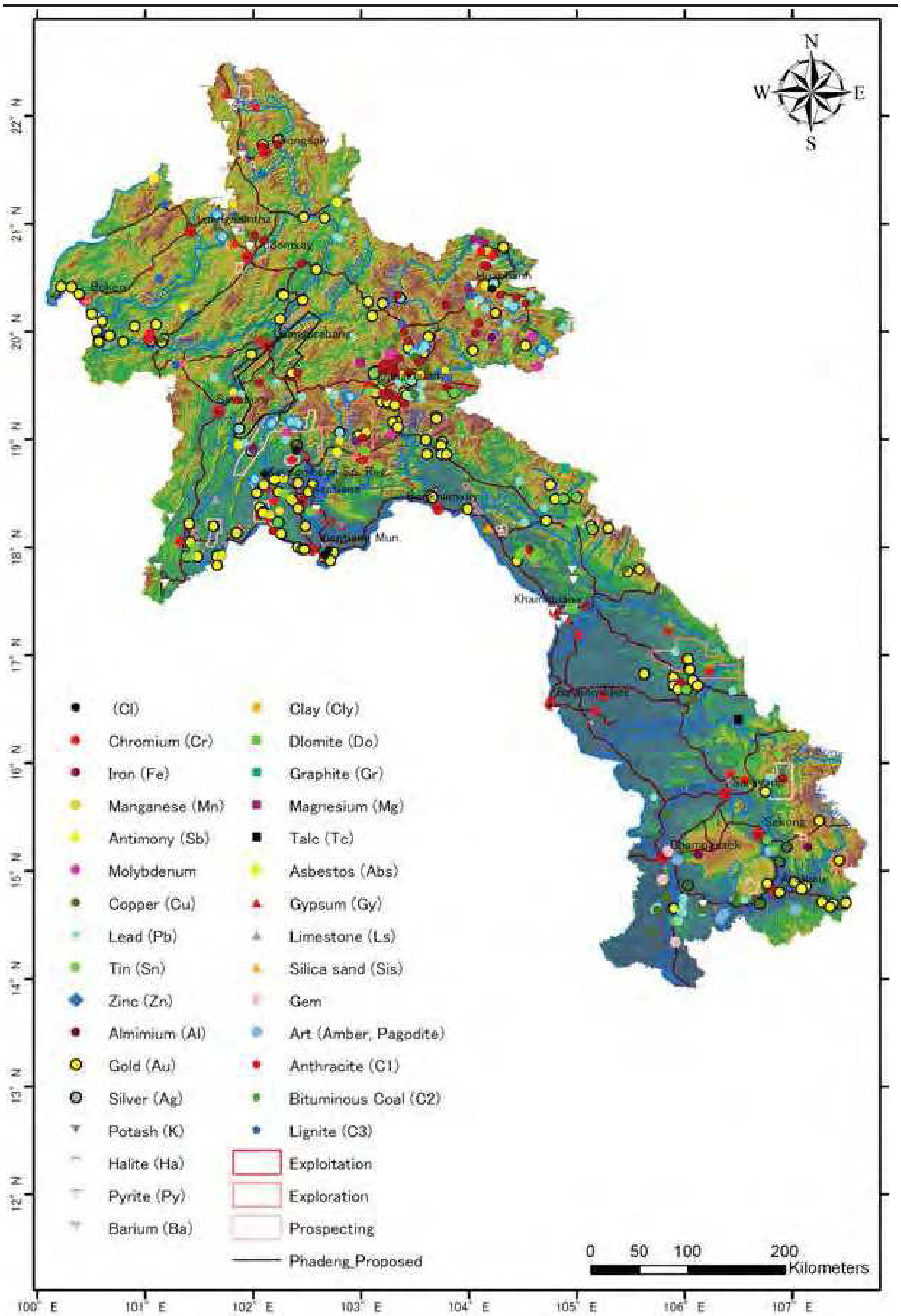
Mineral resources in the Project area were classified according to the 5 zones indicated in *Chapter 1*. In particular, the opportunity loss of mineral exploitation was considered, i.e. if valuable mineral resources were to be inundated by the reservoir. At the same time, the presence of any mineral 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 shows in ***Figure 5.28***, 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 5.28 Mineral Resource Map of Lao PDR



Source: World Bank, 2006.

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

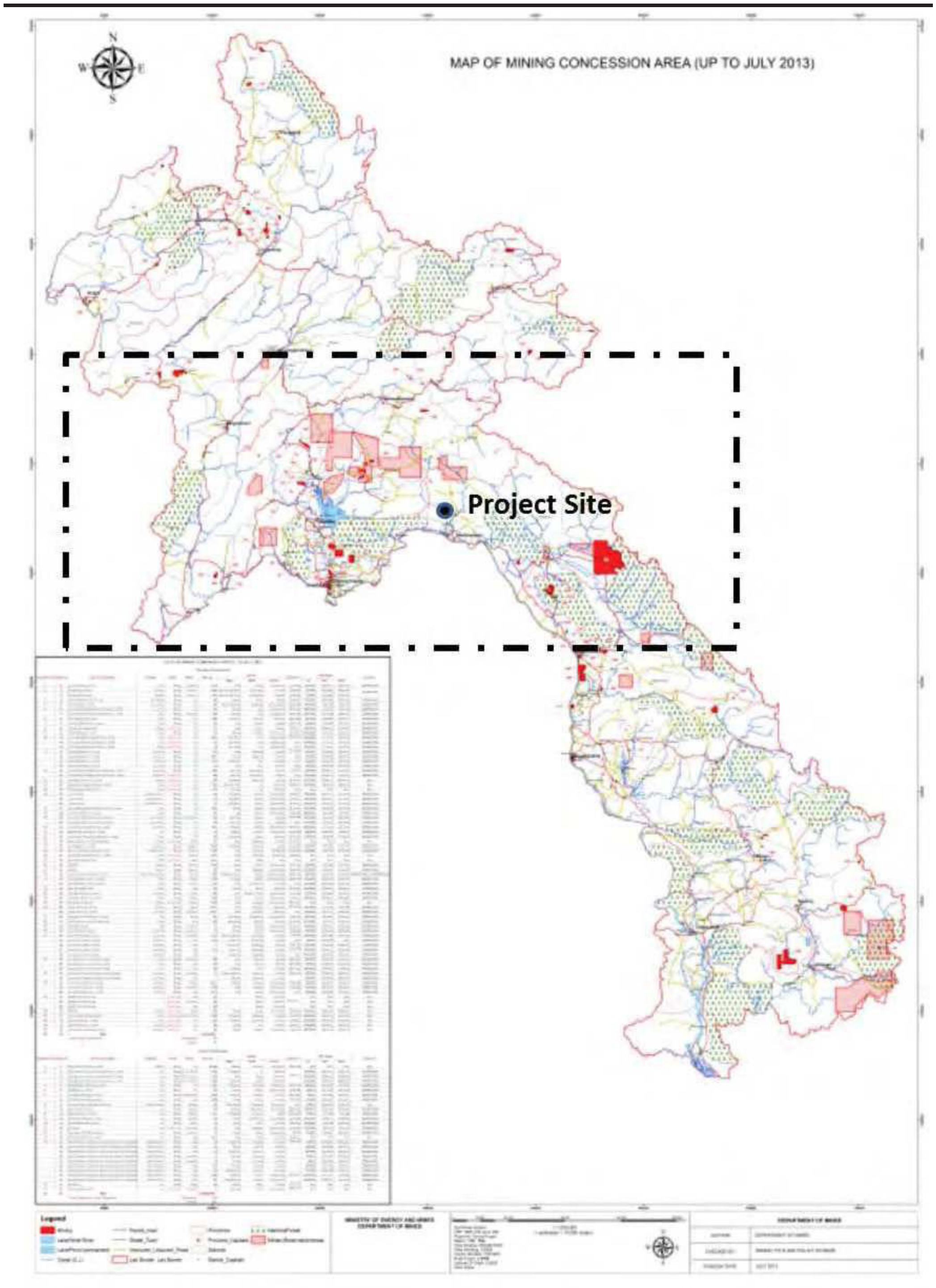
3). One site was found to be a potential source of copper according to a geological study conducted by Lao-Fuda Co., Ltd in March 2007, but this site, which is located in Houixiat Village, Hom District, Vientiane Province, is also far from the Project and so should not have any impact on the Project.

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 Xaysomboun Provinces, as shown in ***Figure** 5.29* and ***Figure 5.30.***

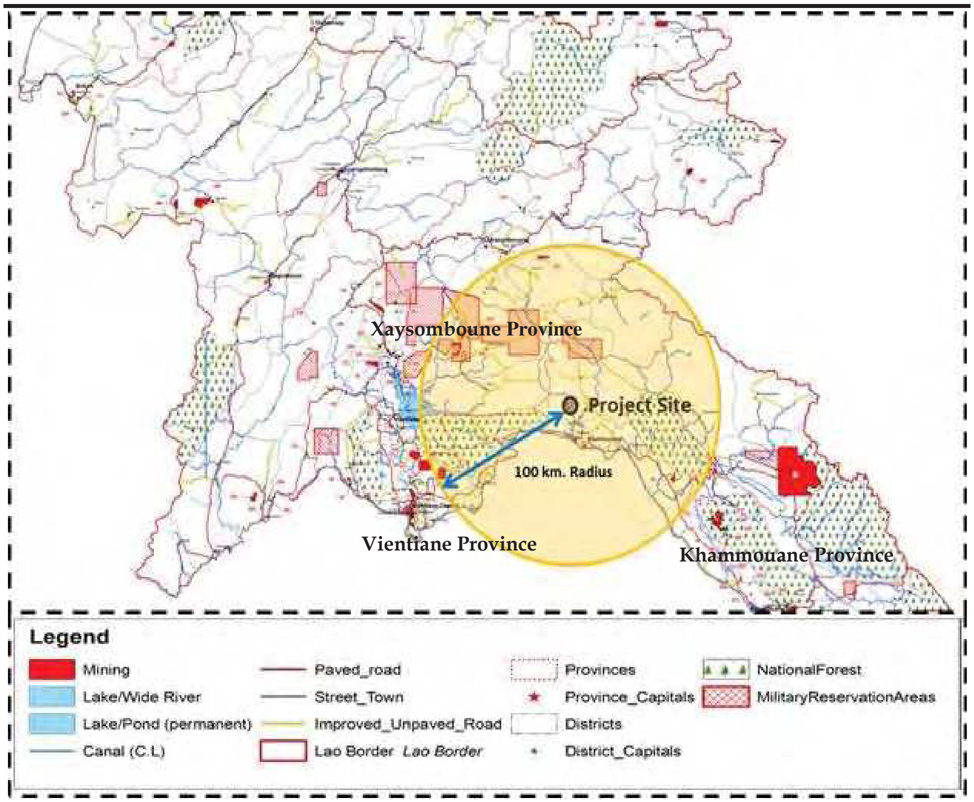
Figure 5.31 to ***Figure 5.33*** shows the pre-existing mining Project in Xieng Khouang, Vientiane and Bolikhamxay Provinces.

Figure 5.29 Map of Mining Concession Area (Ministry of Energy and Mines, Department of Mines, Lao PDR; July 2013)



Source: ERM, 2013.

Figure 5.30 Mining Sites in 100 Kilometres Radius of the Project



Source: ERM, 2013.

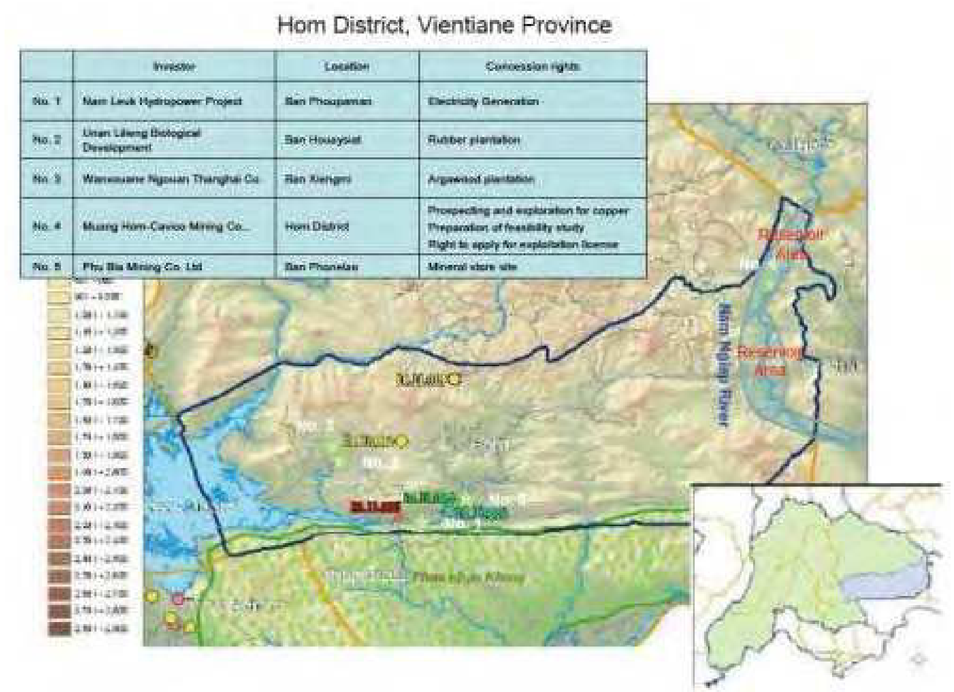
Figure 5.31 Pre-Existing Mining Projects in Thathom District, Xieng Khouang Province

Thathom District, Xieng Khoung Province

	Investor	Location	Concession rights
No. 1	Douangchalerum Phathana Agriculture and Construction CO.	Ban Phaloung and Ban Nham	5 ha lime stone exploitation
No. 2	Saysomboun Gold Mineral Devlopment Company Ltd.	Ban Nham	565 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

Source: Environmental Impact Assessment Report, ERIC, 2012.

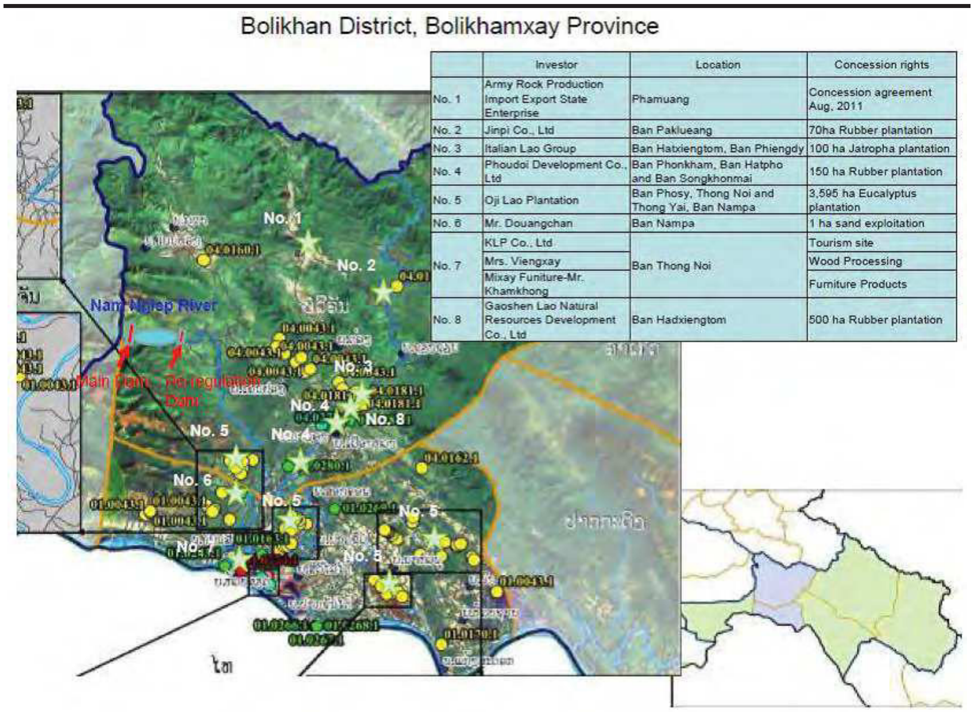
Figure 5.32 Pre-Existing Mining Projects in Hom District, Vientiane Province



	Investor	Location	Concession rights
No. 1	Nam Leuk Hydropower Project	Ban Phoupamian	Electricity Generation
No. 2	Unan Lileng Biological Development	Ban Houaysiat	Rubber plantation
No. 3	Wanxiuane Ngouan Thanghai Co.	Ban Xiengmi	Agarwood plantation
No. 4	Muang Hom-Caveo 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 Phonelau	Mineral store site

Source: Environmental Impact Assessment Report, ERIC, 2012.

Figure 5.33 Pre-Existing Mining Projects in Bolikhan District, Bolikhamxay Province



	Investor	Location	Concession rights
No. 1	Army Rock Production Import Export State Enterprise	Phamuang	Concession agreement Aug, 2011
No. 2	Jinpi Co., Ltd	Ban Paklueang	70ha Rubber plantation
No. 3	Italian Lao Group	Ban Hatxiengtom, Ban Phiengdy	100 ha Jatropha plantation
No. 4	Phoudoi Development Co., Ltd	Ban Phonkham, Ban Hatpho and Ban Songkhonmai	150 ha Rubber plantation
No. 5	Oji Lao Plantation	Ban Phosy, Thong Noi and Thong Yai, Ban Nampa	3,595 ha Eucalyptus plantation
No. 6	Mr. Douangchan	Ban Nampa	1 ha sand exploitation
No. 7	KLP Co., Ltd	Ban Thong Noi	Tourism site
	Mrs. Viengxay		Wood Processing
	Mixay Funiture-Mr. Khamkhong		Furniture Products
No. 8	Gaoshen Lao Natural Resources Development Co., Ltd	Ban Hadxiengtom	500 ha Rubber plantation

Source: Environmental Impact Assessment Report, ERIC, 2012.

5.1.9 *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.

5.1.9.1 *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 Gniun, 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 5.34***), a school (***Figure 5.35***) and a temple (***Figure 5.36***). 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 5.34 Houses at Ban Hat Gniun

Source: Environmental Impact Assessment Report, ERIC, 2012.

Figure 5.35 School at Ban Hat Gniun

Source: Environmental Impact Assessment Report, ERIC, 2012.

Figure 5.36 Temple at Ban Hat Gniun

Source: Environmental Impact Assessment Report, ERIC, 2012.

5.1.9.2 *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 5.37***). The acoustic environment normally consists of natural sounds, such as wind blowing through trees, birds, and pets.

Figure 5.37 Two-Wheel Tractor Pulling a Cart

Source: Environmental Impact Assessment Report, ERIC, 2012.

5.1.9.3 *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 5.18***). 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 5.18 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 Gniun (see ***Figure 5.38***) were mostly the two-wheel tractor and the natural acoustic environment, so sound levels would likely be between 40 to 60 dB.

Figure 5.38 Ban Hat Gniun

Source: Environmental Impact Assessment Report, ERIC, 2012.

5.1.10 *Air Quality*

Air quality in the Project area is still considered to be of generally good 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 not possible because the required permission (from Lao and Thai authorities) for importing the necessary equipment was not granted during the period of field assessment. However, as the Project area has a low density of industrial and transportation activities, and there are no sources of major pollutants in the Project area, 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 good.

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 5.19***.

Table 5.19 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
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)

5.1.11 *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***.

5.1.12 Hydrology and Hydrogeology

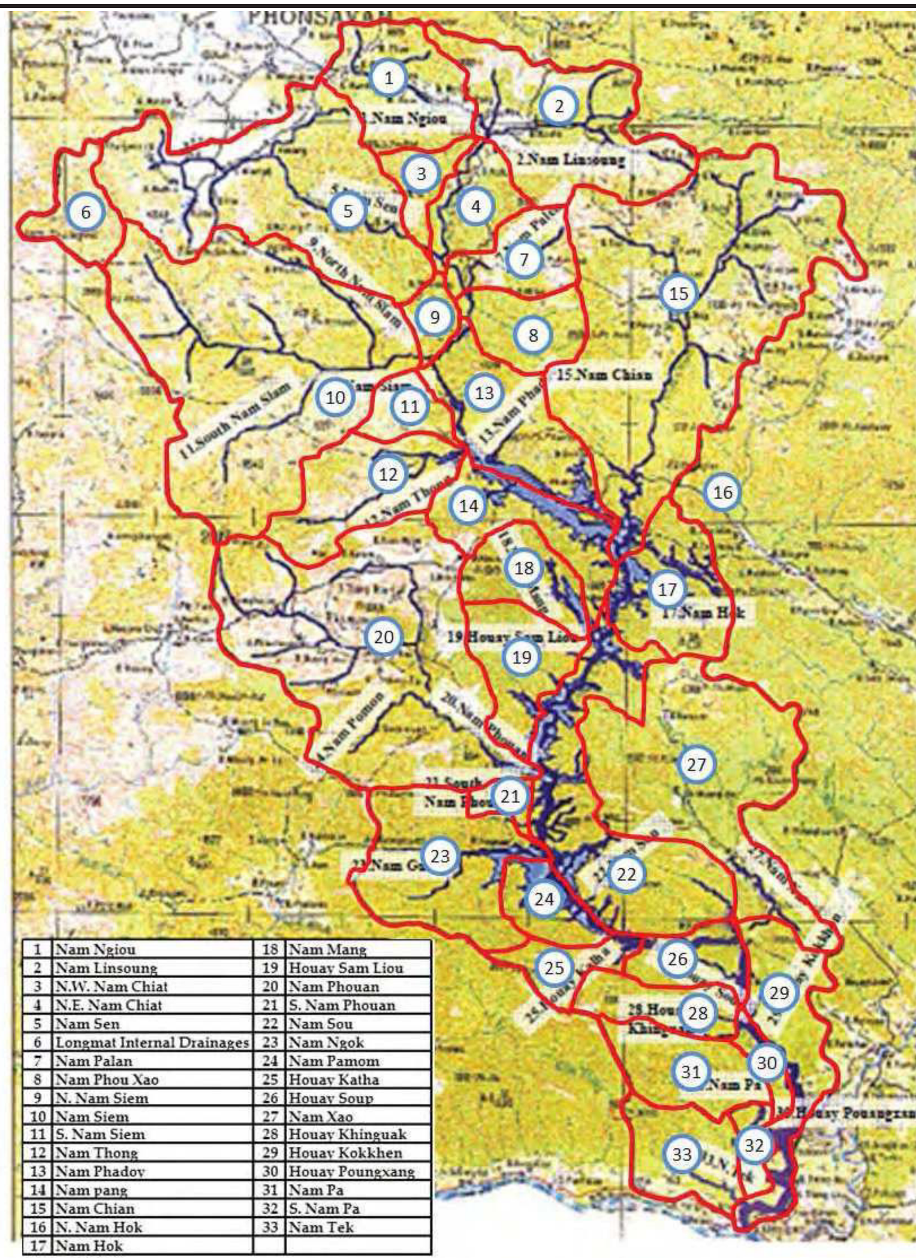
A dam will necessarily change the hydrology of a river. However, measures can be taken to minimize any adverse impacts from changes caused by the dam.

5.1.12.1 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 5.39*** and ***Table 5.20***).

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 5.20***. 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 5.39 Nam Ngiep Sub-Basins and Boundaries



1	Nam Ngiou	18	Nam Mang
2	Nam Linsoung	19	Houay Sam Liou
3	N.W. Nam Chiat	20	Nam Phouan
4	N.E. Nam Chiat	21	S. Nam Phouan
5	Nam Sen	22	Nam Sou
6	Longmat Internal Drainages	23	Nam Ngok
7	Nam Palan	24	Nam Pamom
8	Nam Phou Xao	25	Houay Katha
9	N. Nam Siem	26	Houay Soup
10	Nam Siem	27	Nam Xao
11	S. Nam Siem	28	Houay Khinguak
12	Nam Thong	29	Houay Kokkhen
13	Nam Phadoy	30	Houay Poungxang
14	Nam pang	31	Nam Pa
15	Nam Chian	32	S. Nam Pa
16	N. Nam Hok	33	Nam Tek
17	Nam Hok		

Source: ERM, 2013.

Table 5.20 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

Source: Kansai, 2013.

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.

5.1.12.2 *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 1,538 m) 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.

5.1.12.3 *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 5.21***. 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 5.40***.

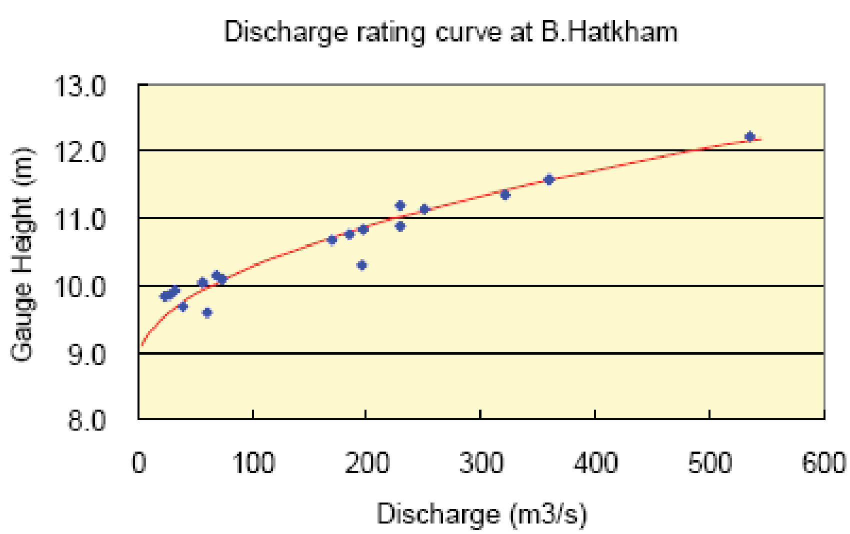
Table 5.21 Basic Hydrological Data

	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	●	●	●	●	△	△	●	●	●	●			△				●	●	●	●	●		●	●				●	●	●	●	●
R3	Muong Mai	Day	158m								●	●						△			△	●	●	●	●	●	●	●	●	●	●	●	●	●	●
R4	Muong Kao (Borikhane)	Day	158m								●	△									●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
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	Houayleuk (Tadleuk)	Day	220m																									●	●	●	△	●	●		
R10	B.Thabok	Day	160m																			●	●	●	●	●	●	●							
R11	Vientiane	Day	170m	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●		●	●	●	●	●	●	●	●	●
R12	Vangvieng	Day	215m				●	△	△		●	△	●	●	●		●			●	△	●	●	●	●	●	●	●	●	●	●	●	●	●	●
R13	Muong Mork	Day	900m																										●	●	●	●	●		
R14	B.Thaviang	Hour	370m																												△	●	●		
Discharge/River water level																																			
	B. Hajyum	Day	-																												△	●	●		
	Muong Mai	Day	153m																			●	●	●	●	●	●	●	●	△	△	●	●	●	●
River water level																																			
	Paksane	Day	142m																			△	●	●	●	●	●	●	●	●	△	●	△	●	●

Source: Environmental Impact Assessment Report, ERIC, 2012.

Note: •: Fully available, Δ : Partly available

Figure 5.40 Discharge Rating Curve



Source: Environmental Impact Assessment Report, ERIC, 2012.

(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.

5.1.12.4 *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 5.22***.

Table 5.22 Assumed Mean Basin Rainfall (1971-2000)

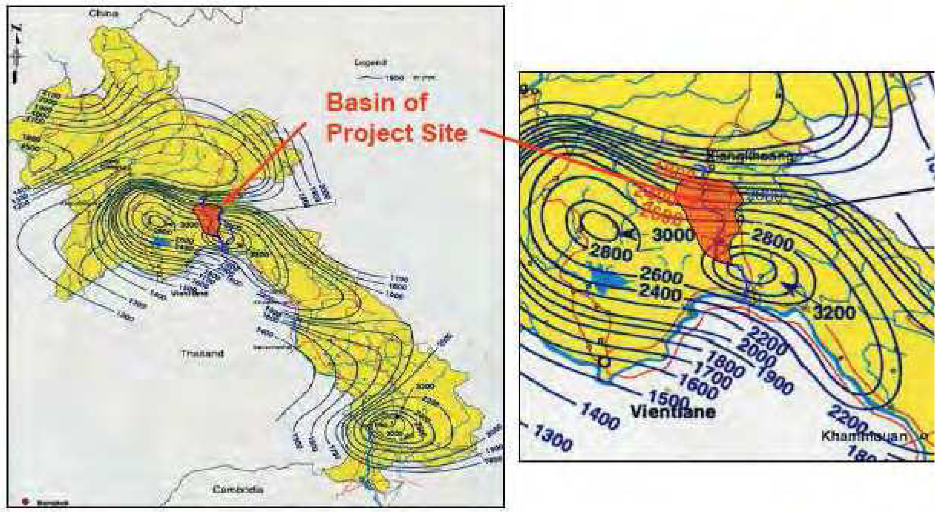
(mm)

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

Source: Environmental Impact Assessment Report, ERIC, 2012.

The mean rainfall of the basin of 1,870 mm/year was selected after considering the Isohyetal Map (***Figure 5.41***). 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.

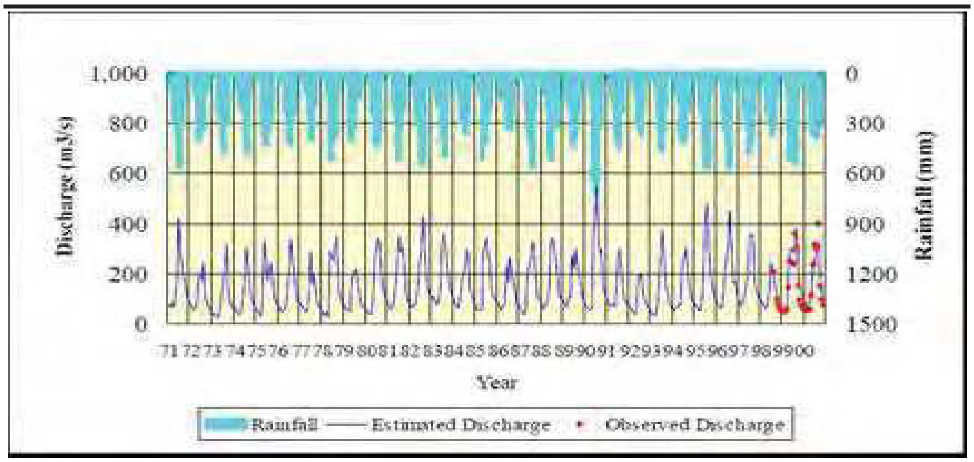
Figure 5.41 Isohyetal Map



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 5.42).*** The model was calibrated and verified.

Figure 5.42 Result of Low Flow Analysis by Tank Model Method



Source: Technical Report, 2011.

Based on the mathematical model (Tank Model), the long-term inflow at the main dam site is estimated as tabulated in ***Table 5.23*** and ***Figure 5.43***. The average inflow is about 148.4 m^3/s, with an annual runoff of around 4,680 mcm. The seasonal distribution (***Figure 5.44***) 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.

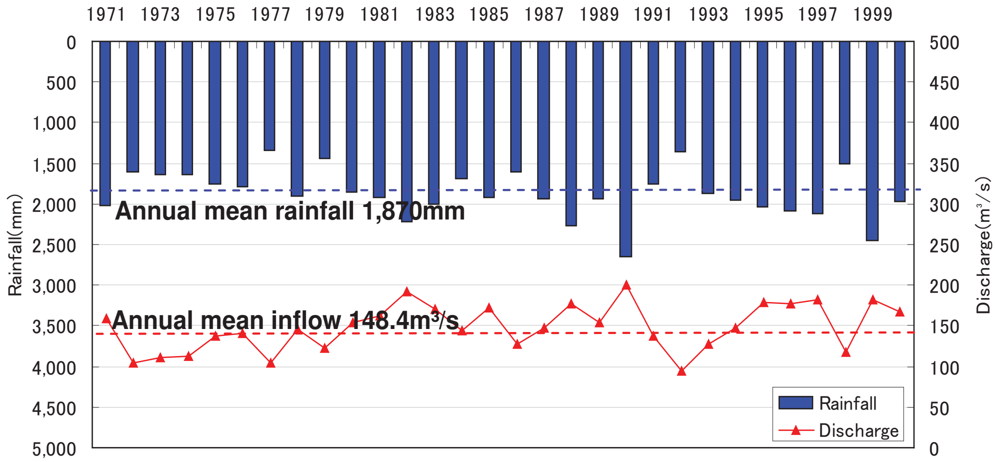
Figure 5.45 shows the duration curve of the inflow at the main dam site, with the flow at probability of being equalled or exceeded. Based on the minimum flow of 26.4 m^3/s, it is equivalent to 99.58% probability.

Table 5.23 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

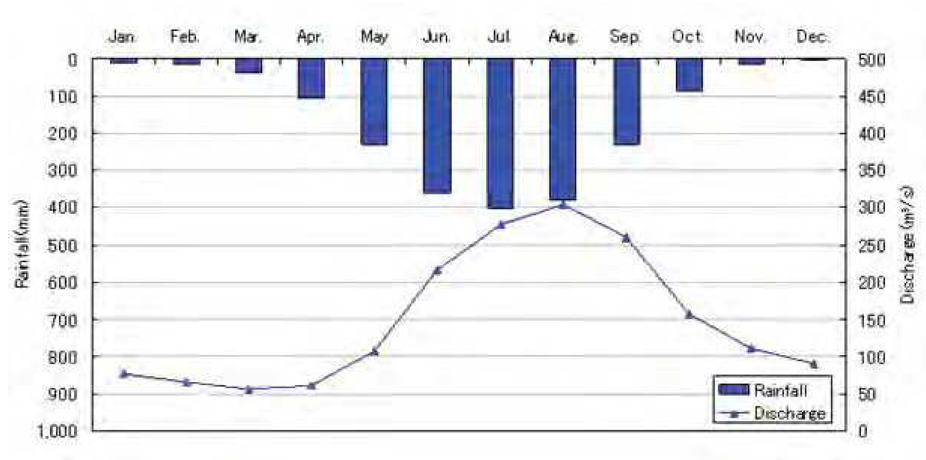
Source: Kansai, 2013.

Figure 5.43 Basin Annual Mean Rainfall and Discharge (Inflow) at Nam Ngiep Dam Site

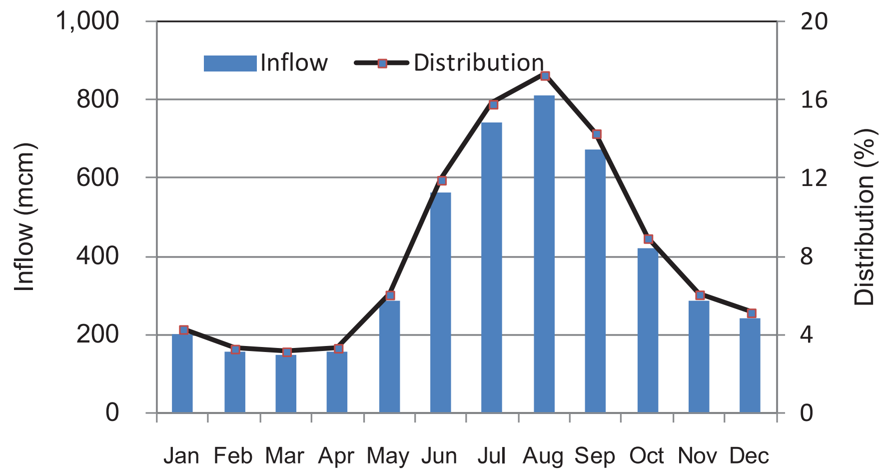


Source: Kansai, 2013.

Figure 5.44 Seasonal Charge of Inflow at Nam Ngiep Dam Site



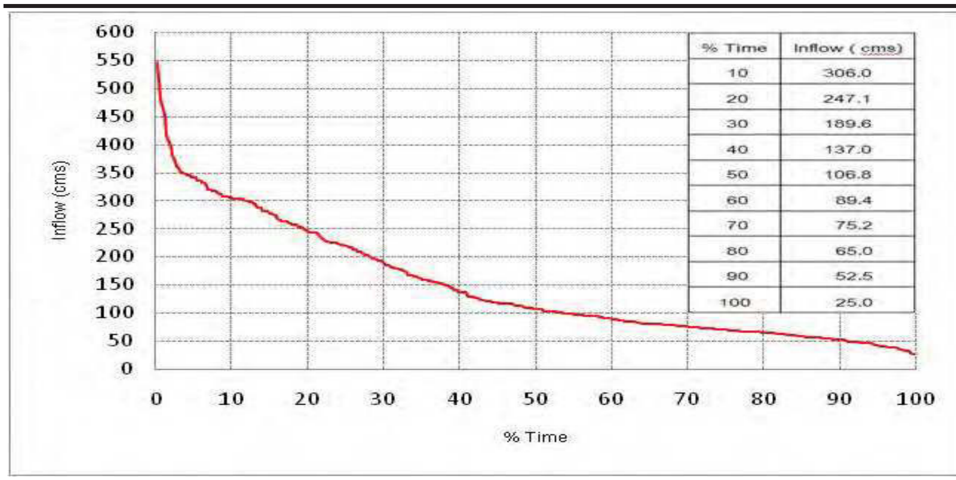
(a) Flow Rate



(b) Runoff

Source: Kansai, 2013.

Figure 5.45 Flow Duration Curve at Nam Ngiep Dam



Source: Kansai, 2013.

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 5.24***).

Table 5.24 Comparison of Hydrological Characteristics with other Projects in North and Middle of Laos

Project	Source	Year	Catchment Area km²	Annual average rainfall mm/year	Annual average discharge m³/s	Specific yield m³/s/100 km²	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	2000	5,640	2,166	200.6	3.56	0.52
Nam Ngum 3	Development		3,873	2,166	106.2	2.74	0.40
Nam Ngum 5	Strategy for LAO		483	1,944	22.7	4.70	0.76
Nam Theun 3	Draft Final Report (LAHMEYER)		2,338	-	110.00	4.70	-
Nam Theun 2	Water Management Plan for the NAM THEUN Final Report (NORPLAN A.S.)	1997	4,013	2,250	233.0	5.81	0.81
Nam Ngum 1	Nam Ngum5	1997	8,460	-	308.0	3.64	-
Nam Ngum 5	Hydropower Project Feasibility		483	2,200	22.8	4.72	0.68

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

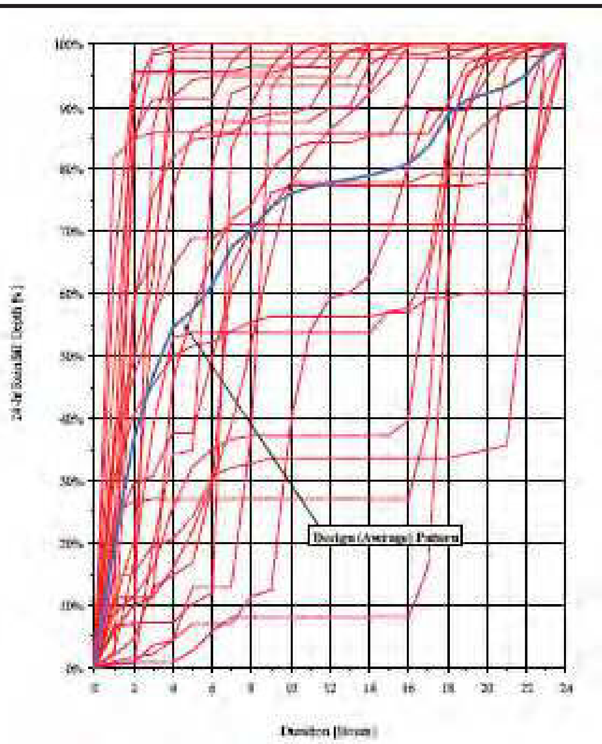
Source: ERM, 2013.

5.1.12.5 *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 5.46).***

Figure 5.46 Accumulated Hourly Rainfall Curves



Source: Environmental Impact Assessment Report, ERIC, 2012.

(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 and Probable Maximum Flood (PMF) were calculated for design of the project facilities. The former was calculated by using a frequency distribution curve of "Log Peason Ⅲ" and the latter was calculated by using unit hydrograph method. The results of the analysis and comparison of the methods are summarized in ***Table 5.25***.

(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 5.25***).

Table 5.25 Flood Analysis Result

Probable year	Probable flood discharge (m3/s)	Method
10,000	7,920	Statistical analysis
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	
Probable Maximum Flood (PMF)	8,430	Unit hydrograph method (Modified Snyder equation)

Source: Environmental Impact Assessment Report, ERIC, 2012.

5.1.12.6 *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 5.26***). 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. ***Table 5.27*** shows the infrastructure of villages in the Project area.

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 5.26 Infrastructure of Villages in the Project Area

Village	Infrastructure Service			Social Welfare							Private and Public Organization
	Electricity	Water Supply	Road	Market	1º school	2º 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

Village	Infrastructure Service			Social Welfare							Private and Public Organization
	Electricity	Water Supply	Road	Market	1° school	2° school	Health center	Temple	Ceme-tery	Grocery	
Zone 5-Resettlement Area											
Hat Gniun	-	✓	✓	-	✓	-	-	-	✓	✓	✓
Thahuea	✓	✓	✓	N/A	✓	N/A	-	✓	✓	✓	N/A

Source: Resettlement and Ethic Development Report, 2014.

Table 5.27 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

Source: Social Impact Assessment Report, 2013.

5.1.12.7 *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.

In accordance with the geologic characteristics, and the mountainous topography type which covers most of the basin area, the potential of groundwater is not expected to be significantly related to that of the surface water.

With regards to the relationship of hydrogeology and slope stability, there are no young rocks or unconsolidated layers after the Tertiary in the dam site and the reservoir area, which means the origin supplying much of sedimentary discharge does not exist in this region. The slope around the reservoir area is generally stable, and topographies suggest large scale landslides are not likely surrounding the reservoir. The flat plane at EL.300m in the left bank of 800 m upstream distant from the dam site, which seems to be made by a prior collapse, will not affect slope stability because the slope is mainly composed of boulders.

5.1.13 *Cultural Resources*

5.1.13.1 *Cultural Heritage of the Project Site*

The first modern humans (Homo sapiens) arrived in Southeast Asia around 50,000 years ago. Their stone-age technology remained little changed until a new Neolithic culture evolved about 10,000 years ago. This was the Hoabinhian, named after an archaeological site in northern Vietnam. Hoabinhian hunter-gatherers spread throughout much of Southeast Asia, including Laos. Their descendants produced the first pottery in the region, and later bronze metallurgy. In time they supplemented their hunting, fishing and gathering by horticulture and eventually rice cultivation, introduced down the Mekong River valley from southern China. These people were the ancestors of the present-day upland minorities, collectively known as the Lao Thoeng (Upland Lao), the largest group of which is the Khamu of northern Laos.

Other Lao Thoeng tribes live in southern Laos, including the Brao and the Katang. Like their northern cousins include Khmer, they speak Austro-Asiatic languages. Southern Laos is believed to be the birthplace of the Cambodian people, from where they spread further south to establish the kingdom of Funan by the 2nd century CE. The earliest kingdom in southern Laos was identified in Chinese texts as Chenla, dating from the 5th century. Its capital was close to Champasak, near the later Khmer temple of Wat Phou. A little later Mon people (speaking another Austro-Asiatic language) established kingdoms on the middle Mekong – Sri Gotapura (Sikhottabong in Lao) with its capital near Thakhek, and Chanthaburi in the vicinity of Vientiane.

Tai peoples probably began migrating out of southern China in about the 8th century. They included the Tai-Lao of Laos, the Tai-Syam and Tai-Yuan of central and northern Thailand, and the Tai-Shan of northeast Burma. They are called Tai to distinguish them from the citizens (Thai) of modern Thailand. All spoke closely related Tai languages, trained wet-rice cultivation along river valleys, and organized themselves into small principalities, known as Mueang or city-states, each presided over by an hereditary ruler, or Chao Mueang (lord of the City). The Tai-Lao, or Lao for short, moved slowly down the rivers of northern Laos, like the Nam Ou and the Nam Khan, running roughly from northeast to southwest, until they arrived at the Mekong, the Great River.

Archeological evidence suggests a complex society in which bronze objects appeared around 1500 BC, and iron tools were known from 700 BC. The proto-historic period is characterized by contact with Chinese culture and the civilizations of Greater India.

