# Draft Environmental Impact Assessment Report

January 2012

# LAO: NAM NGIEP 1 HYDROPOWER PROJECT

Prepared by The Kansai Electric Power Company, Inc., EGAT International Company, Ltd., and Lao Holding State Enterprise for the Asian Development Bank.

## ABBREVIATIONS

| | | |
|---|---|---|
| AAU | – | Assigned Amount Unit |
| ACF | – | Action Contre la Faim |
| ADB | – | Asian Development Bank |
| AGAC | – | Airborne GPS Aero Control System |
| APs | – | Affected Peoples |
| ARI | – | Acute Respiratory Infection |
| B | – | “Ban” Village in Laotian Language |
| BOT | – | Built-Operate-Transfer |
| CA | – | Concession Agreement |
| CDM | – | Clean Development Mechanism |
| CER | – | Certified Emission reduction |
| CEM | – | Construction Environmental Manager |
| COD | – | Commercial Operation Date |
| CPS-NSC,2002 | – | CPS-National Statistical Center,2002 |
| CDEP | – | Committee for Development of Electric Power |
| CPC | – | Committee for Planning and Cooperation |
| DAFEO | – | District Agriculture and Forestry Extension Officer |
| DAFO | – | District Agriculture Forestry Office |
| DHO | – | District Health Office |
| DLF | – | Department of Livestock and Fisheries |
| DMH | – | Department of Meteorology and Hydrology |
| DNA | – | Designated National Authority |
| DOE | – | Department of Electricity |
| DOF | – | Division of Fisheries |
| DOL | – | Department of Land |
| DRWG | – | District Resettlement Working Groups |
| 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 |
| EDL | – | Electricite du Laos |
| EFOs | – | Environmental Field Officers |
| EGAT | – | Electricity Generating Authority of Thailand |
| EIA | – | Environmental Impact Assessment |
| EM | – | Environmental Manager |
| EMC | – | Environmental Management Committee |
| EMMP | – | Environmental Management & Monitoring Plan |
| EMP | – | Environmental Management Plan |
| EMU(s) | – | Environmental Management Unit(s) |
| EPC | – | Engineering, Procurement and Construction |
| EPL | – | Environmental Protection Law (National Law 02/99) |
| EPF | – | Environmental Protection Fund |
| EPMs | – | Environmental Protection Measures |
| ERIC | – | Environmental Research Institute of Chulalongkorn University |
| ERU | – | Emission Reduction Unit |
| ES | – | Environment Section |
| ESIA | – | Environmental and Social Impact Assessment |

| | | |
|---|---|---|
| ESMMU | – | Environment-Social Management and Monitoring Unit |
| ET | – | Emission Trading |
| FAO | – | Food and Agriculture Organization of The United Nations |
| FIMC | – | Foreign Investment Management Committee |
| GHG | – | Green House Gas |
| GPS | – | Global Positioning System |
| GOL | – | Government of Lao PDR |
| HEPP | – | Hydroelectric Power Project |
| FAO | – | Food and Agriculture Organization of The United Nations |
| FDR | – | Family Dispute Resolution |
| FRCD | – | Forest Resource Conservation Division |
| FS, F/S | – | Feasibility Study |
| FTA | – | Federal Transit Administration |
| IEE | – | Initial Environmental Examination |
| IPDP | – | Indigenous Peoples Development Plan |
| IPP | – | Independent Power Producer |
| JI | – | Joint Implementation |
| JBIC | – | Japan Bank for International Cooperation |
| JICA | – | Japan International Cooperation Agency (Japan) |
| KANSAI | – | Kansai Electric Power CO.,INC. |
| LA | – | Loan Agreement |
| Lao IRRI | – | Lao International Rice Research Institute |
| Lao PDR | – | Lao People’s Democratic Republic |
| LDC | – | Least Developed Country |
| LECS | – | Lao Expenditure and Consumption Surveys |
| LHSE | – | Lao Holding State Enterprise |
| LLDC | – | Least Less-Developed Countries |
| LNCE | – | Lao National Committee for Energy |
| LWU | – | Lao Women’s Union |
| MAF | – | Ministry of Agriculture and Forestry |
| MAF-DOF | – | Ministry of Agriculture and Forestry- Department of Forestry |
| MCTPC | – | Ministry of Communication, Transportation, Post and Construction |
| MCH | – | maternal and child health |
| MCM | – | Multi-Chip Modual |
| MIH | – | Ministry of Industry and Handicrafts |
| MOH | – | Ministry of Health |
| MOI | – | Ministry of Industry |
| MOU | – | Memorandum of Understanding |
| MRC | – | Mekong River Commission |
| NAFRI | – | National Agriculture and Forest Research Institute |
| NBCA | – | National Biodiversity Conservation Area |
| NCC | – | National Consulting Company |
| NEAP | – | National Environmental Action Plan |
| NEM | – | New Economic Mechanism |
| NEPO | – | National Energy Policy Office |
| NESMC | – | National Environment and Social Management Committee |
| NGOs | – | Non Governmental Organizations |
| NGPES | – | Nation Growth and Poverty Eradication Strategy |