In the 1930s human remains, ceramics, beads and bronze artifacts were found in Hang cave in Hua Phan Province of Lao PDR. Radiocarbon dating revealed the bones to be 12,000 to 14,000 years old. In 2009 an ancient skull was recovered from Tam Pa Ling cave in the northern of Laos which is at least 46,000 years old, making it the oldest modern human fossil found to date in Southeast Asia. A study conducted in the Ngeubhinh Mouxeu rock shelter of Luang Namtha Province, although unconfirmed, might provide evidence for the area being inhabited possibly as far back as 56,000 BP. Lao Pako, located on the southern bank of Nam Ngum river, shows evidence of ironworking and textile manufacture dating between 4th and 6th centuries CE as well as an advanced pottery tradition similar to northeast Thailand tradition. The nearby Plain of Jars in Xieng Khoung Province was made by a younger megalithic culture, and consists of massive burial sculptured of single piece of stone.

A preliminary archaeological survey of the Project Area was conducted by the Lao PDR Department of Museums and Archaeology in October 2007. The survey was carried out separately, and was not specifically conducted for the EIA.

The survey team was composed of the following:

- Department of Museama and Archaeology (DMA) Professional Staff,
- Office of Information and Culture of Hom District, Vientiane Province: Mr. Buaphet, Chief, and
- Office of Information and Culture of Bolikhan District, Bolikhamxay Province: Mr. Viengnakhone, Deputy Chief.

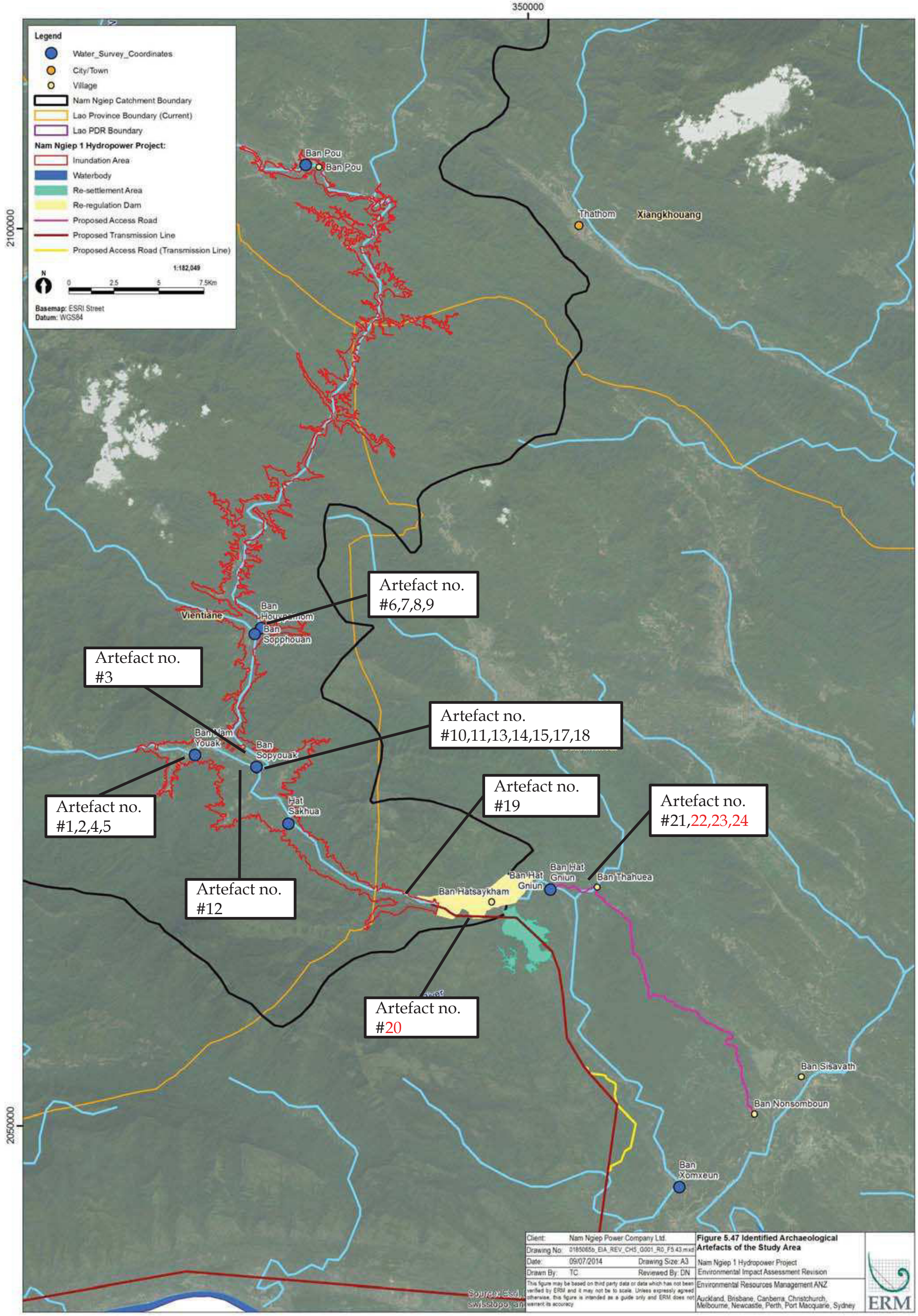
The study area spanned two districts; Hom and Bolikhan. The summary of cultural/archaeological evidence found in the Project area is shown in ***Table 5.28*** below, and the identified archaeological artefacts of the survey are shown in ***Figure 5.47*** and ***Table 5.29***. The location of where the artefacts were detected is shown in ***Figure 5.4.7***.

All archaeological objects detected may not be from the area investigated. They may have been collected as trophies by the villagers interviewed. All finds as part were catalogued and are now stored by DMA.

Table 5.28 Summary of Archaeology Evidence in NNP1 Project Area

No.	**Province**	**District**	**Village**	**Cultural Resources**		**Significant Historical found**	
				Yes	No	Object	Structure
Zone 2 Reservoir Area 2LR							
1			Nam Youak	√		√	
2			Huaypamom		√		
3	Xaysomboun	Hom	Nam Phouan (Sop Phouan)	√		√	
4			Nong (Sop Youak)	√		√	
Zone 3 Construction Area							
5	Bolikhamxay	Bolikhan	Hatsaykham	√		√	√
Zone 5 Resettlement and Near Downstream Area Host Communities							
6	Bolikhamxay	Bolikhan	Hat Gniun		√		
7			Thahuea	√		√	√

Source: Preliminary Archaeological Survey of Nam Ngiep 1 Hydropower Project, Department of Museums and Archaeology, 2007.



350000
2100000
2050000
Legend
Water_Survey_Coordinates
City/Town
Village
Nam Ngiep Catchment Boundary
Lao Province Boundary (Current)
Lao PDR Boundary
Nam Ngiep 1 Hydropower Project:
Inundation Area
Waterbody
Re-settlement Area
Re-regulation Dam
Proposed Access Road
Proposed Transmission Line
Proposed Access Road (Transmission Line)
1:182,049
N
0 2.5 5 7.5Km
Basemap: ESRI Street
Datum: WGS84
Ban Pou
Ban Pou
Thathom
Xiangkhouang
Vientiane
Ban Houypamom
Ban Sopphouan
Artefact no. #6,7,8,9
Artefact no. #3
Artefact no. #10,11,13,14,15,17,18
Ban Nam Youak
Ban Sopyouak
Hat Sakhua
Artefact no. #1,2,4,5
Artefact no. #19
Artefact no. #21,22,23,24
Artefact no. #12
Ban Hat Gniun
Ban Hat Gniun
Ban Thahuea
Ban Hatsaykham
Artefact no. #20
Ban Sisavath
Ban Nonsomboun
Ban Xomxeun
Client: Nam Ngiep Power Company Ltd.
Drawing No: 0185065b_EIA_REV_CH5_G001_R0_F5.43.mxd
Date: 09/07/2014
Drawing Size: A3
Drawn By: TC
Reviewed By: DN
This figure may be based on third party data or data which has not been verified by ERM and it may not be to scale. Unless expressly agreed otherwise, this figure is intended as a guide only and ERM does not warrant its accuracy.
Figure 5.47 Identified Archaeological Artefacts of the Study Area
Nam Ngiep 1 Hydropower Project
Environmental Impact Assessment Revision
Environmental Resources Management ANZ
Auckland, Brisbane, Canberra, Christchurch, Melbourne, Newcastle, Perth, Port Macquarie, Sydney
ERM

Table 5.29 Identified Archaeological Artefacts

Village name	Object inventory number	Designation	Materials	Size (cm.) Length/ Height	Width	Thick	Weight (gm.)	Provenance (owner), Context of find	Picture
UPSTREAM									
Hom District, Vientiane Province									
Ban Nam Youak	1	stone	stone	9.7	at top: 2.8 at middle: 2.9 at base: 3.5	at top: 0.6 at middle: 1.8 at base: 0.2	-	Mr. Bounma Her, 42, found this object in his paddy field near the village in 2002, during earth work, about 40 cm depth.	
	2	polished shouldered axe/adze	stone	7	at top: 1.3 at middle: 2.4 at base: 2.6	at top: 1.7 at middle: 1.9 at base: 0.2	-	Mr. Kayi Song, 45, found in his paddy field near the village on the Nam Youak bank in 2005	

Village name	Object inventory number	Designation	Materials	Size (cm.) Length/ Height	Width	Thick	Weight (gm.)	Provenance (owner), Context of find	Picture
	3	polished shouldered axe/adze (broken)	stone	7.5	at top: 2.5 at middle: 5.4 at base: -	at top: 2 at middle: 2.3 at base: -	-	Mr.Kayi Song, found in 1999 at a slope of Phu Samliem mountain (about 7-8 Km upstream of Nam Ngiep from Ban Sop Youak.	
	4	polished shouldered axe/adze	stone	8	at top: 4 at middle: 4.9 at base: 5.4	at top: 1.1 at middle: 1.1 at base: 0.1	-	Mr.Kayi Song, found in 2004 in his paddy field near the Nam Youak river bank.	
	5	weight for planting stick	stone	outer diam. 8.4-9.4	hole diam. 2.2	2.9	-	Mr.Kayi Song, found in 2003 at Nam Tong creek.	

Village name	Object inventory number	Designation	Materials	Size (cm.) Length/ Height	Width	Thick	Weight (gm.)	Provenance (owner), Context of find	Picture
Ban Sop Phouan (Ban Nam Phouan)	6	polished shouldered axe/adze	stone	3.8	at top: 1.8 at middle: 4.2 at base: 4.2	at top: 0.8 at middle: 0.9 at base: 0.2	-	Heirloom of Mr. La Her.	
	7	polished shouldered axe/adze	stone	5.2	at top: 1.3 at middle: 3.2 at base: 3.2	at top: 1.1 at middle: 1.3 at base: 0.2	-	Chance find by the parent of Mr. Song Vang in 1997, at the foot hill near the village.	
	8	polished shouldered axe/adze (with broken cutting edge)	stone	13.7	at top: 2.4 at middle: 5.2 at base: 6	at top: 1.2 at middle: 1.6 at base: 0.3	-	Mr. Chungkua Vang, 54, found this object at the foot of a big tree on the slope of Thongbay hill near the village.	

Village name	Object inventory number	Designation	Materials	Size (cm.) Length/ Height	Width	Thick	Weight (gm.)	Provenance (owner), Context of find	Picture
	9	polished axe/adze without shoulders	stone	5.3	at top: 2.1 at middle: 2.5 at base: 2.6	at top: 0.1 at middle: 1 at base: 0.1	-	Mr. Por Sung, 23, found in his paddy field this year.	
Ban Sop Youak (Ban Nong)	10	grinding stone in form of a crescent	stone	27	19	10	-	Mr. Saymao Yang, 45, found 2 pieces of stone objects (no.6 & 7) buried together in horizontal position at about 80 cm depth at his paddy field in 2006.	
	11	weight for planting stick	stone	outer diam. 9-9.2	hole diam. 2.9-3.9	2.7	-	Mr. Saymao Yang, 45, found 2 pieces of stone objects (no.6 & 7) buried together in horizontal position at about 80 cm depth at his paddy field in 2006.	

Village name	Object inventory number	Designation	Materials	Size (cm.) Length/ Height	Width	Thick	Weight (gm.)	Provenance (owner), Context of find	Picture
	12	polished axe/adze without shoulders	stone	5.6	at top: 2.2 at middle: 2.5 at base: 2.6	at top: 0.2 at middle: 1.2 at base: 0.2	-	Mr. Saymao Yang, 45, found in 1995 at his former Ban Sop Youak village, located beyond the right bank of Nam Youak river, on the slope of Phu Katha mountain. During digging post holes of his new house, he found this object at about 1m depth.	
	13	a set of 4 copper bars used as money	copper	12.3-12.6	2.2	0.6	-	These currency bars were found 8 together by Mr. Sithong Song in the paddy field near Huay Pamom creek area, about 1 km from the confluent of Sop Youak.	
	14	jar (rim broken)	clay (stoneware)	16	diam. at neck: 12 max.diam: 20 diam. at base: 12	-	-	This jar was found in 2005 by Mr. Yotua Yang, 43, when digging his rice terraces in the former Ban Nong village near Sop Youak confluent. It was burried 80 cm depth in vertical position, and no content inside.	

Village name	Object inventory number	Designation	Materials	Size (cm.) Length/ Height	Width	Thick	Weight (gm.)	Provenance (owner), Context of find	Picture
	15	polished shouldered axe/adze	stone	9.5	at top: 2.5 at middle: 4.3 at base: 5.3	at top: 1.3 at middle: 2.2 at base: 0.2	-	Heirloom of Mr. Kou Yang, 33. His parent moved from former Ban Sop Youak.	
	16	polished axe/adze without shoulders	stone	7.7	at top: 3.6 at middle: 4.2 at base: 5.9	at top: 1.3 at middle: 1.8 at base: 0.2	-	Heirloom of Mr. Kou Yang, 33. His parent moved from former Ban Sop Youak.	
	17	polished shouldered axe/adze	stone	4.8	at top: 1.7 at middle: 3.5 at base: 3.7	at top: 1.2 at middle: 1.6 at base: 0.2	-	This stone tool was found in the cassava plantation of Mr. Vacheu Song, 54, in the area of the old Ban Sop Youak in 1987.	

Village name	Object inventory number	Designation	Materials	Size (cm.) Length/ Height	Width	Thick	Weight (gm.)	Provenance (owner), Context of find	Picture
	18	polished axe/adze without shoulders	stone	2.4	at top: 1.7 at middle: 2 at base: 2.3	at top: 0.8 at middle: 0.8 at base: 0.1	-	This object was found together with others stone tools of similar size and shape, kept in a small pottery pot. The younger brother of Mr. Acheu Song discovered in 1986 then distributed one to each of his family member.	
DOWN STREAM Borikhan District, Bolikhamxay Province									
Ban Hatsaykham	19	polished shouldered axe/adze	stone	17	at top: 1.7 at middle: 3.1 at base: 3.5	at top: 1.7 at middle: 1.7 at base: 0.3	-	Mr. Yeu Song, 54, found this stone tool in Nam Ngiep river during fishing in 2006.	
	20	Bhudda cave	-	-	-	-	-	Buddha cave is located approximately 6 km from Ban Hatsaykham, upstream and on the right bank of Nam Ngiep river. The cave approximately 200 m further inland, at the foothill of Phu Hong, a mountain that belongs to the Phu Kata range. Three bronze statues survived the looting and were then moved to the Bhuddist temple in Ban Hat Gniun for their security.	-

Village name	Object inventory number	Designation	Materials	Size (cm.) Length/ Height	Width	Thick	Weight (gm.)	Provenance (owner), Context of find	Picture
Ban Thahuea	21	Buddha image	bronze	-	-	-	-	This bronze buddha image was found in the ruins of an old temple (site no.1) located on the opposite bank of the actual Ban Thahuea village in 2006, now kept in the new temple.	
	22	Ancient Buddhist temple, Site No.1	brick	-	-	-	-	The site No.1 is located on the right bank of flat terrace of Nam Xao river. The brick structure is situated about 20 m from the river bank. According to the limit of the mound, its shape seems to be rectangular about 8x16 m, orient east-west and 2.5 m high without any precious shape can be survived. The size of bricks is 5 x 11 x 23 m and 5 x 12 x 24 m. Probably the upper structure of this temple is made of wood and cover with roof tiles. The evidence of roof tile still be found in situ.	 

Village name	Object inventory number	Designation	Materials	Size (cm.) Length/ Height	Width	Thick	Weight (gm.)	Provenance (owner), Context of find	Picture
	23	Ancient Buddhist temple, Site No.2	-	-	-	-	-	The site No. 2 is located approximately 100 m south of the site No. 1. A platform of bricks about 1 m high was remained visible on the surface. A big hole about 2 x 2 m and 1.50 m deep indicates a recent vandalism of this site.	 
	24	Ancient Buddhist temple, Site No.3	brick	-	-	-	-	This site is located about 400 m south-west of the site No. 2. Its size is approximately 12 x 18 m, oriented NE-SW. The brick platform remained is about 2 m high. Brick size: 6 x 12 x 24.	

Source: Preliminary archaeological survey of Nam Ngiep 1 Hydropower Project, Department of Museums and Archaeology, 2007.

The *Biodiversity Baseline Assessment Report (**Appendix A**)* also addresses cultural resources within the Project area. According to the report, numerous locally collected polished stone tools have been found in the Project area, indicating human occupation in the area occurred between 4,000 and 12,000 years ago. However, most of the existing villages were settled in the early-1980s and 1990s.The most significant social, religious and cultural sites people were able to identify (during the surveys) in villages in the Project area were grave sites. Reflecting the severable nature of connections people have with grave sites, villagers indicated that the ancestor spirits associated with such grave sites are transferrable to a new location through the performance of a complex ceremony conducted by the village shaman (called a Yao in the surveyed villages).

Each of the Hmong villages visited in the lower reservoir zone had a shaman residing there. Each house has a small shrine that is used by the shaman for ceremonies. According to local beliefs, the shaman is essentially a conduit between the human and spirit worlds. Sickness among Hmong is believed to be the result of contact with evil spirits. At risk of overgeneralising, the shaman's supposed role is to free a person's spirit (or soul) from the malevolence brought through this contact with spirit world. The shaman was identified in these villages as the person most dependent on the naturally occurring forest, though little detail was able to be collected about the extent of this dependence.

Naturally occurring bamboo is used by both Lao and Hmong to make ananimist symbols that are hung above doorways to ward off evil spirits.

5.2 *FISHERIES*

A dry season survey of fisheries was undertaken along Nam Ngiep River in January 2008 at ten stations: six located downstream from the proposed dam and the other four located upstream. A study was undertaken by Theo Visser that analysed the data provided on fisheries within the project area. Village surveys were also completed as part of the survey to determine catches of fish, including amount and species.

The village communities along the Nam Ngiep mainly fish during the onset of the rainy season and towards the end of the rainy season with supplementary fishing during the dry season in deep pools and below rapids. The results of the analysis for fishing related activities are contained in ***Table 5.30***.

Table 5.30 Percentage of Households Involved in Fishing Activities

Village	Fisheries Participation			Fisheries contribution to Total Annual Income	Households receiving Income from Fisheries Activities
	Daily	Weekly	Monthly		
Piengta	20.3%	49.4%	13.9%	1.4%	52.4%
Hatsamkhon	6.8%	6.8%	5.5%	2.5%	40.5%
Pou	11.0%	22.1%	9.7%	3.5%	100.0%
2 UR Zone	12.5%	25.6%	9.8%	2.8%	74.7%
Hatsaykham	81.8%	15.2%	0.0%		
Hat Gniun	16.4%	70.1%	28.4%	6.1%	9.9%
Somsuen	4.9%	61.0%	14.6%	1.3%	11.3%
Thahuea	0.0%	0.0%	0.0%	1.9%	96.0%
Nampa	31.3%	43.8%	81.3%	9.5%	22.6%
Houykhoun	14.5%	53.2%	3.2%	1.0%	2.8%
Thong Noi	15.4%	53.8%	0.0%	2.3%	27.9%
Thong Yai	0.0%	25.0%	12.5%	6.7%	24.4%
Phonsy	27.6%	44.8%	3.4%	12.2%	85.8%
Nam Ngiep	23.8%	28.6%	14.3%	4.3%	28.9%
Sanoudom	50.0%	5.6%	16.7%	0.0%	0.0%
Downstream	15.3%	43.4%	14.2%	3.5%	23.5%
Total	17.3%	34.2%	11.5%	3.1%	32.9%

The villages included in zone 2 Lower Reaches were not included in the census data provided, some seem to have been deserted/moved.

Source: Theo Visser, 2008.

The data for the intensity with which household's fish included in is not mutual exclusive between categories and thus this doesn't allow assessing the total number of fishing households. However it should be assumed that nearly all households fish at some time of the year, except in large population centres where more livelihood specialisation occurs.

Although there is no indication during what time of the year the data was collected, assuming that it represents the same period, it is clear that there are large differences between villages in the indicated importance of fishing as a livelihood. Villages in the lower reaches of the Nam Ngiep have a much higher occurrence of households that fish on a daily basis and hence are more likely to fish for supplemental income. This probably is caused by the proximity of mainstream Mekong and backwater effect during the flood season that would create better opportunities for fishing. Furthermore the occurrence of households that indicate that they are fishing on a daily basis is especially high for Hatsaykham, at the proposed dam site. This may be because of expected compensation for loss of fishing grounds, or perhaps due to an existing natural feature like rapids with deep pools that could explain fish aggregating at that location.

The information on actual income seems to support the above trends, fishing is somewhat more important in the lower reaches of the Nam Ngiep. According to the census data, fisheries is generally a lot less important for household income than other income generating activities, especially agriculture/livestock tends to be important as well as small business and daily labour in some villages. Fisheries are comparable in importance to collection of NTFPs. However the interpretation of income data is heavily dependent on how the data was collected. Data on income is notoriously difficult to collect accurately, more so when a census is used as the only instrument for data collection. However even if the actual income levels are inaccurate, it is probable that the relative importance between sources of income is representative of the actual situation given that the same methodology is used for all categories. This would suggest that daily catches may be quite low or that access to markets is limited or simply that the importance of the fisheries lies in food security and supplemental income and only is important seasonally. ***Table 5.31*** outlined the proportion of household owning a boat and the proportion of catch put for sale.

Table 5.31 ***Proportion of Households Owning a Boat and Proportion of Catch for Salesale***

Village	Paddle Boat	Motor Boat	Mainly Sale
Piengta	29.1%	31.6%	12.7%
Hatsamkhon	24.7%	32.9%	13.7%
Pou	37.2%	35.9%	2.8%
2 UR Zone	32.0%	34.0%	8.1%
Hatsaykham	33.3%	57.6%	18.2%
Hat Gniun	61.2%	16.4%	14.9%
Somsuen	46.3%	7.3%	7.3%
Thahuea	0.0%	0.0%	0.0%
Nampa	43.8%	25.0%	25.0%
Houykhoun	25.8%	38.7%	8.1%
Thong Noi	3.8%	30.8%	0.0%
Thong Yai	0.0%	6.3%	0.0%
Phonsy	48.3%	24.1%	0.0%
Nam Ngiep	14.3%	42.9%	9.5%
Sanoudom	38.9%	11.1%	11.1%
Downstream	31.2%	19.9%	7.5%
Total	31.7%	28.0%	8.3%

Source: Theo Visser, 2008.

Despite the seemingly low level of contribution to household income a large number of households own (or have access to) a boat as shown in ***Table 5.31***. As with the previous census data on frequency of fishing, it is not clear if the data on paddle boats and motorised boats is mutually exclusive as the boat engine is detachable and thus a better question would have been to ask if the households owns a boat engine. Regardless, the available data indicates that a relatively large number of households have access to a boat and a third of the households also have access to a motorised boat. That the households upstream seem to have a somewhat higher proportion of households with motorised boats probably reflects the lack of road access and thus the reliance on river transport.

As shown in ***Table 5.31***, around 8% of the households indicate that more than 50% of the catch is sold. Furthermore, the large differences between villages, with four downstream villages indicating none of the households sell more than 50% of their catch and a comparison with the 2012 fish consumption survey make it likely that this is an over-simplification of the actual situation. Information on food consumption from the census clearly indicates that fish is the single most important source of animal protein with over 85% of the households eating it every week.

In summary the impression is that currently almost all households are involved in fishing on a part-time basis. Most fishing is done close to the settlement areas and is only of importance during the wet season when fish migrate upstream in the Nam Ngiep basin from the Mekong River. Fishing is foremost conducted for consumption of fresh fish with occasional processing and fish trading when large quantities or large fish are caught. Catches tend to be low mainly with gillnet and mainly catch small indigenous cyprinids. There doesn't seem to be an established trade network nor any form of management or fishermen organisation.

5.3 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***).

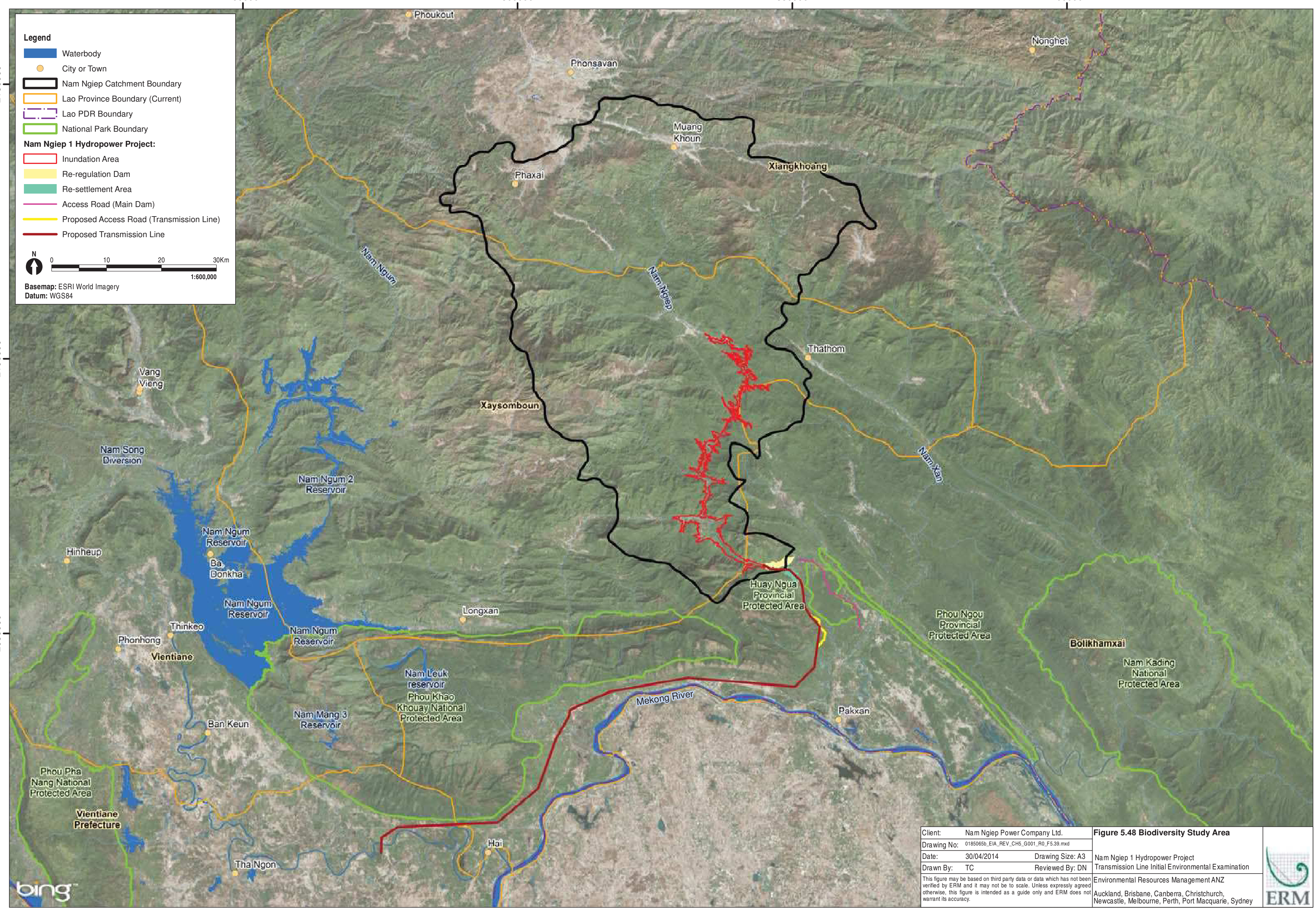
The description of the biological environment focuses on developing an understanding of the biodiversity directly and indirectly relevant to the Project and its activities. For the purposes of this assessment, the following terminology applies:

- Study area – the area encompassing all areas assessed for biodiversity values. This includes the Project are and candidate offset sites (***Figure 5.48***).
- Project area (the focus of this impact assessment) – the area potentially directly and indirectly affected by the Project. This area is consistent with the Project 'area of influence' in accordance with the ADB SPS. This includes the footprint of disturbance of the various project components (direct impact area) as well as areas of the wider Nam

Ngiep River catchment (indirect impacts).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 km northeast from Vientiane or 50 km north from Pakxan District.



Client:	Nam Ngiep Power Company Ltd.
Drawing No:	0185065b_EIA_REV_CH5_G001_R0_F5.39.mxd
Date:	30/04/2014 — Drawing Size: A3
Drawn By:	TC — Reviewed By: DN

This figure may be based on third party data or data which has not been verified by ERM and it may not be to scale. Unless expressly agreed otherwise, this figure is intended as a guide only and ERM does not warrant its accuracy.

Figure 5.48 Biodiversity Study Area

Nam Ngiep 1 Hydropower Project
Transmission Line Initial Environmental Examination

Environmental Resources Management ANZ

Auckland, Brisbane, Canberra, Christchurch, Newcastle, Melbourne, Perth, Port Macquarie, Sydney

ERM

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 127 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.*

5.3.1 *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 inspection (direct data), interviews with villagers (indirect data) 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 a number of additional field investigations were undertaken in 2013 and 2014:

- 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.
- Field reconnaissance were 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 and 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.

- Targeted survey specific to threatened primate species and their habitats within the inundation area were undertaken by Dr Phaivanh Phiopalath in December 2013.
- Targeted fast water habitat survey for fish species was undertaken by Dr Kottelat in 2014.
- Critically endangered fish species habitat assessment was undertaken in the Nam Ngiep and other catchments across Lao PDR by a team led by Mr Terry Warren Warren in 2014.

These sources provide description of vegetation communities and habitats, and species that may occur in the Project area and information used to identify biodiversity values. The outcomes are included as part of the baseline assessments and reported in three supporting reports provided in Appendix A, E and F. A summary of the survey methods, including the key literature references, is provided in ***Table 5.32.***

Table 5.32 Summary of Survey Methods and Information Sources

Researcher	Date	Location	Study Topic
Terrestrial			
Dr Will Duckworth	November 2013	Main dam and inundation area	• Peer review of critical habitat assessment for IUCN red list species detected during survey
Dr Phaivanh Phiapalath	November 2013	Main dam inundation area	• Targeted IUCN listed primate species survey and critical habitat assessment

Pheng Phengsintham[12]	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	NNP1 Project area (from the	• Interview of local residents • Targeted searches of fauna or signs of

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

Researcher	Date	Location	Study Topic
	2007	dam site north)	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 2007	Ten stations including stations at Hatsaykham, Hat Gniun and Xomxeun.	• Fish sampling using a seine net • Plankton sampling • Benthic sampling
PAFO	Date unknown	Huay Ngua PPA	• Interview of local residents • Camera trapping
Dr M Kottelat	March 2014	Nam Ngiep River	• Endemic and migratory fish
Mr Terry Warren	March – May 2014	Nam Ngiep River	• *Lucioprynius striolatus* assessment for distribution and habitat areas

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.

5.3.2 *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 Provincial Protected Area (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. The PPA, as it stands, does not meet any reserve classifications under the IUCN classifications schedule.

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 neighboring countries. 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 national protected area near Vientiane and to the South of the project area 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.

5.3.3 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.

5.3.3.1 Land Cover

The Lao landscape has historically been dominated by dense forest and, despite more recent clearance, retains significantly more forest coverage than neighboring 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 ADB definition, can be identified within the Project Area (refer to ***Table 5.33*** and ***Figure 5.49***).

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.

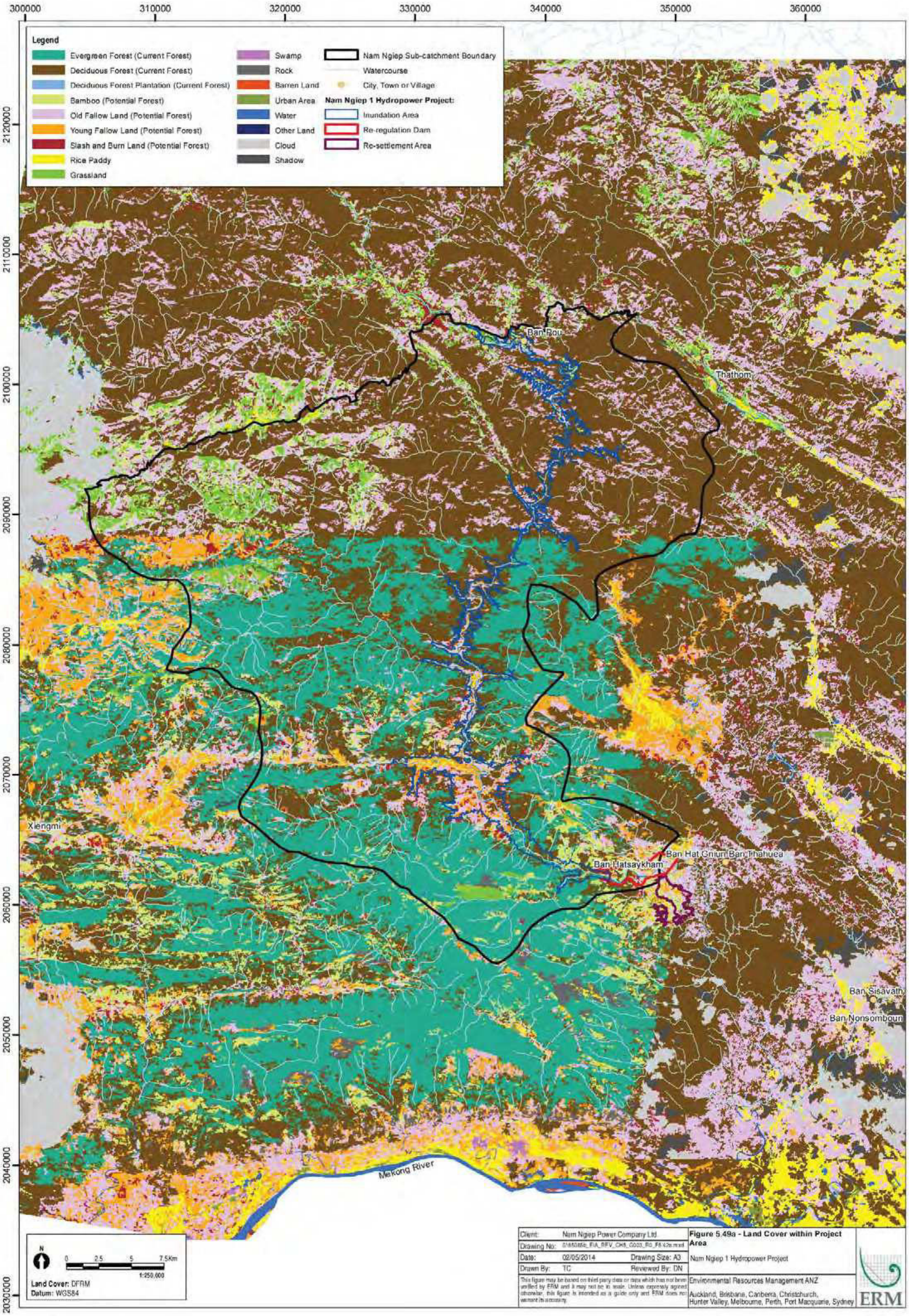
Within the main dam, approximately 50 per cent of the area is mapped as natural habitat with deciduous forest the dominant land cover type. Patches of natural habitat are dispersed throughout the main dam inundation area though it is the narrower stretches of the inundation area where the majority of 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.



Legend
Evergreen Forest (Current Forest)
Deciduous Forest (Current Forest)
Deciduous Forest Plantation (Current Forest)
Bamboo (Potential Forest)
Old Fallow Land (Potential Forest)
Young Fallow Land (Potential Forest)
Slash and Burn Land (Potential Forest)
Rice Paddy
Grassland
Swamp
Rock
Barren Land
Urban Area
Water
Other Land
Cloud
Shadow
Nam Ngiep Sub-catchment Boundary
Watercourse
City, Town or Village
Nam Ngiep 1 Hydropower Project:
Inundation Area
Re-regulation Dam
Re-settlement Area
300000
310000
320000
330000
340000
350000
360000
2120000
2110000
2100000
2090000
2080000
2070000
2060000
2050000
2040000
2030000
Ban Pou
Thathom
Xiengmi
Ban Hatsaykham
Ban Hat Gniun
Ban Thahuea
Ban Sisavathy
Ban Nonsomboun
Mekong River
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0
2.5
5
7.5Km
1:250,000
Land Cover: DFRM
Datum: WGS84
Client: Nam Ngiep Power Company Ltd
Drawing No:
Date: 02/05/2014
Drawing Size: A3
Drawn By: TC
Reviewed By: DN
This figure may be based on third party data or data which has not been verified by ERM and it may not be to scale. Unless expressly agreed otherwise, this figure is intended as a guide only and ERM does not warrant its accuracy.
Figure 5.49a - Land Cover within Project Area
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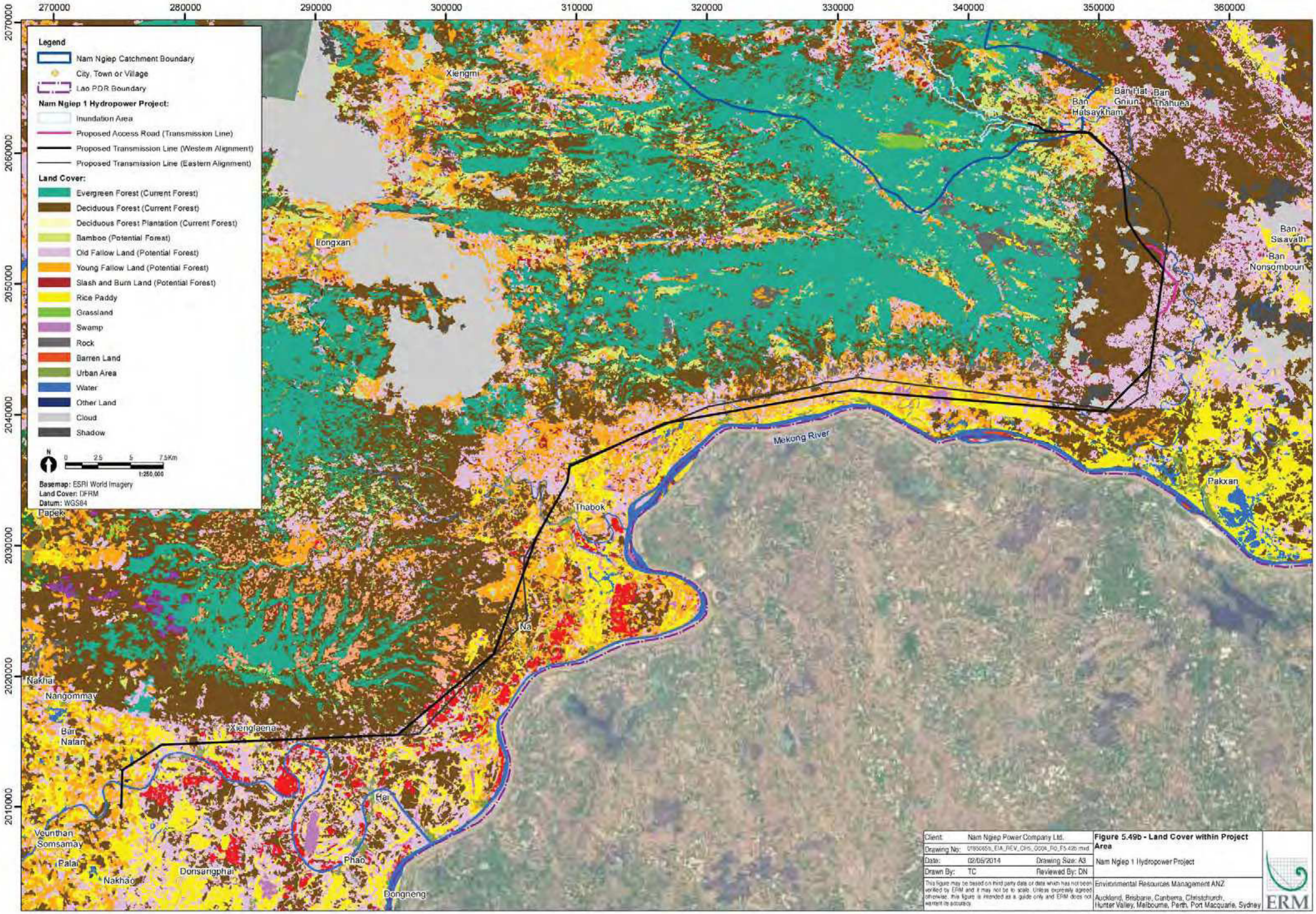

Client:	Nam Ngiep Power Company Ltd.	Figure 5.49b - Land Cover within Project Area
Drawing No:	0185065b_EIA_REV_CH5_G004_FIG_F5.49b.mxd	Nam Ngiep 1 Hydropower Project
Date: 02/05/2014	Drawing Size: A3	
Drawn By: TC	Reviewed By: DN	

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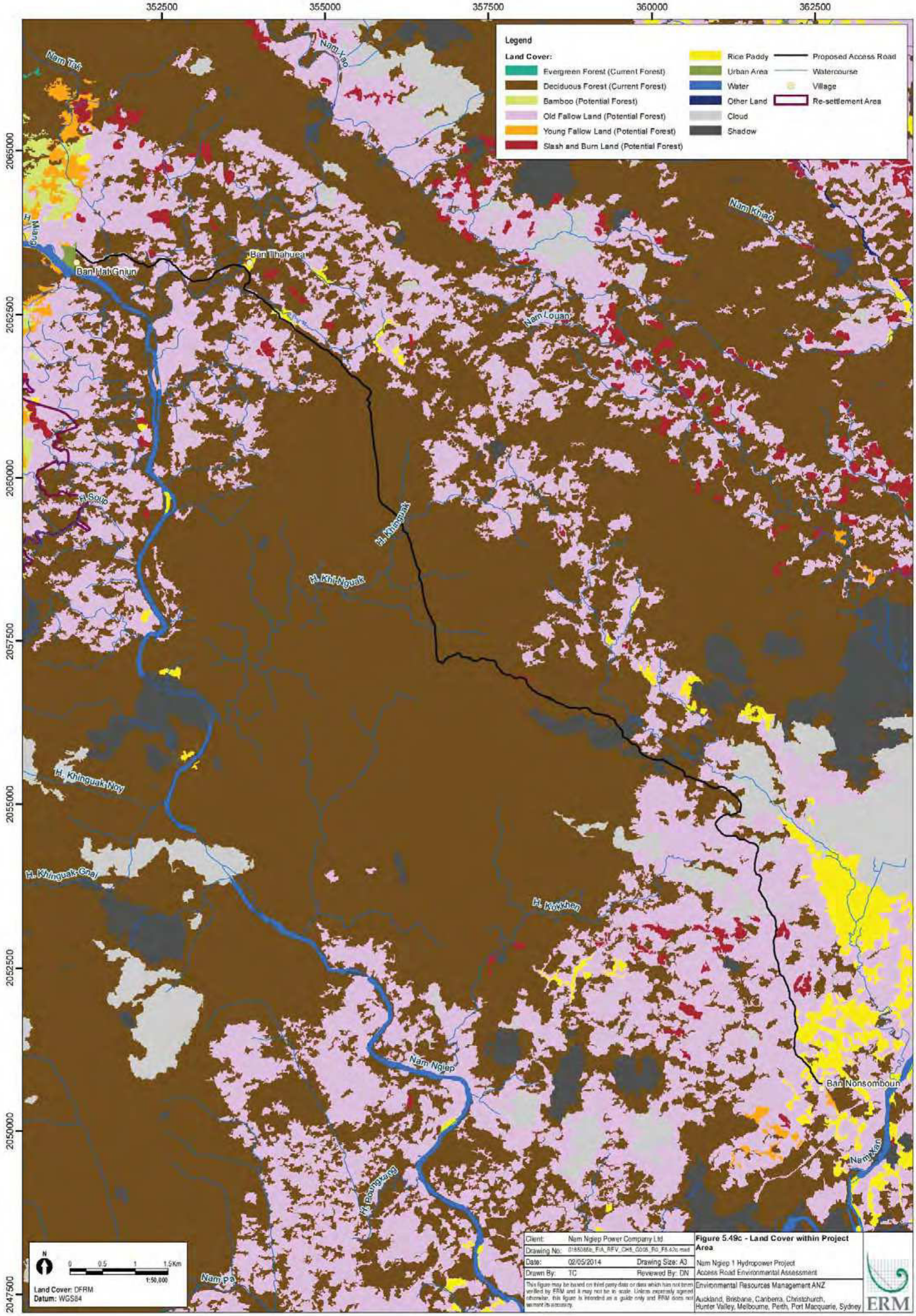


Figure 5.49c - Land Cover within Project Area

Table 5.33 Landcover within the Project Areas

Land Cover	IFC Habitat Class	Description	Area (ha) Main dam	Re-regulation dam	Resettlement	Access Road*	Transmission Line#	Total (ha)	% of Total
Natural Habitat								196,328	
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.	2,690	131	56	19	122	3,018	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 agriculture 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								96,139	
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.	1,321	194	163	12	124	1,814	21%
Young fallow land (YFL)	M	Land that has been recently ploughed and tilled and left un-seeded during a growing season.	1,036	143	82	5	68	1,334	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								8,3924	
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%

Land Cover	IFC Habitat Class	Description	Area (ha)					Total (ha)	% of Total
			Main dam	Re-regulation dam	Resettlement	Access Road*	Transmission Line#		
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	6,741	696	467	51	404	8,359	

Source: ERM, 2013.

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

5.3.3.2 *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 5.50*** and the area of each classification is detailed within ***Table 5.34***.

Table 5.34 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 Gniun	<1	1	6	3

Forest type	Impacted (- to 0)	Low (0 - 0.4)	Moderate (0.4 - 0.6)	High (0.6 - 0.8)
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%

Source: ERM, 2013.

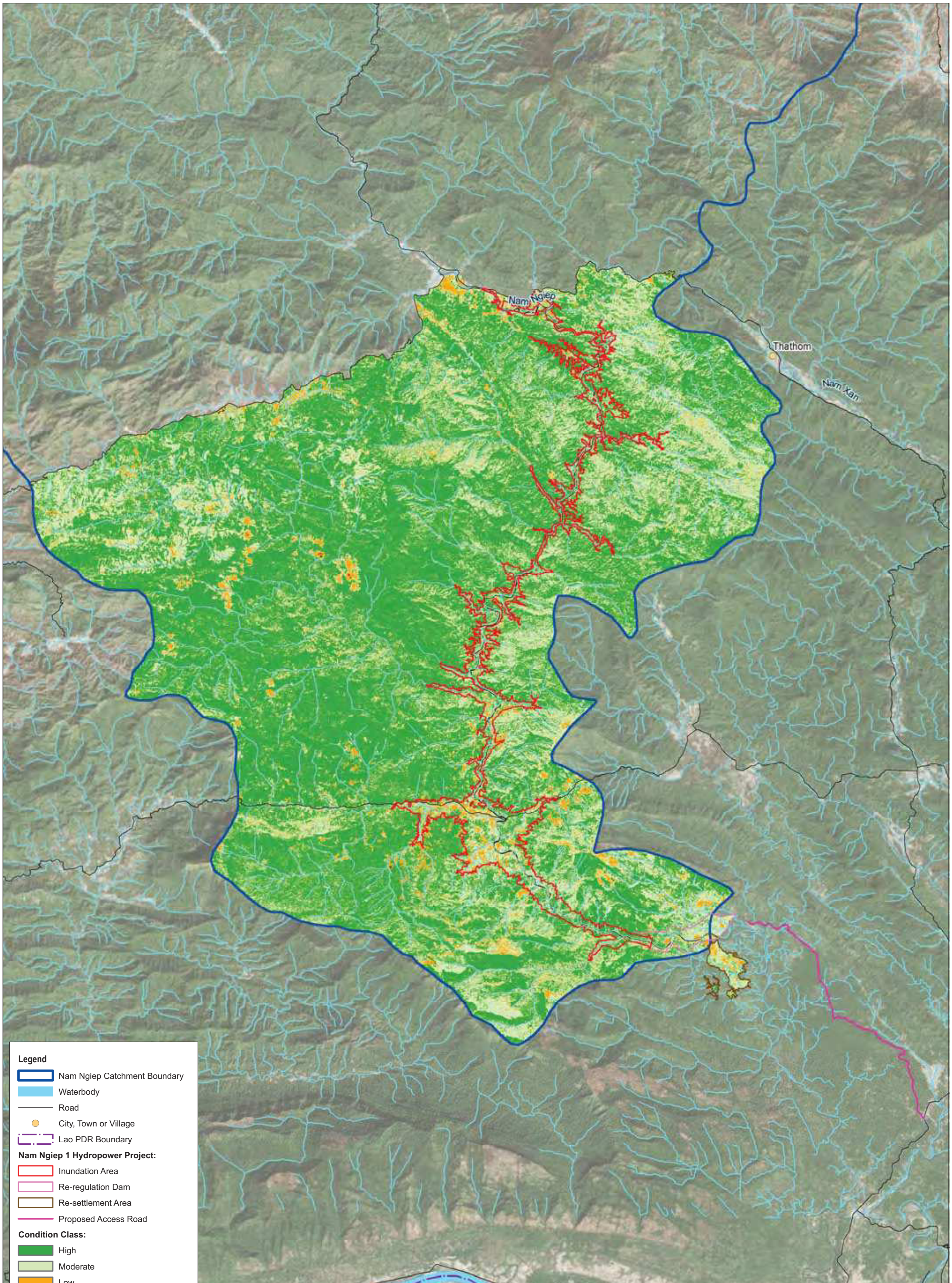
Over 80 per cent of the Project Area is classified as moderate or high NDVI. Only 5 per cent of the Project Area is classified as impacted NDVI.

5.3.3.3 *Forestry Classification Mapping*

Forestry classification mapping identifies both protection forest and production forest across the Project Area. ***Figure 5.51*** 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.



Client:	Nam Ngiep Power Company Ltd.		Figure 5.50 Vegetation Condition (NDVI) Map A within Project Area
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Date:	13/09/2013	Drawing Size: A3	
Drawn By:	TC	Reviewed By: DN	
This figure may be based on third party data or data which has not been verified by ERM and it may not be to scale. Unless expressly agreed otherwise, this figure is intended as a guide only and ERM does not warrant its accuracy.			Environmental Resources Management ANZ Auckland, Brisbane, Canberra, Christchurch, Hunter Valley, Melbourne, Perth, Port Macquarie, Sydney

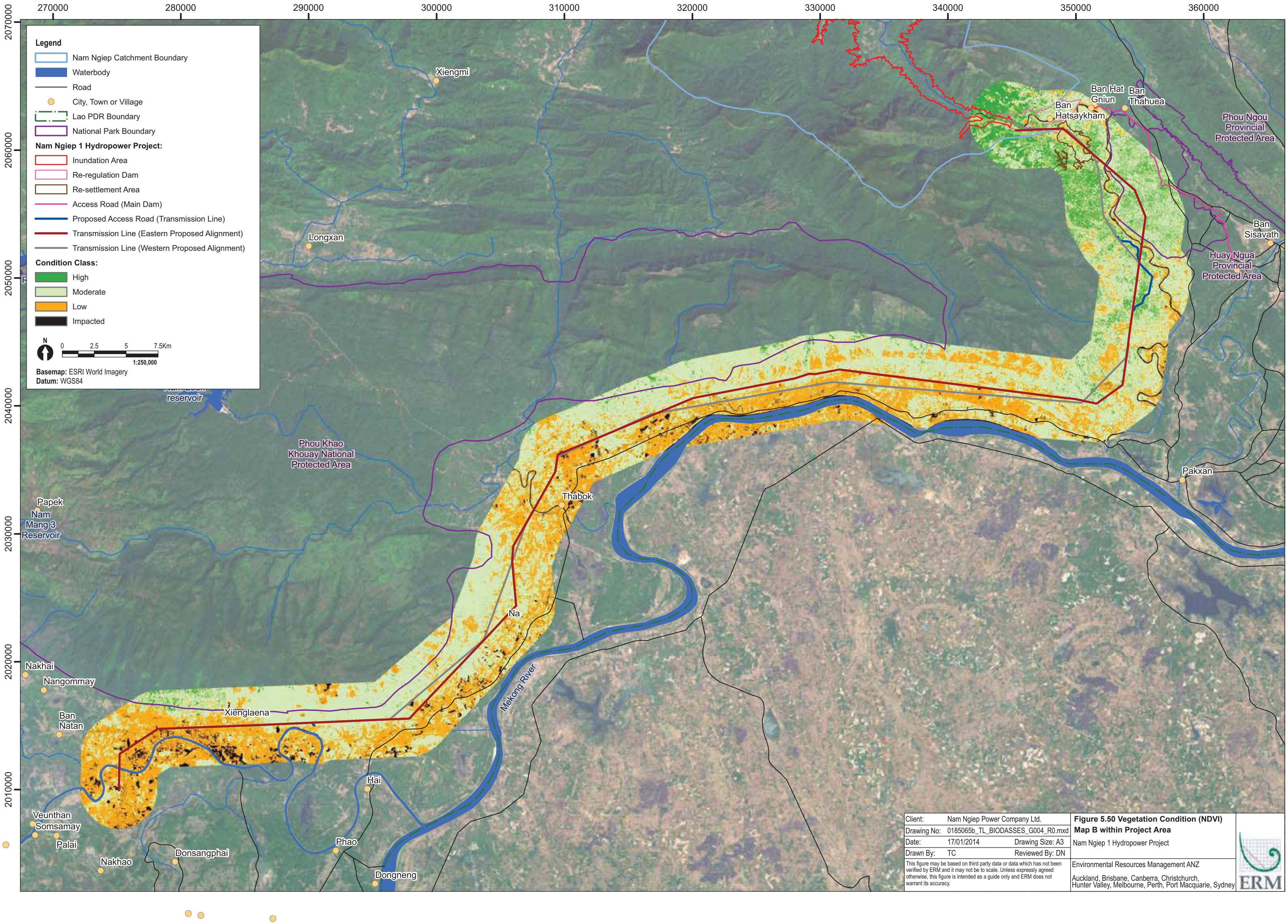
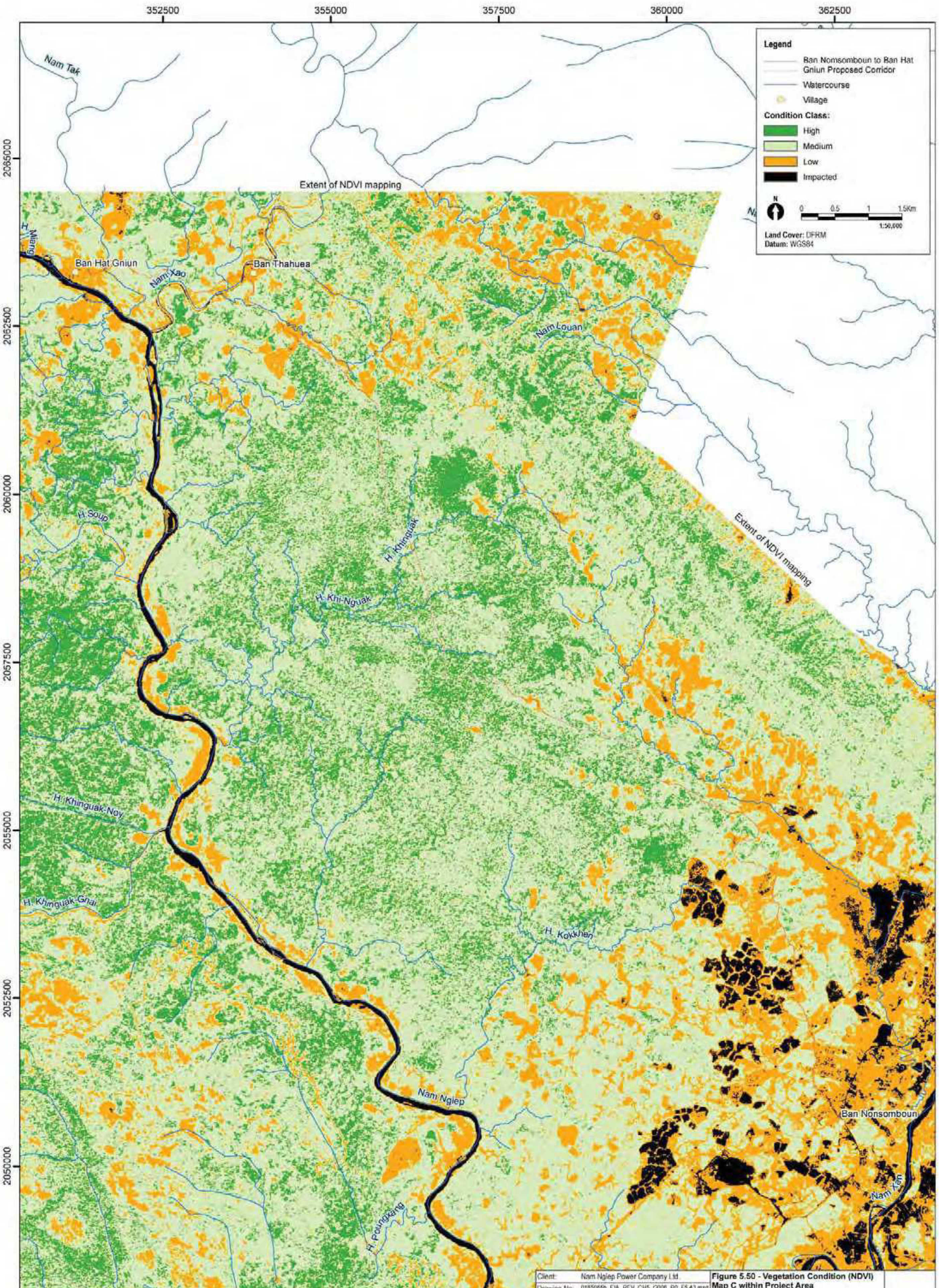


Figure 5.50 Vegetation Condition (NDVI) Map B within Project Area



Client:	Nam Ngiep Power Company Ltd.		
Drawing No:	0185065b_EIA_REV_CH5_G006_R0_F5.43.mxd		
Date:	02/05/2014	Drawing Size: A3	
Drawn By:	TC	Reviewed By: DN	

Figure 5.50 - Vegetation Condition (NDVI) Map C within Project Area

Nam Ngiep 1 Hydropower Project

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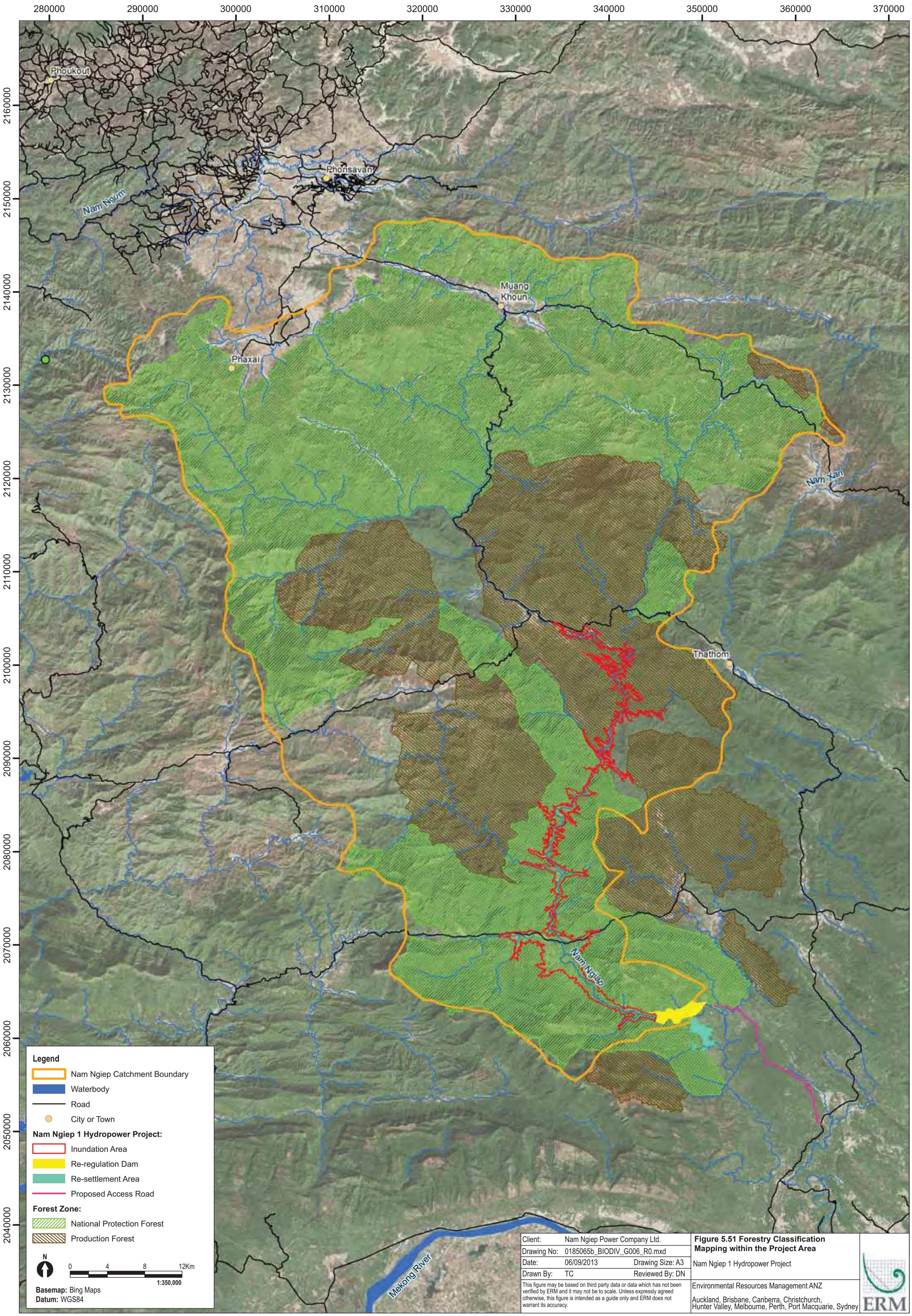

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Nam Ngum
Muang Khoun
Phaxai
Nam Xan
Thathom
Nam Ngiep
Mekong River
Legend
Nam Ngiep Catchment Boundary
Waterbody
Road
City or Town
Nam Ngiep 1 Hydropower Project:
Inundation Area
Re-regulation Dam
Re-settlement Area
Proposed Access Road
Forest Zone:
National Protection Forest
Production Forest
N
0 4 8 12Km
1:350,000
Basemap: Bing Maps
Datum: WGS84
Client: Nam Ngiep Power Company Ltd.
Drawing No: 0185065b_BIODIV_G006_R0.mxd
Date: 06/09/2013
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Drawn By: TC
Reviewed By: DN
This figure may be based on third party data or data which has not been verified by ERM and it may not be to scale. Unless expressly agreed otherwise, this figure is intended as a guide only and ERM does not warrant its accuracy.
Figure 5.51 Forestry Classification Mapping within the Project Area
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ERM

5.3.3.4 *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 5.35***).

Table 5.35 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 5.36***). 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 5.36 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. ERM, 2013.

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.

The main Project components will not be located within National Biodiversity Conservation Areas; only the access road between Ban Nonsomboun to Ban Hat Gniun will pass through the Houay Ngua Provincial Protected Area. Details regarding assessment of potential environmental impacts from this access road are presented in ***Appendix E***.

5.3.4 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 5.3.4.1* below.

The primary vegetation types at each of the components of the Project is summarised in ***Table 5.37*** based on the 2013 TISTR survey results.

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

Table 5.37 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.

Source: ERM 2013.

For the forest types the forest canopies are divided in 3 classes. The dominant species for each survey locations are summarised in ***Table 5.38***.

Table 5.38 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*.

Source: ERM, 2013.

5.3.4.1 *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 5.39***).

Table 5.39 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

Source: ERM, 2013.

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 5.3.11*). 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.

5.3.5 *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 an 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 5.40***.

Table 5.40 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
	Sum Average for all species Forest		**72.7**		**2,677**

Source: Environmental Impact Assessment Report, ERIC, 2012.

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 5.41*** presents the main species of NTFPs found within the Project Area.

Table 5.41 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 (Bloom grass)	*Erianthus arundinaceus(Retzius)*
4	Kha Khom	*Alpinia Malaccensis*	Man Paa (Groundnut)	*Adinandra laotica Gagnepain*
5	Nhot Khon Khen		Man Koy (Groundnut)	*Discorea hippida 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*

No	Dry Evergreen and Mixed Deciduous Forest		Unstocked Forest	
	Lao Name	**Scientific Name**	**Lao Name**	**Scientific Name**
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*		

Source: Environmental Impact Assessment Report, ERIC, 2012.

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).

5.3.6 *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;[13] 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, and 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 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 5.52.***

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

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

the main dam. The habitat and species detected at each of the main surveyed areas are summarised in ***Table 5.42***.

Table 5.42 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 new 125 km transmission line alignment proposed will not pass through the Huay Ngua PPA. The alignment remains on the west bank of Nam Ngiep River, passing the eastern site of Huay Ngua PPA and rejoins the original alignment south of Huay Ngua PPA..

Source: ERM 2013.

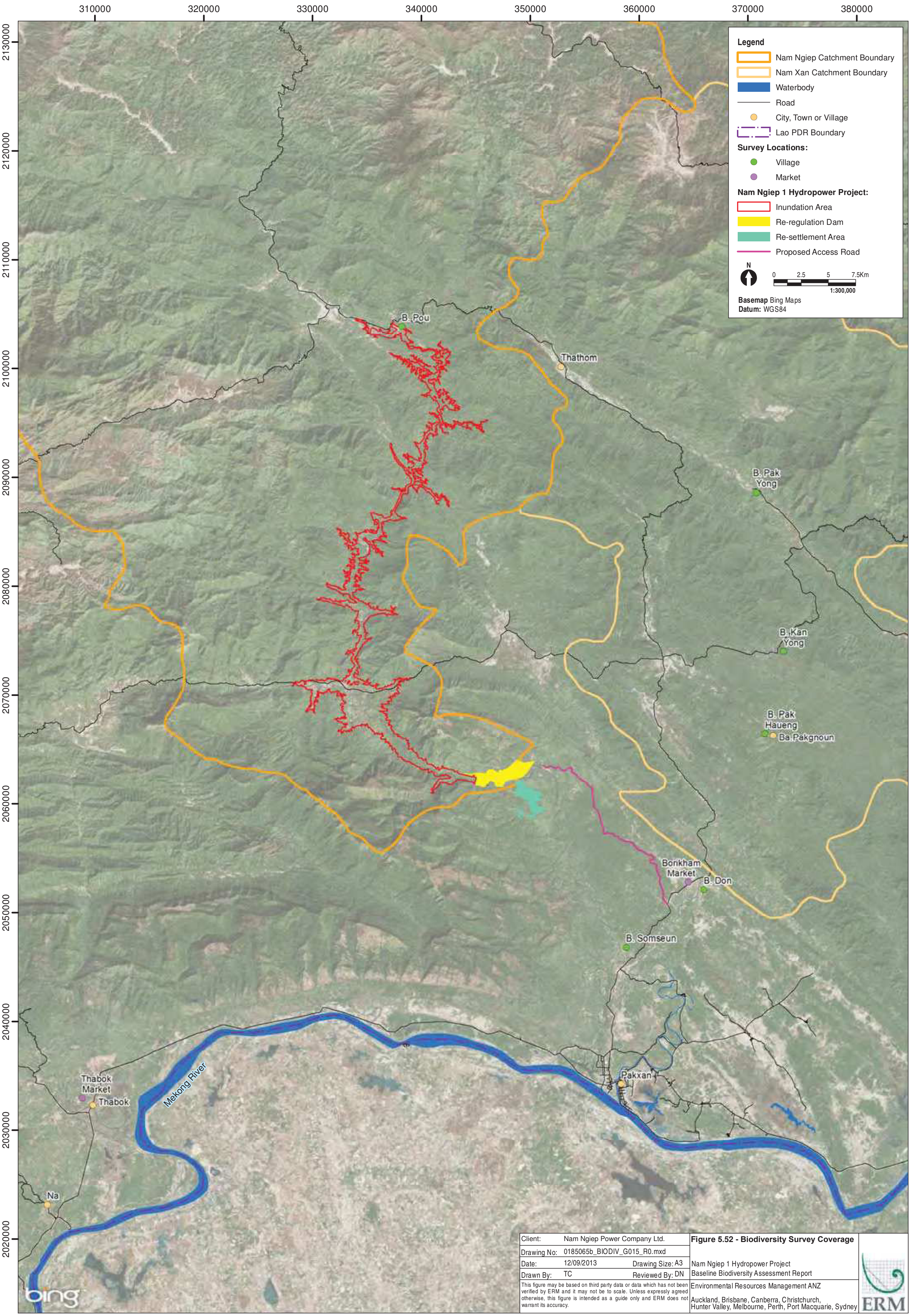


Figure 5.52 - Biodiversity Survey Coverage

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 threatened and protected species and biodiversity.

5.3.6.1 *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 5.3.11*.

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 5.43 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 5.43 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					
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

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
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 megacephalum*	R	EN	x		x		x	x
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

Source: ERM, 2013.

5.3.6.2 *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 5.3.11*).

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.

5.3.7 *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 Pakxan. 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 m^3/s) occur between June and September with lowest discharge volumes (50-75 m^3/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.

5.3.8 *Aquatic Habitats*

Aquatic riverine and tributary habitats were assessed during TISTR 2013 site surveys. Seasonal variation was observed in terms of water depth, clarity, flow and wetted width. Habitat characteristics recorded are summarised in ***Table 5.44.***

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 5.44 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

Source: Environmental Impact Assessment Report, ERIC, 2012.

5.3.9 *Aquatic Biota*

5.3.9.1 *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).

Targeted fast water survey in the Nam Ngiep detected 56 species (53 within the main dam inundation area and 34 outside the main dam inundation area).

A full species list is provided in the Nam Ngiep 1 Hydropower Project - Biodiversity Baseline Assessment Report (***Appendix A***).

5.3.9.2 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 Nam Ngiep 1 Hydropower Project - Baseline Biodiversity Report (***Appendix A***).

5.3.9.3 Threatened Fish Species

Aquatic surveys across the Project area detected eleven species listed as critically endangered, endangered or vulnerable on the IUCN Red List (summarised in ***Table 5.45).*** Species listed as critically endangered or endangered are considered candidates for critical habitat and these species records have been queried further in *Section 5.3.11.* 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 5.45 IUCN Listed Fish Species Reported within the Project Area

Family/Common Name	Scientific Name	EIS 2012		TISTR Survey 2013				Kottelat Survey 2014		IUCN Status
		Inside Project area	**Outside Project area**	**Upper Nam Ngiep**	**Lower Nam Ngiep**	**Huay Ngua**	**Resettlement Site**	**Upper Nam Ngiep**	**Lower nam Ngiep**	
Giant barb	*Catlocarpio siamensis*					x				CR
Leaping barb	*Laubuca caeruleostigmata*			13					x	EN
Striped catfish	*Pangasianodon hypothalamus*					x			x	EN
	Lucioprynus striolatus							x		EN
Thicklipped barb	*Probarbus labeamajor*					x				EN
Mrigal carp	*Cirrhinus cirrhosus*				2					VU
	Hemimyszon confluens							x	x	VU
	Labeo pierrei							x		VU
	Rhinogobius albimaculatus							x		VU
Bandan sharp-mouth barb	*Scaphognathops bandanensis*					3				VU
Jaguar loach	*Yasuhikotakia splendida*				1	4		x		VU

Source: ERM, 2013.

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

5.3.10 *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.

5.3.11 *Priority Biodiversity Values*

The ADB Safeguard Policy Statement (2009) and Environment Safeguards Good Practice Sourcebook (2012) (the 'Source Book') describes habitat area categories to be considered including modified habitat, natural habitat and critical habitat. The Asian Development Bank Environmental Safeguards Good Practice Source Book (the 'Source Book') (ADB 2012) contain specific requirements for different habitat types that relate to their likely conservation value. These categories provide a mechanism to rank areas of importance across the site. .

The baseline assessment describes the modified and natural habitats in accordance with the SPS and Source Book and has undertaken an assessment to identify the presence of critical habitat that may directly or indirectly impacted by the Project. The assessment identifies critical habitat in accordance with the definitions of the SPS and draws upon the criteria and thresholds defined by international guidelines.

5.3.11.1 *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 5.53*** shows the distribution of these modified land uses within the Project Area.

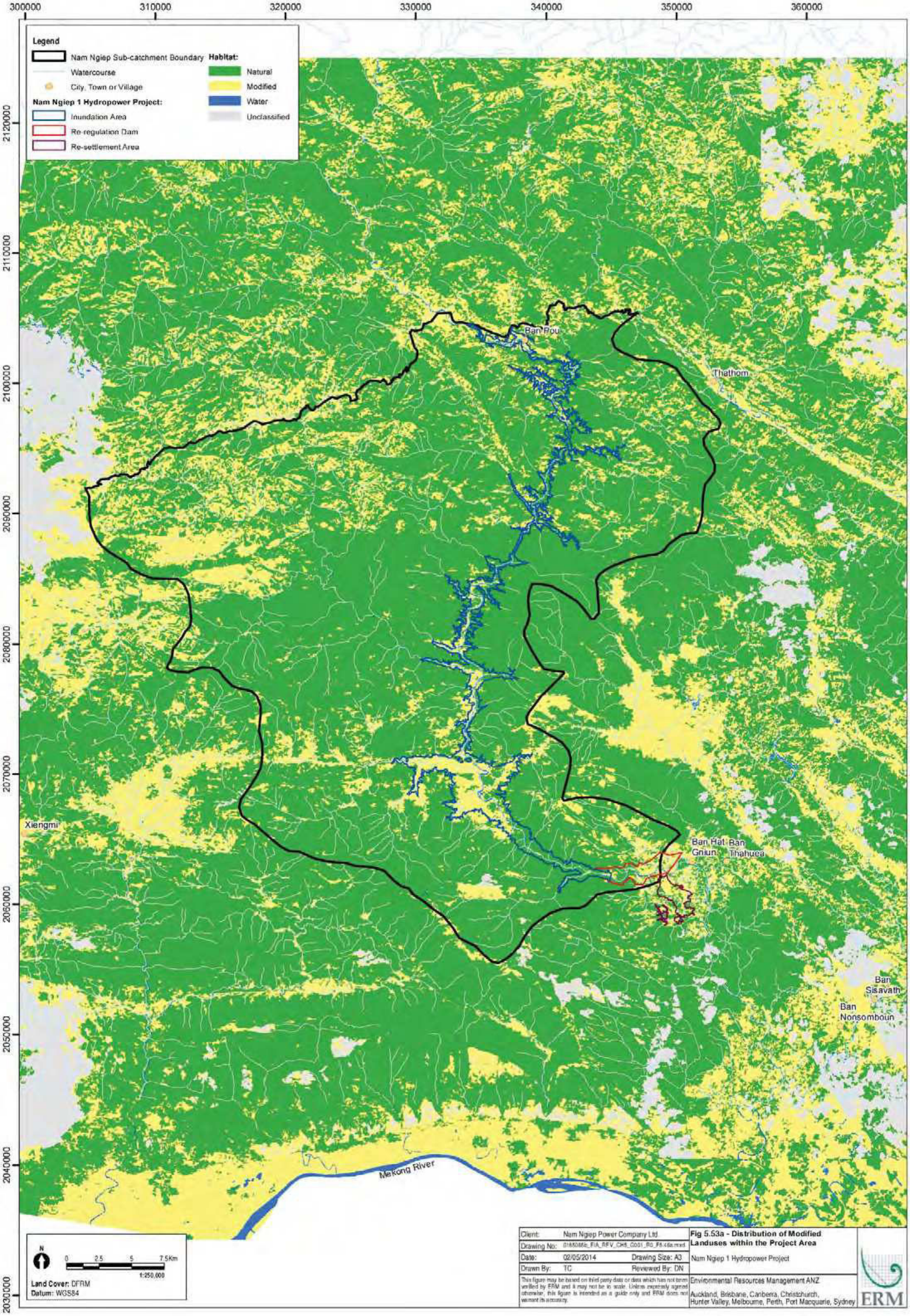
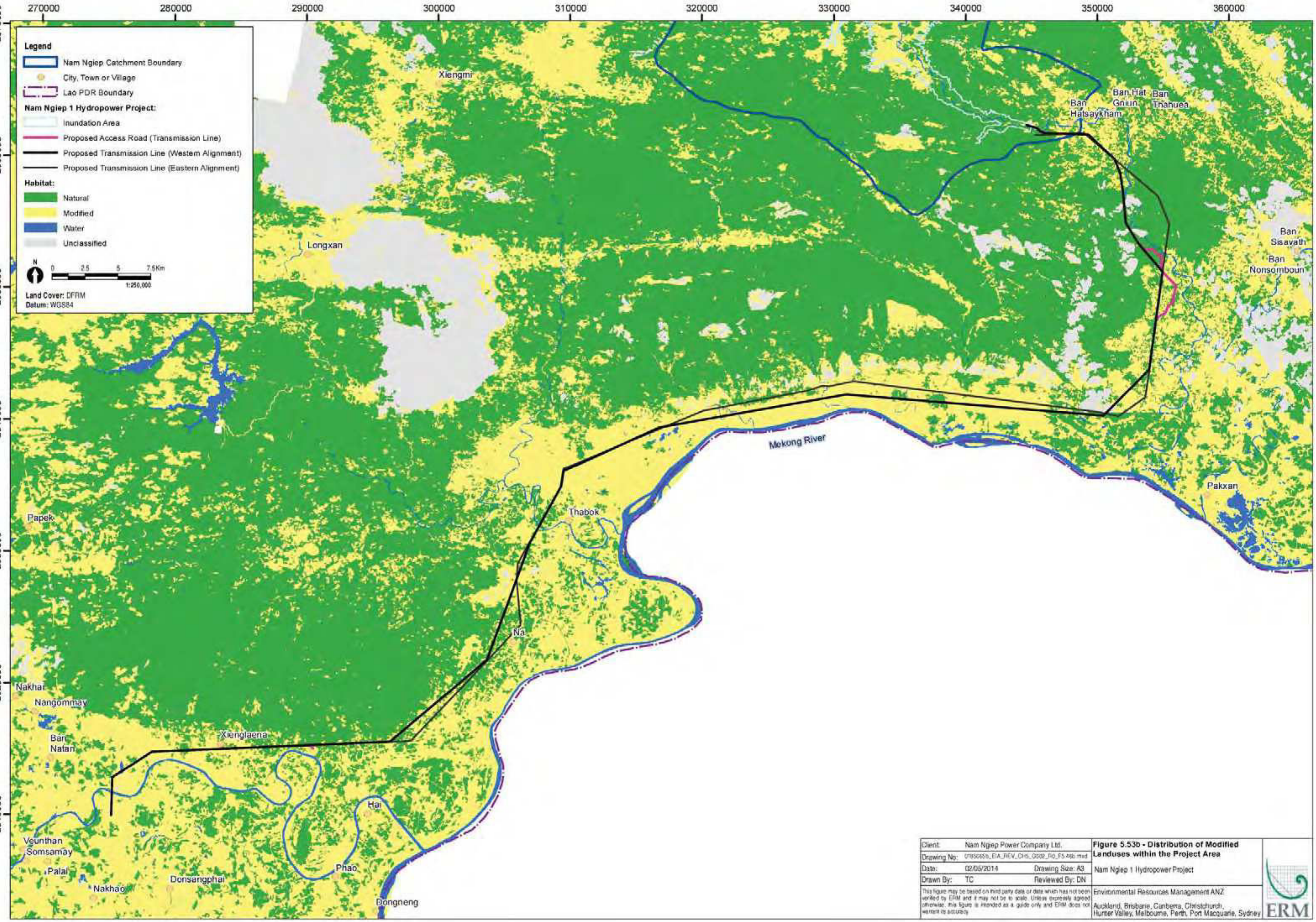


Fig 5.53a - Distribution of Modified Landuses within the Project Area



Client:	Nam Ngiep Power Company Ltd.		**Figure 5.53b - Distribution of Modified Landuses within the Project Area**
Drawing No:	0185065b_EIA_REV_CH5_G002_R0_F5.46b.mxd		
Date:	02/05/2014	Drawing Size: A3	Nam Ngiep 1 Hydropower Project
Drawn By:	TC	Reviewed By: DN	
This figure may be based on third party data or data which has not been verified by ERM and it may not be to scale. Unless expressly agreed otherwise, this figure is intended as a guide only and ERM does not warrant its accuracy.			Environmental Resources Management ANZ Auckland, Brisbane, Canberra, Christchurch, Hunter Valley, Melbourne, Perth, Port Macquarie, Sydney

5.3.11.2 *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 5.53*** shows the distribution of the natural habitat land uses within the Project Area.

5.3.11.3 *Critical Habitat*

Critical habitat is an area that has high biodiversity value. It includes (ADB, 2012):

- habitat required for the survival of critically endangered or endangered species;
- areas having special significance for endemic or restricted-range species;
- sites that are critical for the survival of migratory species;
- areas supporting globally significant concentrations or numbers of individuals of congregatory species;
- areas with unique assemblages of species or that are associated with key evolutionary processes or provide key ecosystem services; and
- areas having biodiversity of significant social, economic, or cultural importance to local communities.

The assessment of the biological environment identified a number habitat types and IUCN species that may be impacted by the Project. Overall the biological aspects of the Project Area demonstrating high biodiversity values include:

- Natural habitats within the Project Area (being areas impacted by project components) and the forested areas of the watershed below FSL level;
- Aquatic habitats along the Nam Ngiep River and its tributaries from the Mekong River to upstream of the FSL;
- All CR, EN listed species and endemic aquatic and terrestrial species identified within the Project Area.

In order to identify if the Project is located within critical habitat, the criteria and thresholds described in the International Finance Corporation (IFC) Performance Standard 6 Guidance Note 2012 have been used to guide the determination. The criteria include:

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

- Criterion 2: Endemic and/or restricted-range species (Tier 1 and Tier 2 sub-criteria for habitat for these species 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 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 focussed on the relevance of Criterion 1-3.

Using baseline data and consultation with species experts each species assessed for critical habitat. A summary of the analysis is provided in ***Table 5.46***. The species screened (i.e. candidate species) 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 5.46 Summary of Critical Habitat Assessment

Species	Habitat Requirements	Criteria	Record Direct	Record In-direct	Likely Critical Habitat	Comment
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.
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

Species	Habitat Requirements	Criteria	Record		Likely Critical Habitat	Comment
			Direct	In-direct		
						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						
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	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

Species	Habitat Requirements	Criteria	Record		Likely Critical Habitat	Comment
			Direct	In-direct		
	hunted for it to survive.					similar habitat in the country. As such the Project Area is considered unlikely to be critical habitat for the species.
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.
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	Habitat use may vary across its wide range, but in general	1		✓	No	The general patterns in northern southeast Asia suggest it

Species	Habitat Requirements	Criteria	Record		Likely Critical Habitat	Comment
			Direct	In-direct		
Smooth-coated otter	it seems mostly to occur in areas of gentle terrain, in both flowing and standing wetlands.					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.
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	The species is arboreal and nocturnal, and inhabits tropical evergreen rainforest, semi-evergreen forest, and moist	1		✓	No	This loris plausibly remains widespread and common in the Project area, but this is equally true of much of Lao

Species	Habitat Requirements	Criteria	Record		Likely Critical Habitat	Comment
			Direct	In-direct		
Bengal slow loris	deciduous forest					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.
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 village 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.
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 village interview data, the precautionary approach should be considered and the threats to the species should be

Species	Habitat Requirements	Criteria	Record		Likely Critical Habitat	Comment
			Direct	In-direct		
						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.
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' 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.
Rusa unicolor Sambar	Habitat is reported as wooded areas, more commonly in broken areas amid semi-evergreen forest but also open	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

Species	Habitat Requirements	Criteria	Record		Likely Critical Habitat	Comment
			Direct	In-direct		
	deciduous forest and unbroken evergreen forest.					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' 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.
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		✓	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

Species	Habitat Requirements	Criteria	Record		Likely Critical Habitat	Comment
			Direct	In-direct		
	1,560 m. The species is perhaps most common in unlogged forest.					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.
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

Species	Habitat Requirements	Criteria	Record		Likely Critical Habitat	Comment
			Direct	In-direct		
						morphologically distinctive races as separate conservation units.
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' 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.
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	Rivers with good fringing forest.	1		✓	No	With no information on the status in the Project area no

Species	Habitat Requirements	Criteria	Record		Likely Critical Habitat	Comment
			Direct	In-direct		
Lesser fish eagle						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).
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 habitat 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	The species inhabits fast flowing, cool, rocky mountain	1		✓	No	The Project area contains small perennial streams and a

Species	Habitat Requirements	Criteria	Record		Likely Critical Habitat	Comment
			Direct	In-direct		
megacephalum Big-headed turtle	brooks and streams, usually narrower than 1 m and less than 10 cm deep.					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						
Catlocarpio siamensis Giant barb	The species inhabits floodplain and main river habitats feeding on algae, phytoplankton, vegetation and small fish. The size of the population is reported to have declined rapidly since 1990. The species is very rare in Thai and Lao Mekong and associated tributaries. Spawning areas are unknown and little is known about spawning behaviour.	1,3		✓	No	The species was not detected during seasonal or targeted fast water habitat surveys within the Project area. Potential habitat for the species is more likely to occur downstream of the reservoir, and as such the Project threat relates to the modification of the topography of its habitat and alteration of the flow pattern (especially disruption of daily and annual cycle) impacting spawning sites and the reproduction of the species. Environmental Flows Assessment identifies flow release regime to manage downstream flows for maintaining normal river functions to manage this threat to potential habitat.
Catlocarpio siamensis Giant barb	The species inhabits floodplain and main river habitats feeding on algae, phytoplankton, vegetation and small fish. The size of the population is reported to have declined rapidly since 1990. The species is very rare in Thai and Lao Mekong and associated tributaries. Spawning areas are unknown and little is known about spawning behaviour.	1,3		✓	No	The species was not detected during seasonal or targeted fast water habitat surveys within the Project area. Potential habitat for the species is more likely to occur downstream of the reservoir, and as such the Project threat relates to the modification of the topography of its habitat and alteration of the flow pattern (especially disruption of daily and annual cycle) impacting spawning sites and the reproduction of the species. Environmental Flows Assessment identifies flow release regime to manage downstream flows for maintaining normal river functions to manage this threat to potential habitat.
Laubuca caeruleostigmata	Found in large rivers and flooded forest. In Thailand 60% of populations extirpated in 10 years due to loss of habitat.	1,3	✓		Unlikely	Species profile information identifies the importance of flood areas and large river environments. If the species is

Species	Habitat Requirements	Criteria	Record		Likely Critical Habitat	Comment
			Direct	In-direct		
Flying minnow	It is likely that the species is rare in Lao PDR.					present downstream of the reservoir where this habitat occurs, the alteration of the flow pattern (especially disruption of daily and annual cycle) may have an indirect impact. Environmental Flows Assessment identifies flow release regime to manage downstream flows for maintaining normal river functions to manage this threat to potential habitat.
Luciocyprinus striolatus		1		✓	No	Species population size is not well documented. The specialist studies undertaken identified a number of locations where the species is known by local villagers that have not been previously reported in literature. As this species is not considered a long distance migrator, the upper and middle Nam Ngiep may be considered a management unit. Village interview indicate that although rare there are regular occurrences of the species in the Nam Ngiep. Collation of information regarding the distribution of the species, and as such the location of populations, identified at least 14 river basins where there are known records of the species occurring. As such this population is not one of 10 or fewer discrete management sites globally for the species (Tier 1). Given challenges associated with existing threat conditions in the Nam Ngiep and the presence of other management units more likely to support the recovery of the species, the population is not considered to be a regionally-important concentration (Tier 2).
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. Major threats to the species globally include overexploitation, habitat degradation, and changes in	1,3		✓	Unlikely	Species profile information suggests that the species utilises main or larger river channels and floodplain areas and undertakes long distance migrations and as such more confirmation of presence of the species is required. If the species is present downstream of the reservoir where

Species	Habitat Requirements	Criteria	Record		Likely Critical Habitat	Comment
			Direct	In-direct		
	water quality and flow.					this habitat occurs, the alteration of the flow pattern (especially disruption of daily and annual cycle) may have an indirect impact. Environmental Flows Assessment identifies flow release regime to manage downstream flows for maintaining normal river functions to manage this threat to potential habitat and monitoring would be required.
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. It is known to undertake short distance migrations for spawning in November and January. The species feeds on aquatic plants, insects and shelled molluscs.	1,2,3		✓	No	The species is not known to occur in the Project area part of the catchment. Species profile information suggests that the species utilises main or larger river channels. 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 (Tier 1).
Wallago leeri	Species habitat is listed as rocky rapids in large streams and rivers.	2		r	NA	Fish have been previously been misidentified in the Mekong as *W. leeri* that are more likely *W. micropogon*. Targeted fast water habitat survey did not detect the species *W. micropogon*.
Migratory fish species		3	✓	✓	No	Potential habitat for Mekong migratory species may occur in reaches of the Nam Ngiep downstream of the dam infrastructure. The migratory species detected a generally species requiring large river or floodplains habitats. Due to the nature of the gorge where the dam is located the majority of this habitat is located downstream of the dam rather than within the inundation areas. Indirect impacts to downstream habitats relating to environmental flows will need to be considered during impact assessment.