| | | |
|---|---|---|
| NNHP 1 | – | Nam Ngiep Hydropower Project 1 |
| NNT | – | Nakai Nam Thuen |
| NTEC | – | Nam Theun 2(NT2) Electricity Company |
| NTFPs | – | Non-Timber Forest Products |
| NTPC | – | Nam Theun 2(NT2) Power Company |
| OCHA | – | (The United Nations) Office for the Coordination of Humanitarian Affairs |
| O&M | – | Operation and Maintenance |
| OC | – | Ownership Company |
| ODA | – | Official Development Assistance |
| OE | – | Operational Entity |
| PAFO | – | Provincial Agriculture and Forestry Office |
| PDA | – | Project Development Agreement |
| PDD | – | Project Design Document |
| PDP | – | Power Development Plan |
| PESMC | – | Provincial Environment and Social Management Committee |
| PHO | – | Provincial Health Office |
| PMO | – | Prime Minister's Office |
| PPA | – | Power Purchase Agreement |
| PRC | – | People's Public of China |
| PRP | – | Preliminary Resettlement Plan |
| RAP | – | Resettlement Action Plan |
| RC | – | Resettlement Committee |
| RMU | – | Resettlement Management Unit |
| RS | – | Resettlement Section |
| RWG | – | Resettlement Working Group |
| SCADA | – | Supervisory control and data acquisition |
| SDS | – | Social Development Section |
| SIA | – | Social Impact Assessment |
| SP | – | Sub Plan |
| SPC | – | Special Purpose Company |
| ST | – | Station |
| STEA | – | Science, Technology and Environment Agency |
| TPA | – | Third Party Access |
| TOR | – | Terms of Reference |
| UNDP | – | United Nations Development Program |
| UNEP | – | United Nations Environment Program |
| UNFCCC | – | UN Framework Convention on Climate Change |
| UNICEF | – | United Nations Children's Fund |
| UXO | – | Unexploded Ordnance |
| VDC | – | Villages Development Cluster |
| VHV | – | Village Health's Volunteers |
| WB | – | World Bank |
| WCD | – | World Commission on Dams |
| WHO | – | World Health Organization |
| WMCA | – | Watershed Management Conservation Agency |
| WREA | – | Water Resources and Environment Agency |

## WEIGHTS AND MEASURES

| | | |
|---|---|---|
| ASL | – | Above Sea Level |
| B/C | – | Benefit – Cost, Economic efficiency |
| BOD | – | Biological Oxygen Demand |
| CC | – | Combined Cycle Power Plant |
| CEC | – | Cation Exchange Capacity |
| cent/kWh | – | Cent per kilo watt |
| CFRD | – | Concrete Faced Rock fill Dam |
| $cm^3/s$ | – | Cubic centimeter per second |
| COD | – | Chemical Oxygen Demand |
| dB | – | Decibels |
| dBA | – | Decibels Adjusted |
| DBH | – | Diameters at Breast Height |
| DO | – | Dissolved Oxygen |
| DSCR | – | Debt Service Cover Ratio |
| ECRD | – | Earth Core Rockfill Dam |
| EIRR, FIRR | – | Economic/Financial Internal Rate of Return |
| EL( ) m | – | Meters above Sea level |
| EU | – | European Union |
| F/C | – | Forage species/carnivorous species ratio |
| FSL | – | Full Supply Level of Reservoir |
| FWL | – | Flood Water Level |
| GDP | – | Gross Domestic Product |
| GW | – | Giga Watt |
| GWh | – | Giga Watt Hour (one million watt hour) |
| ha | – | Hectare |
| HH | – | Household |
| Hz | – | Hertz |
| IMR | – | Infant Mortality Rate |
| IRR | – | Internal Rates of Return |
| JTU | – | Jackson Turbidity Unit |
| km | – | Kilometer |
| km2 | – | Square meter |
| kV | – | Kilo Volt |
| kW | – | Kilo Watt |
| L/day | – | Liter per day |
| m | – | Meter |
| m3/s | – | Cubic meter per second |
| MAP | – | Mean Annual Precipitation |
| MAR | – | Mean Annual Runoff |
| mg/ m3 | – | Milligram per Cubic meter |
| Mg/l | – | Milligram per liter |
| mm | – | Millimeter |
| mm3 | – | Cubic Millimeter |
| MOL | – | Minimum Operation Water Level |
| MSL | – | Mean Sea Level |
| MW | – | Mega Watt (one million watt) |
| NE-SW | – | Northeast-Southwest |
| NHWL | – | Normal High Water Level |