Note: r = species included at request

Species	Habitat Requirements	Criteria	Record		Likely Critical Habitat	Comment
			Direct	In-direct		

Source: Baseline Biodiversity Assessment (ERM, 2014).

5.3.12 *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.

The assessment identified areas of modified and natural habitats, and habitats for conservation significant species associated with the Project area. Modified habitat types were not identified to play a significant role in habitat suitability for priority biodiversity values.

No flora species or fauna species were determine likely to have critical habitat within the Project area. For most species, the Project area was not considered of significant importance to the species.

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

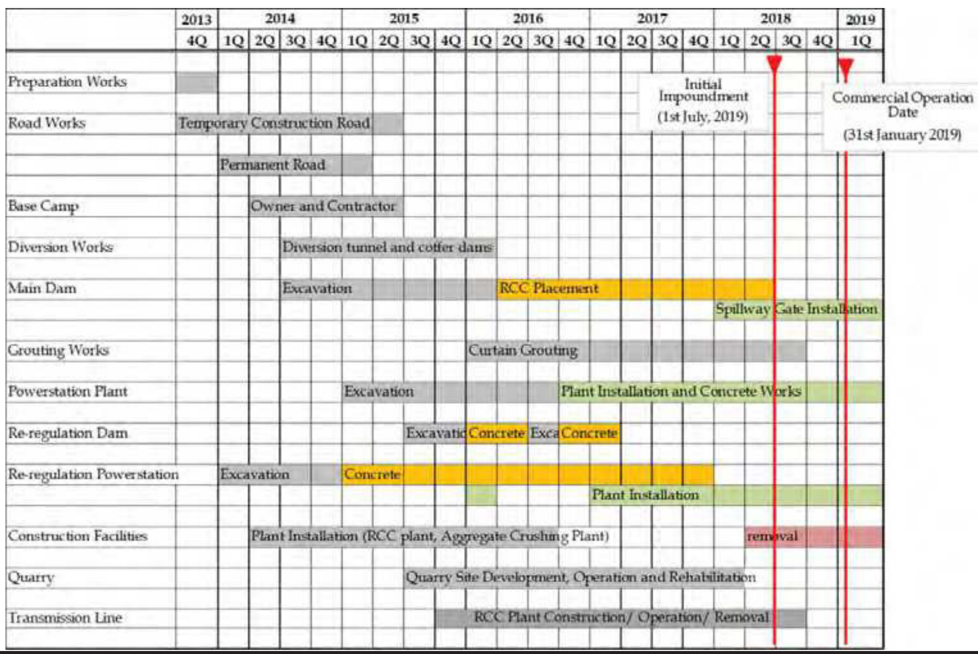
- Re-regulation Powerhouse
- Transformer and Switchyard

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 70 months, as shown in ***Table 6.1***.

Table 6.1 Tentative Schedule of Construction Activities



Source: Kansai, 2013.

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.

Reservoir clearance should be implemented for both main and re-regulation inundation areas which are proposed as the reservoirs of the Project.

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

Source: Environmental Impact Assessment Report, ERIC, 2012.

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)[1] has an agreement between ADB and the Project. The primary purpose of the panel is to review and advise the Project on matters relative to dam safety and other critical aspects of the dam, its appurtenant structures, the watershed area, the area surrounding the reservoir and downstream areas.

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, as well as climate risk. In additional the DSRP will review the safety of all aspects of the re- regulation dam and re- regulation reservoir, as well as main dam and main reservoir.

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1 The Dam Safety Review Panel (DSRP) is the independent review panel consisting of three or more experts, appointed by the Project, that has full responsibility for the safety of the dam, irrespective of its funding sources or construction status and for the dam life.

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 watershed areas have been converted to other land uses[2], 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.

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2 Brooks, 1993

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 watershed 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***).

The water quality model was composed of three sections of the Project, main reservoir, re-regulation reservoir and downstream river.

Although the accuracy of the one-dimensional model is empirically sufficient for water quality prediction, the two-dimensional model was adopted for the main reservoir is quite long and complicated topography in vertical and longitudinal direction. The one-dimensional model was applied to assess the water quality of re-regulation reservoir and downstream river.

The model features of main reservoir, re-regulation reservoir and downstream river are described as below;

1. Main Reservoir – modeling the distribution of the water quality variables in the reservoir
    - Two- dimensional model

- Governing equations; continuity equation, momentum equation, conservation of heat, conservation of water quality concentrations and equation for some components of the dissolved oxygen.
- Predicting values; temperature, suspended solid and dissolved oxygen.

2. Re-Regulation reservoir – settlement of suspended solid and organic materials according to the hydraulic retention time, considering re-aeration from atmosphere, heat transfer to and from atmosphere.
   - One- dimensional model
   - Predicting values; temperature and dissolved oxygen.
3. Downstream River – Modeling the transport of water quality variables along the river reaches.
   - One- dimensional model
   - Predicting values; temperature and dissolved oxygen.

The data that has to input in the model are consist of geometry, meteorology, stream inflow to the impounded area, water level and water quality into the main reservoir including the water temperature, dissolved oxygen and suspended solid.

In addition the dispersion coefficient, solar radiation and dissolved oxygen of the Nam Theun 2 project have been adopted for NNP1 predicted computation.

The water quality modelling assumptions and results including the mesh model result of two- dimensional model are shown in ***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 x 10^{-3} m^3/s[3] (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 x 10^{-3} m^3/s will not have a significant impact on water quality.

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[3] 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 litters/person/day. (www.spo.moph.go.th/). Water use of Nam Ngum 2 Hydroelectric Power Project was designed at 50-60 L/person/day.

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.

It should be noted that, recently, there have been sporadic observations of downstream villagers using the Nam Ngiep River for consumption purposes. This is most likely due to the water use pressures from a temporary increase in population due to the influx of workers in the area. As such, NNP1PC should review water availability in the downstream communities, and provide drinking water (i.e. bottled water) to communities where there has been an impact on drinking water availability.

During construction, microbiological contamination in the Nam Ngiep River is not expected to substantially increase from current background levels. However, the baseline water quality in the river was found to be not suitable for use as drinking water. While construction activities are not anticipated to cause substantial increases in microbiological contamination, villagers should be discouraged from using the Nam Ngiep River for consumption purposes due to the existing contamination levels.

Figure 6.2 Water Drainage Channel Provided along an Elevated Unpaved Road

Source: Environmental Impact Assessment Report, ERIC, 2012.

Figure 6.3 Large Sediment Load due to Unpaved Road

Source: Environmental Impact Assessment Report, ERIC, 2012.

The area to be cleared for construction has been estimated to cover about 1,431 km^2 or 187.3 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 Gniun (21.2 km length, .5-10 m. Width)	42.4
• Ban Hat Gniun to Dam Site (9.5 km length, 6.6 m Avg. width)	15.8
Approximate right of way 5 m. of each side of route	
Quarry site	46
Office	10.2
Spoil disposal area	32.7
Total	**187.3**

Source: Environmental Impact Assessment Report, ERIC, 2012.

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

3) Drinking water sources

As discussed above, the influx of construction workers during the construction phase may place additional strains on downstream community drinking water sources. NNP1PC should review water availability in the downstream communities, and provide drinking water (i.e. bottled water) to communities where there has been an impact on drinking water availability.

In addition, where possible villagers should be discouraged from using the Nam Ngiep River for consumption purposes due to the existing contamination levels.

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)[4]. 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.

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[4] Federal Transit Administration, 1995

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	

Source: Environmental Impact Assessment Report, ERIC, 2012.

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)	LA_{eq} [dB(A)]	Time base [hours]	LA_{max}, 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"[5], 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.

Noise from Worker Camps

The low noise impact from worker camps activities will be generated. The potential of noise nuisance to the residential area nearby caused from worker transportation for working in the morning and evening. Recreation activities of workers causing noise will not be allowed to occur after the resting time of villagers nearby.

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.

5 World Health Organization, 1999

- 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.
- Activities, causing noise in worker camps shall be strictly prohibited in resting time of villagers.
- ESMMP and Contractor's ESMMP shall be prepared prior to construction phase to reduce noise impact from Project activities. The ESMMP shall provide the map of Project transportation, worker camp, nearby villages and noise monitoring station by the Project and Contractor.

(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

Distance from source	Explosive mass	Vibration level	
(m)	(kg/d)	PPV (mm/s)	Freq (Hz)
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
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

Source: Environmental Impact Assessment Report, ERIC, 2012.

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***[6]. 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: Environmental Impact Assessment Report, ERIC, 2012.

6 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.

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.

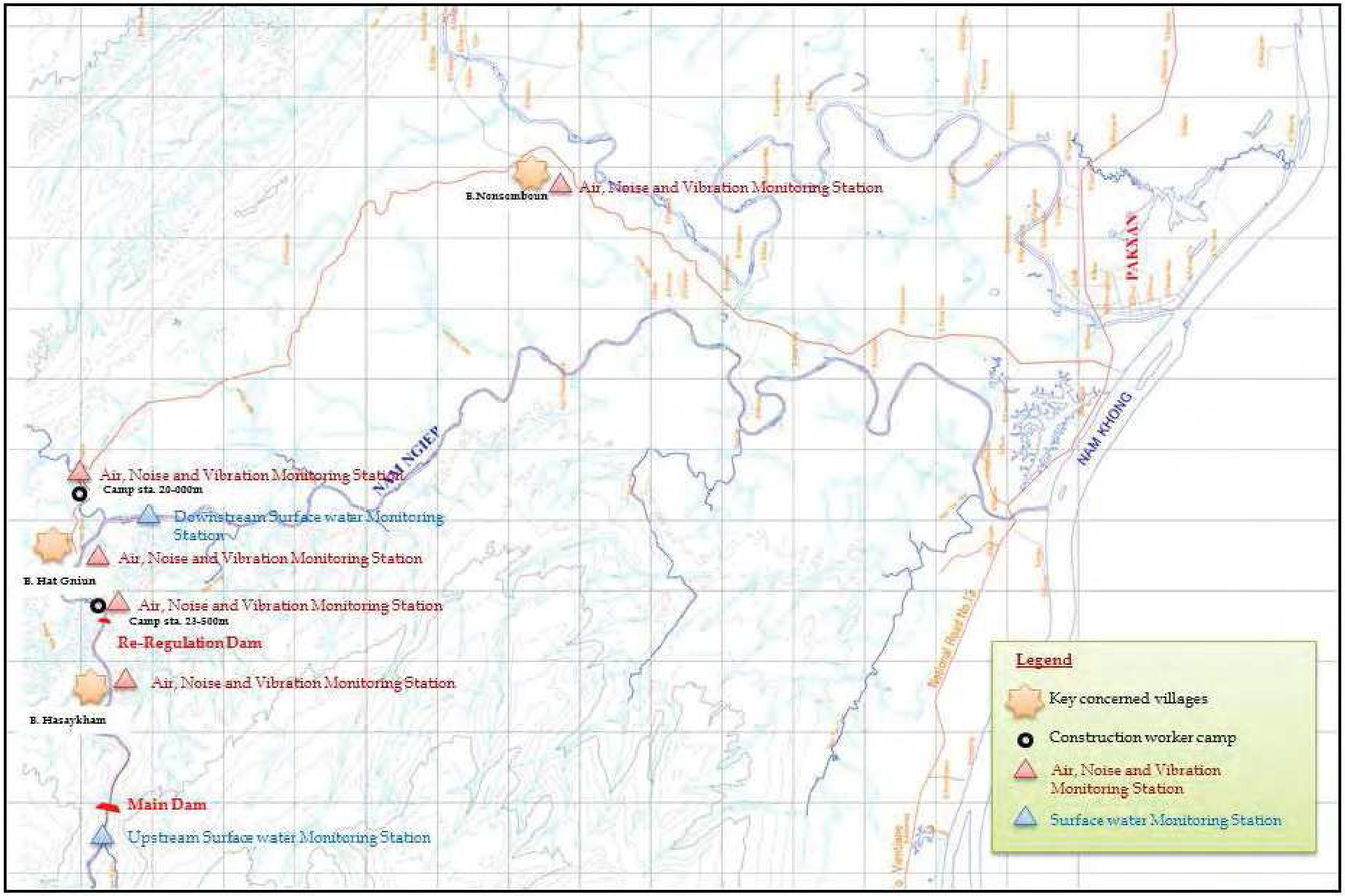
In addition, an air monitoring program in the area of construction activities that generate dust will be routinely conducted, and sampling locations and parameters specified in applicable standards will be identified specifically in the Site-Specific Environmental Management Plan. Parameters should include, 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



Source: ERM, 2013.

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.

Greenhouse Gas Emissions

The use of approximately 27 million litters 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[7].

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:

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

[7] http://data.un.org/CountryProfile.aspx?crName=Lao%20People's%20Democratic%20Republic

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.

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 as outlined in the Quarry and Construction Layout Sub-Plan, and the Landfill Management Plan (preparation in progress).

6.2.2.9 Sediment Transport

There are two components to consider with regards to potential impacts to sediment transport: 1) suspended fraction and, 2) bedload fraction. Bedload fraction is that which is deposited into the reservoir, and suspended fraction, which is the dominant form, is that which would mostly be passed through the turbines (and also some settling into the reservoir).

It can be expected that there will be some change to downstream in-channel alluvial material, and the closer to the dam the more rapid this change will take place. However, the time scale of these potential changes is expected to be quite large, taking place over many years. This is supported by the current stability of the downstream geomorphological baseline of the Project area, as discussed in *Chapter 5*. The potential of sediment yield is expected to be only slightly impacted, due to the geology and topography consisting of mainly sedimentary rocks distributed horizontally. In addition, in a worst case scenario of all sediment yield being trapped by the dam, at a rate of 1,000 ton/km^2/year (as in the case of the NNP3 study), the dead storage of the dam reservoir has a capacity to sustain this sediment load for 308 years.

Another issue related to dam sediment through-put is that of 'colmation'. Colmation is a common effect from dams created by the regulation of flow that attenuates large floods and smooths out stream discharge. Because of this flow attenuation, fine sediment that passes through the dam (often the very fine particles) fall from the water column and build up on the interstitial spaces of the stream bed. As floods occur less frequently, the bed is disturbed/circulated less often, and this fine sediment can form a hard layer that inhibits bi-directional interaction between the water column and stream bed. This process can cause potential impacts on the food chain by altering the compositions of macroinvertabrate species and abundance. Further assessment of the related impacts to biodiversity are explored in *Section 6.2.3* and 6.3.2.

In summary, although there are expected to be some changes in downstream sedimentation patterns due to the Project, the erosion potential of downstream alluvial material is expected to be minimal, and colmation affects are manageable. The potential impacts of downstream alluvial material erosion and colmation, including construction activities across the catchment that both generate sediment yield and trapping such as sand bed and gravel extraction, shall be controlled by mitigation measures for erosion, as indicated in *Chapter 10.*

6.2.2.10 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.

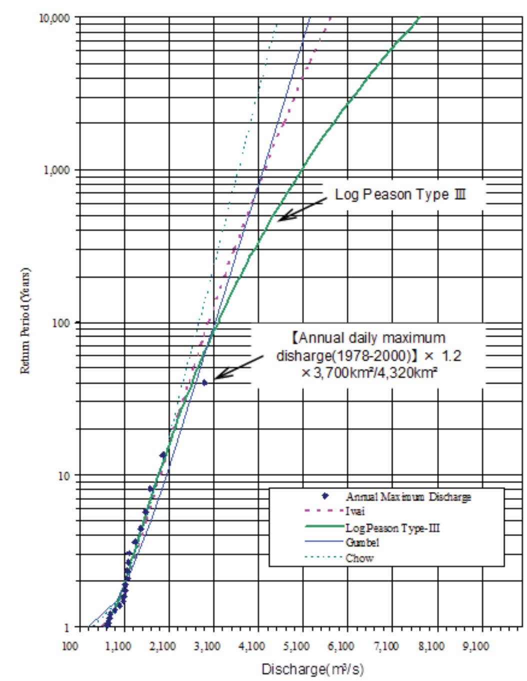
At the dam construction site, there is a proper procedure in place to handle flooding during the construction period. The diversion tunnel would handle flooding only during the first wet season after RCC placement (approximately 6 months). During this period, floods higher than 1.5-year return period (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 (m^3/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 meth (Modified Snyder equation applied)

Source: Technical Report, 2011.

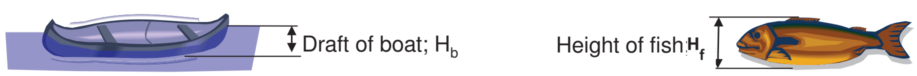
It should be noted that minimum flows to mitigate environmental impacts along the Nam Ngiep River downstream from the construction site are not applicable to the Pakxan area at the mouth of the river 40 km from the site. This is because the Pakxan area is affected more by fluctuations or influences from the Mekong River than from the Nam Ngiep River.

6.2.2.11 *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 riparian conduit. Instead, during this period, water will be released downstream from the re-regulation reservoir, which stores natural inflow from its side watershed (25 sq.km). Within 2 weeks, the reservoir water level at the main dam will reach the sill elevation of the riparian conduit, 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 release in accordance with concession agreement) to 27 m^3/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.

The section with reduced water (minimum 5.5 m^3/s environmental flow) is limited to between the re-regulation dam to a point 3 km downstream where it reaches the confluence of the Nam Xao River. At this confluence point the minimum flow will increase to more than 38.7 m^3/s with the inflows from the Nam Miang, Nam Tak and Nam Xao Rivers. For this reason, the discussion following is focused on the 'Reduced Water 3 km Section.

Required minimum water depth for navigation and fish has been considered. Based on experience with similar projects, the minimum required water depth for navigation is 0.5 m (Hb) and 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.

Based on the non-uniform flow analysis, that minimum water depth is more than 0.5m if maintained at 5.5 m^3/sec.

Table 6.10 Flow Requirement in Annex C of Concession Agreement During Impoundment

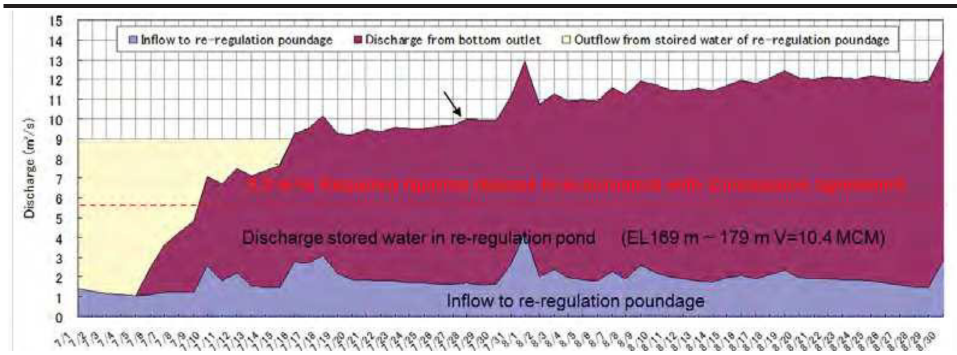
River reach	Absolute Minimum Flow	Water depth (measured at a fixed point immediately downstream of the re-regulation dam)
Downstream of the re-regulation dam	Min 5.5 m^3/s at all times in the dry season and in the rainy season	0.5 m

Source: Concession Agreement, Annex C Environmental and Social Obligations, 2013.

Figure 6.6 Discharge Scheme during Initial Impounding

Source: NNP1PC, 2014.

Figure 6.7 Environmental Flow during Impoundment (Average Flow of Year 1994)



Source: NNP1PC, 2014.

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.
- Watershed management planning is required to manage activities upstream to ensure reservoir water quality is maintained.

6.2.2.12 Fisheries

Impacts to fisheries can be divided into those impacts downstream and upstream of the reservoir.

Upstream impacts on fisheries will be determined by the ability of the reservoir to support fisheries biomass and the ability of those fish to be caught. The species mix also will change, meaning different fish may be caught. Technologies used in the fishery will also need to change to enable the changed resource to be accessed.

Downstream impacts on fisheries will be influenced by the quality and quantity of water discharged. As outlined in the environmental flows assessment, it has been determined that sufficient water quality and quantity will be provided to maintain fisheries in the medium to long term. Short term impacts are likely during impoundment before the environmental flow regime is initiated. There will also be higher dry season flows which will influence fisheries.

There is uncertainty on the exact impacts as a result of the impoundment and it is realistic to implement an adaptive management framework to respond to changes in fisheries. This monitoring framework will respond by offering solutions to reductions in catch, technologies used and to supplement fisheries resources where they are shown to be lost.

Management of the fisheries should be initiated to manage impacts and changes in the fishery. The following measures will be adopted:

- Fishery dependency survey will be undertaken for communities that will be resettled;
- Socio-economic livelihood survey for all villages in the project area;
- Recurring food consumption survey (including fish consumption) covering multiple seasons;
- Routine Fish Catch Monitoring for downstream villages (including resettled households);
- Routine Fish Catch Monitoring for Nam Ngiep Reservoir; and
- Regular (monthly) food consumption monitoring.

- Aquaculture programs

6.2.2.13 *Watershed Management*

It is recommended that NNP1PC develop a comprehensive Watershed Management Plan (WMP) in conjunction with the GOL. This should be developed by a Watershed Management Committee for the Nam Ngiep Watershed. The WMP should be developed in conjunction with MONRE and be undertaken by a suitably qualified person experienced in water shed managemenact activities in Lao PDR. It is understood that NNP1PC has commenced this task with GOL.

Establishment of a Watershed Management Committee

A Watershed Management Committee (WMC) should be established to oversee the development of the WMP framework. The WMC should have the following key objectives:

1. coordinate and advise the Government on the development of policies, strategies and plans, including Nam Ngiep WMC WMP;
2. monitor the implementation of the WMP, advise on development projects in order to reduce negative water resource impacts,
3. advise GOL on resolving disputes, and coordinate and promote water resource awareness and participation;
4. assist GOL to ensure that water resources are developed and protected in a sustainable manner and in accordance with national policies and objectives; and
5. set up a subcommittee to administer and oversee the implementation of biodiversity offsets and species offset plans.

Development of a Watershed Management Plan

A detailed WMP for the Nam Ngiep Watershed should be developed through both technical surveys to assess the watershed and along the mainstream to identify issues and "hotspots", and through consultation and negotiation to strengthen conservation in the watershed biodiversity offset area, the various protection forests, and with the district watershed management units. The implementation of this watershed management plan will need to be monitored and adapted over time as necessary.

It is recommended that the WMP is structured to include the following objectives:

- Maintaining the flows and water resources of the Nam Ngiep;
- Maintaining the diversity and productivity of aquatic resources of the Nam Ngiep;
- Maintaining the vegetation cover and soils in the Nam Ngiep catchment;
- Maintaining the diversity and productivity of landscape and terrestrial ecosystems of the Nam Ngiep catchment;

- Maintaining the equitable use of water and natural resources with appropriate sharing of benefits of hydropower by different sectors, districts and communities in the Nam Ngiep watershed;
- Reducing the risks and impacts of water related disasters in the Nam Ngiep – especially floods and droughts; and
- Establishing a fully functional and representative Watershed Management Committee for the Nam Ngiep watershed, including representation from other major developers (mining and hydropower).

The WMP will be required to be developed in discussion with MONRE.

Watershed Management Actions

Management actions associated with each of the objectives contained in the WMP should include:

- Maintaining the flows and water resources of the Nam Ngiep River to achieve:
  - i) Land-use management
  - ii) Water resource management
  - iii) Water quality management
  - iv) Environmental flows
- Maintaining the diversity and productivity of aquatic resources of the Nam Ngiep River:
  - i) Land-use management
  - ii) Dam design considerations
  - iii) Managing aquatic ecosystems
  - iv) Managing fishery resources
- Maintaining the vegetation cover and soils in the Nam Ngiep catchment
  - i) Land-use management
  - ii) Managing soil erosion and sediments from the hydropower projects
  - iii) Managing soil erosion in the catchment
- Maintaining the diversity and productivity of landscape and terrestrial ecosystems of the Nam Ngiep catchment
  - i) Land-use management
  - ii) Protected Areas
  - iii) Forest Offset programme
  - iv) NTFP collection and the wildlife trade
- Maintaining the equitable use of water and natural resources with appropriate sharing of benefits of hydropower by different sectors, districts and communities in the Nam Ngiep watershed
  - i) Land-use management
  - ii) Multiple use of Reservoirs
  - iii) River transport and navigation
  - iv) Compensation and Sharing the benefits of hydropower
- Reducing the risks and impacts of water related disasters in the Nam Ngiep – especially floods and droughts

i) Flood management
ii) Dam safety
iii) Considering climate change

6.2.2.14 Cultural Resources

Direct impacts to cultural resources from the Project consist of:

- Sites and objects of archaeological, historical, cultural and natural beauty significance may be lost if they are inundated.
- The sense of history of the area will be lost as the sites of cultural and historical values will be inundated and will be no longer visible.
- Sites of archaeological significance offering high potential for ecotourism may be lost.

Indirect impacts consist of:

- Appreciation of arts and culture may be decreased
- Looting and illicit traffic of antiques may increase.

6.2.2.14(1) Mitigation Measures

Department of Museums and Archaeology

The mitigation measures suggested by the Department of Museums and Archaeology to decrease both direct and indirect impacts are described as follows:

- Conduct systematic search for archaeological sites by implementing transects of test-pits within the villages that will be inundated in order to document, analyze and rescue archaeological materials.
- Acquire the archaeological artefacts owned by the villagers before they sell to antique dealers (start a provincial collection of national treasures and objects of Museum values).
- Construct a museum to house the collections, conserve, interpret, exhibit and carry out public education programs concerning awareness to cultural heritage and protection of environment.
- Improve or create (if absent) a system of cultural heritage management at provincial, district and village levels. Train the local staff to deal with protection, chance find that will occur during earthworks for project constructions. Coordinate with the existing system at government level (Ministry of Information and Culture, National Committee for the protection of national cultural heritage).
- Organise campaigns of public information and education concerning the protection of cultural heritage in order to raise public awareness and participation in cultural heritage activities.
- Integrate actions of the document and undertake assessment of cultural heritage resources found during construction.

Chance Find Procedures

To minimize impacts to artifacts Chance Find Procedures have been developed. The objectives of the Chance Find procedures:

- Minimize impacts to resources from all NNP1 related activities,
- Ensure that artifacts uncovered are appropriately recorded, documented and reported to the appropriate line agencies.

To identify and manage any chance finds and comply with the relevant regulations, the following actions will need to be employed by the Project proponent:

- A suspected PCR find should not be moved or interfered with.
- A suspected PCR find should be reported immediately to the Village Chief and Provincial Ministry of Information and Culture (PMIC) representative.
- All work potentially impacting on the find should be suspended whilst the find is assessed by these parties.
- The PMIC rep and Village Chief will immediately mark the location of the find and take the necessary precautions to protect the site from further disturbance (including limiting access to the site).
- If the find contains suspected human remains the PMIC rep and Village Chief will be required to notify the relevant District Administration immediately and take instructions from the District Administration.
- The PMIC rep and Village Chief will need to record the depth of the artifact and document and photograph the artifact in situ. If the artifact can be safely removed without damage.
- The PMIC rep and Village Chief will need to prepare a Chance Find Report which will include:
- The date and time of discovery.
- Location of the discovery.
- Description of the PCR.
- Estimated weight and dimensions of the PCR.
- Any protection measures implemented.
- The Chance Find Report must be submitted to the Provincial Ministry of Information and Culture, and PAFO within 48 hrs.

The PMIC representative and Village Chief may remove the PCR to a secure location. If the artifact is large and cannot be easily removed, or is one of a number of objects, then the Ministry of Information and Culture must be informed as soon as possible to allow them to investigate the find in situ. Construction activities should recommence only after approval has been granted.

Should a chance find or investigation interfere with forestry operations or livelihood enhancement activities, or affect the planned location of facilities etc, then the PMIC rep and Village Chief will need to liaise with the Ministry of Information and Culture to determine the best course of action.

The PMIC representative and Village Chief should advise any contractors of any changes to PCR procedures or operations as a result of the chance find.

For disputed PCR artifacts, ownership will be determined by the Ministry of Information and Culture of Lao PDR.

6.2.2.15 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 (*Section 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. 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.

Source: ERM, 2013.

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 ADB Critical Habitat definition)	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.*

Source: ERM, 2013.

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 km². 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.*				

Source: ERM, 2013.

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. A number of the threats relate to both construction and operation activities and as such an assessment of significance has been undertaken in this section and in *Section 6.3.2.2*.

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.
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 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.
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.

Source: ERM, 2013.

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
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***.	Medium	Medium	Moderate

Impact	Description	Comment	Sensitivity	Magnitude	Significance
		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.			
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
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
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

Impact	Description	Comment	Sensitivity	Magnitude	Significance
	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
	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	Medium	Small	Minor

Impact	Description	Comment	Sensitivity	Magnitude	Significance
		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).			
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

Source: ERM, 2013

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**
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 ADB SPS identified that there is no critical habitat for terrestrial species within the project area. 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	High	Small	**Moderate**

Impact	Description	Comment	Sensitivity	Magnitude	Significance
		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.			
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	Medium	Small	**Minor**

Impact	Description	Comment	Sensitivity	Magnitude	Significance
		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).			
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. No critical habitat was determined within the project area for aquatic 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.	High	Small	**Moderate**

Impact	Description	Comment	Sensitivity	Magnitude	Significance
		The Giant barb, leaping barb, *Luciocyprinus striolatus*, Striped catfish and Thicklipped barb are also found in the aquatic habitats of the Project area. Spawning sites for *L. striolatus* have been identified within and upstream of the main dam full supply level (FSL). 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.			
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.	Medium	Small	**Minor**
	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. 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.			-

Source: ERM, 2013.

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 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 6.15***) 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 6.16***. 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.

Source: ERM, 2013.

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 ADB SPS. Following assessment of each of the candidate species against the threshold criteria it was determined that no species are likely to have critical habitat within the Project area. The area downstream of the Project area is recognised for the large river and floodplain habitat values for migratory fish species.

As such, measures specific to these species have been considered and will be included and developed further for inclusion in a Biodiversity Action Plan (BAP) for the project area..

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.

. The BAP is a separate document to the Biodiversity Offset Management Plan that will be developed for the management of biodiversity within the biodiversity offset area.

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 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

Value/Species	Key threats	Specific management measures
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, White winged duck, Greater coucal, Red-breasted parakeet, Darter	Hunting	• Raise awareness of the protection of the species to trade (live birds and feathers) through education of construction team members • Rehabilitation of any disturbed areas as soon as practical after clearing

Value/Species	Key threats	Specific management measures
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 (see Section *6.4*) 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 and riparian releases during filling of re-regulation dam • 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

Source: ERM, 2013.

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

Source: Environmental Impact Assessment Report, ERIC, 2012.

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 watershed 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 (See ***Figure 6.9***).
- Use of organic fertilizer, composed of leftover food, animal dung, bacteria, and water (See ***Figure 6.10***).
- 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

The general layout of the resettlement area is shown in ***Figure 6.11***.

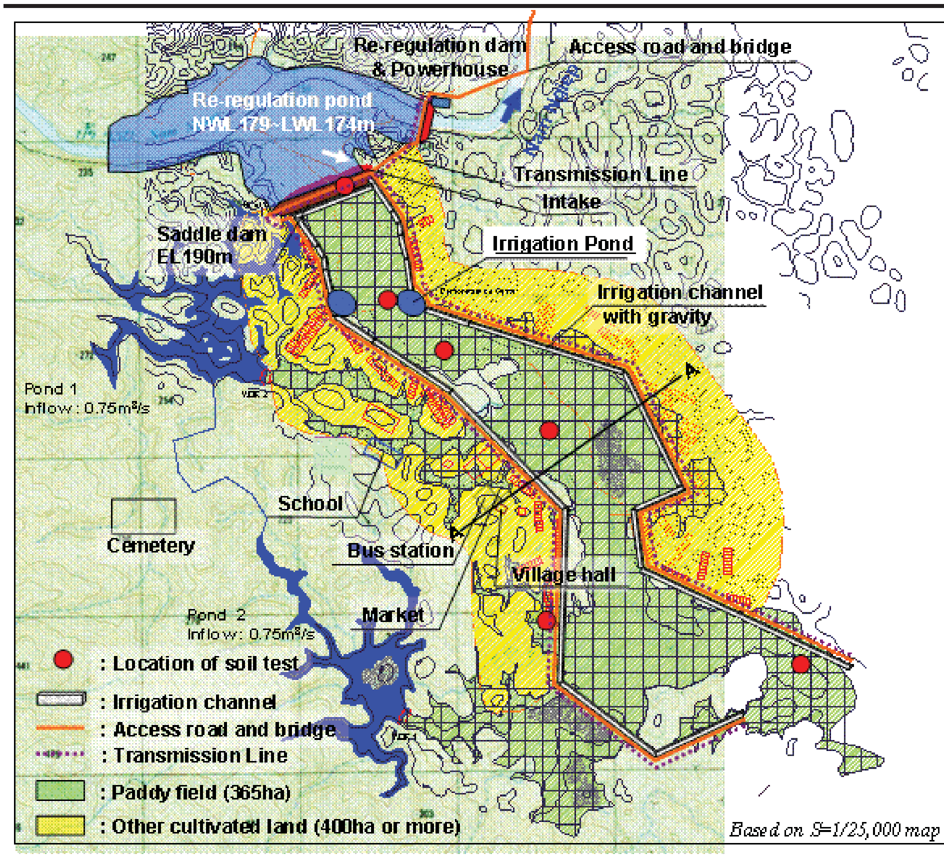
Figure 6.9 Practices of Using Bio-Char in Thailand.

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)

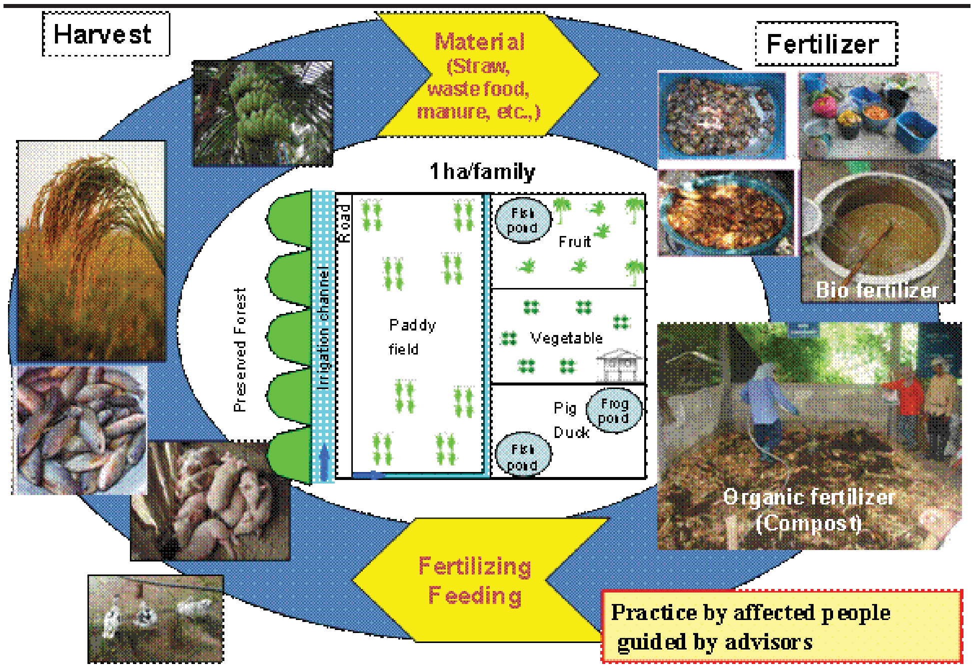
Figure 6.11 Infrastructure within the Resettlement Area



Source: Environmental Impact Assessment Report, ERIC, 2012.

- Sustainable Lifecycle Management (See ***Figure 6.12***): 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.

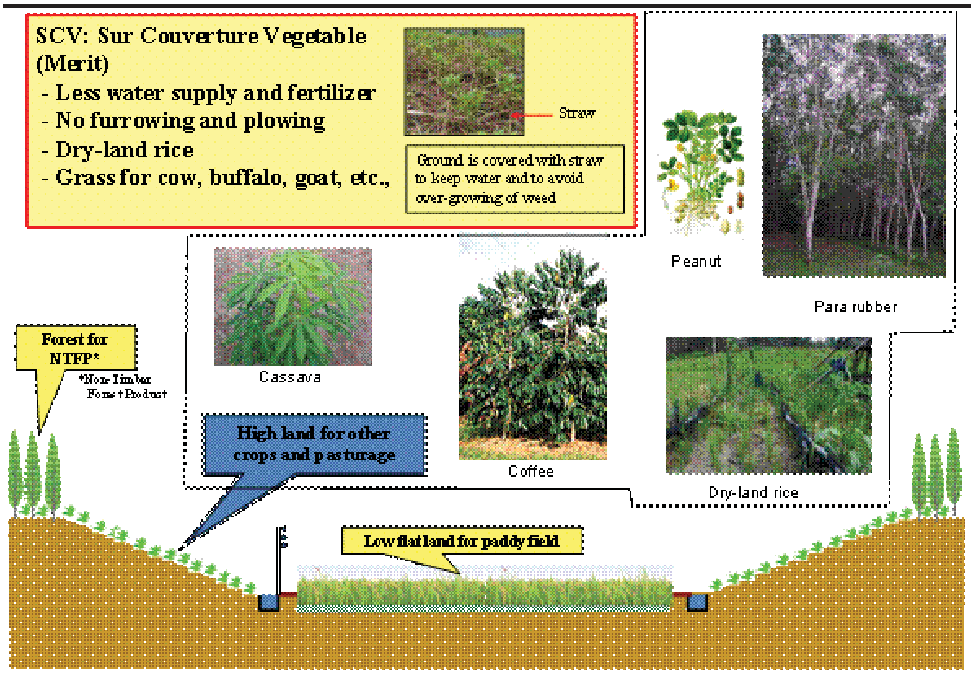
Figure 6.12 Sustainable Lifecycle Management



Source: Environmental Impact Assessment Report, ERIC, 2012.

- Implement crop management (See *Figure 6.13*) 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 votive grass, which can prevent loss of soil nutrients and improve capture and efficient use of water.

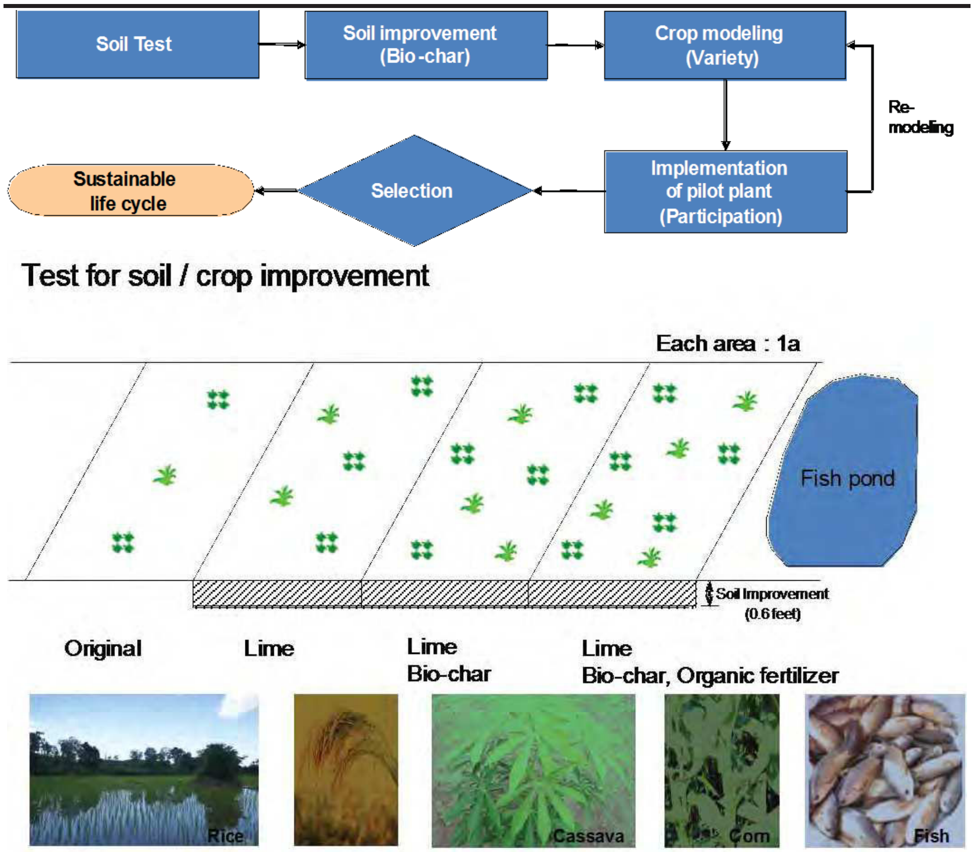
Figure 6.13 Crop Management



Source: Environmental Impact Assessment Report, ERIC, 2012.

To achieve the above mentioned mitigation measures, a pilot plant will be constructed as shown in ***Figure 6.14***.

Figure 6.14 Pilot Plant



Source: Environmental Impact Assessment Report, ERIC, 2012.

6.3.1.4 *Erosion and Sedimentation*

Sedimentation

The sediment yield from the watershed and in the reservoir should be taken into account during the design life of the Project. The long-term protection of the watershed 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 watershed area (3,700 km^2) should ensure that sediment yield will remain at the current estimated low level. Steeper slopes in the watershed 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 watershed 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.

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.

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 a 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.

The geological stability of the of the main dam and reservoir area will prevent mass movement during and following inundation.

6.3.1.5 Reservoir and River Water Quality

This section outlines an analysis of the predicted reservoir and river water quality for the Nam Ngiep 1 Reservoir and downstream of the re-regulation dam. 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***).

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 Watershed, 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.

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.

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[8], 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.

Figure 6.15 *Algal Bloom and Debris Degradation during the Early Stage of Water Impoundment of a Small Reservoir in Feung*

Source: Environmental Impact Assessment Report, ERIC, 2012.

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.

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 watershed will affect the quantitative and qualitative characteristics of the water. Natural forests, crops and communities are found throughout the watershed area.

8 Reference: Water Quality in Hydroelectric Project: Consideration for Planning in Tropical Forest Regions, WB Technical Paper No.20, 1984

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 watershed 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.

Cultivation around the dam FSL level will be managed through a watershed management framework. This framework will aim to manage activities within the watershed that cause harm water quality within the reservoir.