| | | |
|---|---|---|
| NWL | – | Normal Water Level |
| oC | – | Degree Celsius |
| PICAD | – | Participatory Integrated Conservation Committee |
| PM 10 | – | Particulate Matter 10 |
| PMF | – | Probable Maximum Flood |
| PMP | – | Probable Maximum Precipitation |
| PPV | – | Peak Particle Velocities |
| RCC | – | Roller Compacted Concrete |
| ROE | – | Return on Equity |
| RWL | – | Rated Water Level |
| SLC | – | Salvage Logging Committee |
| SS | – | Suspended Solid |
| t/km2/yr | – | tonnes per square meter per year |
| ton/ha | – | tonne per hectare |
| TWL | – | Total water level |
| US$ | – | US Dollar |
| USBM | – | United States Bureau of Mines |
| VFA | – | Village Forest Associations |
| μm | – | Micrometer |

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# ABBREVIATIONS

| Lao PDR Agencies | | Foreign | |
|---|---|---|---|
| CDEP | Committee for Development of Electric Power | ADB | Asian Development Bank |
| CPC | Committee for Planning and Cooperation | EGAT | Electricity Generating Authority of Thailand |
| DAFEO | District Agriculture and Forestry Extension Officer | ERIC | Environmental Research Institute of Chulalongkorn University |
| DAFO | District Agriculture Forestry Office | FAO | Food and Agriculture Organization of The United Nations |
| DHO | District Health Office | IRRI | International Rich Research Institute |
| DMH | Department of Meteorology and Hydrology | IUCN | World Conservation Union (Switzerland) |
| DOE | Department of Electricity | JBIC | Japan Bank for International Cooperation |
| DOF | Division of Fisheries | JICA | Japan International Cooperation Agency (Japan) |
| DOL | Department of Land | KANSAI | Kansai Electric Power CO.,INC. |
| EDL | Electricite du Laos | MRC | Mekong River Commission |
| EMU(s) | Environmental Management Unit(s) | NBCAs | National Biodiversity Conservation Areas |
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| LECS | Lao Expenditure and Consumption Surveys | UNEP | United Nations Environment Program |
| LHSE | Lao Holding State Enterprise | UNICEF | United Nations Children's Fund |
| LNCE | Lao National Committee for Energy | WB | World Bank |
| LWU | Lao Women's Union | WCD | World Commission on Dams |
| MAF | Ministry of Agriculture and Forestry | WHO | World Health Organization |
| MAF-DOF | Ministry of Agriculture and Forestry-Department of Forestry | **Unit and technical Term** | |
| MCTPC | Ministry of Communication, Transportation, Post and Construction | ASL | Above Sea Level |
| MIH | Ministry of Industry and Handicrafts | B/C | Benefit – Cost, Economic efficiency |
| MOH | Ministry of Health | BOD | Biological Oxygen Demand |
| MOI | Ministry of Industry | CC | Combined Cycle Power Plant |
| NAFRI | National Agriculture and Forest Research Institute | CEC | Cation Exchange Capacity |
| NCC | National Consulting Company | cent/kWh | Cent per kilo watt |
| NGPES | Nation Growth and Poverty Eradication Strategy | CFRD | Concrete Faced Rock fill Dam |
| PAFO | Provincial Agriculture and Forestry Office | $cm^3/s$ | Cubic centimeter per second |
| PHO | Provincial Health Office | COD | Chemical Oxygen Demand |
| PMO | Prime Minister's Office | dB | Decibels |
| STEA | Science, Technology and Environment Agency | dBA | Decibels Adjusted |
| WMCA | Watershed Management Conservation Agency | DBH | Diameters at Breast Height |
| WREA | Water Resources and Environment Agency | DO | Dissolved Oxygen |
| AAU | Assigned Amount Unit | DSCR | Debt Service Cover Ratio |

# ABBREVIATIONS (continued)

| Other | | Unit and technical Term | |
|---|---|---|---|
| ACF | Action Contre la Faim | ECRD | Earth Core Rockfill Dam |
| AGAC | Airborne GPS Aero Control System | EIRR, FIRR | Economic/Financial Internal Rate of Return |
| APs | Affected Peoples | EL( ) m | Meters above Sea level |
| ARI | Acute Respiratory Infection | EU | European Union |
| B | "Ban" Village in Laotian Language | F/C | Forage species/carnivorous species ratio |
| BOT | Built-Operate-Transfer | FSL | Full Supply Level of Reservoir |
| CA | Concession Agreement | FWL | Flood Water Level |
| CEM | Construction Environmental Manager | GDP | Gross Domestic Product |
| COD | Commercial Operation Date | GW | Giga Watt |
| CPS-NSC,2002 | CPS-National Statistical Center,2002 | GWh | Giga Watt Hour (one million watt hour) |
| DLF | Department of Livestock and Fisheries | ha | Hectare |
| DRWG | District Resettlement Working Groups | HH | Household |
| EAC | Environmental Assessment Committee | Hz | Hertz |
| EAMP | Environmental Assessment and Management Plan | IMR | Infant Mortality Rate |
| EAP | Emergency Action Plan | IRR | Internal Rates of Return |
| ECCD | Early Childhood Care for Development | JTU | Jackson Turbidity Unit |
| EFOs | Environmental Field Officers | km | Kilometer |
| EIA | Environmental Impact Assessment | $km^2$ | Square meter |
| EM | Environmental Manager | kV | Kilo Volt |
| EMC | Environmental Management Committee | kW | Kilo Watt |
| EMMP | Environmental Management & Monitoring Plan | L/day | Liter per day |
| EPC | Engineering, Procurement and Construction | m | Meter |
| EPL | Environmental Protection Law (National Law 02/99) | $m^3/s$ | Cubic meter per second |
| EPMs | Environmental Protection Measures | MAP | Mean Annual Precipitation |
| ES | Environment Section | MAR | Mean Annual Runoff |
| ESIA | Environmental and Social Impact Assessment | $mg/\ m^3$ | Milligram per Cubic meter |
| ESMMU | Environment-Social Management and Monitoring Unit | Mg/l | Milligram per liter |
| FDR | Family Dispute Resolution | mm | Millimeter |
| FRCD | Forest Resource Conservation Division | $mm^3$ | Cubic Millimeter |
| FS, F/S | Feasibility Study | MOL | Minimum Operation Water Level |
| FTA | Federal Transit Administration | MSL | Mean Sea Level |
| GPS | Global Positioning System | MW | Mega Watt (one million watt) |
| HEPP | Hydroelectric Power Project | NE-SW | Northeast-Southwest |
| IEE | Initial Environmental Examination | NHWL | Normal High Water Level |
| IPDP | Indigenous Peoples Development Plan | NWL | Normal Water Level |
| IPP | Independent Power Producer | $^oC$ | Degree Celsius |
| LA | Loan Agreement | PICAD | Participatory Integrated Conservation Committee |
| LDC | Least Developed Country | PM 10 | Particulate Matter 10 |
| LLDC | Least Less-Developed Countries | PMF | Probable Maximum Flood |
| MCH | maternal and child health | PMP | Probable Maximum Precipitation |
| MCM | Multi-Chip Modual | PPV | Peak Particle Velocities |