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:

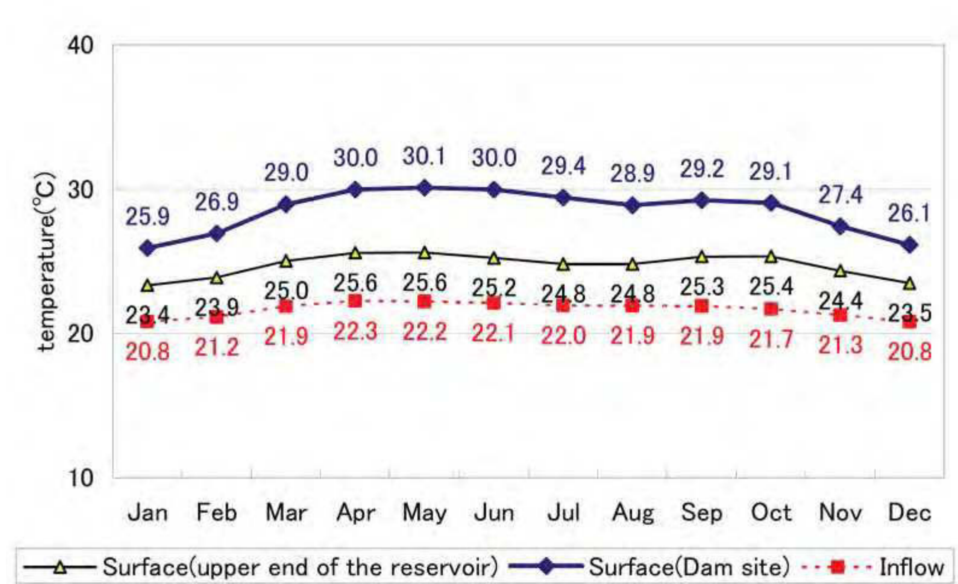
$$S_d = S_{df}\{1 - (1 - k)n\}$$

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

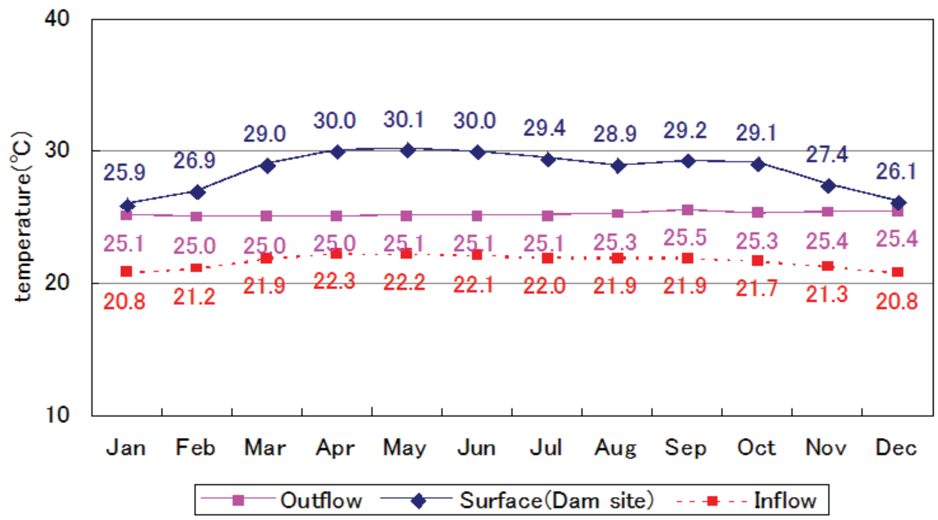


Source: Environmental Impact Assessment Report, ERIC, 2012.

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



Source: Environmental Impact Assessment Report, ERIC, 2012.

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.

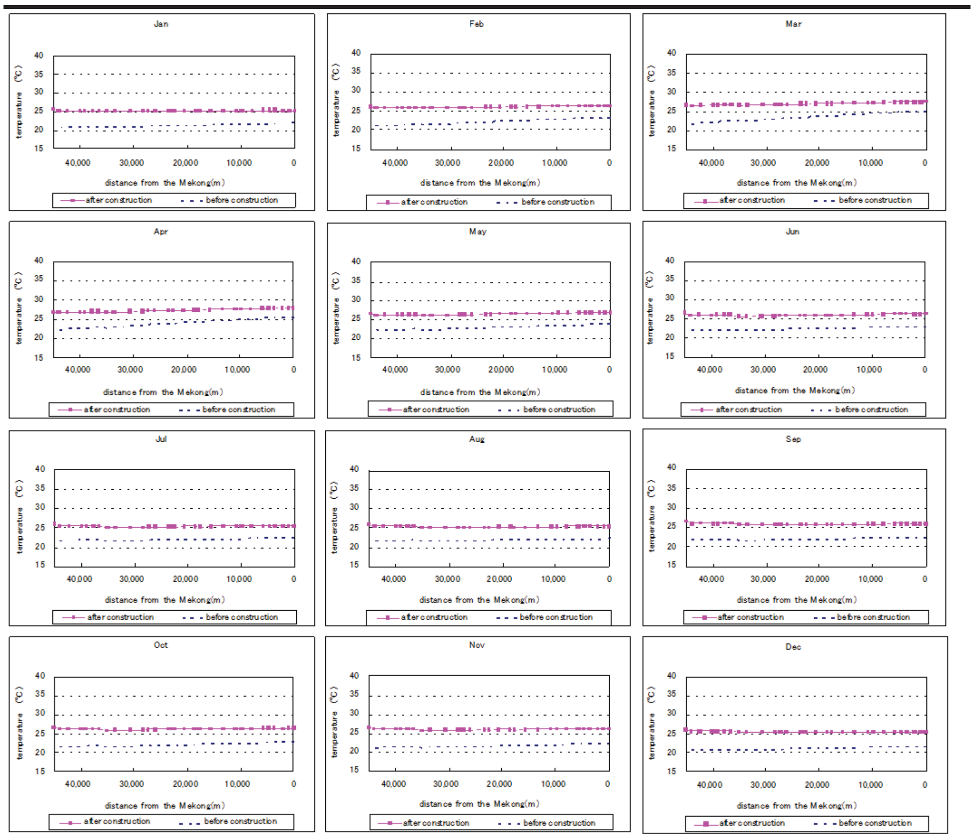
However, it should be noted that, for the water quality model, water temperature of before dam was estimated based on inflow at the upper reach of the reservoir, which was less than 25°C. Although the reservoir surface water temperature is higher, released water temperature would be around 25 to 27 °C, which is same condition of the downstream river, because water release is conducted form the boundary of stratification.

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.[9] 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.

Figure 6.18 Comparison of Downstream Water Temperatures of NNP1



Source: Kansai, 2013.

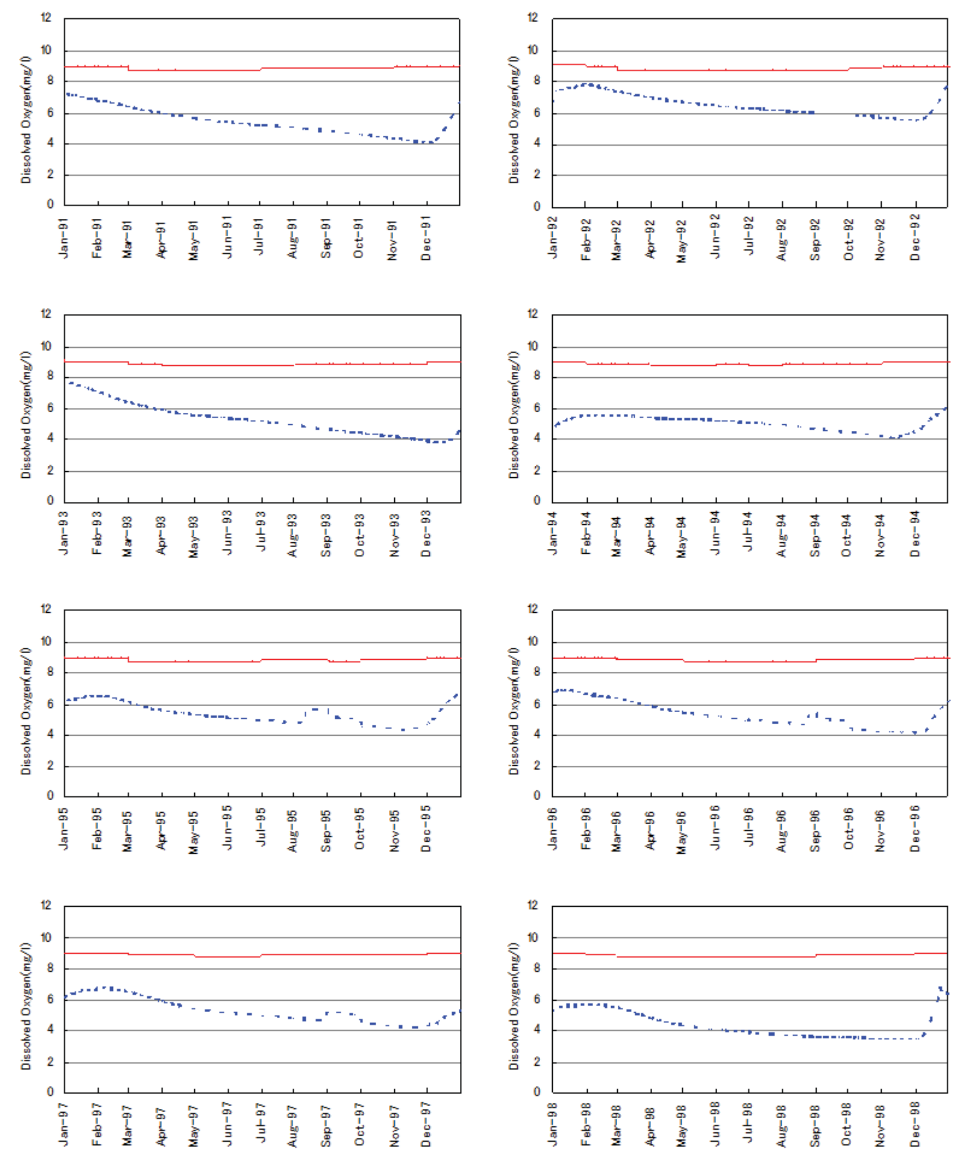
Dissolved Oxygen

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

9 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

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***).

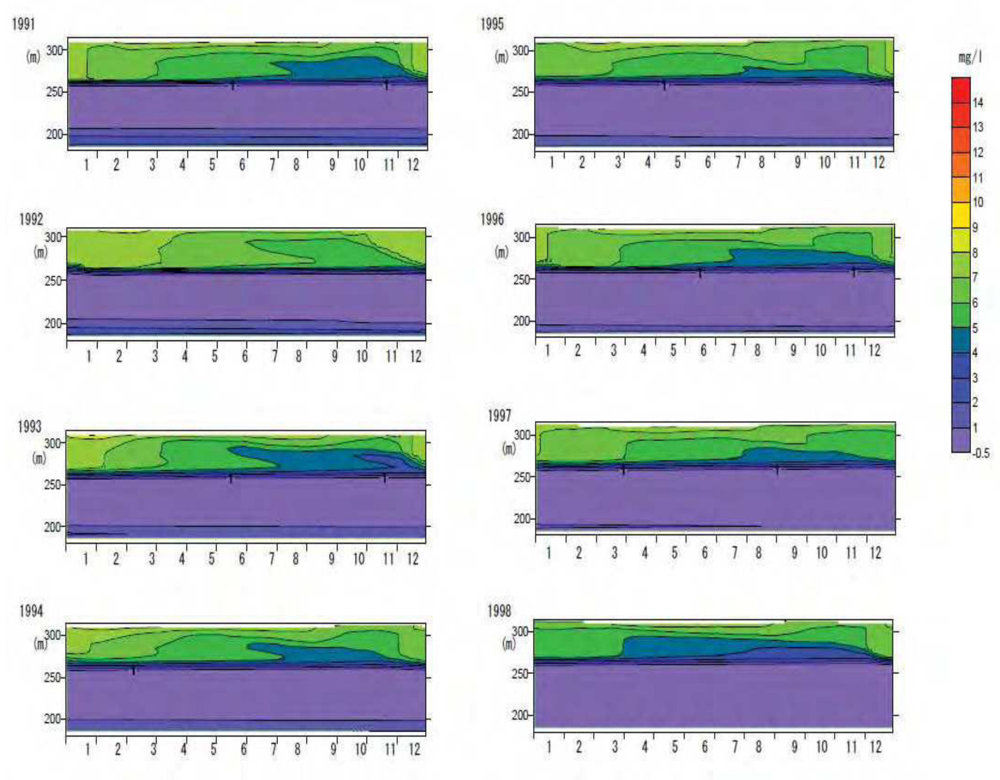
Figure 6.19 Comparison of Inflow and Discharged DO



Source: Kansai, 2013.

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

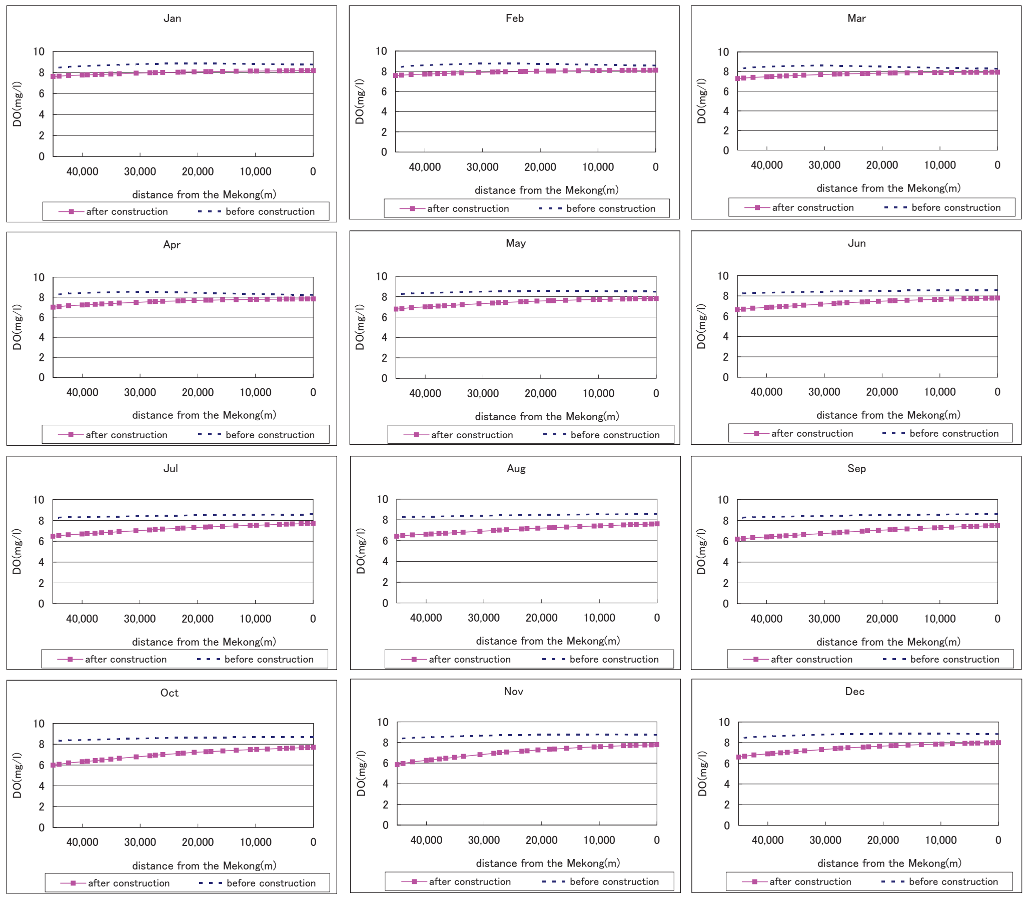


Source: Kansai, 2013.

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)



Source: Kansai, 2013.

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.[10]

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.

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10 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.

According to the water quality models, the DO of discharge should be optimum for fish during the daytime. Low DO could be determined by 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.

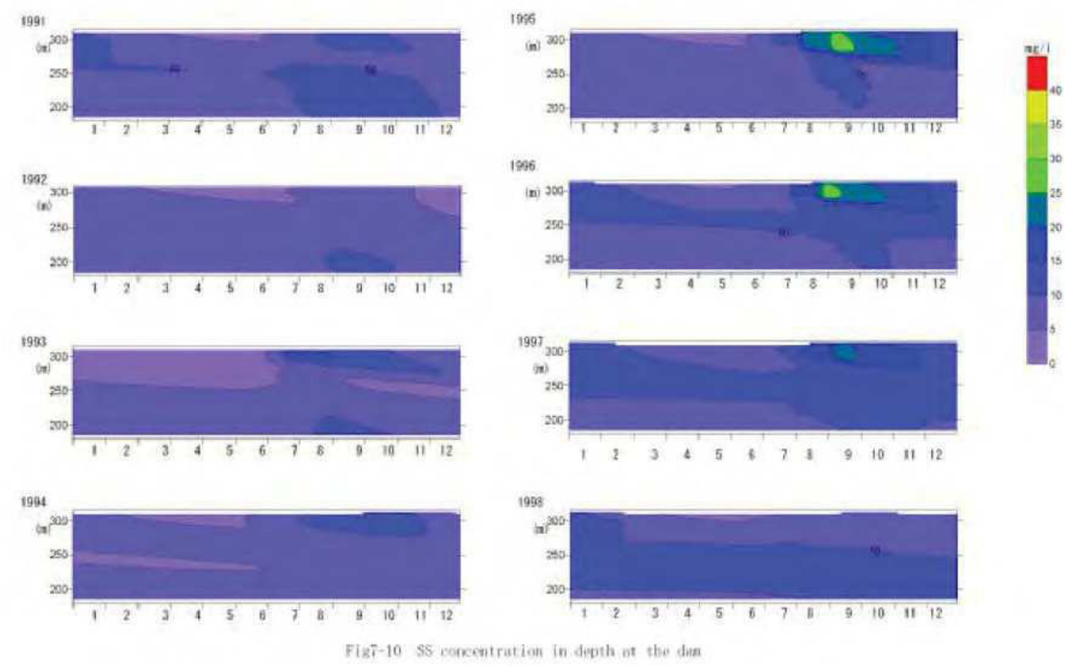
The details of data collection for reservoir water quality such as method, timing and frequency, are shown in *Concession Agreement Annex C: Environmental and Social Obligation (Appendix F)*.

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[11]. 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



Source: Kansai, 2013.

Sedimentation at the dam would also imply 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.

The most critical period of the Project in terms of downstream water quality will be when the impounded water is first discharged. Based on a qualitative analysis, water pollutants from point sources as well as non-point sources of agricultural drainage and open defecation that have accumulated under anaerobic conditions may 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. As with the construction phase, NNP1PC should review water availability in the downstream communities, and provide drinking water (i.e. bottled water) to

11 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.

communities where there has been an impact on drinking water availability. In addition, where possible villagers should be discouraged from using the Nam Ngiep River for consumption purposes.

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 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.

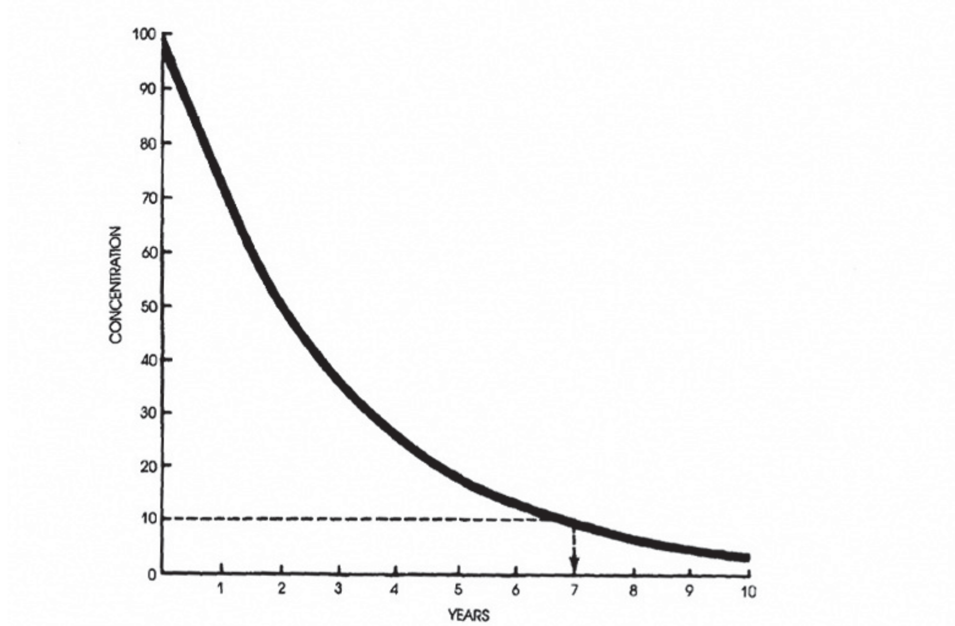
Engineering works will be designed to comply with the agreed water quality standards at various points in the purpose-built system, including the point of release into the Nam Ngiep River below the regulating dam site, and releases from the Nam Ngiep downstream into any natural watercourse or location 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)



Source: Environmental Impact Assessment Report, ERIC, 2012.

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[12] and another 15~20% of total carbon would be degraded anaerobically to carbon dioxide[13]. Based on this study, approximate 35% of

12 Wetzel, 1983

13 David Hamilton, 1997

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”[14].

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.

[14] Environmental Management Support Programme, 2012

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

Source: ERM, 2013.

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[15] (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.

15 Good Practice Guidance for Land Use, Land-Use Change and Forestry, IPCC National Greenhouse Gas Inventories Programme, 2003.

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[16]), and the Lao PDR grid (0.135 ton CO_2/ MWh[17]), representing the destinations of electricity from the NNP1 Project. Combining the above emission factors with the annual generation of 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.

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:

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16 http://forums.asialeds.org/wp-content/uploads/2013/11/SESSION-5-Jiro-Ogahara-LEDS_Asia_Ogahara_20130927.pdf

17 LEDS Workshop 2013 Manila, September 30, 2013.

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:

Low flow analysis

The watershed 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 6.20***) 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 [4.3 km] during dry and rainy season respectively (measured at the deepest point in any cross-section)	• 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 events per 24 hours and in any 7 days consecutive period

Source: Concession Agreement, Annex C Environmental and Social Obligations, 2013.

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	27.0

Source: Kansai, 2013.

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 every day.

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.

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

Source: ERM, 2013.

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.

During operation the environmental flow would be augmented to 27.0 m^3/s, released through the re-regulation dam gate during off peak hours on the weekend. The predicted minimum water depth, river surface width and flow velocity occurring along the 3 km downstream of the re-regulation dam are 1.0 m, 58.1 m and 0.1 m/s respectively.

When the release flow drops from 160.0 to 27.0 m^3/s over 4 hours ramp down time the maximum reduction of width of water surface change reaches 160.0 m near the B. Hatsaykham village. The maximum reduction in the flow velocity drops by 0.7 m/s at the most occurring at the section between the re-regulation dam and the B. Hatsaykham Village.

Water is released through the re-regulation dam gate surface water whilst the higher temperature is predicted as a result of the increasing water temperature (maximum 4°C higher) in the main reservoir than that before the construction. Due to oxygenation and dilution the DO concentration increases as the water flows downstream from the main reservoir. DO concentration of discharged water from the re-regulating dam is over 6 mg/L almost all the year.

During years of extreme drought when there is insufficient water in the main reservoir for normal operation, a discharge of environmental flow of 27.0 m^3/s will be secured and released continuously downstream through the main powerhouse intake at EL 275.5 m, rather than the riparian release conduit located 30 m below the intake.

Water temperature in the main reservoir would be about 4°C higher than that before the construction. The predicted range of the DO in the main reservoir outflow discharge varies from 3.5 mg/L to 7.9 mg/L through the year.

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.
- If low DO is identified in the reservoir or downstream of the re-regulation dam, further investigations into the cause of the water quality is to be undertaken. Based on the results of the investigations, options should be considered to improve DO within the water.

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 operation. 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 construction activities, de-commissioning activities, and operational and maintenance activities.This includes lighting.
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.
Alteration of Flow Regime	Effects on habitats caused by alterations to natural flow regime.
Creation of new habitats	Creation of new habitats and introduction of species as a result of reinstatement works, habitat enhancement proposals and landscaping.
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.

Source: ERM, 2013.

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
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
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

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, including IUCN listed species 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.	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

Source: ERM, 2013.

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.

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 NNP1 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 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, behavior disturbance, fauna mortality and habitat fragmentation for native species.

Table 6.25 Mitigation and Management Measures, Operation 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. This will also include monitoring of biodiversity and fish biomass in the downstream environment.
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.

Source: ERM, 2013.

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 3944 ha of natural habitat and 3549 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-regulation dam	Resettlement	
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-regula-tion 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**

Source: ERM, 2013.

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. This risk assessment approach is outlined in the revised EIA for the NNP1 Project (ERM 2013). ***Table 6.27*** outlines the terrestrial species that have been identified that have residual impacts remaining after mitigation. ***Table 6.28*** outlines the fish species that have residual impacts on their habitats following mitigation.

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
	Golden jackal	Himalayan black bear
Birds	Wreathed hornbill	Red-breasted parakeet
	Great hornbill	Lesser fish-eagle
	Green peafowl	Siamese fireback
	White winged duck	Silver pheasant
	Greater coucal	Grey peacock pheasant
Reptiles	Reticulated python	Elongated tortoise
	King cobra	Big-headed turtle

Source: ERM, 2013.

Table 6.28 Aquatic Species with Residual Impacts following Mitigation

Species name	Common name
Catlocarpio siamensis	Giant barb
Laubuca caeruleostigmata	Leaping barb
Luciocyprinus striolatus	
Pangasianodon hypothalamus	Striped catfish
Probarbus labeamajor	Thicklipped barb
Cirrhinus cirrhosus	Mrigal carp
Scaphognathops bandanensis	Bandan sharp-mouth barb
Yasuhikotakia splendida	Jaguar loach
Labeo pierrei	
Rhinogobius albimaculatus	
Hemimyzon confluens	

Source: ERM, 2013.

6.3.2.8 *Management of Luciocyprinus Striolatus*

Spawning areas for *Luciocyprinus striolatus* (IUCN Red List Endangered) were detected in the catchment of the Nam Ngiep River in 2014, including within the inundation area. Although the habitat is not considered to be critical habitat in accordance with the ADB SPS, the impacts from the project to the species include: loss of habitat, including spawning habitat; permanent fragmentation of habitat; and degradation of habitat, and given the IUCN status (Endangered) specific management measures have been defined for this species.

The purpose of the mitigation is to minimise the magnitude of the impact to the species and to improve and maintain the habitat for the species in the Nam Ngiep River.

Watershed Management above Full Supply Level

The key threats identified in the Nam Ngiep River above FSL include: impacts from water releases from the Nam Ngiep 2 Hydro Scheme; fishing and poaching; and impacts on habitat associated from soil erosion, sedimentation and chemical pollution associated with logging, deforestation and agriculture.

The approach proposed for watershed management to protect the species habitat necessary for its lifecycle and mitigate against the threats identified. An adaptive management framework would be necessary to be designed to aid in mitigation against these impacts from the threats. The approach is outlined in ***Table 6.29.***

Implementation of this management framework will require a close working relationship with landholders, Ministry of Natural Resources and Environment (MONRE) and the Nam Ngiep 2 Hydro Power Scheme.

Table 6.29 Watershed Management Framework for L. striolatus

Activity	Action	Responsibility
Research	• Undertake research into the biology of the species, including population size, breeding cycle and habitat requirements • Undertake a comprehensive assessment of key threats to the species	NNP1 on association with LaRREC
Management	• Develop a management plan for the species in the Nam Ngiep aligned with conservation outcomes for the species and peer reviewed by relevant scientists. • Manage key threats, including impacts from landuses such as forestry and agriculture. • Incorporate key actions into the Watershed Management Plan being prepared by MONRE • Approach and discuss management actions with Nam Ngiep 2 Hydro Power Scheme. • Align the watershed management program with the captive breeding program (See *Section 6.2.1*).	NNP1; LaRREC; MONRE
Education	• Undertake an education program with local villagers regarding the species, including informing them of the declining population and the requirement for conservation.	NNP1; LaRREC; MONRE
Monitoring	• Monitoring of the species presence in the Nam Ngiep River including: population size; threats; effectiveness of education programs; and water quality should occur on a regular basis.	NNP1; LaRREC; MONRE
Governance	• NNP1 Offset Advisory Committee to oversee the implementation of the management framework, including reporting and adaptive management approaches to the species conservation.	NNP1PC; LaRREC; MONRE

Source: ERM, 2013.

Captive Breeding

Captive breeding of *L. striolatus* would have the objective of preserving the genetic resource of the population as well as ensuring that the population could be restocked in the Nam Ngiep River. This measure would guard against future population decline in the river due to threats. This measure is not intended to occur in isolation and will be undertaken with strategic watershed management activities to protect and enhance the habitat with the Nam Ngiep for the species.

Contact has been made with fisheries experts to determine the suitability of captive breeding for the population of *L. striolatus* in the Nam Ngiep River. Dr Morioka from the Japan International Research Center for Agricultural Sciences (JIRCAS) has provided initial advice on the practicality of captive breeding for the species. Contact has also been made with Dr Philippe Cacot from the French Agricultural Research Centre for International Development (CIRAD). Both of these scientists work with the Living Aquatic Resources Research Centre (LaRREC) in Lao PDR.

The recommendations from Dr Morioka suggest that captive breeding for the species is feasible. The approach would require further ecological assessment of the species lifecycle, including information on the biology of the species and its breeding triggers and population size in the Nam Ngiep River. Capture of mature individuals would then be required to form a captive population of both sexes. For genetic diversity, the number of individuals captured should be representative of the population size (10 or more of each sex has been recommended. Dr Morioka believes that LaRREC has the resources available to undertake the research and captive breeding of the species at their facilities in Vientiane.

Species Recovery Coordination

To assist in planning of recovery actions for the species across Lao PDR, it is planned that a species recovery taskforce for L. striolatus be established. This approach would work with Government of Lao to establish a framework for coordination across government agencies to facilitate research and conservation for the species. The recovery taskforce would be led by MONRE and include key members from DESIA, Department of Forestry and Resource Management, Department of Finance and LaRREC. The key objectives of the committee would be to: coordinate research on the species biology; establish a framework to raise awareness of the species within GOL and the community; work with hydropower companies to promote conservation; coordinate captive breeding programs; and undertake education campaigns across the species range to raise awareness of the conservation status of the species and methods to assist conservation.

Co-management of Nam Theun Population

To offset any residual impacts on the species and to ensure the long term persistence of the species, it is planned that a co-management program occur in conjunction with the Nam Theun 2 HydroPower Company (NT2).

L. striolatus is not threatened upstream of the NT2 Reservoir as the majority of the watershed is contained within a protected area. During fish population monitoring, young and adult specimens were found 4 years after impoundment upstream of the Reservoir and downstream of the Nakai Dam. The presence of this species upstream of the Reservoir is mainly due to the configuration of the dams.

Preliminary discussions have occurred with Dr Maud Cottet from NT2 regarding potential co-management of the species within the Nam Theun and Nam Ggouang watersheds. The focus of the co-management will be to fund research into the biology of the species; education within the Nam Theun/Nam Ngouang watershed to protect the species from fishing; and establishment or extension of the conservation area.

6.3.2.9 *Biodiversity Offsetting*

A *Biodiversity Offset framework* has been developed based on the analysis of the options undertaken by ERM contained in the *Biodiversity Offset Design Report for the Nam Ngiep Power 1 Project* (NNP1 Project) (ERM 2014). This offset framework was designed using the Business and Biodiversity Offset Program (BBOP). In principal agreement has been reached for this framework with GOL.

The loss of biodiversity values caused by other projects upstream (such as the Nam Ngiep 2 Hydro Scheme) as well as impacts from activities in the watershed (forestry and agriculture) has a cumulative detrimental impact on biodiversity values. Offsets designed for the Project will not directly offset the impacts of these other projects, but will provide a basis for arresting further degradation and have positive contributions to conservation within the watershed.

The offsets are designed to mitigate against residual impacts identified for the Project in relation to species and habitats and to achieve a no-net-loss of biodiversity values.

In relation to specific offsets for the NNP1 Project, it is planned that the biodiversity offset framework includes:

1. Forested and riverine areas of the Nam Ngiep Watershed to manage biodiversity in terrestrial and aquatic habitats; and
2. Species specific offsets within the Nam Ngiep Watershed and other candidate offset sites (potentially PKK NPA).

The area contained in the watershed was analysed using the "Habitat Hectares" model that determines the type and condition of the habitats lost with the relative gain from management of candidate offsets site over a set management period (In this case, 27 years being the length of the concession agreement). Based on this approach, there is sufficient "like for like" habitat able to be managed to achieve a sufficient gain in biodiversity value over the life of the concession agreement to achieve a "no-net-loss" habitat values in the chosen offset areas.

The legal mechanism to secure the biodiversity offset area is recommended to be a "Provincial Government Decree" to secure the Protection Forests of the Nam Ngiep 1 watershed for the purposes of a biodiversity offset. This Decree is recommended to classify the protection forests as a "Total Protection Zone" under the Forestry Law, prohibiting all uses other than those that sustain the local community. Production forests will be managed for sustainable timber production by introducing techniques to protect habitats for species identified.

To administer and govern the identified offset areas, it is planned that an "NNP1 Offset Advisory Committee" be established. This Committee would be formed with membership from PONRE, DFRM and NNP1PC. This would be chaired by DFRM at representatives from MONRE, the community, NNP1PC (as an observer) and an independent technical advisor holding seats on the committee. Other representatives and stakeholders can be invited to sit on the Committee as required.

Management of habitats within the watershed will include the development of a management plan including the following key actions: monitoring and evaluation; management of hunting; sustainable forestry management in production forests; wildlife corridors; sustainable forest product use (NTFP); management of weeds and pests; fire management; sediment and erosion control; assisted natural regeneration; habitat installation (eg. nest boxes and salt licks); community engagement and development and education and awareness

Both the Nam Ngiep and PKK NPA are included in the offset package in order to increase the opportunities for identifying and protecting target species identified as having residual impacts on their habitats. These species will be subject to a survey to identify their location, either within the watershed or within PKK NPA. However, if these species are not identified or management is not successful in either location, additional offsets may be required elsewhere in Lao PDR.

In determining species offsets, the first step will be a comprehensive survey in the Nam Ngiep Watershed offset area to identify the target species. This would then be followed up with a comprehensive species survey in PKK or other areas within Lao PDR, if required, to identify presence of the target species. A *Species Offset Management Plan* will be prepared that outlines the management actions required for the target species once their presence has been confirmed.

Species specific offsets for management will be prepared. These will include survey and monitoring of species presence within offset areas; identification of core habitat and management of identified populations; species specific management actions identified to manage identified populations; targeted campaigns to manage key threats (eg. education and awareness activities for individual species); alignment of conservation priorities to national and international management plans and requirements and monitoring the effectiveness of offset management activities on species populations

6.3.2.10 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 6.30 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			Proposed Mitigation Measures
				Low	Medium	High	
Physical Environment							
Topography	• Alteration to topography from construction of access road, main dam, re-regulation dam, transmission line, workers camps and quarries.	• Main dam and re-regulation dam construction • Site clearing for construction • Excavation works • Slope stabilization • Underground works • Transmission line construction • Road construction • Quarrying	• Dam and re-regulation dam construction within the Nam Ngiep River • Spoil management stockpiles • Access Road Construction within Huay Nua Provincial Protected Area • Transmission Lines routes adjacent to Nam Ngiep River • Quarries used during construction for main dam, re-regulation dam				• No mitigation measures are required solely for changes in topography, but mitigation measures for erosion and sediment (below) should be applied to also minimize impacts to topography.
Meteorology	• No impact expected	• Reservoir clearing and burning (if any)	• Reservoir				• No mitigation measures are required solely for changes in meteorology, but mitigation measures for air quality (below) should be applied to also minimize impacts to meteorology.

Environmental Aspects	Nature of Impact	Concerned Activities (that would cause impacts)	Impact Area	Magnitude and Level of Impacts: Low	Medium	High	Proposed Mitigation Measures
Geology, Landforms and Seismology	• Landslide and/or rock movement may impact the Project	• Earthquake and Seismic events	• Slopes near Project area	■			• 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).

Environmental Aspects	Nature of Impact	Concerned Activities (that would cause impacts)	Impact Area	Magnitude and Level of Impacts: Low	Medium	High	Proposed Mitigation Measures
Erosion and Sedimentation	• Erosion of disturbed areas from construction of access road, main dam, re-regulation dam, transmission line, workers camps and quarries. • Increased sediment load discharged into aquatic systems adjacent to construction sites. • Management of spoil from excavation and tunneling.	• Main dam and re-regulation dam construction • Site clearing for construction • Excavation works • Slope stabilization • Underground works • Transmission line construction • Road construction • Quarrying	• Dam and re-regulation dam construction within the Nam Ngiep River • Spoil management stockpiles • Access Road Construction within Huay Nua Provincial Protected Area • Transmission Lines routes adjacent to Nam Ngiep River • Quarries used during construction for main dam, re-regulation dam			High	• Development and implementation of an Erosion and Sediment Control Plan to be incorporated into the construction environmental management plan for all project components. • Land clearing activities should be performed during the dry period only. • Best practices for excavation and working within the riverbed should be conducted when constructing the main dam and re-regulation dam. • Limitation of land disturbing activities to take place only in design construction boundary. • Appropriate drainage should be implemented along all access roads, quarry site, soil stockpiles and other construction sites. • Appropriate standards should be applied to project components including drainage works, sediment traps, diversion, culverts and other structures designed to treat water before discharge into natural and/or constructed watercourses should be conducted. • All soil stockpiles should be managed to prevent discharge of contaminated sediment into watercourses. • All quarries should be managed and prevent

Environmental Aspects	Nature of Impact	Concerned Activities (that would cause impacts)	Impact Area	Magnitude and Level of Impacts: Low	Medium	High	Proposed Mitigation Measures
						High	discharge of contaminated sediment into watercourses.
Upstream reservoir and river water quality	• Water pollution from increased sediment and erosion from project components increasing suspended solids and turbidity in the river and reservoir • Faecal coliform impacts from workers camps during construction and villages upstream of the main reservoir. • Nutrients entering the main reservoir from upstream sources.	• Discharge of wastewater from worker camps. • Water pollution from construction activities.	• All construction sites within the watershed of the river, including workers camps and quarries • Construction of the main dam and reregulation dam, including tunneling and coffer dam construction • Access Roads constructed upstream of the main dam and re-regulation dam.		Medium		• Prepare a watershed management framework in conjunction with GOL to manage land use planning, point and diffuse water pollution within the watershed. • To provide designated wastewater treatment facilities. • On-site toilets at working areas and toilet facilities at worker camps should be installed • Direct discharge of wastewater into natural receiving water is not allowed. • To provide designed contaminant treatment facilities for each significant construction site • To conduct best practice in management of earthworks • To provide designed settling ponds for

Environmental Aspects	Nature of Impact	Concerned Activities (that would cause impacts)	Impact Area	Magnitude and Level of Impacts: Low	Medium	High	Proposed Mitigation Measures
					■		sediment settling before release to environment. • Implementation of mitigation measures for erosion and sedimentation control.
Downstream reservoir and river water quality	• Changes in water quality, including Dissolved Oxygen, Suspended Solids and Temperature from discharges downstream from the re-regulation dam • Water pollution from increased sediment and erosion from project components increasing suspended solids and turbidity in the river and reservoir • Faecal coliform impacts from workers camps during construction and villages upstream of the main reservoir.	• Changes in water quality from re-regulation dam discharges during high and low flow • Discharge of wastewater from worker camps. • Water pollution from construction activities. • Water pollution from road and quarry construction	• Riverine environments immediately downstream of the reregulation dam that are used for human use or provide aquatic habitats. • All construction sites within the downstream watershed of the river, including workers camps and quarries • Construction of the main dam and reregulation dam, including tunneling and coffer dam construction • Access Roads construction downstream of the main dam and re-		■		• Prepare and implement a construction environmental management plan for all project components. • Undertake discharges according to the environmental flows regime to ensure adequate downstream water flows (minimum of 5.5m3/sec) • Maintain a dry season flow to ensure adequate water depth. • Monitor water quality and flows downstream from the re-regulation dam. • Mitigation measures outline for "upstream reservoir water quality" outlined above.

Environmental Aspects	Nature of Impact	Concerned Activities (that would cause impacts)	Impact Area	Magnitude and Level of Impacts			Proposed Mitigation Measures
				Low	Medium	High	
			regulation dam				
Noise and Vibration	• Noise of construction activities impacts to surrounding area from tunneling, main and re-regulation dam construction • Noise from construction machinery • Noise from quarrying activities • Noise from passing traffic through local villages along the access road	• Use of machinery for cutting and land excavation • Moving of equipment to the site along the access road • Material transportation along the access road • Blasting works for quarries, main and reregulation dam site • Machinery operation during construction period for all construction sites • Workers camp	• Ban Hat Gniun village • Workers camps within the construction area • All construction sites that use heavy machinery or undertake blasting • Residences along the access road from Paksan to B an 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. • Construction activities that may generate harmful noise should be limited only to day time, e.g. 6 am to 7 pm. • People shall be warned in advance regarding blasting works. • Trespassing to the blasting area shall be strictly controlled. • Location of the workers camp away from the main construction sites.
	• Vibration from construction activities may cause impacts to surrounding area	• Blasting activities	• Residences near the Project				• 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. • 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.

Environmental Aspects	Nature of Impact	Concerned Activities (that would cause impacts)	Impact Area	Magnitude and Level of Impacts: Low	Medium	High	Proposed Mitigation Measures
				■			• Monitor and record air blast and vibration for blasts within 1,000 feet (330 m) of worker camps and other occupied structures. 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.

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	• Increased dust particles and fugitive dust into atmosphere from construction works • Increased dust particles and fugitive dust into the atmosphere along the access road	• 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	• All quarry sites for dam and access road construction • Crushing and Batching plants for dam construction • Road construction areas especially through Huay Ngua Provincial Protected Area • Embankment and channel construction for the main dam and re-regulation dam • Haulage of materials along the access road • Construction of worker camps • Communities around main construction and communities along the access road				• 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 machinery
Potential Contaminated Sites	• Contamination from chemical and hazardous wastes into environment from construction sites and machinery maintenance sites	• Chemical storage areas • Drum reconditioning or recycling • Electric transformers • Explosive product and storage	• Concrete batching plant near the main and reregulation dam construction • Quarries and associated				• 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. • Appropriate training should be conducted

Environmental Aspects	Nature of Impact	Concerned Activities (that would cause impacts)	Impact Area	Magnitude and Level of Impacts: Low	Medium	High	Proposed Mitigation Measures
		• Landfill operation • Pest control • Petroleum product and oil storage • Machinery maintenance areas	infrastructure for the storage of hazardous materials • All vehicle storage and maintenance sites				for all workers responsible for handling hazardous waste. • Best practice and emergency response procedure will be developed and implemented for all construction sites. • Warning/safety signs and rules must be located in the most ppropriate places.
Hydrology	Change in flow downstream during construction of the re-regulation and main dams	• Construction of the main dam and re-regulation dam and Diversion tunnel	• Riverine environments immediately downstream of the reregulation dam that are used for human use or provide aquatic habitats.				• 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.
	Reservoir impoundment downstream from the re-regulation dam	• Reservoir impoundment	• Upstream riverine environments up to FSL, including tributaries. • Riverine environments				• 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

Environmental Aspects	Nature of Impact	Concerned Activities (that would cause impacts)	Impact Area	Magnitude and Level of Impacts			Proposed Mitigation Measures
				Low	Medium	High	
			immediately downstream of the reregulation dam that are used for human use or provide aquatic habitats.				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 permanent access road through the forest areas • Reservoir clearing • Reservoir impoundment	• 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 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.

Environmental Aspects	Nature of Impact	Concerned Activities (that would cause impacts)	Impact Area	Magnitude and Level of Impacts: Low	Medium	High	Proposed Mitigation Measures
				■			• The remaining forest areas in the watershed, 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 watershed 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

Environmental Aspects	Nature of Impact	Concerned Activities (that would cause impacts)	Impact Area	Magnitude and Level of Impacts			Proposed Mitigation Measures
				Low	Medium	High	
							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.
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.
Biodiversity Values	• Permanent loss of habitat	• Permanent loss of 8359 ha habitat within inundation and footprint area from all project components. • Approximately 5180 ha	• Inundation area for the main Dam and re-regulation dam				• Develop and implement a Biodiversity Action Plan (BAP) and manage residual impact through a Biodiversity Offset Plan (BOP) • Minimize the extent of disturbance where possible (logging and hunting rules, design

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 Protection Forest will be inundated					and layout consideration, clear demarcation, forest guard • Develop Biological Resources management program and management plan • Rehabilitation of temporarily disturbed areas
	• Alteration of 73 km stretch of lotic aquatic habitat to lentic aquatic habitat	• Transition of habitat will occur as the main dam and re-regulation dam fill to supply level • Impact to habitat for endemic fish species in the lower reaches of tributaries of the Nam Ngiep	• Inundation area for the Dam and re-regulation dam • Lower reaches of tributaries of the Nam Ngiep River				• Develop and implement a BAP and manage residual impact through BOP focusing on watershed management and riparian protection. • Specific management for endemic fish species identified in tributaries of the Nam Ngiep River
	• Loss of habitat for IUCN terrestrial CE and E species	• The project footprint intersects habitat suitable for these species	• All project components, but in particular the inundation area for the main dam and re-regulation dam				• Develop and implement a BAP and manage residual impact through BOP • Establish wildlife protection team • Rehabilitation of temporarily disturbed areas • Minimise extent of disturbance where possible (logging and hunting rules, design and layout consideration, clear demarcation, forest guard
	• Degradation habitat adjacent to project areas	• Increased access to the area through access roads increases poaching and hunting	• Huay Ngua Provincial Protected Area • Perimeter of the main dam and re-regulation dam				• Develop and implement a BAP and manage residual impact through BOP • Elephant exclusion fencing where appropriate • Raise awareness to discourage poaching and hunting

Environmental Aspects	Nature of Impact	Concerned Activities (that would cause impacts)	Impact Area	Magnitude and Level of Impacts: Low	Medium	High	Proposed Mitigation Measures
					■		• Watershed management activities (including erosion and sediment control)
	• Impacts on Huay Ngua Provincial Protected area from road re-construction activities	• Indirect impacts on habitats along the access road route • Impacts on threatened plants removed because of the access road re-construction	• Hua Ngua Provincial Protected Area		■		• Develop and implement a BAP and manage residual impact through BOP • Minimise extent of disturbance where possible (logging and hunting rules, design and layout consideration, clear demarcation, forest guard • Check points to manage illegal poaching along access road • Rehabilitation of temporarily disturbed area • Replanting of trees to compensate for those lost through construction • Raise awareness to discourage poaching and hunting • Watershed management activities (including erosion and sediment control

Source: Environmental Impact Assessment Report, ERIC 2012 and developed by ERM, 2013.