# ABBREVIATIONS (continued)

| **Other** | | **Unit and technical Term** | |
|---|---|---|---|
| MOU | Memorandum of Understanding | RCC | Roller Compacted Concrete |
| NBCA | National Biodiversity Conservation Area | ROE | Return on Equity |
| NEAP | National Environmental Action Plan | RWL | Rated Water Level |
| NEM | New Economic Mechanism | SLC | Salvage Logging Committee |
| NESMC | National Environment and Social Management Committee | SS | Suspended Solid |
| NGOs | Non Governmental Organizations | $t/km^2/yr$ | tonnes per square meter per year |
| NNHP 1 | Nam Ngiep Hydropower Project 1 | ton/ha | tonne per hectare |
| NNT | Nakai Nam Thuen | TWL | Total water level |
| NTFPs | Non-Timber Forest Products | US$ | US Dollar |
| O&M | Operation and Maintenance | USBM | United States Bureau of Mines |
| OC | Ownership Company | VFA | Village Forest Associations |
| ODA | Official Development Assistance | µm | Micrometer |
| PDA | Project Development Agreement | CDM Terms | |
| PDP | Power Development Plan | CDM | Clean Development Mechanism |
| PESMC | Provincial Environment and Social Management Committee | CER | Certified Emission reduction |
| PPA | Power Purchase Agreement | DNA | Designated National Authority |
| PRC | People's Public of China | EB | Executive Board of the CDM |
| PRP | Preliminary Resettlement Plan | EMP | Environmental Management Plan |
| RAP | Resettlement Action Plan | ERU | Emission Reduction Unit |
| RC | Resettlement Committee | ET | Emission Trading |
| RMU | Resettlement Management Unit | GHG | Green House Gas |
| RS | Resettlement Section | JI | Joint Implementation |
| RWG | Resettlement Working Group | NA | Not Available |
| SDS | Social Development Section | OE | Operational Entity |
| SIA | Social Impact Assessment | PDD | Project Design Document |
| SP | Sub Plan | SCADA | Supervisory control and data acquisition |
| ST | Station | SPC | Special Purpose Company |
| TOR | Terms of Reference | SWL | Surcharge Water Level |
| TPA | Third Party Access | UNFCCC | UN Framework Convention on Climate Change |
| UXO | Unexploded Ordnance | | |
| VDC | Villages Development Cluster | | |
| VHV | Village Health's Volunteers | | |

# CHAPTER 1

# INTRODUCTION

## 1.1 GENERAL BACKGROUND

The development of hydropower facilities, with planned and managed environmental impacts, 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, almost untapped, hydropower potential beyond its own needs 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. 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.

The government owned Electricite du Laos (EdL) owns and operates a number of hydropower projects. 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: Some of the studies involved in this estimate are up to 30 years old and it must be borne in mind that limitations in hydrological, geological and other technical information render the estimate approximate. Furthermore, it represents an upper limit, bearing in mind that the socio-environmental impacts associated with development of some part of the total potential may be considered unacceptable by today's more stringent standards.

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 Thuen 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 projects, among them the Nam Ngiep 1 Hydropower Project.

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

The main objective of the NNHP-1 is to provide commercial electricity to neighboring countries of the Lao PDR in order to earn foreign exchange needed for national development, with a secondary objective of providing electricity for the national grid. It is expected that one of the main environmental impacts caused by the NNHP-1 will be the loss of forest ear. Assessing the main features of the project, it can be seen that the reservoir will inundate forested area of 66.9 $km^2$ (6,690 ha), of which more than half is now scrub or unstocked forest. Taking the entire official forest area into account, the comparative loss of forest of the NNHP-1 will be much less than that of Nam Theun 2: the ratio of loss official forest land per MW of NNHP-1 will be 23.7 ha/MW compared to that of Nam Theun 2 at 41.7 ha/MW. Given the highly degraded condition of the unstocked forest in the reservoir, the ratio of loss of actual forest is even less, at about 12 ha/MW.

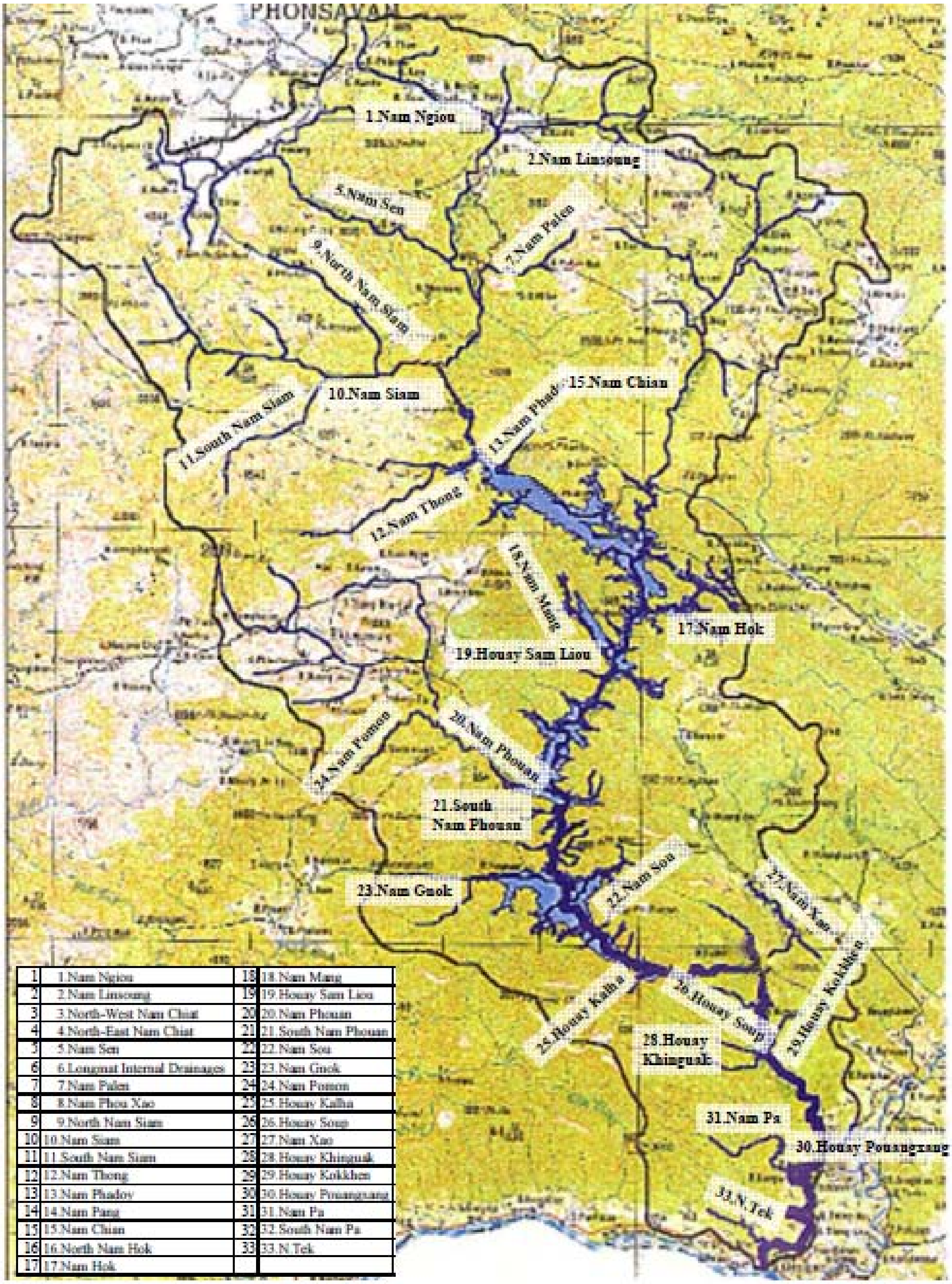



Figure 1-1 Tributaries of Nam Ngiep Watershed Area.

## 1.2 OBJECTIVES OF THE EIA

The objectives of the 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.

## 1.3 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), until recently the Water Resources and Environment Agency (WREA), which had earlier been the Science, Technology and Environment Agency (STEA). 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 of the NNHP-1 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 studies are to:

1) Analyze the following: a 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.
4) Identify alternatives and analyze the environmental impacts of each alternative and propose measures to avoid or prevent impacts.
5) Estimate the magnitudes of environmental impacts and assess the significance of impacts. The assessment of the significance included 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 Summary of EIA Reports.
8) Prepare an Environmental Management Plan (EMP) to be implemented by the project proponents during project implementation and operation.

## 1.4 RATIONALE OF EIA

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

The environmental assessment for the Nam Ngiep 1 Hydropower Project is based on the feasibility study of Nippon Koei in 2000 and in 2002. These recommended the proposed alternative for the dam with a full supply level (FSL) at EL 320 m as the most promising design for the project. This alternative is able to provide an economically viable and financially attractive project, while also minimizing environmental and social impacts.