Table 6.31 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: Low	Medium	High	Proposed Mitigation Measures
Physical Environment							
Meteorology	• Localized changes to ambient air temperatures and relative humidity, and water temperature 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 reservoir and inundation of forest area	• Localized climatic condition	■			• 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 may exert pressure on surrounding geology, with potential to cause an earthquake	• Reservoir and surrounding slopes	■			• Routine inspection of dam structure is recommended, particularly after initial storage of water in the reservoir
Soil	• Reduced soil fertility and/or land suitability at resettlement sites.	• Resettlement	• Resettlement sites	■			• Improvement in soil fertility at resettlement sites should be considered. • Crop management should be conducted. • Prevent loss of soil nutrients with appropriate erosion control.

Environmental Aspects	Nature of Impact	Concerned Activities (that would cause impacts)	Impact Area	Magnitude and Level of Impacts			Proposed Mitigation Measures
				Low	Medium	High	
Erosion and Sedimentation	• Soil erosion in the watershed area	• Increased agricultural activities because of access to the area above FSL	• Watershed area				• Watershed Management Plan should be implemented.
	• Build up of sediments in reservoir	• Reservoir creation	• Reservoir area				• Erosion and sedimentation control plan should be implemented.
	• Erosion along the riverbank	• Regulating water release will alter the characteristics of water flow and have a scouring effect on the river bank	• Riverine environments immediately downstream of the reregulation dam that are used for human use or provide aquatic habitats.				• Regularly monitor riverbank erosion.
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	• Riverine environments immediately downstream of the reregulation dam that are used for human use or provide aquatic habitats.				• 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 may be caused by vehicles traveling to and from the site. • Possible greenhouse gas emissions from vegetation left following impoundment	• Communities along the access road				• Clearance of biomass prior to impoundment
Potential Contaminated Sites	• Contaminated of chemical and hazardous into environment	• Use 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, pesticides and fertilizers must be avoided to prevent soil and water pollution.
		• Accidental spills 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 for use shall be clarified.
	• Change in flow downstream during operation of the re-regulation and main dams (operational discharges)	• Operation of environmental flow regime	• Riverine environments immediately downstream of the reregulation dam that are used for human use or provide aquatic habitats.				• Undertake discharges according to the environmental flows regime to ensure adequate downstream water flows (minimum of 5.5m3/sec) • Maintain a dry season flow to ensure adequate water depth. • Monitor water quality and flows downstream from the re-regulation dam.

Environmental Aspects	Nature of Impact	Concerned Activities (that would cause impacts)	Impact Area	Magnitude and Level of Impacts			Proposed Mitigation Measures
				Low	Medium	High	
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 • Undertake discharges according to the environmental flows regime to ensure adequate downstream water flows.
	• Backwater effect at the confluence of Mekong River	• Operation of environmental flow regime	• The confluence of Mekong River				• Develop water quality model for prediction and further planning. • Undertake discharges according to the environmental flows regime to ensure adequate downstream water flows.
Hydrology	• Change in flow downstream during operation of the re-regulation and main dams (operational discharges)	• Operation of environmental flow regime	• Riverine environments immediately downstream of the reregulation dam that are used for human use or provide aquatic habitats.				• 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. • Undertake discharges according to the environmental flows regime to ensure adequate downstream water flows. • 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.

Environmental Aspects	Nature of Impact	Concerned Activities (that would cause impacts)	Impact Area	Magnitude and Level of Impacts			Proposed Mitigation Measures
				Low	Medium	High	
							• 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 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.
Biological Environment							
Terrestrial Ecology/Wildlife	• Disturbance of wildlife	• Continuous impact from construction phases	• Upstream area, Reservoir and downstream area				• Strict rules against logging outside the approved construction and inundated areas. • 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.

Environmental Aspects	Nature of Impact	Concerned Activities (that would cause impacts)	Impact Area	Magnitude and Level of Impacts: Low	Medium	High	Proposed Mitigation Measures
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.

Environmental Aspects	Nature of Impact	Concerned Activities (that would cause impacts)	Impact Area	Magnitude and Level of Impacts			Proposed Mitigation Measures
				Low	Medium	High	
Aquatic Biota	• Changing of habitats for fish, especially spawning grounds • Decreasing of fish populations	• 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 prohibited
	• 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				• 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.

Environmental Aspects	Nature of Impact	Concerned Activities (that would cause impacts)	Impact Area	Magnitude and Level of Impacts			Proposed Mitigation Measures
				Low	Medium	High	
Biodiversity Values	• Permanent loss of habitat	• Permanent loss of 8359 ha habitat within inundation and footprint area from all project components. • Approximately 5180 ha of Protection Forest will be inundated	• Inundation area for th main Dam and re regulation dam				• Develop and implement a Biodiversity Action Plan (BAP) and manage residual impact through a Biodiversity Offset Plan (BOP) • Minimize the extent of disturbance where possible (logging and hunting rules, design and layout consideration, clear demarcation, forest guard • Develop Biological Resources management program and management plan • Rehabilitation of temporarily disturbed areas
	• Alteration of 73 km stretch of lotic aquatic habitat to lentic aquatic habitat	• Transition of habitat will occur as the main dam and re-regulation dam fill to supply level • Impact to habitat for endemic fish species in the lower reaches of tributaries of the Nam Ngiep	• Inundation area for th Dam and re-regulatio dam • Lower reaches of tributaries of the Nam Ngiep River				• Develop and implement a BAP and manage residual impact through BOP focusing on watershed management and riparian protection. • Specific management for endemic fish species identified in tributaries of the Nam Ngiep River
	• Loss of habitat for IUCN listed aquatic species and endemic species	• The inundation area impacts species below the dam wall and above FSL in tributaries and upstream	• Flows discharges from th main dam and re regulation dam • Inundation area flowing habitats in tributaries				• Develop and implement a BAP and manage residual impact through BOP focusing on watershed management and riparian protection. • Specific management for endemic fish species identified in tributaries of the Nam Ngiep River • Additional management measures for the species *Luciocyprinus striolatus* (See separate section for mitigation for this species)

Environmental Aspects	Nature of Impact	Concerned Activities (that would cause impacts)	Impact Area	Magnitude and Level of Impacts			Proposed Mitigation Measures
				Low	Medium	High	
	• Alteration of flows downstream of the re-regulation dam in the Nam Ngiep River	• Alteration of flows may alter habitat values downstream • Installation of the dam will restrict movement of aquatic species up- and down-stream of the dam walls • Filling of the dams will result on greater restriction of movement for species that cross the Nam Ngiep or aquatic fauna moving up- and downstream	• Dam and re-regulation dam • Downstream of the re-regulation dam			High	• Develop and implement a BAP and manage residual impact through BOP • Natural flows maintained during construction using a diversion • Water quality monitoring • See hydrology mitigation measures above

Source Environmental Impact Assessment Report, ERIC 2012 and developed by ERM, 2013.

6.4 *UNANTICIPATED IMPACTS*

Unanticipated Impacts throughout the Project will be addressed as per the relevant sections of ADB's SPS, which are as follows:

- **Unanticipated Environmental Impacts**
  Where unanticipated environmental impacts become apparent during project implementation, the borrower/client will update the environmental assessment and EMP or prepare a new environmental assessment and EMP to assess the potential impacts, evaluate the alternatives, and outline mitigation measures and resources to address those impacts.

- **Unanticipated Involuntary Resettlement Impacts**
  If unanticipated involuntary resettlement impacts are found during project implementation, the borrower/client will conduct a social impact assessment and update the resettlement plan or formulate a new resettlement plan covering all applicable requirements specified in this document.

- **Unanticipated Indigenous Peoples Impacts**
  If unanticipated impacts on Indigenous Peoples become apparent during project implementation, such as a change in the project's footprint, the borrower/client will carry out a social impact assessment and update the IPP or formulate a new IPP covering all applicable requirements specified in this document.

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 and 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 less 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

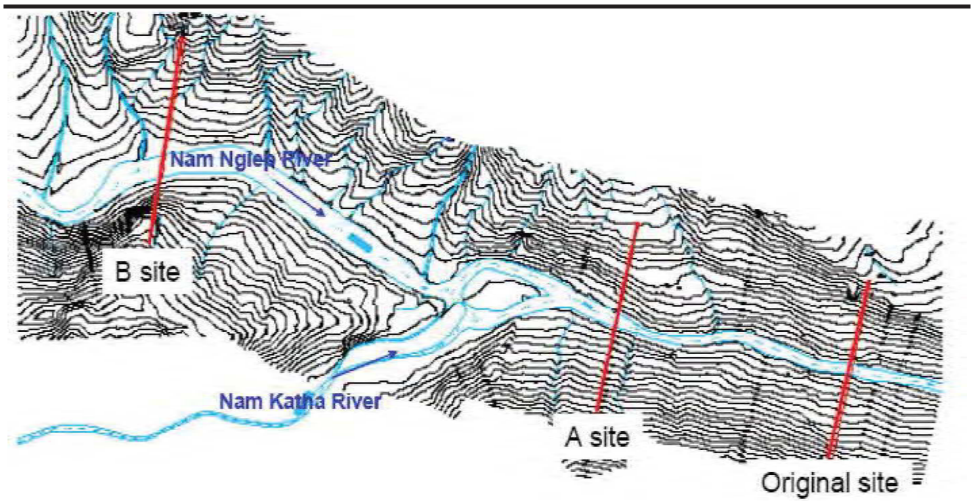
7.3.3.1 Overview

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

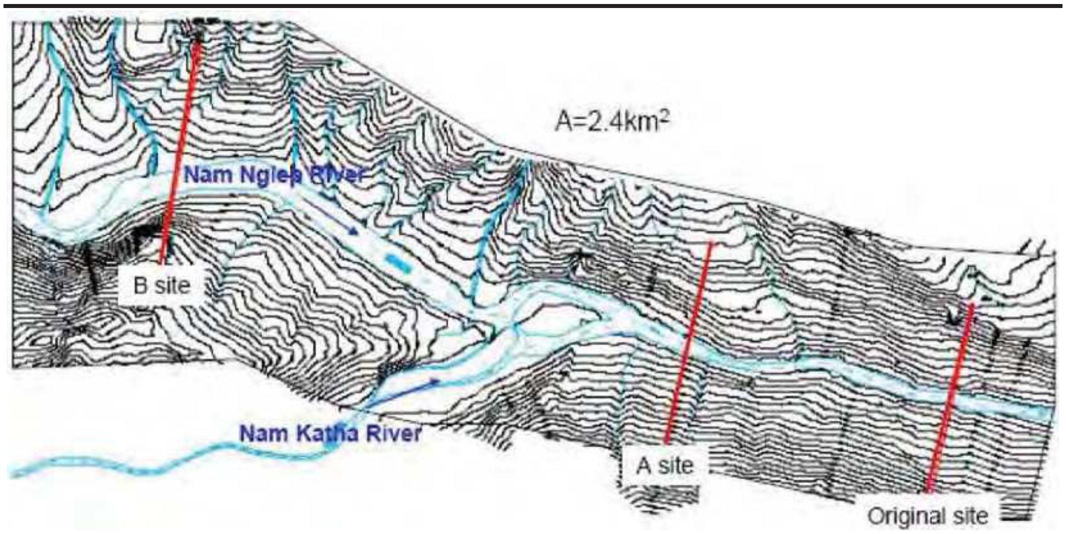


Source: Technical Report, 2011.

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.

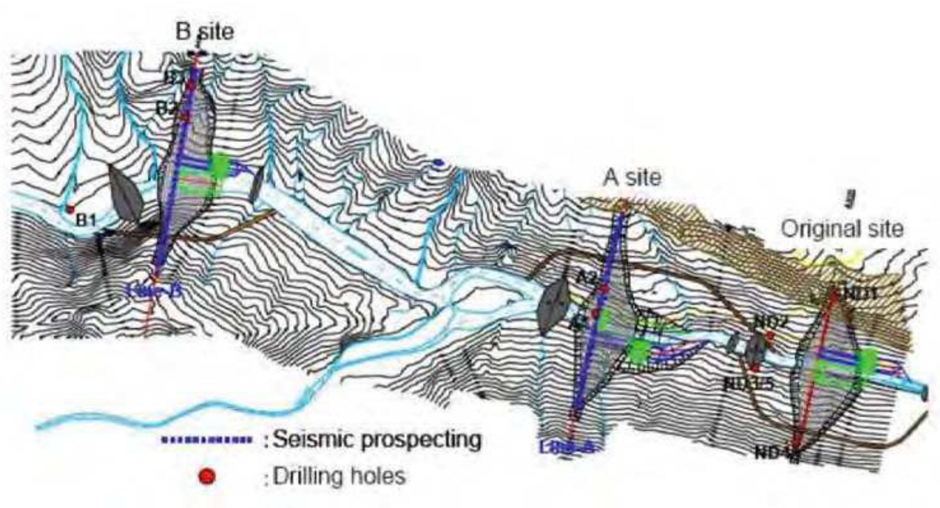
The seismic wave prospecting was to verify the weathering conditions of the foundation rock, and the drilling surveys aimed to identify the thickness of the river deposit. Meanwhile, JICA-F/S conducted the alkali-aggregate reaction tests and reported a "positive alkali-aggregate reaction". Since these 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

Source: Technical Report, 2011.

Figure 7.3 Geological Survey Plan



Source: Technical Report, 2011.

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.
Note: A: Good, B: Fair, C: Poor

Workability of the original site was given an evaluation of site 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.

Site B is also located upstream of the Nam Katha River, thus avoiding inundation of this tributary and impacting on the aquatic resources and flows contributed by this river to the main stream of the Nam Ngiep River.

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 Report in 2004	JICA F/S(Phase-II) 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)

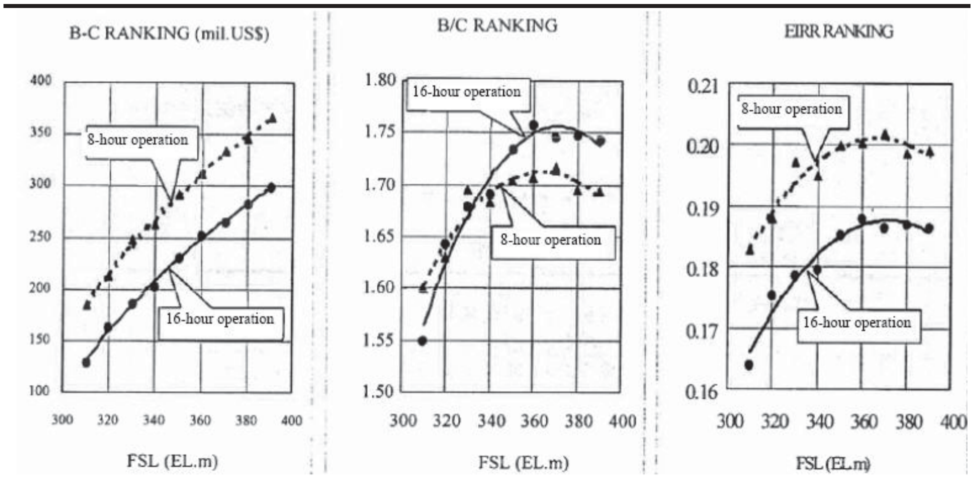
Flood Water Level (FWL)	EL. 320.0 m
Normal Water Level (NWL)	EL. 320.0 m
Rated Water Level (RWL)	EL. 312.0 m
Minimum Operation Water Level (MOL)	EL. 296.0 m
Maximum Plant Discharge	230 m^3/s

Source: Technical Report, 2011.

(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 as shown in ***Table 7.6***. 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, 2011.

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.

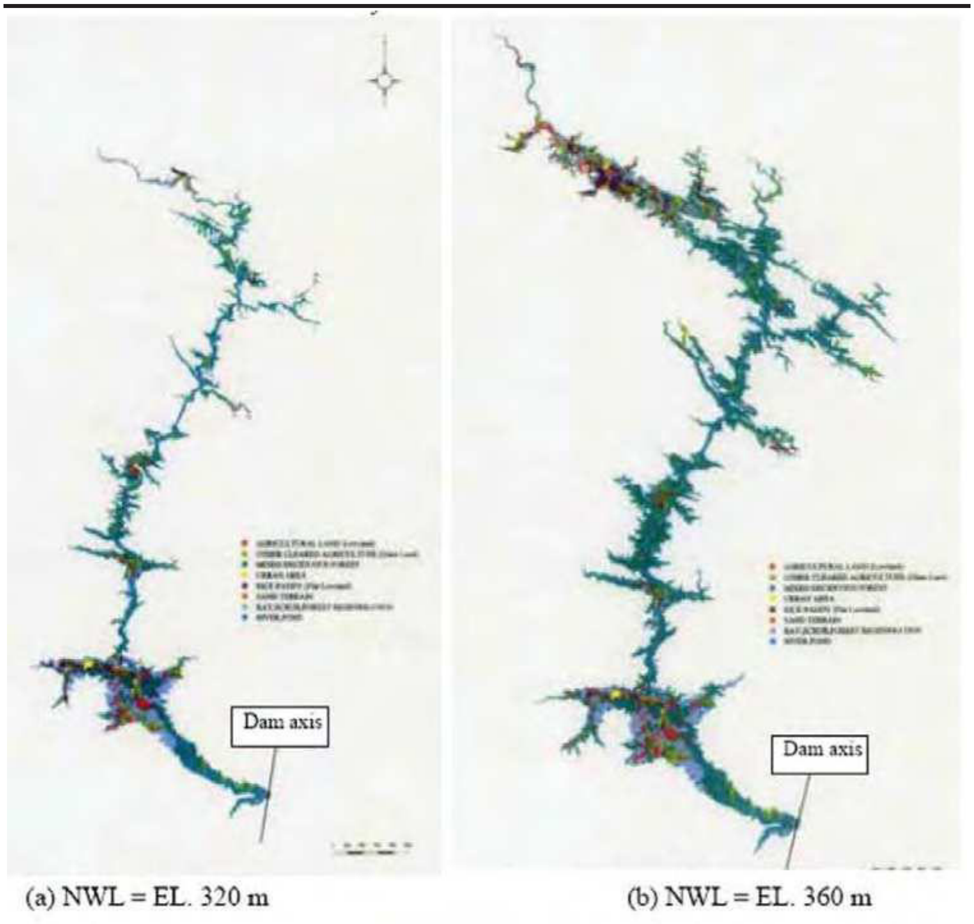
(2) Flood Water Level (FWL) of the main reservoir

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

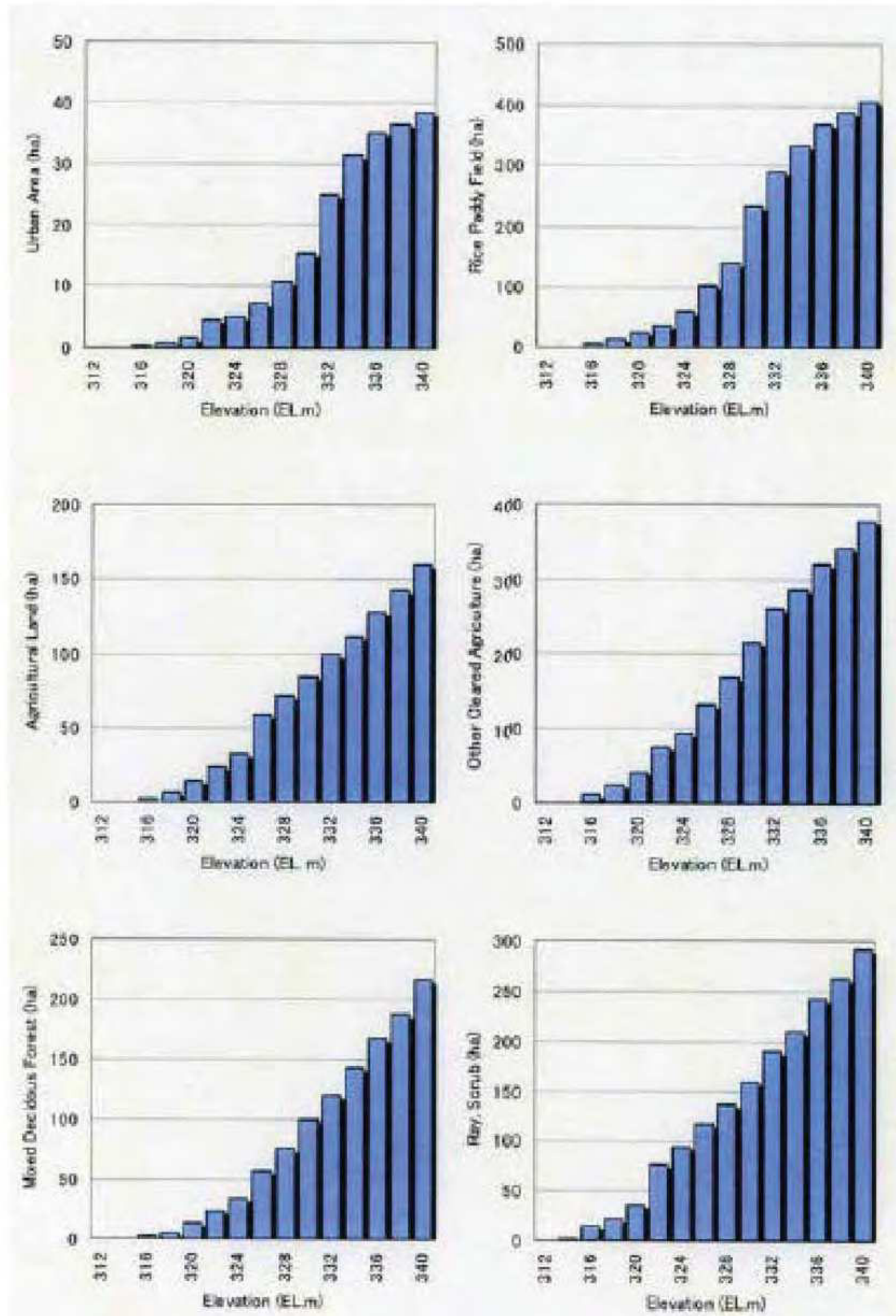
The maximum plant discharge was determined so that the annual peak energy for 95% dependability of the total analyzed period (30 years) should not fall below 80% of the annual average peak energy. The maximum plant discharge depended on the level set for NWL and MOL.

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)

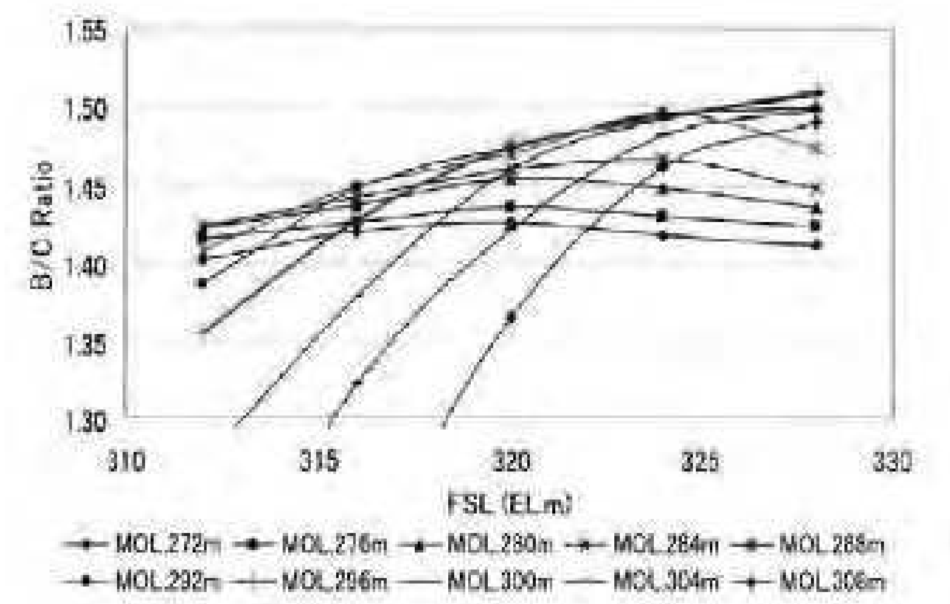


Source: JICA-F/S, 2002.

(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 was divided a plant discharge rate into 2 stages (the maximum is 48 m^3/s for 15 hours and minimum is 27 m^3/s for 17 hours), the maximum discharge rate of Alternative 1 is higher than Alternative B at 39 m^3/s throughout 32 hrs. The operation cost per unit of Alternative 1 is cheaper than Alternative 2 due to the dividing into 2 stages of Alternative 1.

In terms of maintaining downstream environmental flows the minimum discharge rate at 27 m^3/s of alternative 1 is lower than the discharge rate of Alternative 2 (39 m^3/s) but it is considered that Alternative 2 will maintain sufficient environment flows within the main stream.

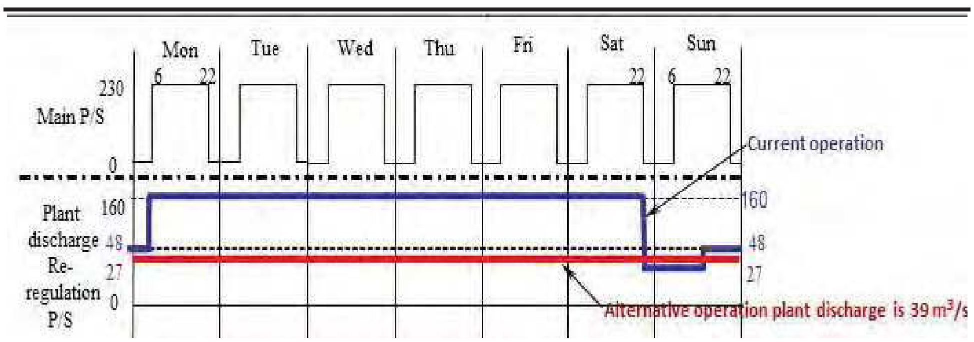
Therefore Alternative 1 is the preferred option.

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 <u>* 48 m^3/s is minimum plant discharge guaranteed by the Contractor</u>	2 turbines and generators, Total discharge: 80 m^3/s × 2 =160 m^3/s <u>* Minimum plant discharge of 39 m^3/s is possible</u>
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**

Source: JICA-F/S, 2002.

Figure 7.8 The Alternatives of Operation of Re-Regulation Power Station



Source: Kansai, 2013.

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	Originally built by French and US troops in 1960s.
	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.	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	21.2 km	22.7 km
(Ban Nonsomboun to Ban Hat Gniun)	[(PPA) 11.8 km + 10.4 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

	Proposed Road	Alternative Route
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

Source: Environmental Assessment for NNP1 Access Road from Ban Nonsomboun to the Main Dam, 2014.

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.

Proposed Road	Alternative Route	Conclusion
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.
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.

Source: Environmental Assessment for NNP1 Access Road from Ban Nonsomboun to the Main Dam, 2014.

The Alternative Road is also located close to or within the boundary of Phou Ngou Provincial Protection Forest, though there is a buffer zone of about 50 to 100 m between Huay Ngua PPA and Phou Ngou Provincial Protection Forest according to the Provincial Department of Natural Resource and Environment. Also, in a certain area of the Alternative Road, the environment circumstances are recovered to almost natural conditions because the route is no longer used as frequently.

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*

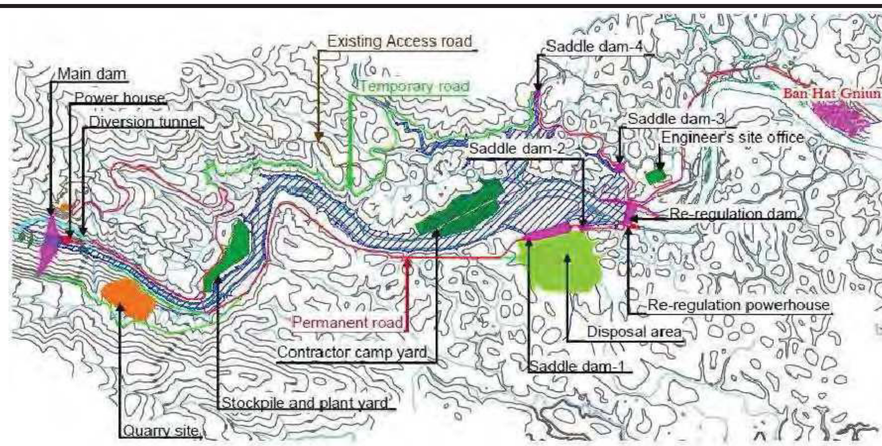
Due to the need to access multiple locations in the construction area between Ban Hat Gniun and the Dam Site, and geographic constraints, including steep topography, a requirement for access via each side of Nam Ngiep, and an objective to minimize watercourse crossings (in order to minimize impacts to 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.

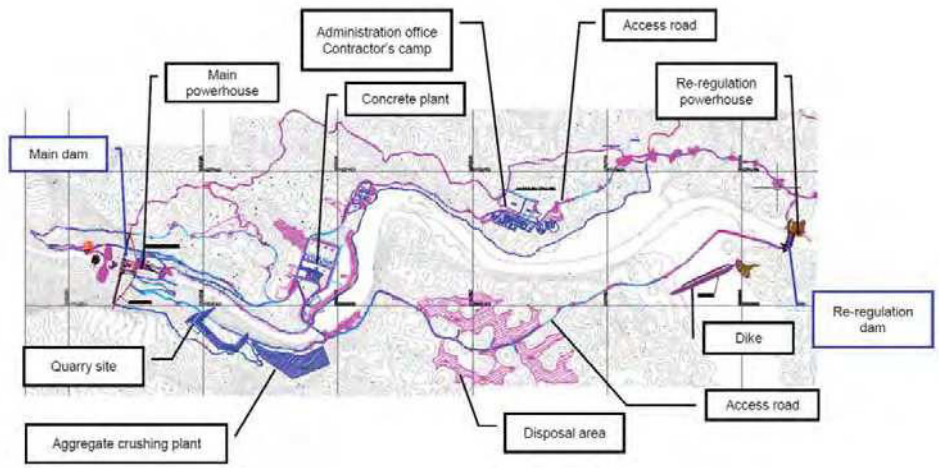
There have been two alternatives of access road alignments adopted in NNP1, as shown in ***Figure 7.9*** and ***Figure 7.10.***

Figure 7.9 Previous Proposed Alignment (2008)



Source: Environmental Assessment for NNP1 Access Road from Ban Nonsomboun to the Main Dam, 2014.

Figure 7.10 Current Alignments (2013)



Source: Environmental Assessment for NNP1 Access Road from Ban Nonsomboun to the Main Dam, 2014.

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. Avoided Wat Ptabat Phansane Temple.
EGAT route (August 2007)	Avoided areas of mixed forest, residential areas and Wat Ptabat Phansane Temple. EGAT route was found to intersect area frequently used by elephant herd.
Initial IEE route (February 2011)	Avoided areas of mixed forest, residential areas, Wat Ptabat Phansane Temple and area frequently used by elephant herd. Huay Ngua PPA was established in 2010, and initial IEE route was found to intersect the PPA.
IEE V1 route (January 2014)	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 as shown in ***Figure 7.11***. For this IEE, new alternative routes to avoid the PPA were considered. The base alignment considered in this report is referred to as the Eastern Alignment. The alternative considered, which avoids Huay Ngua PPA by remaining on the west bank of the Nam Ngiep River, is referred to as the Western Alignment. The following alternative routes were considered to avoid the PPA:

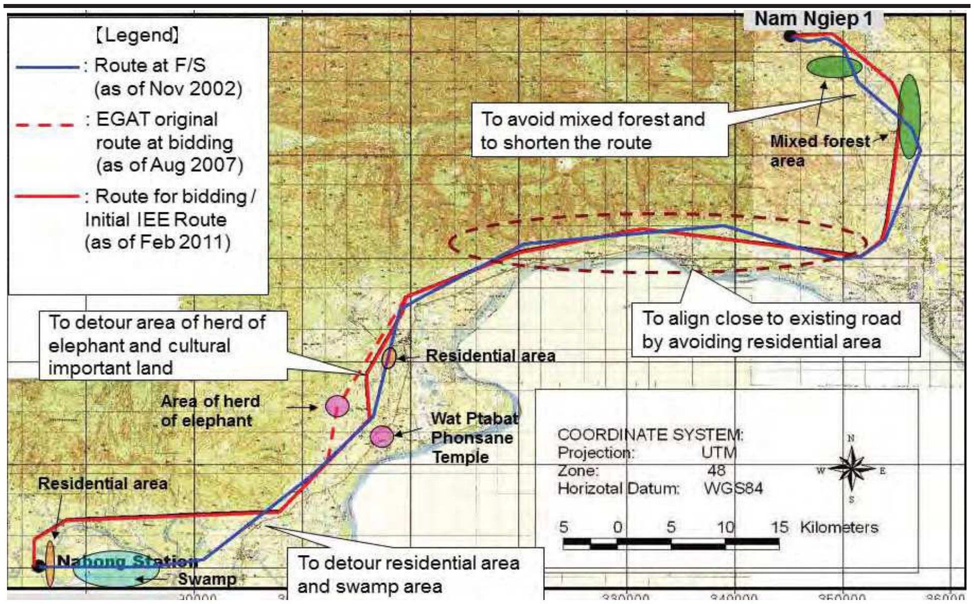
- Eastern Alignment: the alignment runs along the east bank of Nam Ngiep, adjacent to an existing access road that intersects Huay Ngua PPA, then from south of Huay Ngua PPA runs parallel to the EDL transmission line route.

- Western Alignment: the alignment remains on the west bank of Nam Ngiep, avoiding Huay Ngua PPA, and rejoins the original alignment south of Huay Ngua PPA. The gradient on the west bank is steep.

An analysis of considerations with respect to vegetation and habitats for the two alignments was carried out in the NNP1 Transmission Line IEE (Appendix F). The analysis split each route into five different segments, with each segment analyzed for its potential impact to the habitat type and land condition. The results indicated that, overall, the Western Alignment traverses less natural habitat and contains a higher proportion of low condition vegetation in comparison to the Eastern Alignment.

Based on the assessment of the cost, constructability, reliability and environment and social impacts provided in ***Table 7.11***, the Western Alignment was considered the preferred option.

Figure 7.11 Alternative Alignments Considered for the Project Transmission Line



Source: NNP1 Transmission Line from the Main Dam to Vientiane IEE report, 2014.

Table 7.11 Comparison of Environmental and Social Impacts, and Feasibility of Proposed Road and Alternative Route

Consideration	Original (2012 Alignment)	Eastern Alignment	Western Alignment
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.

Consideration	Original (2012 Alignment)	Eastern Alignment	Western Alignment
		Traverses more natural habitat than Western Alignment.	Traverses less natural habitat and more low condition vegetation than the Eastern Alignment.
	Fair	Good	Excellent
Social impact	No residential area	Passing close to Thahuea village	No residential area
	Excellent	Poor	Excellent
Evaluation	Fair	Good	Good

Source: NNP1 Transmission Line from the Main Dam to Vientiane IEE report, 2014.

7.4.2.2 *Substation 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

Source: NNP1 Transmission Line from the Main Dam to Vientiane IEE report, 2014.

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.

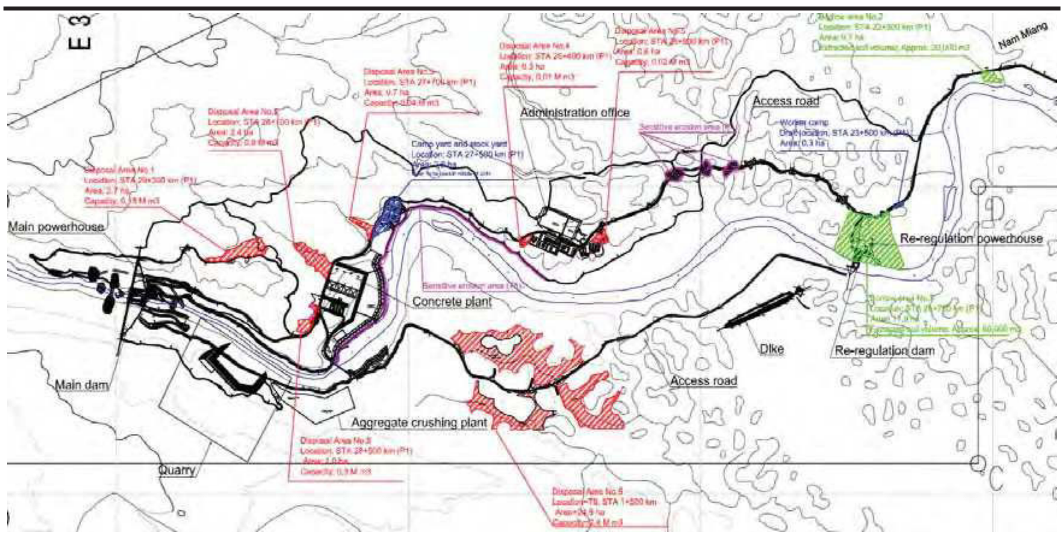
The EMP-Sub Plan 02 for Spoil Disposal is proposed as a guideline for safety precautions during construction, and for minimizing the environmental impact of spoil disposal areas of the Project.

Table 7.13 Capacity of Spoil Disposal Areas

Description	Location	Area (ha)	Perimeter (m)	Capacity Volume (m^3)	Expected Disposal Volume (m^3)
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	

Source: NNP1PC, 2013.
Note: *U/C: under consideration

Figure 7.12 The Spoil Disposal Area Locations of the Project



Source: NNP1PC, 2013.

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 STAKEHOLDER IDENTIFICATION

The stakeholders that have been engaged by the Project shall be identified as International Stakeholders, GOL authorities and other relevant stakeholders.

8.2.1 *Internal Stakeholders and GOL Authorities*

NNP1PC had undertaken rigorous scoping and revision of findings to identify authorities and stakeholders in relation to the design, construction and operation of the Project. The finding indicates 5 main types of internal stakeholders and authorities in relation to environmental aspects prescribed in ***Table 8.1*** below.

Table 8.1 Key Stakeholders in relation to the Project

Relevant Stakeholder
1. Developer
NNP1PC
EGATi
KANSAI Electric Power Co., Inc.
Lao Holding State Enterprises
2. Financier
ADB
JBIC
3. GOL Authorities at District Level
Hom District
Bolikhan District
Pakxan District
Thathom District
4. GOL Authorities at Provincial Level
Xaysomboun Province
Bolikhamxay Province
5. Government of Lao
Ministry of Natural Resources and the Environment (MONRE)

Source: ERM, 2013.

8.2.2 *Other Stakeholders*

Moreover, NNP1PC had identified other important stakeholders, importantly, the people who will be both directly and indirectly affected from the design and construction of the Project. These groups of stakeholders are described in ***Table 8.2***.

Table 8.2 Other Stakeholders in relation to the Project

Stakeholders in Construction Area (Main Dam and Re-regulation Dam and Components)
1. Resettlers (Category); Zone 2 Lower Section of the Reservoir (2LR) and Zone 3 Construction Area ▪ Ban Houaypamom ▪ Ban Sopyouak ▪ Ban Sopphuane ▪ Ban Namyouak ▪ Ban Hatsaykham ▪ Ban Pou (10 households) ▪ Ban Hatsamkhone (5 households)
2. Partially Impacted Persons (Category 2) Zone 2 Upper Section of the Reservoir ▪ Ban Pou ▪ Ban Hatsamkhone ▪ Ban Piengta
3. Project personnel

4. Village Organization ▪ Village Headman and Deputy ▪ Village Security (Konglon) ▪ Police ▪ Health Volunteers (Orsomor) ▪ Lao Youth ▪ Lao Women's Union
Stakeholders along the Transmission Line
Stakeholders along the 230 kV transmission line (125 km) ▪ Ban Nabong, Pak Ngum District ▪ Ban Thakokhai, Pak Ngum District ▪ Ban Nonh, Pak Ngum District ▪ Ban Xienglea Na, Pak Ngum District ▪ Ban Xienglea Tha, Pak Ngum District ▪ Ban Veunkabao, Pak Ngum District ▪ Ban Na, Thaphabat District ▪ Ban Somsaath, Thaphabat District ▪ Ban Palai, Thaphabat District ▪ Ban Thabok, Thaphabat District ▪ Ban Sisomxay, Thaphabat District ▪ Ban Nongkuen, Thaphabat District ▪ Ban Pakthouay Neu, Thaphabat District ▪ Ban Pakthouay Tai, Thaphabat District ▪ Ban Vuenthat, Thaphabat District ▪ Ban Xaysavang, Thaphabat District ▪ Ban Pak Ngiep, Pakxan District ▪ Ban Nampa, Bolikhan District ▪ Ban Hat Gniun, Bolikhan District Stakeholders along the 115 kV transmission line (40 km) ▪ Ban Nampa, Bolikhan District ▪ Ban Huaykhoun, Bolikhan District ▪ Ban Thongnoi, Pakxan District ▪ Ban Thongyai, Pakxan District ▪ Ban Sanaxay, Pakxan District ▪ Ban Anusonxay, Pakxan District It shall be noted that the 115kV transmission line is not included in the scope of work for NNP1PC.

Source: ERM, 2013.

Table 8.3 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 8.3 Summary of Stakeholders

Stakeholder	Potential Project Impact	Relative Priority of Interest	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 NNP1	(-)(+)	1	The comprehensive environmental, economic, social and cultural impacts of the Project

Stakeholder	Potential Project Impact	Relative Priority of Interest	Key Stakeholders' Interests in the Project
reservoirs, and/or construction of various Project components			What properties and how much property will be affected? Privately owned or public property? What will they get in return? How will the losses be compensated or the impacts be mitigated? Where will they be resettled? How will their livelihoods be affected by the Project? Who are the main people responsible or the people or organizations to contact in case compensation or mitigations measures are unsatisfactory? Can they take part in the project as workers or some other capacity? What will be their sources of income after the project? Will they still be able to continue their existing ways of life or livelihoods?
Indirectly affected people: who are in the same communities as some of the directly affected people, or who share the Nam Ngiep basin	(-)(+)	2	What will be the impacts of the project? Can they be certain there will be no direct impacts to them? Will they also have the right to participate in the development programs or other activities of the Project that can provide benefits? Is there any chance for them to be hired to work for the project? What will be their livelihoods with the project? Will they still be able to continue their existing ways of life or livelihoods?
Labourers and other staff	(+)	3	Good living conditions in the workers' camp and good facilities Adequate protection in hazard prone areas or protection from hazardous materials Sufficient training for the assigned tasks
Village Organizations: Village Headman and Deputy Village Security Police Health Volunteers Lao Youth Lao Women Union Front for National Construction	(-)(+)	1	Continuation of existing organizational arrangements at the new resettlement sites Boundaries and land use of the new villages Land reallocation criteria and fair application of the criteria Management of newly introduced development projects Priority of participation in the

Stakeholder	Potential Project Impact	Relative Priority of Interest	Key Stakeholders' Interests in the Project
			newly introduced development projects or activities Ability to be the first line of approach for Grievance Procedures
Secondary Stakeholders			
Developers: NNP1PC EGAT KANSAI LHSE	(+)		Costs The most economical and practical process The fastest way to implement the plan efficiently Efficient and effective communication with stakeholders Investment profit and positive image Ability to meet loan and legal requirements of GOL and Lenders
Development Lenders: ADB and JBIC + Banks adhering to Equator Principles (Development Banks)	(+)		Reduce poverty among APs and promote national development of Lao PDR The project is implemented according to approved plans and Concession Agreement Affected people are adequately compensated Integration of the project into the overall plans and policies of the banks Assure compliance with social and environmental safeguards to protect people, flora, fauna, and environment in the project area Managing reputational risk to the Banks based on sound project planning and implementation
Commercial Lenders: different commercial banks from Thailand and other countries	(+)		Dividends Continuing repayment of debts Reputation from being involved in a development project Avoidance of bad publicity due to project controversies
Government of Lao PDR via various line ministries, Prime Minister's Office MONRE MAF Ministry of Communication, Transport, Post and Construction Ministry of Industry and Handicrafts DOE Ministry of Labour and Social Welfare Ministry of Information and	(-)(+)		Integration of the Project into the National Development Plan 2010-2015 and the Millennium Development Goals Implementation of activities according to the Concessions Agreement Sustainability of positive developments Budget in-flows Development of infrastructure Technology transfers Minimizing environmental and social impacts

Stakeholder	Potential Project Impact	Relative Priority of Interest	Key Stakeholders' Interests in the Project
Culture Ministry of Education Ministry of Health			Benefits to the local people, distributed thoroughly and evenly Effective communication between the Project, GOL authorities, provincial and district counterparts, and affected people Involvement of district and provinces in project implementation
GOL Authorities at Provincial Level: Vientiane Province, Xaysomboun Province, Bolikhamxay Province	(-)(+)		Integration of Project and its elements into provincial development plans Selection and management of personnel required to help implement and/or monitor the Project
GOL Authorities at District Level: Hom District, Bolikhan District, Pakxan District, Thaphabath District, Pak Ngum District, Thathom District	(-)(+)		Integration of Project and its elements in district development plans Selection and management of personnel required to help implement and/or monitor the Project Benefit to the district and local people Land use and land reallocation, + issuance of legal tenure documents
External Stakeholders			
NGOs and other external stakeholders	(-)(+)		Impacts on environment within Nam Ngiep watershed Impacts on environment of the Mekong River Impacts of the Project on local people and the Lao PDR Issues of culture, gender, ethnicity, etc. Compliance with IFI safeguards policies
Media	(-)(+)		Accompanying hydropower development in Mekong sub-region and disclose information to a global public, including the national audiences of developers

Source: Social Impact Assessment, 2014.

8.3 CONSULTATION TECHNIQUES

The Project plans to conduct a formal community consultation in order to elicit concerns and opinions from relevant stakeholders. Methodology and techniques to be applied are described below.

8.3.1 *Methodology*

Methodology to elicit the stakeholders' perceptions and concerns is carefully designed by taking into account the stakeholders' understanding and expectations toward the Project. The consultation methodology emphasizes the following areas:

- The Project's objectives and composition are understood;
- The presented information including the Project description, potential impacts and related mitigations measure are transparent and easily understood by the stakeholders; and
- The presented information does not attempt to mislead or cause any misunderstandings, false reputation upon the Project.
- The environmental and social information of the Project shall be disclosed by posted on the Project's web site and engagement activities shall be arranged on stakeholders continuously.

During the public consultation and Project disclosure, it has been important to take into consideration the following issues:

i. the local authority structures, ensuring however that participation in consultation was not dominated by local authorities;
ii. the need to enter into good faith negotiations with affected ethnic group households;
iii. the active participation of women and vulnerable groups and the consideration of their needs and wants in planning of mitigation measures; and
iv. the proper documentation of the process as well as the accurate recording of participation and results of the stakeholder information and consultation process.

8.3.2 *Techniques*

Techniques for public consultation have been designed to suit the needs of each target audience as well as meet the requirements of the diverse and numerous stakeholders involved in this Project, outlined in the previous chapter. The techniques adopted include the following methods:

- Use of ***visual presentations*** including pictures, diagrams and posters, especially at the local and regional level; lately, this included a 3D-model of the proposed resettlement area.
- ***Face-to-face and practical communication***; intensified in places where levels of literacy are recognized as being low. This includes the use of seminars, workshops, village meetings, semi-structured interviews,

small group meetings, models, participatory rural appraisal techniques, and site visits.

- ***Translation*** into ***Lao*** language of Project documents and summaries; these were used in particular for local leaders, regional officials and national stakeholders. Furthermore, verbal translation into ***Hmong*** language, above all during village consultation meetings
- Use of ***local Project information*** centres in Thathom, Bolikhan, and Hom District. These centres enable the distribution of information about the project, the collection of feedback from stakeholders, the ability to deal with inquiries and requests for additional information, and form a place to conduct periodic meetings with village and district representatives. It furthermore supports the information dissemination policy outlined in the CA.
- Direct discussion with the stakeholders through electronic or written media, group and individual briefings, distribution of detailed project information, and field trips to the project area for ***national and international stakeholders***.
- Dissemination of the Project documents (EIA, REDP and Social obligations of the Company, for example) through the Company and ADB websites.
- Establishment of through various public information centres.
- Site visits for international stakeholders.

The NNP1PC shall inform and invite stakeholders and local public authorities to participate in the Consultation Meeting held in different affected areas. The meetings discuss environmental impacts and implementation of mitigation measures during the construction period, including public relations such as grievance redress mechanism and key contact persons to handle complaints received from the locals, and governmental agencies in the area. The Project acknowledges complaints and keeps record of questions, concerns and recommendations from local people and authorities.

Key element for disclosure is the prepared impact assessment and planning and implementation documents, which will be sheared with the wider public as different channels;

- On a publicly accessible Project's web site.
- In the Company' offices at a publicly accessible place during office hours.
- Publication and provision to Project related district and provincial authorities.
- Publication and posting at information centres in Sopyouak village.
- Through dissemination meetings with PAPs using relevant ethnic languages and appropriate techniques.
- Information Display at central public locations in affected communities.

The following table (***Table 8.4***) contains a tentative schedule for disclosing documents. All public documents will be disclosed to the Project's website.

Table 8.4 NNP1 Document Disclosure Schedule/ Social Components

Document	Audience	Targeted time of disclosure
Draft SIA, REDP, SDP	MONRE	2012
Land Acquisition and Compensation Plan Access Road (LACP-AR)/ 1st Report	ADB	January 2014
Draft updated SIA, REDP, SDP incl. RAP, LIRP, and EDP LACP-AR / 1st Report	PAPs, ADB, Wider Public	March 2014
Updated SIA, REDP, SDP incl. RAP, LIRP, and EDP LACP-AR / 2nd Report	PAPs, GoL, ADB, Wider Public	April 2014
Monthly Reports	RMU	Monthly starting from one month after the Effective date (i.e. end of September 2014) until 3 years after COD (i.e. early 2022)
Quarterly Reports	RMU, PRLRC	3-Monthly starting three months after the Effective date (i.e. end of November 2014) until 3 years after COD (i.e. early 2022)
Annual Reports	RMU, PRLRC	12-Monthly starting three months after the Effective date (i.e. end of September 2015) until 3 years after COD (i.e. early 2022)
LACP Transmission Lines	PAPs, GoL, ADB, Wider Public	October 2014
Baseline Reports	MONRE, PRLRC, ADB	December 2014
Updated LIRP and EDP	MONRE, PAPs, ADB, Wider Public	6 months after the Effective Date, i.e. around February 2015

Source: Social impact Assessment, 2014.

8.4 CONSULTATION ACTIVITIES

Consultation 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.

The record of consultation meetings to obtain such information has involved the utilization of village meetings and focus group discussions which affect people in various project areas, as outlined in methodology since 2007 to 2013. A summary of these meetings is presented in ***Table 8.5***. The engagement plan and arrangement will be provided by SMO to ensure the stakeholder engagement activities are implemented appropriately during construction period and this engagement plan and arrangement will be revised and updated (by SMO) continuously throughout the Project operating.

Table 8.5 Summary of Stakeholder Meetings

Stakeholder Group	Date	Public Consultations and Disclosure, key information, timing and approaches taken	Participants	Content
Central Level: Stakeholders including international Finance Institutes, MONRE, other GOL Organizations	May 2011 July 2011	Consultation and discussion at Hom District Technical Workshop and site visit to proposed resettlement site by MONRE	GOL, NNP1, ADB, IOs, Media	Presentation of the Project and initial results of the social document preparation
	April 2014	2 Broad Stakeholder Forums incl. GOL, IOs, iNGOs, NPAs, Press, etc.	GOL, NNP1, ADB, IOs, iNGOs, NPAs,	Presentation of the Project, impacts, and

Stakeholder Group	Date	Public Consultations and Disclosure, key information, timing and approaches taken	Participants	Content
and Agencies, General Public, and NGOs.			Media	social and environmental mitigation measures
Provincial Level: Bolikhamxay, Vientiane, and Xieng Khouang Provinces (not included is day-to-day cooperation with the RMU and related meetings) / now Xaysomboun Province	April 22, 2008	Consultation and discussion at Bolikhamxay Provinces	PAPs: 23; GOL: 31; NNP1: 9; Consultants: 30	Understanding of the proposed ESIA reports presented by the Consultancy Company hired by the Project
	April 24, 2008	Consultation and discussion at Xieng Khouang Provinces	PAPs: 43; GOL: 79; NNP1: 18; Consultants: 21	
	April 28, 2008	Consultation and discussion at Vientiane Provinces	PAPs: 22; GOL: 42; NNP1: 17; Consultants: 12	Collection of comments and proposals from the related agencies on the ESIA draft as well as suggested mitigation measures
	April 04, 2012	Consultation and discussion by Vientiane and Bolikhamxay Provinces	PAPs: 44; GOL: 38; NNP1: 29; Consultants: 3	Discussion of Project and GOL answers of 12 questions raised by 2LR villagers
	February 26, 2013	Consultation with the newly established Province of Xaysomboun	GOL incl. Provincial Governor, NNP1PC	Discussion of Project, Entitlements, Standards, and Procedures
District Level: Bolikhan, Pakxan, Hom, and Thathom Districts (not included is day-to-day cooperation with the DCCs and related meetings)	January 16, 2008	Public Consultation at Bolikhan District	PAPs: 18; GOL: 32; NNP1: 9; Consultants: 10	Presentation and consultation on the development of ESIA documents
	January 18, 2008	Consultation and discussion at Hom District	PAPs: 16; GOL: 28; NNP1: 9; Consultants: 12	
	February 21, 2008	Consultation and discussion at Thathom District	PAPs: 13; GOL: 56; NNP1: 8; Consultants: 5	Presentation of first concepts of mitigation measures
	June 09, 2008	Consultation and discussion at Hom District	PAPs: 10; GOL: 9; NNP1: 1; Consultants: 8	Collection of comments from the stakeholders participating in the meeting
	June 12, 2008	Consultation and discussion at Pakxan District	PAPs: 14; GOL: 8; NNP1: 1; Consultants:	

Stakeholder Group	Date	Public Consultations and Disclosure, key information, timing and approaches taken	Participants	Content
			6	
	July 2, 2008	Consultation and discussion at Thathom District	PAPs: 18; GOL: 4; NNP1: 1; Consultants: 4	
	November 5, 2008	Consultation and discussion at Hom District	PAPs: 8; GOL: 16; NNP1: 1; Consultants: 7	
Joint Inter-Zone Village Meetings with Representatives	July 2013	Consultations and resettlement site visit with elders from 2LR and Z3	2 x RMU representatives of every Province, Project staff, 6-10 male and female PAP representatives from each village from 2LR and Z3	Information on Project status; presentation of a 3D model of Houaysoup; decision of villagers on where to plan residential area; villagers comments and requests; site visit; traditional ceremonies
Zone 1& 2UR villages:	Jul 2011	Household and village survey at 3 villages	All households	Data collection for ESIA Draft
Villagers, Village Authorities	October 2, 2011	Consultation Meeting at Ban Pou	PAPs: 181; GOL: 5; NNP1: 7; Consultants: 8	Information on updated ESIA reports and PAP's suggestions; focus-group-discussions have been conducted, too
	October 3, 2011	Consultation Meeting at Hatsamkhone	PAPs: 100; GOL: 5; NNP1: 7; Consultants: 8	
	October 3, 2011	Consultation Meeting at Ban Piengta	PAPs: 72; GOL: 5; NNP1: 7; Consultants: 8	
	December 08, 2012	Focus Group Discussions at Ban Pou	Groups of 5-10 people	Ideas of development of women, youth, and elders and input and requests towards the Projects
	December 09, 2012	Focus Group Discussions at Ban Hatsamkhone		
	December 11, 2012	Focus Group Discussions at Ban Piengta		
	August 13, 2013	Village Consultation Meeting at Ban Pou	PAPs:109 ; GOL: 2; NNP1: 6	Presentation of Project structure; entitlements; GRM; discussions on entitlements; decision to relocate within village
	August 14, 2013	Village Consultation Meeting at Ban Hatsamkhone	PAPs:70 ; GOL: 2; NNP1: 6	
	August 15, 2013	Village Consultation Meeting at Ban Piengta	PAPs: 89; GOL: 2; NNP1: 6	

Stakeholder Group	Date	Public Consultations and Disclosure, key information, timing and approaches taken	Participants	Content
				boundaries and support Project; BCS Agreements and request to the Project;
Zone 2LR villages: Villagers, Village Authorities	October 31, 2007	Consultation Meeting at Sopyouak	PAPs: 62; GOL: 9; NNP1: 5; Consultants: 5	Data collection for ESIA Draft
	September 16, 2011	Consultation Meeting at Namyouak	PAPs: 124; GOL: ; NNP1: 7; Consultants: 9	Information on updated ESIA reports and PAP's suggestions; focus-group-discussions have been conducted, too
	September 17, 2011	Consultation Meeting at Sopyouak	PAPs: 92; GOL: 2; NNP1: 7; Consultants: 9	
	September 18, 2011	Consultation Meeting at Sopphuane	PAPs: 34; GOL: 1; NNP1: 7; Consultants: 9	
	September 19, 2011	Consultation Meeting at Houaypamom	PAPs: 130; GOL: 3; NNP1: 7; Consultants: 8	
	March 4 to 7, 2012	Consultation Meetings at 4 villages	Total participants: 171	Discussion of Project and GOL answers of 12 questions raised by 2LR villagers
	May 2012	Informal Meetings, with lenders at 4 villages		
	August 31, 2013	Consultation Meeting at Namyouak	118 Participants	Presentation of Project structure; entitlements; GRM; discussions on entitlements and RAP; BCS Agreements and request to the Project;
	September 1, 2013	Consultation Meeting at Sopphuane	79 Participants	
	September 2, 2013	Consultation Meeting at Houaypamom	51 Participants	
	September 3, 2013	Consultation Meeting at Sopyouak	100 Participants	
	September 3, 2013	Consultation with elders of all 4 villages	Around 40 incl. NNP1, elders plus additional villagers	Discussion of Project timeline and next steps
	4-5 December 2013	Participation at Hmong New Year	NNP1PC, Villagers and representatives	Informal discussions on Project development
	March 2014	Start of continuing work of the Community Consultations Team in the	NNP1PC, Villagers	Discussions of Entitlements, options of

Stakeholder Group	Date	Public Consultations and Disclosure, key information, timing and approaches taken	Participants	Content
		villages		resettlement, resettlement and livelihood planning
Zone 3: Villagers, Village Authorities	July 2011	Household and village survey at Hatsaykham	All households included	Data collection for ESIA Draft
	September 25, 2011	Consultation Meeting at Hatsaykham	PAPs: 77; GOL: 1; NNP1: 6; Consultants:	Information on updated ESIA reports and PAP's suggestions; focus-group-discussions have been conducted, too; PAPs of Z3 requested to resettle to Houaysoup
	May 2012	Informal Meetings, with lenders at Hatsaykham		
	November 13-14, 2012	Focus Group Discussions at Hatsaykham	Groups of 5-10 people	Ideas of development of women and elders and input and requests towards the Projects
	December 18, 2013	Village Consultation Meeting	NNP1PC, RMU, villagers of Hatsaykham and Hat Gniun	Entitlements, Grievance Redress Mechanism, Access Road Development
	March 2014	Start of continuing work of the Community Consultations Team in the villages	NNP1PC, Villagers	Discussions of Entitlements, options of resettlement, resettlement and livelihood planning
Zone 4 and 5: Villagers, Village Authorities	October 29, 2007	Consultation Meeting at Ban Hat Gniun	PAPs: 30; GOL: 11; NNP1: 3; Consultants:	Broad consultation on env. and social mitigation measures
	September 26, 2011	Consultation Meeting at Hat Gniun	PAPs: 54; GOL: 3; NNP1: 6; Consultants:8	Information on updated ESIA reports and PAP's suggestions; focus-group-discussions have been conducted, too;
	September 26, 2011	Consultation Meeting at Thahuea	PAPs: 51; GOL: 3; NNP1: 6; Consultants:8	
	May 2012	Informal Meetings, with lenders at and Hat Gniun		

Stakeholder Group	Date	Public Consultations and Disclosure, key information, timing and approaches taken	Participants	Content
	November, 14-15, 2013	Focus Group Discussions at Hat Gniun	Groups of 5-10 people	Ideas of development of women and elders and input and requests towards the Projects
	November, 15, 2013	Focus Group Discussions at Thahuea	Groups of 5-10 people	Ideas of development of women and input and requests towards the Projects
	December 17, 2013	Village Consultation Meeting	NNP1PC, RMU, villagers of Nonsomboun and Sisavath	Entitlements, Grievance Redress Mechanism, Access Road Development

Source: Social Impact Assessment, 2014.

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 especially in environmental issues 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.

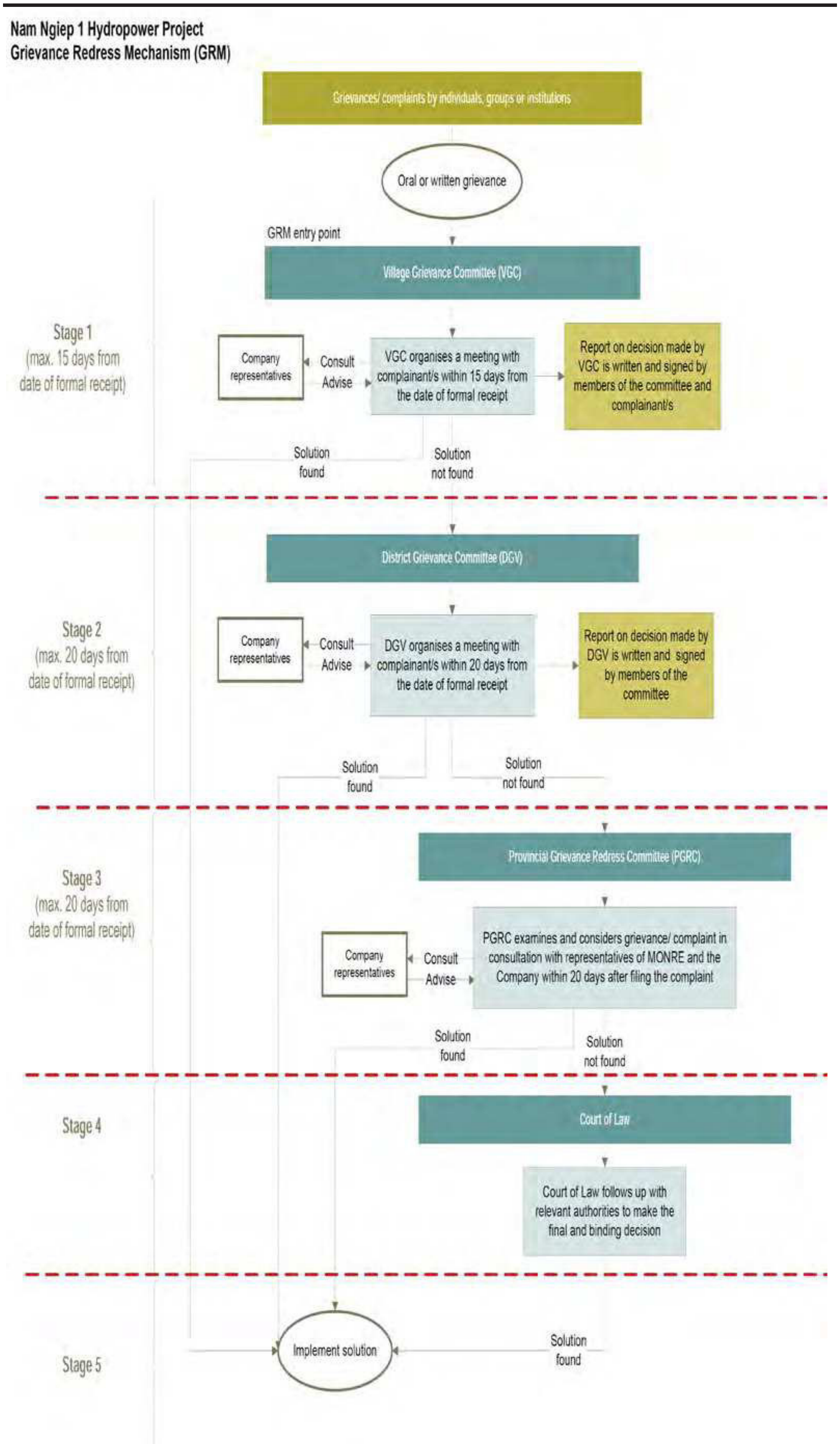
The GRM will address all grievances raised by PAPs, including those associated with land acquisition, compensation, resettlement and livelihood restoration, and environmental matters.

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



Source: ERM, 2013.

Stages and timeframes associated with the GRM procedures are as follows:

- Stage 1: PAPs will register grievances on any aspect of environmental, 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. The company representative shall be a one of Village Grievance Committee members incase grievance against the project activities.

- 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. • Representation from the Project team (SMO Manager, if necessary).
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 (SMO Manager, if necessary).
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 (SMO Manager, if necessary).

Source: ERM, 2013.

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. All cases of grievance made to the District Grievance Committee and Provincial Grievance Redress Committee shall be reported to the Independent Advisory Panel (IAP) of 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.

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 21 EMP Sub-Plans, which have been developed as guidelines for minimizing environmental impacts from specific activities of the Project, primarily during construction. These 21 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 every 2 (two) years by internal review, 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 SPS 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.

The Contractor's EMP (ESMMP and SSESMMP) shall be submitted to NNP1PC for review before commencement of construction within a date and time agreed between NNP1PC and the Contractor. The mitigation measures of the ESMMP and SSESMMP shall be included from the EMP of NNP1PC to prevent and decrease the impact of importance environmental aspects for its effective implementation.

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*

Objective

- To prevent landslides.
- To avoid reservoir induced seismic activity.

Actions to be Taken

The slope and geology around the reservoir, 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 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, as a precautionary measure, annual observations will be made for all steep slopes and remedial actions taken for evaluate the safety of the dam. As a precautionary measure, s routine 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.

Responsible Unit / Agency

NNP1PC /Environmental Management Office (EMO).

Cost Estimate (USD)

No additional costs expected.

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*

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 and sedimentation.
- To estimate the predicted level of sediment-related situations which will occur at the Project site (i.e. soil erosion).

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 07: Vegetation Clearing , Sub-Plan 08: Landscaping and Re-vegetation, and Sub-Plan 11: Spoil Disposal. 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 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.
- The maximum permissible slope for stockpiles of excavated material and mapping of all areas prone to soil erosion at all construction sites shall be obligated to the Contractor before preparing the erosion control plans.

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, 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.

Responsible Unit/Agency

- For all prevention and mitigation measures: NNP1PC / Contractor / Sub-Contractor.
- For monitoring: Environmental Management Unit (EMU) and EMO.

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)

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.	Monthly and weekly in rainy season							

10.1.1.3 *Reservoir and River Water Quality*

Objective

To control the quality of discharge through water courses.

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 02: Water Ability and Pollution Control. 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.
- Review water availability in the downstream communities, and provide drinking water (i.e. bottled water) to communities where there has been an impact on drinking water availability.
- Villagers should be discouraged from using the Nam Ngiep River for consumption purposes due to the existing contamination levels.

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 by NNP1PC and Contractor. 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 07: 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.

<u>Specifications of monitoring are as follows:</u>

- 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.

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.

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

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.

Objective

To mitigate the impacts of water quality deterioration due to decaying organic matter (i.e., plants and forest matter).

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 07: Vegetation clearing and also related in Sub-Plan 03: Emission and Dust Control, Sub-Plan 05: Waste Management, and Sub-Plan 06: Hazardous Material Management.

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 inundation area such as the reservoir, dams, powerhouse(s), spillway(s), and switchyard(s) before the commencement of impoundment. The other areas such as construction sites and camp areas shall be done by the Company before commencement of construction, to avoid potential impacts of biomass clearance of the Project.

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 (VDC), 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 07: Vegetation Clearing (***Appendix H***).

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.

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.

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 at least some residences are within 500 m of construction activities.

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).

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 04: Noise Control and also related in Sub-Plan 11: Spoil Disposal, Sub-Plan 12: Quarry and Construction Layout Management, Sub-Plan 14: Construction of Work Camps, and Sub-Plan 16: Training and Awareness. 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 80 dB(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.

Measures for Vibration Control Plan:

- 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***.

Responsible Unit/Agency

- For all prevention and mitigation measures: NNP1PC / Contractor / Sub-Contractor.
- For monitoring: EMU and EMO.

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.

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.

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).

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 03: Emission and Dust Control and also related in Sub-Plan 01: Erosion and Sediment Control, Sub-Plan 05: Waste Management, and Sub-Plan 15: 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.

Responsible Unit/Agency

- For all prevention and mitigation measures: NNP1PC / Contractor / Sub-Contractor.
- For monitoring: EMU and EMO.

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.

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*

Objective

- To prevent site contamination.
- To monitor and report measurements to the relevant organization(s).

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: Waste Management, Sub-Plan 06: Hazardous Material Management, Sub-Plan 20: Emergency Preparedness, and also related on Sub-Plan 11: Spoil Disposal, Sub-Plan 12: Quarry and Construction Layout Management and Sub-Plan 14: 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. Firefighting 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.

Responsible Unit/Agency

- For all prevention and mitigation measures: NNP1PC / Contractor / Sub-Contractor.
- For monitoring: EMU and EMO.

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.

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>

Objective

- To monitor water levels both of upstream and downstream.
- To inform the local people about water levels and related issues.

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.

Responsible Unit/Agency

- EMU and EMO.

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).

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__

Objective

- To establish early warning systems in the event of floods.
- To train local people for emergency flood situations.

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.

Responsible Unit/Agency

- For Development of plan and warning system: NNP1PC, Construction Contractor, and EMO.

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.

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*

Objective

- To prevent landslides.
- To avoid reservoir induced seismic activity.

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.

Responsible Unit/Agency

- NNP1PC and EMO.

Cost Estimate (USD)

No additional costs expected.

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.

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.

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.

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.

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).

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*

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.

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.

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

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).

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*

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.

Actions to be Taken

- 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.
    -

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.

Responsible Unit/Agency

EMU and EMO

Cost Estimate (USD)

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).

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).

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	Biweekly Monitoring Plan: Temperature, pH, conductivity, turbidity, SS, DO, COD, BOD_5, total coliform and fecal coliform	Biweekly									
2	Seasonal Monitoring Plan: 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	Seasonal Monitoring Plan: 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.

Objective

To monitor the quality and other characteristics of the groundwater in areas downstream from the dam.

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.

Responsible Unit/Agency

EMU and EMO.

Cost Estimate (USD)

USD 5,000 per test, once every 3 years (year 1, 4 and 7, total USD 15,000 of 3 times).

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.

Objective

Monitoring of the use of these materials will be part of the operations procedure for the Project.

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.

Responsible Unit/Agency

- For monitoring: EMU and EMO.

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.

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*

Water Level Monitoring

Objective

- To monitor water levels.
- To inform the local people about water levels and related issues.

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.

Responsible Unit/Agency

EMU and EMO.

Cost Estimate (USD)

Monitor water levels and reporting: USD 1,000 per year (Total 27 years of operation phase, USD 27,000).

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

Objective

- To establish early warning systems in the event of flooding.
- To train local people for emergency flood situations.

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.

Responsible Unit/Agency

NNP1PC, EMU and EMO.

Cost Estimate (USD)

Training: USD 2,000 per year (total 27 year of operation phase, USD 54,000).

Work Plan:

	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

Objective

To rescue wildlife that might be affected by inundation.

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.

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

Cost Estimate (USD)

USD $30,000 for survey, USD $80,000 for the rescue and protection of wildlife animals, USD $10,000 for monitoring.

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											

	Work Plan	Frequency	Pre construction	Construction Phase (year)						Operation Phase (year)			
				1	2	3	4	5	6	1	2	3-8	>8
3	Release wildlife in a new habitat	At appropriate time					– –	– –	– –	–			

__Wildlife protection and conservation awareness__

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

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.

Responsible Unit/Agency

- Implementation: PAFO, DAFO, EMO, Social Management Office (in work with villagers).
- Monitoring: EMU, EMO.

Cost Estimate (USD)

US$ 27,000 per year; USD $10,000 for monitoring.

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 logging and poaching	monthly											
4	Monitor animal habitat	yearly											
5	Monitor animal diversity and density	yearly											

Management of habitat and vegetation clearing

Objective

- Reduce disturbance of flora and fauna, including flora and fauna listed on the IUCN Red List, due to construction activities

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.

Responsible Unit/Agency

- Implementation: PAFO, DAFO, EMO, Social Management Office (in work with villagers).
- Monitoring: EMU, EMO.

Cost Estimate (USD)

US$ 35,000 per year; US $10,000 for monitoring per year.

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

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.

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.

Responsible Unit/Agency

- Implementation: PAFO, DAFO, EMO, Social Management Office (in work with villagers).
- Monitoring: EMU, EMO.

Cost Estimate (USD)

US$ 55,000 per year; US $10,000 for monitoring per year

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

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.

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.

Responsible Unit/Agency

- Implementation: PAFO, DAFO, EMO, Social Management Office (in work with villagers).
- Monitoring: EMU, EMO.

Cost Estimate (USD)

US$ 55,000 per year; US $15,000 for monitoring per year.

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)

Objective

- Reduce degradation of habitat through appropriate rehabilitation of habitats.
- Ensure the appropriate rehabilitation of disturbed areas with native endemic species.

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.

Responsible Unit/Agency

- Implementation: PAFO, DAFO, EMO, Social Management Office (in work with villagers)
- Monitoring: EMU, EMO

Cost Estimate (USD)

US$ 80,000 per year; US $20,000 for monitoring per year.

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 re-vegetate disturbed areas	monthly											
3	Monitoring program	yearly											

10.3 *UNEXPLODED ORDINANCES (UXO)*

Objective

To facilitate service for and management of UXO survey and clearance.

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 Sub-Plan 13: Unexploded Ordnance (UXO) Survey and Disposal and also related in Sub-Plan 06: Hazardous Material Management and Sub-Plan 16: Training and Awareness.

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.

Responsible Unit/Agency

NNP1PC and EMO

Cost Estimate (USD)

USD 600,000 per clearing area; the budget must be prepared before preconstruction phase

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 21: Cultural Resources and also related Sub-Plan 16: Training and Awareness (***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 14: Construction of Work Camps and also related in Sub-Plan 16: Training and Awareness, 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.

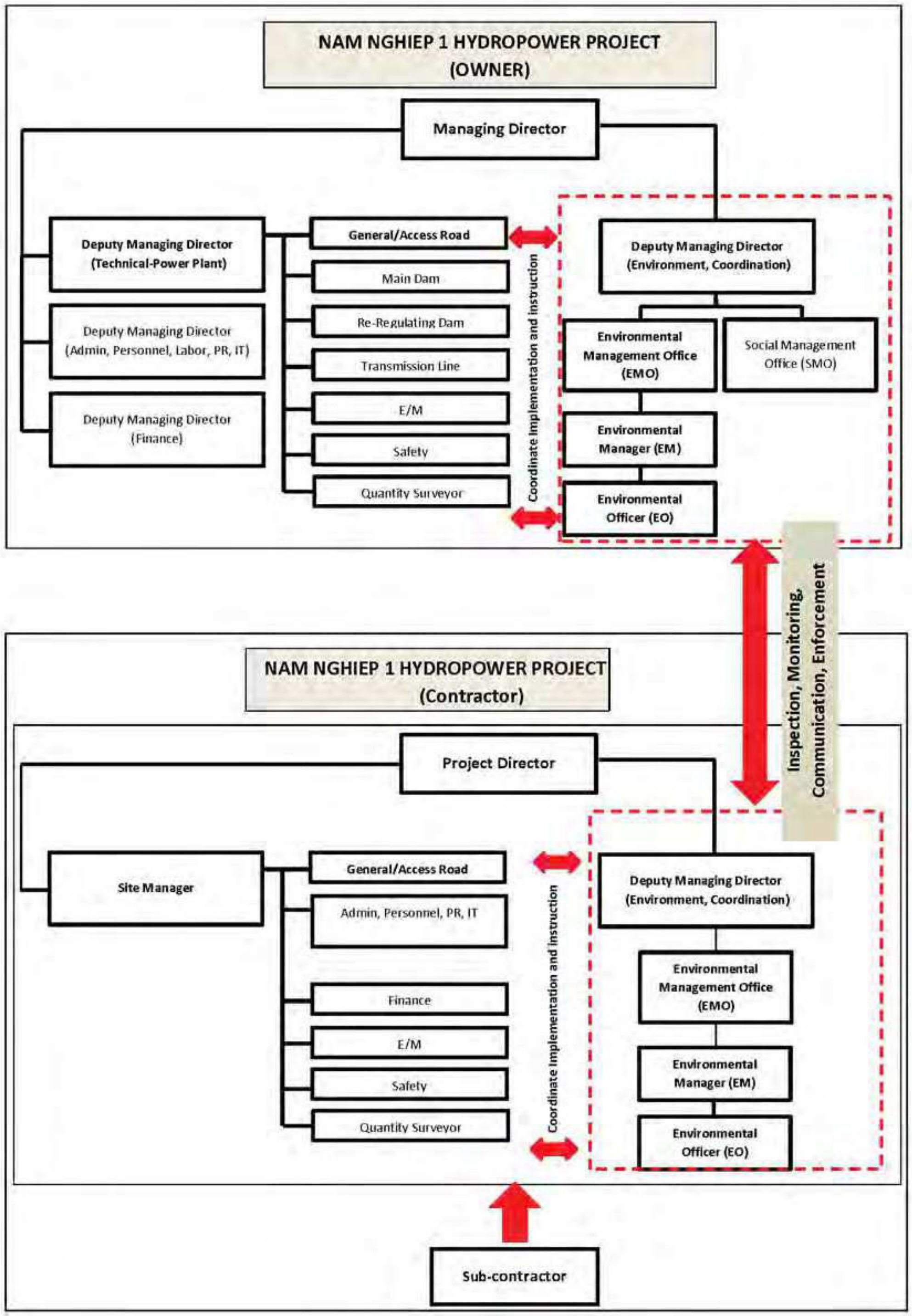
The technical details of the monitoring measures will be included in the ESMMP, SSEMP and Contractor's EMPs, including parameters, methods and sampling locations for the Project environmental aspects.

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



Source: Kansai, 2013.

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 qualities 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	Temperature, pH, Suspended Solids (SS), DO, Fecal coliforms, Oil & Grease

Environmental Aspect	Monitoring Action	Frequency of Monitoring	Monitoring Criteria
		incidents	
	Visual Inspection of sedimentation/effluent pond design, maintenance, etc.	Weekly	Cleanliness of station, drainage of sludge and 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

Environmental Aspect	Monitoring Action	Frequency of Monitoring	Monitoring Criteria
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
	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

Environmental Aspect	Monitoring Action	Frequency of Monitoring	Monitoring Criteria
CONTROL DUST AND NOISE			
Construction Area/Communication along access road	Visual inspection implementation of pollution control measures	Routine	To ensure that dust and noise generated from construction activities will not cause nuisance to personnel, public and wildlife
	Monitoring dust and noise in sensitive areas	Monthly	Applicable dust and noise standards (*Appendix I*)
Machines, heavy equipment	Inspection machine and heavy equipment that generates dust and noise	Monthly	To ensure that dust and noise generated from heavy construction machinery will not cause nuisance to personnel, public and wildlife
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 protection	Ensure top soil properly managed and preserved for	Weekly during large excavation	Visual observation; Design documentation

Environmental Aspect	Monitoring Action	Frequency of Monitoring	Monitoring Criteria
	eventual use in restoration	works; as requested thereafter	
	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
		Weekly	Visual observation
	Monitor clearing operations by Company to ensure no trees felled	As required	According to Project design and clearances given
Re-vegetation/ Compensatory Reforestation Program	Ensure re-vegetation 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

Environmental Aspect	Monitoring Action	Frequency of Monitoring	Monitoring Criteria
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 management of landfill	Weekly	Access restricted, waste 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

Environmental Aspect	Monitoring Action	Frequency of Monitoring	Monitoring Criteria
	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 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			
	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	Daily observation in dry season	Visual observation; Number of watering /day; Number of watering trucks

Environmental Aspect	Monitoring Action	Frequency of Monitoring	Monitoring Criteria
	emission		
	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; 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

Environmental Aspect	Monitoring Action	Frequency of Monitoring	Monitoring Criteria
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			
	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 reporting	Verify implementation of occupational injury and illness reporting procedure	Monthly	Register and compile injuries 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.

Environmental Aspect	Monitoring Action	Frequency of Monitoring	Monitoring Criteria
	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
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

Environmental Aspect	Monitoring Action	Frequency of Monitoring	Monitoring Criteria
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.

Source: Environmental Impact Assessment Report, ERIC 2012 and developed by ERM, 2014.

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

Source: Concession Agreement, Annex C Environmental and Social Obligations, April 2013.
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

Item		10 Years Budgets (USD)							
		Pre	**C1**	**C2**	**C3**	**C4**	**C5**	**C6**	**O1-O3**
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**

Source: ERM, 2013

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.

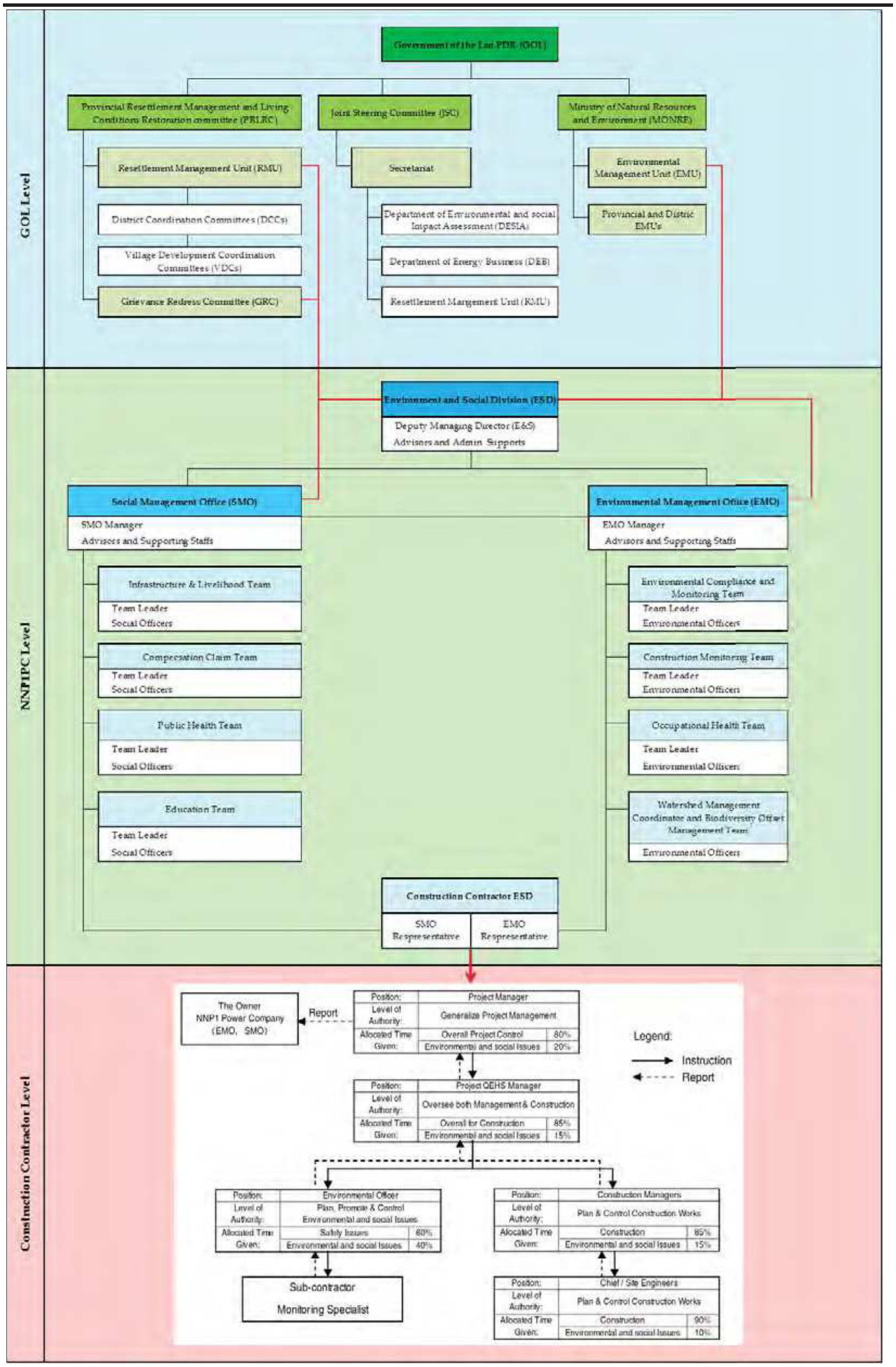
An indicative budget is presented for the environmental management and monitoring of the Nam Ngiep 1 Hydropower Project (NNP1). There are four components to this budget, as follows:

- 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.*

Note that the proposed budget shown in this chapter not includes the budget for access road activities. However, the budget for environmental issues for access road is presented in ***Appendix E*** of this report.

Figure 12.1 NNP1PC Level of Project Organization Charge



Source: ERM, 2014.

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														

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**
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														
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**
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									

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
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													

Source: ERM, 2014.

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**

Source: Environmental Impact Assessment Report, ERIC, 2012

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																

	Item	Unit	No. year	Unit Price	Amount	Pre-Cons.	C1	C2	C3	C4	C5	C6	O1	O2	O3	O4-O8	>O8
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					
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

Source: ERM, 2014

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.

NNP1 Offset Concession Agreement Available Funds	Before COD	After COD	Total
Available to be used for Biodiversity Offset Under Clause 54 of Annex C of the CA			
Wildlife Protection Program Protection program	$356,000	$432,000	$788,000
Wildlife conservation awareness	$72,000	$96,000	$168,000
Wildlife translocation	$90,000	-	$90,000
Forest regeneration	$450,000	$1,200,000	$1,650,000
Survey and monitoring of aquatic biota	$336,000	$840,000	$1,176,000
Sub Total	$1,304,000	$2,568,000	$3,872,000
Available Funds from the Watershed Management Fund Item 1-6 of Annex C of the CA			
Watershed Management Fund*	$3,250,020	$3,300,000	$6,550,020
Species Offset Management**	TBD		
Total	**$4,754,020**	**$6,468,000**	**$11,522,020**

**Clause 4i of Annex C of the Concession Agreement Requires that the following budget breakdown is applicable to watershed management activities:*

i. *$5,650,000 for forestry management and reservoir boundary survey in the catchment area, comprising:*
   - *US$ 10,000 (survey, single payment),*
   - *US$ 400,000 per year for 6 years from the Effective Date, and*
   - *US$ 120,000 per year for 27 years from COD);*

ii. *US$ 800,000 for replantation, based upon the area of the reservoir (single payment);*

iii. *US$ 40,020 for wildlife removal in the reservoir area, comprising of an annual recurring payment of US$ 6,670 per year for six (6) years prior to impoundment;*

iv. *US$ 60,000 for water quality monitoring by MONRE, comprising of an annual recurring payment of US$ 12,000 per year for the first five (5) years following COD.*
Watershed management shall consist of the following activities in the reservoir area: (i) translocation of wildlife within the watershed and/or in the identified biodiversity offset area; and (ii) forestry protection and management for the entire catchment area, including: replantation of forests, survey of tree species and timber, protection of wildlife, monitoring of landslides and identification of activities of third persons that could have an impact on the watershed, the allocation of water and water quality.