## 1.5 STUDY AREA AND METHODOLOGY

### 1.5.1 STUDY AREA

The project area was divided into five zones, according to major features created by the project or their location to the project. Figure 1-2 shows the village in the project area and indicates in which zone these villages lie:

| | |
|---|---|
| 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) |

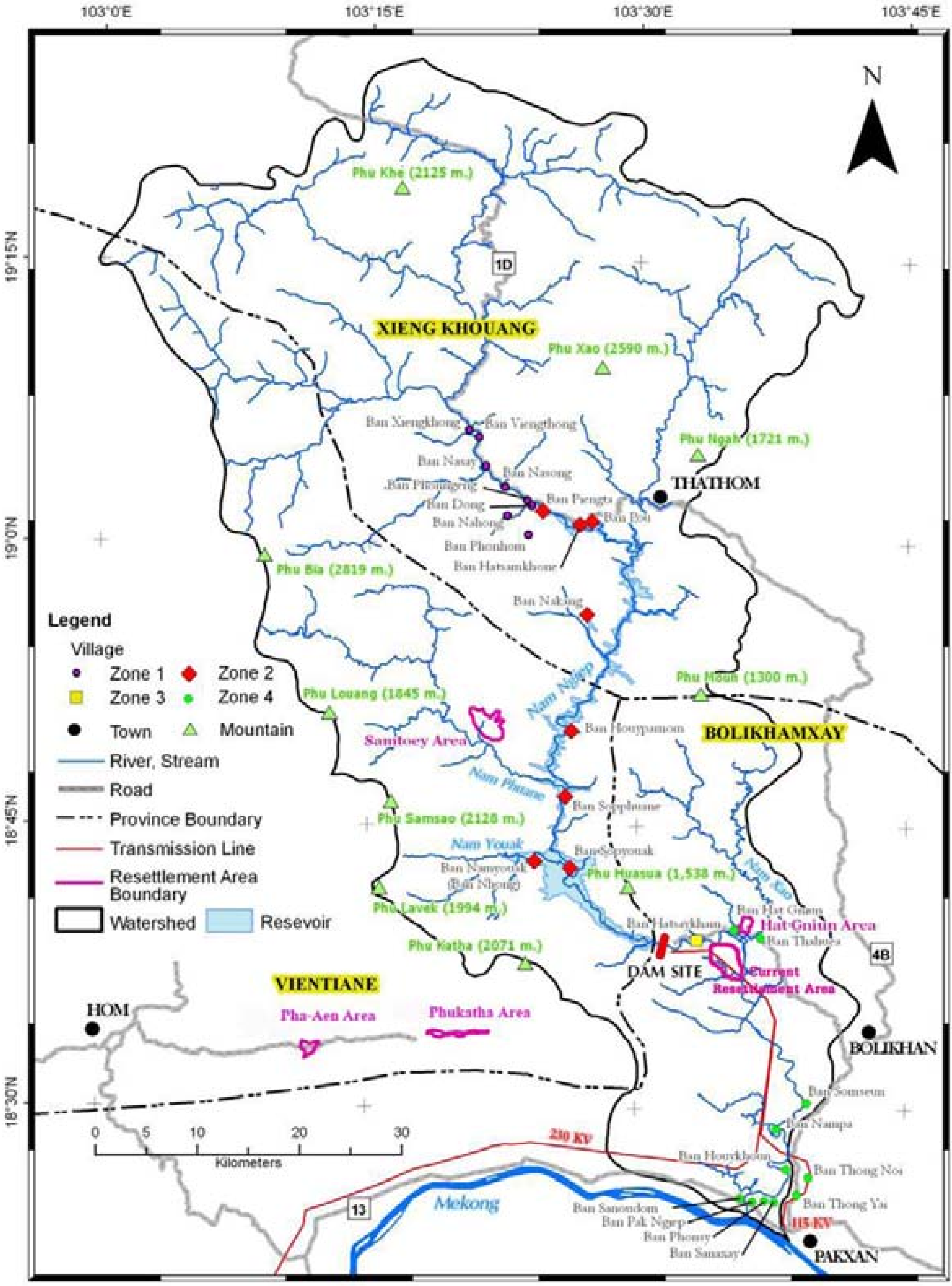



Figure 1-2 Zones in the study area.

### 1.5.2 METHODOLOGY

The methodology for the EIA study on the environmental and social impacts expected from construction and operation of the Nam Ngiep Hydropower Project consisted of several stages.

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 impact.

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

The environmental assessment involves the inventory and description of the baseline environment, the predicted impact on t hose baseline conditions, and the prescription of mitigation measures to address these impacts. Accordingly, this information is presented in the following discussion, where appropriate, as separate subheadings under each major environmental parameter.

The environmental issues are each evaluated as a subsection volume. Each evaluation includes:

1) Reference to information available from earlier (or ongoing) studies.

2) A background of the approach used by the EIA team 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 Nam Ngiep Project impacts on forests, woodlands and other land covers with analogous habitats unaffected by t he project.

6) Potential threats to the forest resources in the absence of the Nam Ngiep Project.