*** Currently unfunded in the CA and will be determined once appropriate costing has been completed*

13 INSTITUATIONAL ARRANGEMENTS

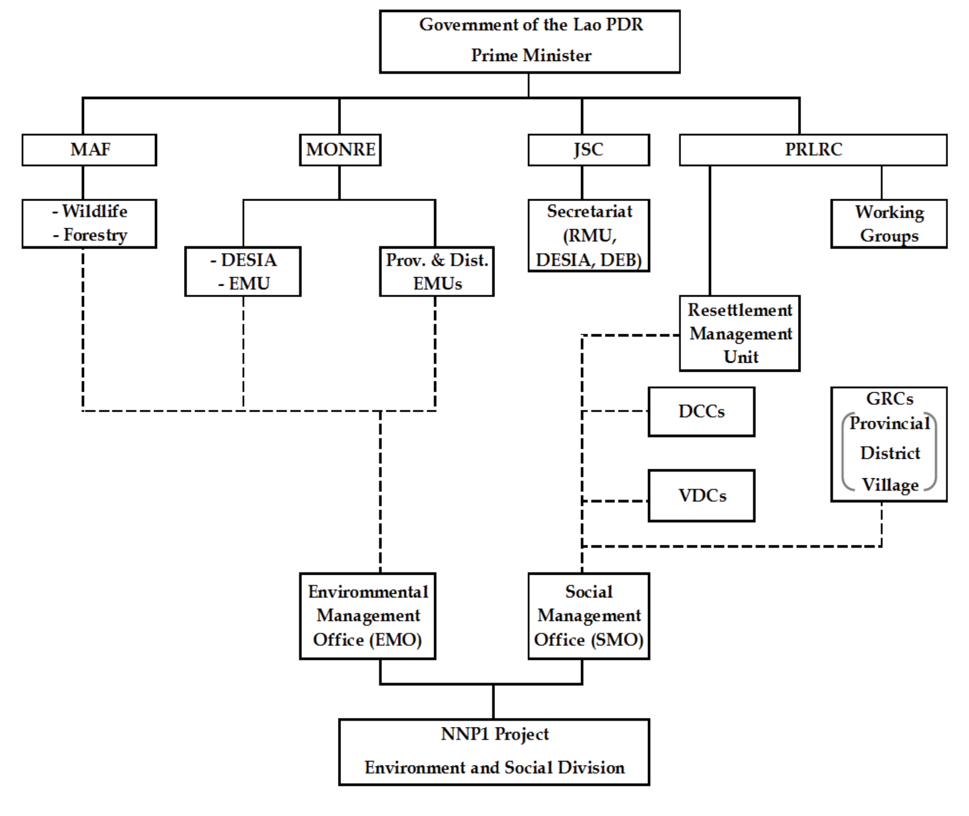
While it is the responsibility of the Project owners and developers to mitigate any adverse environmental impacts and to assure environmental conditions will enhance the lives and livelihoods of the people in the Project area, it is the responsibility of the government to monitor the effectiveness of 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



Source: Environmental Impact Assessment Report, ERIC, 2012.

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 Business (DEB) 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 implementation of mitigations and prevention 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 Construction (LFNC). 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 (DCCs) 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 NNP1PC's 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 Development Coordination Committees

The DCCs will establish Village Development Coordination Committees (VDCs) as necessary in those villages affected by the Project. With the support of the SMO 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 NNP1PC 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 (DMD) will be appointed to head the ESD on a full time basis. The DMD 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 DMD 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:

- Establishing environmental baseline data in the Project area i.e. watershed, upstream, dam site, downstream and resettlement areas;
- 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 to DMD, and work closely with EMO and the RMU and other GOL support staff. The SMO will consist of three sections.

a) Infrastructure section

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.

b) Resettlement Section

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.

c) Livelihood Restoration Section

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 compensation claim 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 relocate from Project Construction Lands areas;
- 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 in Project Construction Lands; and
- Coordinate with the RMU to undertake cash compensation to entitled APs together with Compensation Disbursement Agent.

In addition, a consultation team, public 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 *BIODIVERSITY OFFSET ADMINISTRATION*

13.3.1 *Legal Requirements*

The protection forests of the Nam Ngiep watershed currently do not have sufficient legal protection from illegal and inappropriate activities that may impact aquatic and terrestrial habitats. This means that a legal mechanism should be established to secure the land tenure for offsets to manage land-use activities and to enable the administration and management of those areas.

The Concession Agreement requires the biodiversity offset area to be classified as a "Conservation Area". However, it is recommended that a "Provincial Government Decree" be used to secure the Protection Forests of the Nam Ngiep 1 watershed for the purposes of a biodiversity offset.

This can be achieved under the provisions of the *Forestry Law 1996* by declaring the forested areas and define to a "Total Protection Zone"[1] or "Controlled Use Zone"[2] under the existing Protection Forest classifications. The area could also be declared as a "Provincial Protected Area" by the provincial governor.

The recommended offset area is within the newly created Xaysomboun province. This would mean that the Xaysomboun Provincial Government would be required to draft and proclaim the chosen Decree.

The *Water Resources Law 1996*, *Land law 2003* and the *Wildlife and Aquatic Animals Law 2007* may also be used to implement and enforce offset management activities. However, no specific changes to these laws are required specific to establishing the offset for the NNP1 Project.

13.3.2 *Administration and Governance*

To administer and govern the identified offset areas, it is recommended that an "NNP1 Offset Advisory Committee" be established. This Committee should be formed with membership from PONRE, DFRM and NNP1PC.

This would be chaired by DFRM at representatives from MONRE, the community, NNP1PC (as an observer) and an independent advisor holding seats on the committee. Other representatives and stakeholders can be invited to sit on the Committee as required. The Committee would:

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[1] *Total protection zone* are the forest areas of which the slope is above 35 degrees, containing areas of water resources, forests along the rivers, roads and other areas with a high risk of environmental degradation. These areas must be strictly protected and it is prohibited to conduct activities such as shifting cultivation, cutting, destruction, burning, removing trees, collecting firewood, feeding animals, constructing houses or any other construction activities, including extraction of soil, stones, mining and ore and harvesting of NTFP with exceptional cases stated in *Articles 44* and *70* of the *Forestry Law*.

[2] *Controlled use zone* is the forest area without high risk of environment impacts. These areas must be protected similar to the total protection zone, but people are allowed to use wood and forest products according to the management plan.

- Lead the development of a conservation needs assessment for the offset areas;
- Provide overall direction to the offset package and resolve any disputes;
- Recommend employment of appropriately qualified persons with experience in conservation and landscape restoration to provide capacity building to DFRM;
- Review the annual report to determine the adequacy of management measures;
- Recommend to NNP1PC to release funds; and
- Review recommended changes in management plans and actions.

The recommended roles and responsibilities for offset management are outlined in ***Table 13.1***.

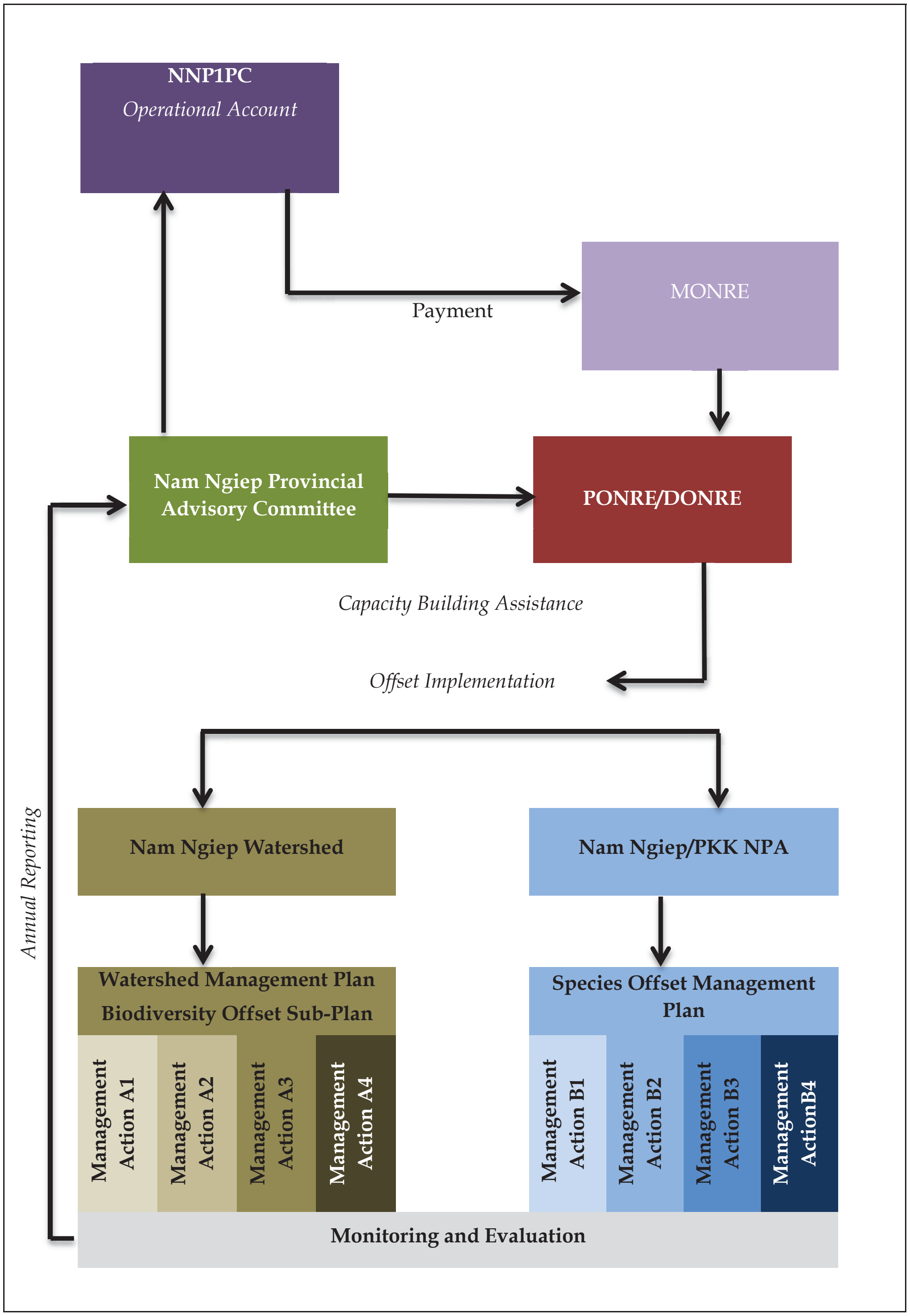
Figure 13.2 outlines the proposed structure for offset administration and management.

Table 13.1 Roles to administer and manage the NNP1 Offsets

Agency	Roles
MONRE	Coordinate across government agencies for the administration of funds as technical coordination team may be established.
PONRE/DFRM	Coordinate offset management activities at the provincial and district level and directed management of the offset sites. Chair and provide support for the Nam Ngiep 1 Offset Advisory Committee.
DONRE	Implement offset management through the application of management measures. Work with the capacity building NGO when needed to implement and monitor the effectiveness of offset management.
Capacity Building NGO	Assist GOL agencies in the design of offset measures and implementation of the offset package.
NNP1PC	Oversee the implementation of offset site management and provide funding based on performance measures.
Independent Advisor	Provide independent advice to NNP1 Offset Advisory Committee on the adequacy of offset measures.
Capacity Builder	Provide support and technical advice for the development and implementation of management plans, monitoring and evaluation.

Source: ERM, 2014.

Figure 13.2 Proposed structure, roles and responsibilities for offset management.



Source: ERM, 2014.

13.4 *WATERSHED MANAGEMENT STRATEGY*

It is recommended that NNP1PC develop a comprehensive Watershed Management Plan (WMP) in conjunction with the GOL. This should be developed by a Watershed Management Committee for the Nam Ngiep Watershed.

13.4.1 *Establishment of a Watershed Management Committee*

A Watershed Management Committee (WMC) should be established to oversee the development of the WMP framework. The WMC should have the following key objectives:

1. Coordinate and advise the GOL on the development of policies, strategies and plans, including Nam Ngiep WMC WMP;
2. Monitor the implementation of the WMP, advise on development Projects in order to reduce negative water resource impacts,
3. Advise GOL on resolving disputes, and coordinate and promote water resource awareness and participation;
4. assist GOL to ensure that water resources are developed and protected in a sustainable manner and in accordance with national policies and objectives; and
5. set up a subcommittee to administer and oversee the implementation of biodiversity offsets and species offset plans.

13.4.2 *Development of a Watershed Management Plan*

A detailed WMP for the Nam Ngiep Watershed should be developed through both technical surveys to assess the watershed to identify issues and "hotspots", and through consultation and negotiation to strengthen conservation in the watershed biodiversity offset area, the various protection forests, and with the district watershed management units. The implementation of this watershed management plan will need to be monitored and adapted over time as necessary and involve other proposed hydropower schemes and operators within the watrershed.

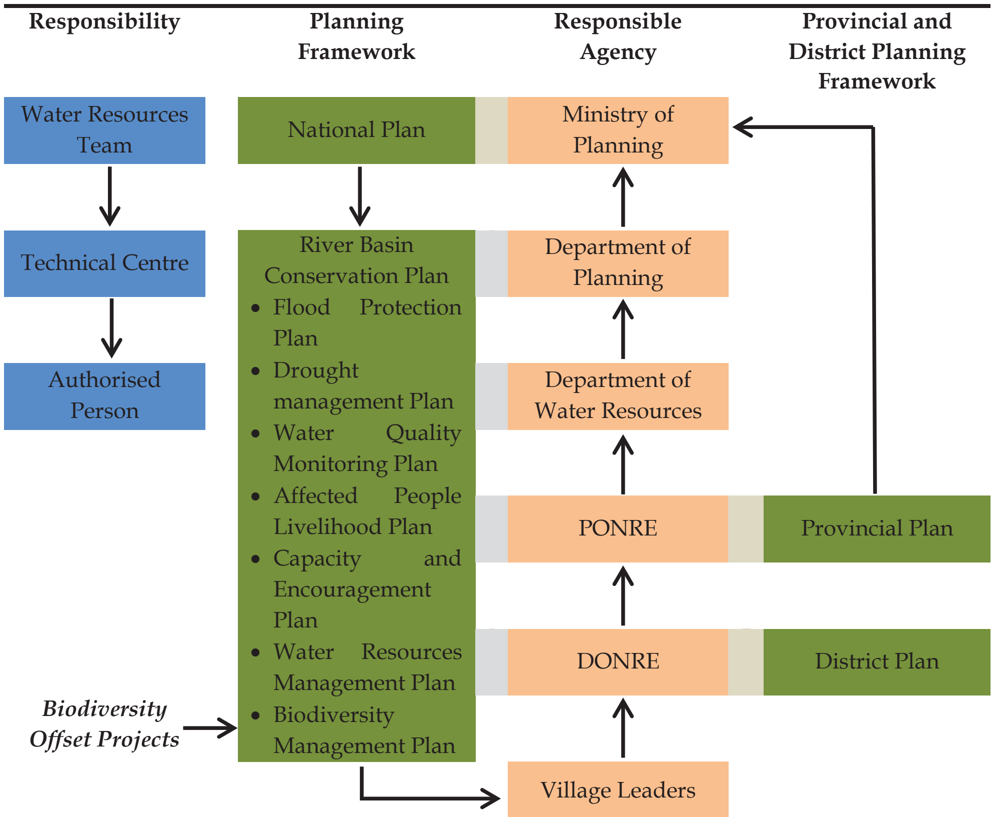
It is recommended that the WMP is structured to include the following objectives:

- Maintaining the flows and water resources of the Nam Ngiep;
- Maintaining the diversity and productivity of aquatic resources of the Nam Ngiep;
- Maintaining the vegetation cover and soils in the Nam Ngiep catchment;
- Maintaining the diversity and productivity of landscape and terrestrial ecosystems of the Nam Ngiep catchment;
- Maintaining the equitable use of water and natural resources with appropriate sharing of benefits of hydropower by different sectors, districts and communities in the Nam Ngiep watershed;

- Reducing the risks and impacts of water related disasters in the Nam Ngiep – especially floods and droughts; and
- Establishing a fully functional and representative Watershed Management Committee for the Nam Ngiep watershed.

The WMP will be required to be developed with input from NNP1PC and in discussion with MONRE. ***Figure 13.3*** outlines the draft MONRE Department of Water Resources River Basin Management Planning guidelines. These guidelines should be used to develop with WMP. Suitably qualified persons experienced in the watershed management should assist NNP1PC and GOL in the development and implementation of the WMP.

Figure 13.3 Draft MONRE River Basin Management Plan Guideline Framework



PONRE – Provincial office of Natural Resources and Environment

DONRE – District office of Natural Resources and Environment

Source: ERM, 2014.

13.4.3 Management Actions

Management actions associated with each of the objectives contained in the WMP should include:

- Maintaining the flows and water resources of the Nam Ngiep River to achieve:
  i) Land-use management

ii) Water resource management
iii) Water quality management
iv) Environmental flows

- Maintaining the diversity and productivity of aquatic resources of the Nam Ngiep River:
  i) Land-use management
  ii) Dam design considerations
  iii) Managing aquatic ecosystems
  iv) Managing fishery resources

- Maintaining the vegetation cover and soils in the Nam Ngiep catchment
  i) Land-use management
  ii) Managing soil erosion and sediments from the hydropower projects
  iii) Managing soil erosion in the catchment

- Maintaining the diversity and productivity of landscape and terrestrial ecosystems of the Nam Ngiep catchment
  i) Land-use management
  ii) Protected Areas
  iii) Forest Offset programme
  iv) NTFP collection and the wildlife trade

- Maintaining the equitable use of water and natural resources with appropriate sharing of benefits of hydropower by different sectors, districts and communities in the Nam Ngiep watershed
  i) Land-use management
  ii) Multiple use of Reservoirs
  iii) River transport and navigation
  iv) Compensation and Sharing the benefits of hydropower

- Reducing the risks and impacts of water related disasters in the Nam Ngiep – especially floods and droughts
  i) Flood management
  ii) Dam safety
  iii) Considering climate change

Land-use Management

It is recommended that a comprehensive land-use management strategy be developed with all stakeholders in the Nam Ngiep Catchment. It is recommended that MONRE be approached to prepare an "Integrated Landscape Map" for the Nam Ngiep Catchment to assist in the development of the WMP.

Soil erosion

With the high risk of soil erosion in the Nam Ngiep catchment, especial attention needs to be paid to reducing this risk in sensitive areas. The following actions are recommended:

- A detailed study of the catchments of the Nam Ngiep mainstream and each of the tributaries should be carried out to determine the sensitivity to soil erosion and to identify and prioritise critical areas where soil erosion management measures should be implemented. This study should consider both the slopes and soils, and the status of the existing vegetation cover, and land use practices, e.g. shifting cultivation, rubber plantations etc.
- Based upon this study appropriate soil conservation measures should be put in place in the critical areas, e.g. through re-vegetation, check dams etc. or through changed land use practices. This will require negotiation and agreement on the measures to be undertaken with technical and financial support for the different district agencies, communities and land users.
- Particular attention should be paid in managing soil erosion in the Protection Forests (national, provincial and district) that have been designated for watershed protection, and support provided to the appropriate agencies (PAFO and DAFOs) for rehabilitation, re-vegetation and ongoing management of these areas.

Multiple uses of reservoirs

The following management actions are recommended in relation to the multiple use of the main dam and re-regulation dam:

- A feasibility study to identify the opportunities for multiple use of all of the reservoirs should be carried out prior to development, including both consumptive and non-consumptive use of water and natural resources associated with the Nam Ngiep. This study should also identify what needs to be done to develop potential for the different sectors -water supply, agriculture, forestry, fisheries, mining, transport and tourism.
- An optimization study should be carried out to consider the hydrological balance and changes in the operation of the hydropower development which these multiple uses may require.

River transport and navigation

The following management actions are recommended to maintain river transport and navigation and should be incorporated into the WMP:

- Recognising the importance of river transport on the Nam Ngiep, provision should be made for safe and easy boat landings above and below each dam with facilities for transfer of people and goods between these boat landings.

Environmental flows

In order to maintain the ecological functions of the river system, together with the associated goods and services provided by the Nam Ngiep, adequate flows of water through the system have been determined by the NNP1 Project Environmental Flow Assessment (ERM 2014) and should be considered and incorporated into the WMP for the Nam Ngiep catchment. Consultation with other hydropower projects should also occur to agree and coordinate adequate environmental flow regimes within the basin.

Water resource management

Water resource management should try to ensure a balance the demand for water with its availability in the catchment, whilst maintaining adequate flows down the river to ensure ecosystem functioning. The following actions will be required to be incorporated into the WMP:

- To facilitate a balanced approach to water resource management a rapid scoping study on current and future water resource use options should be undertaken before finalising decisions on the development of hydropower in the river. The current and future demands for water should be taken into consideration
- The contribution to the Mekong flows by the Nam Ngiep, once regulated by the hydropower, needs to be incorporated into water resource management planning further downstream, especially in the reach below the confluence with the Nam Ngiep.

Water quality management

Good water quality should be maintained in all stretches of the Nam Ngiep, including all the proposed reservoirs. This should include the dam construction period, reservoir filling and during operation of the Project. The following actions will be required to be incorporated into the WMP:

- Water quality and environmental monitoring programmes should be designed and started as soon as possible before construction to establish a reliable baseline
- Sources of pollution along both tributaries and mainstream of the Nam Ngiep should be identified and measures taken to manage and reduce these to an acceptable level.
- Strict compliance with environmental management measures during the construction period to minimize the risks of loss of water quality especially from waste waters from construction camps, high sediment loads and accidental spillage of toxic materials.
- Appropriate features should be included in the designs of the hydropower projects to minimize potential loss of water quality.

Managing aquatic ecosystems

The following actions are recommended to be considered in the WMP to manage and maintain the functioning of aquatic ecosystems:

- Carry out surveys of tributaries to assess the aquatic ecosystems and fisheries and suggest measures to enhance their role in proposed reservoir fisheries, e.g. spawning
- Consider measures to enhance the diversity of habitats in the reservoirs, e.g. raised artificial wetland areas on the reservoir edges, artificial reefs, not clearing some large trees in the reservoirs.

Managing fishery resources

The following actions are recommended to be considered an incorporated into the WMP:

- Start immediate monitoring of fish and fish catches, to establish baseline and follow changes and mortalities of fish during construction and operation of the hydropower projects.
- Include specific fisheries management recommendations in the environmental management plans for the construction period, e.g. to minimize the impacts on water quality and disturbance
- Ensure adequate compensation for fishers for loss of fishery resources
- Comprehensive reservoir fishery management plans to be developed, funded and implemented, including establishing critical habitats and fish conservation zones.
- Consider establishing aquaculture that will be complementary to the wild fishery in the reservoirs, with appropriate choice of species, providing support and training for local fishers

Flood management

The following actions should be incorporated into the WMP:

- Major tributaries will require on-going hydrological monitoring and modelling
- Flood emergency preparedness plan is required, especially given the nature of occupation of low lying areas and use of the river
- A communication network for early warning of floods to riparian communities should be established. This can be similar to networks that need to be set up by the hydropower project operator to warn downstream communities of changes in daily flow
- Coordination of flood relief across provincial boundaries

Dam safety

The following actions should be considered to be incorporated into the WMP:

- Each dam operator in the Nam Ngiep Watershed should prepare a dam break analysis and make adequate provisions for dealing with such emergency situations
- Each dam operator in the Nam Ngiep Watershed should prepare and publish Dam Safety Preparedness Plans for each hydro power project including a simplified version for riparian communities

- The communications network between the individual dam operators needs to be established for both operational needs and emergency situations
- Each dam operator in the Nam Ngiep Watershed should establish good communication networks with the riparian communities, upstream and downstream of each hydro power project, to warn of daily changes in flow and to provide flood warnings.

Considering climate change

The following actions should be considered to be incorporated into the WMP:

- A risk assessment of the impacts of climate change, especially on floods and drought on dam design and operation should be carried out.
- Engineers should review Project design specifications and hydrology, factoring in climate change modelling, and modify the designs if necessary.

13.4.4 Relationship between Biodiversity Offset Management and Watershed Management

This offset framework is designed to manage the defined offset areas. These areas are contained within the area of responsibility of the *Watershed Management Committee*. The Committee will have overall responsibility for managing the watershed of the Nam Ngiep River. The purpose of the watershed management activity is to manage activities in the watershed to protect water quality and manage future development through landuse planning and management. It should be noted that the area for management is the entire Nam Ngiep watershed, including areas of aquatic habitats downstream of the dam wall.

Management of the offset areas will be through a sub-plan of the *Nam Ngiep Watershed Management Plan* and will be managed by a separate sub-committee of the *Watershed Management Committee*. The primary focus of the sub-committee will be managing the offset areas for conservation of terrestrial and aquatic biodiversity. The offset areas are also only part of the watershed management area, being the production and protection forests of the Nam Ngiep watershed.

Management measures required for the watershed should be complementary to the biodiversity offset management areas. Particular attention should be made to the design of the *Watershed Management Plan* in relation to the management of aquatic and terrestrial habitats.

The conservation needs assessment undertaken for terrestrial and aquatic habitats should be used as one of the primary inputs into the watershed management planning process.

13.4.5 *Recommended Roles and Responsibilities of Stakeholders*

Table 13.2 outlines the recommended roles and responsibilities of stakeholders for development and implementation of the WMP.

Table 13.2 Roles and Responsibilities of Stakeholders for Watershed Management Activities

Stakeholder group	Roles	Rights	Responsibilities
Provincial Government agencies: Xaysomboun, Bolikhamsay and Vientiane			
Agriculture and Forestry	Management of agricultural, livestock, forest and fisheries resources in province, including national and provincial protected areas, and addressing issues such as soil erosion and shifting cultivation	As per legal mandate	Implementing agriculture and forest policies Agriculture and livestock extension Irrigation development Soil conservation Fisheries management and development of aquaculture Management of protected areas and wildlife
Water Resources and Environment	Management of water resources (surface and groundwater), water quality, Flood management. Management of environment	As per legal mandate	Implementing water and environment policies Monitoring of environmental water quality and flows Supervision of compliance of environmental management plans of Projects
Energy and Mines	Management of hydropower development, and mining	As per legal mandate	Concession agreements, development of technical guidelines, supervision and monitoring of hydropower and mining
Public works and transportation	Roads and river transport	As per legal mandate	Rules and regulations for navigation and river transport on Nam Ngiep
Industry and Commerce	Development of industry and commerce	As per legal mandate	Regulations for the development of industries
Public health	Health care, clinics, hospital management	As per legal mandate	Provision of health services, Water borne disease management, STDs and HIV/AIDS
Land management	Management of land holdings, land use planning	As per legal mandate	Land titling, compensation regulations
District government agencies	Management of district, its people and natural resources	As per legal mandate	Application of the various national and provincial policies and programmes at local level

Stakeholder group	Roles	Rights	Responsibilities
Communities and natural resource users			
Community leaders	Community governance	Rights as per appointment/election as community leader	Ensuring welfare and peace in community, representation of community at district levels and in negotiations with developers
Farmers	Land users	Landholdings. Land user rights, Access to community land	Managing land sustainably for livelihoods and food production
Fishers	Water body users	Access to waters for fishing	Use of legal means for fishing for livelihoods and food production
Collectors of NTFPs	Forest users	Access to forests	Sustainable collection of legal NTFPs for livelihoods and food production
Traders in natural resource products	Trading	Rights to trade in fish, NTFPs and other natural resources	Ensuring legal use of NTFPs and wildlife products
Private sector			
Hydropower operators	Development and operation of hydropower projects	Concession agreement rights to develop hydropower	Safe development and operation of hydropower projects. Management of environmental impacts, compensation payments and social development packages for affected peoples
Mines	Development and operation of mines in river basin	Concession agreement rights to develop mining	Safe development and operation of mines. Management of environmental impacts, compensation payments and social development packages for affected peoples
Industry	Development of factories	Rights as per regulations and licenses to operate	Health and safety of workers, management of environmental impacts and pollution
Tourism industry	Provision of tourism services, accommodation, food, visitor activities	Rights as per regulations and licenses to operate	Safe and attractive tourism services, management of environmental and social impacts
Agricultural concession	Development of agricultural and agroforestry	Concession agreement	Safe development and operation of plantations.

Stakeholder group	Roles	Rights	Responsibilities
holders and plantations	plantations	rights to develop plantations	Management of environmental impacts, compensation payments and social development packages for affected peoples
River transport sector	Providing river transport services	Rights as per regulations and license to operate public boats	Safe and effective river transport

Source: ERM, 2014.

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;
- NNP1PC Accidents 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.

14.1.3 Supplementary Report

The quarterly report shall be prepared and submitted by NNP1PC every 3 (three) months after the starting date of the construction phase. Also, the six monthly report shall be submitted every 6 (six) months thoroughly covering the scope as the monthly report and annual report.

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

Source: Environmental Impact Assessment Report, ERIC, 2012

Note:

[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

In conclusion, this Environmental Impact Assessment (EIA) Study has been conducted in accordance with the Lao PDR regulatory requirements and the international standards including ADB SPS, EPs, IFC PS and associated guidelines.

This EIA Study builds on the findings from a number of surveys and studies such as biodiversity baseline survey, environmental baseline sampling, IEE for Access Road and IEE for Transmission Line, which all form part of the appendices to this EIA Study.

Potentially significant impacts have been identified considering all Project facilities both during the construction and operation phases. Such impacts have then been assessed in detail as part of this EIA Study. Mitigation measures and monitoring program have been prepared to reduce the potential negative impacts and/ or enhance the potential positive impacts.

On the basis of this assessment, it is concluded that all potential negative impacts arising from the Project can be effectively managed and mitigated, provided that recommended mitigation measures are implemented and regular monitoring is undertaken. No potentially-insurmountable impacts were identified which would necessitate a fundamental alteration of proposed Project design parameters. Further information regarding potential impacts and mitigation measures can be found in ***Chapter 6*** and ***Chapter 10*** of this report respectively.

To facilitate the implementation of recommended mitigation measures, management and monitoring activities, the findings of this EIA Study have been used to develop the Environmental and Social Monitoring and Management Plan (ESMMP) for both access road and the overall construction were conducted in line with the Environmental Management Plan (EMP) suggested in this report. The EMP set outs specific mitigation and management measures that should be employed along with subsequent actions to facilitate continuous improvement in Project's health, safety and environmental performance.

In addition, the Site Specific ESMMP will be developed to detail the key mitigation measures and monitoring plan for such area of works and also to highlight the appropriate implementation of such measures.

Potential significant impacts are summarized, along with the proposed management mitigation/ enhancement measures in ***Section 15.1.2*** to ***Section 15.1.4*** below.

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 *Potential Significant Environmental Impact Assessment – Environmental Aspects*

15.1.2.1 *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 dB(A), 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 dB(A).

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.

15.1.2.2 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.

15.1.3 Potential Significant 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 Houay 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 Houay 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; • 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.

Source: ERM 2013.

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.

15.1.3.1 *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.

15.1.3.1 Habitats

The impact assessment 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.

No flora species or terrestrial fauna species were determine likely to have critical habitat within the Project area. For most species, the Project area was not considered of significant importance to the species. For a number of species the Project has potential to pose a threat and as such recommendations to manage key threats to the species identified along the access road and main dam inundation area.

15.1.3.2 Primates

Surveys undertaken by TISTR in 2013 recorded vocalisation assumed to be White-cheeked gibbon (*Nomascus leucogenys*) in the vicinity of the main dam and consultation with experts identified there may be potential for other primate species to occur. Targeted surveys were undertaken specific to primate species within the watershed in order to confirm the presence of populations and suitability of habitat. Key habitat areas were identified for the White-cheeked gibbon outside the FSL, mineral licks for Phayre's leaf monkey (*Trachypithecus phayrei*) were detected within the FSL and no signs of the Red shanked douc langur (*Pygathrix nemaeus*) were detected. These findings informed an assessment for critical habitat. The targeted survey indicated that the Project area does not contain key habitat areas for primate species, with areas outside the Project area, which will not be directly impacted, more likely to support populations. Specific management measures will be employed for managing indirect impacts to species habitats and mitigate the loss of mineral licks for Phayre's leaf monkey.

15.1.3.3 Fish Species

One fish species, *Luciocyprinus striolatus*, was specifically assessed against the ADB Critical Habitat criteria. It was determined that the critical habitat is not triggered for the species as the Nam Ngiep River is not a regionally significant concentration for the species when compared to other Discrete Management Units (DMU) within the species range.

Two migratory fish species were identified within the project footprint. Expert surveys and advice indicated that migratory fish identified were unlikely to travel upstream to above the dam wall, preferring the meandering riverine environment of the lower watershed. Sufficient environmental flows and inflows from other tributaries of the Nam Ngiep below the dam wall will sustain habitat for these species

Nine endemic fish species (two new-to-science) were identified in the tributaries of the Nam Ngiep above the dam and below FSL. Expert survey and advice indicated that sufficient habitat would remain for these species following inundation within the tributaries above FSL. Management of habitat for these species will focus on protecting the forested watershed to maintain water quality in these tributaries.

15.1.4 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. 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.

The residual impacts on biodiversity values are quantified as follows.

15.1.4.1 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.

Approximately 73 km of riverine and associated riparian habitats of the Nam Ngiep River and its tributaries will be inundated following dam construction. This impact will include the permanent transition of lotic (flowing water) aquatic habitat to lentic (still water) aquatic 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
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

Source: ERM, 2013

15.1.4.2 *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 15.4*** outlines the fish species that have residual impacts on their habitats following mitigation. Management of the residual impacts on the aquatic environment is contained in the biodiversity offset and watershed management recommended measures.

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
	Golden jackal	Himalayan black bear
Birds	Wreathed hornbill	Red-breasted parakeet
	Great hornbill	Lesser fish-eagle
	Green peafowl	Siamese fireback
	White winged duck	Silver pheasant

	Species	
	Greater coucal	Grey peacock pheasant
Reptiles	Reticulated python	Elongated tortoise
	King cobra	Big-headed turtle

Source: ERM, 2013

Table 15.4 ***Aquatic Species with Residual Impacts following Mitigation***

Species name	Common name
Catlocarpio siamensis	Giant barb
Laubuca caeruleostigmata	Leaping barb
Luciocyprinus striolatus	
Pangasianodon hypothalamus	Striped catfish
Probarbus labeamajor	Thicklipped barb
Cirrhinus cirrhosus	Mrigal carp
Scaphognathops bandanensis	Bandan sharp-mouth barb
Yasuhikotakia splendida	Jaguar loach
Labeo pierrei	
Rhinogobius albimaculatus	
Hemimyzon confluens	

Source: ERM, 2013

15.1.4.3 *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.

15.1.5 *Biodiversity Offsetting*

A *Biodiversity Offset framework* has been developed based on the analysis of the options undertaken by ERM contained in the *Biodiversity Offset Design Report* *for the Nam Ngiep Power 1 Project* (NNP1 Project) (ERM 2014). This offset framework was designed using the Business and Biodiversity Offset Program (BBOP). In principal agreement has been reached for this framework with GOL.

The loss of biodiversity values caused by other projects upstream (such as the Nam Ngiep 2 Hydro Scheme) as well as impacts from activities in the watershed (forestry and agriculture) has a cumulative detrimental impact on biodiversity values. Offsets designed for the Project will not directly offset the impacts of these other projects, but will provide a basis for arresting further degradation and have positive contributions to conservation within the watershed.

The offsets are designed to mitigate against residual impacts identified for the Project in relation to species and habitats and to achieve a no-net-loss of biodiversity values.

In relation to specific offsets for the NNP1 Project, it is planned that the biodiversity offset framework includes:

1. Forested and riverine areas of the Nam Ngiep Watershed to manage biodiversity in terrestrial and aquatic habitats; and
2. Species specific offsets within the Nam Ngiep Watershed and other candidate offset sites (potentially PKK NPA).

The area contained in the watershed was analysed using the "Habitat Hectares" model that determines the type and condition of the habitats lost with the relative gain from management of candidate offsets site over a set management period (In this case, 27 years being the length of the concession agreement). Based on this approach, there is sufficient "like for like" habitat able to be managed to achieve a sufficient gain in biodiversity value over the life of the concession agreement to achieve a "no-net-loss" habitat values in the chosen offset areas.

The legal mechanism to secure the biodiversity offset area is recommended to be a "Provincial Government Decree" to secure the Protection Forests of the Nam Ngiep 1 watershed for the purposes of a biodiversity offset. This Decree is recommended to classify the protection forests as a "Total Protection Zone" under the Forestry Law, prohibiting all uses other than those that sustain the local community. Production forests will be managed for sustainable timber production by introducing techniques to protect habitats for species identified.

To administer and govern the identified offset areas, it is planned that an "NNP1 Offset Advisory Committee" be established. This Committee would be formed with membership from PONRE, DFRM and NNP1PC. This would be chaired by DFRM at representatives from MONRE, the community, NNP1PC (as an observer) and an independent technical advisor holding seats on the committee. Other representatives and stakeholders can be invited to sit on the Committee as required.

Management of habitats within the watershed will include the development of a management plan including the following key actions: monitoring and evaluation; management of hunting; sustainable forestry management in production forests; wildlife corridors; sustainable forest product use (NTFP); management of weeds and pests; fire management; sediment and erosion control; assisted natural regeneration; habitat installation (eg. nest boxes and salt licks); community engagement and development and education and awareness

Both the Nam Ngiep watershed and PKK NPA are included in the offset package in order to increase the opportunities for identifying and protecting target species identified as having residual impacts on their habitats. These species will be subject to a survey to identify their location, either within the watershed or within PKK NPA. However, if these species are not identified or management is not successful in either location, additional offsets may be required elsewhere in Lao PDR.

In determining species offsets, the first step will be a comprehensive survey in the Nam Ngiep Watershed offset area to identify the target species. This would then be followed up with a comprehensive species survey in PKK or other areas within Lao PDR, if required, to identify presence of the target species. A *Species Offset Management Plan* will be prepared that outlines the management actions required for the target species once their presence has been confirmed.

Species specific offsets for management will be prepared. These will include survey and monitoring of species presence within offset areas; identification of core habitat and management of identified populations; species specific management actions identified to manage identified populations; targeted campaigns to manage key threats (eg. education and awareness activities for individual species); alignment of conservation priorities to national and international management plans and requirements and monitoring the effectiveness of offset management activities on species populations.

15.1.6 Watershed Management

It is recommended that NNP1PC develop a comprehensive Watershed Management Plan (WMP) in conjunction with the GOL. This should be developed by a Watershed Management Committee for the Nam Ngiep Watershed. NNP1PC is currently in negotiations with MONRE to develop the WMP.

15.1.6.1 Establishment of a Watershed Management Committee

A Watershed Management Committee (WMC) should be established to oversee the development of the WMP framework. The WMC should have the following key objectives:

1. Coordinate and advise the Government on the development of policies, strategies and plans, including Nam Ngiep WMC WMP;
2. Monitor the implementation of the WMP, advise on development projects in order to reduce negative water resource impacts,
3. Advise GoL on resolving disputes, and coordinate and promote water resource awareness and participation;
4. assist GoL to ensure that water resources are developed and protected in a sustainable manner and in accordance with national policies and objectives; and
5. set up a subcommittee to administer and oversee the implementation of biodiversity offsets and species offset plans.

A detailed WMP for the Nam Ngiep Watershed should be developed through both technical surveys to assess the watershed and along the mainstream to identify issues and "hotspots", and through consultation and negotiation to strengthen conservation in the watershed biodiversity offset area, the various protection forests, and with the district watershed management units. The implementation of this watershed management plan will need to be monitored and adapted over time as necessary.

It is recommended that the WMP is structured to include the following objectives:

- Maintaining the flows and water resources of the Nam Ngiep;
- Maintaining the diversity and productivity of aquatic resources of the Nam Ngiep;
- Maintaining the vegetation cover and soils in the Nam Ngiep catchment;
- Maintaining the diversity and productivity of landscape and terrestrial ecosystems of the Nam Ngiep catchment;
- Maintaining the equitable use of water and natural resources with appropriate sharing of benefits of hydropower by different sectors, districts and communities in the Nam Ngiep watershed;
- Reducing the risks and impacts of water related disasters in the Nam Ngiep – especially floods and droughts; and
- Establishing a fully functional and representative Watershed Management Committee for the Nam Ngiep watershed, including representatives from other hydropower schemes.

The WMP will be required to be developed by NNP1PC in discussion with MONRE. Technical assistance from suitably qualified persons experienced in the development of watershed management plans should be sought.

15.1.7 *Management Actions*

Management actions associated with each of the objectives contained in the WMP should include:

- Maintaining the flows and water resources of the Nam Ngiep River to achieve:
  - i) Land-use management
  - ii) Water resource management
  - iii) Water quality management
  - iv) Environmental flows
- Maintaining the diversity and productivity of aquatic resources of the Nam Ngiep River:
  - i) Land-use management
  - ii) Dam design considerations
  - iii) Managing aquatic ecosystems
  - iv) Managing fishery resources
- Maintaining the vegetation cover and soils in the Nam Ngiep catchment
  - i) Land-use management
  - ii) Managing soil erosion and sediments from the hydropower projects
  - iii) Managing soil erosion in the catchment
- Maintaining the diversity and productivity of landscape and terrestrial ecosystems of the Nam Ngiep catchment
  - i) Land-use management
  - ii) Protected Areas
  - iii) Forest Offset programme
  - iv) NTFP collection and the wildlife trade
- Maintaining the equitable use of water and natural resources with appropriate sharing of benefits of hydropower by different sectors, districts and communities in the Nam Ngiep watershed
  - i) Land-use management
  - ii) Multiple use of reservoirs
  - iii) River transport and navigation
  - iv) Compensation and sharing the benefits of hydropower
- Reducing the risks and impacts of water related disasters in the Nam Ngiep – especially floods and droughts
  - i) Flood management
  - ii) Dam safety
  - iii) Considering climate change

15.1.8 *Relationship between Biodiversity Offset Management and Watershed Management*

This offset framework is designed to manage the defined offset areas. These areas are contained within the area of responsibility of the Watershed Management Committee. The Committee will have overall responsibility for managing the watershed of the Nam Ngiep River. The purpose of the watershed management activity is to manage activities in the watershed to protect water quality and manage future development through landuse planning and management. It should be noted that the area for management is the entire Nam Ngiep watershed, including areas of aquatic habitats downstream of the dam wall.

Management of the offset areas will be through a sub-plan of the Nam Ngiep Watershed Management Plan and will be managed by a separate sub-committee of the Watershed Management Committee. The primary focus of the sub-committee will be managing the offset areas for conservation of terrestrial and aquatic biodiversity. The offset areas are also only part of the watershed management area, being the production and protection forests of the Nam Ngiep watershed.

Management measures required for the watershed should be complementary to the biodiversity offset management areas. Particular attention should be made to the design of the Watershed Management Plan in relation to the management of aquatic and terrestrial habitats.

The conservation needs assessment undertaken for terrestrial and aquatic habitats should be used as one of the primary inputs into the watershed management planning process.

15.2 RECOMMENDATIONS

Recommendations for the Project are as follows:

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.

Environmental Flow Regime

Management of the environmental flows downstream of the dam should be implemented and monitored to determine their effectiveness at protecting biodiversity and ecosystem service values downstream. An evaluation and management framework should be prepared to complement the environmental flow regime. An adaptive management framework should also be utilized to amend flow strategies based on water quality and biological data on downstream effects.

Watershed Management

Management of the watershed is a critical component for managing the aquatic habitat and ecosystem services values of the Nam Ngiep River. Threats from upstream hydroelectric schemes, forestry, mining, increasing urbanization and agriculture all pose a threat to the sustainable management of the watershed and hence the management of good quality water inflows into the dam.

A comprehensive watershed management framework is required that has the ability to manage identified risks, propose collaborative efforts with other stakeholder interests and actively engages GOL in administering and managing the values of the watershed. This framework should be developed as the overarching approach to achieving sustainable development in the watershed. NNP1PC should actively engage with GOL to promote a watershed management framework.

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.

Biodiversity Mitigation and Offsetting

Managing biodiversity values to achieve a no-net-loss of biodiversity is required to demonstrate compliance with ADB safeguards policies and to ensure the long-term sustainability of habitats and species populations. Implementation, management and monitoring of the biodiversity offsets recommended will require close collaboration with GOL, third party capacity builders and NNP1PC to deliver on this commitment. The approach taken should ensure positive engagement of the local community and GOL in management, be adequately funded and resourced and be responsive to changing ecological information.

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.

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.

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.

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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