This volume presents, where applicable, with project and without project impact scenarios for various environmental issues. This is particularly relevant for the terrestrial and biodiversity resources that are expected to undergo rapid and systematic depletion due to logging and accompanying encroachment from various human activities, if there is no project.

## 1.6 AUTHORS

| Environmental Aspects | Researcher | |
|---|---|---|
| | Environmental Research Institute Chulalongkorn University | National Consulting Company |
| **Physical Environments** | | |
| 1) Topography | Assoc. Prof. Pongsri Chanhow | - |
| 2) Meteorology | Dr. Sangchan Limjirakan | Dr. Inthavy Akkharath |
| 3) Geology, Landforms, Seismology | Asst. Prof. Dr. Chakkaphan Suthirat | - |
| 4) Soils | Dr. Nukoon Tawinteung | Dr. Hatsadong Phannavong |
| 5) Erosion and Sedimentation | Asst. Prof. Dr. Chakkaphan Suthirat | Dr. Inthavy Akkharath |
| 6) Surface and Groundwater Quality | Dr. Kallaya Suntornvongsagul | Dr. Phousi Inthapannya |
| 7) Mineral Resources | Asst. Prof. Dr. Chakkaphan Suthirat | - |
| 8) Noise and Vibration | Assoc. Prof. Prathan Areebhol | - |
| 9) Air Quality | Dr. Tussanee Pluksasith | - |
| 10) Potential Contaminate Site | Dr. Ekawan Luepromchai | - |
| Biological Environments | | |
| 1) Terrestrial Ecology/Wildlife | Dr. Rattanawat Chaiyarat | Assoc. Prof. Dr. Sengdeuane Wayakone |
| 2) Forest/Vegetation Cover | Asst. Prof. Dr. Sakhan Teejuntuk | Assoc. Prof. Dr. Sengdeuane Wayakone |
| 3) Wetlands | Dr. Somrudee Jitpraphai | - |
| 4) Aquatic Biota and Habitats | Prof. Wit Tarnchalanukit | Dr. Sinthavong Viravong |

| Environmental Aspects | Researcher | |
|---|---|---|
| | Environmental Research Institute Chulalongkorn University | National Consulting Company |
| **Socio-Economics and Cultural Environments** | | |
| 1) Population and Communities | Mr. Satien Rujiravanich | Assoc. Prof. Dr. Sengdeuane Wayakone |
| 2) Socio-economics | Assoc. Prof. Dr. Somchai Ratanakomut | Assoc. Prof. Dr. Sengdeuane Wayakone |
| 3) Land Use | Mr. Luechai Kroutnoi | Dr. Inthavy Akkharath |
| 4) Infrastructure Facilities | Mr. Luechai Kroutnoi | Mr.Panya Simonkol |
| 5) Water Use and Water Supply | Mr. Dheerabol Gangaketu | Dr. Phousi Inthapannya |
| 6) Transportation | Asst.Prof. Dr. Sompong Sirisoponsilp | - |
| 7) Navigation | Asst. Prof. Dr. Sompong Sirisoponsilp | - |
| 8) Energy Sources | Assoc. Prof. Withaya Yongchareon | - |
| 9) Public Health | Asst. Prof. Pakorn Sumethanurugkul | Dr. Onechanh Keosavanh |
| 10) Public Safety and Occupation Health | Dr. Benjalak Karnchanasest | Dr. Onechanh Keosavanh |
| 11) Agriculture | Dr. Supot Faungfupong | Dr. Hatsadong Phannavong |
| 12) Fisheries/Aquaculture | Dr. Jintana Salaenoi | Dr. Sinthavong Viravong |
| 13) Industries | Mr. Luechai Kroutnoi | Mr.Panya Simonkol |
| 14) Mineral Development | Asst. Prof. Dr. Chakkaphan Sutthirat | Dr. Khamfeuane Sioudom |
| 15) Archaeology | Asst. Prof. Sinchai Krabuansang | Dr. Viengkeo Souksavatdy |
| 16) Aesthetic / Recreation / Tourism | Dr.Pongsak Vadhanasindhu<br>Assoc.Prof.Dr. Thavivongse Sriburi | Assoc. Prof. Dr. Sengdeuane Wayakone |
| 17) Resettlement | Mr. Satien Rujiravanich | Dr. Sengdara Kattignasack |
| 18) Land Acquisition and Compensation | Mr. Satien Rujiravanich | Assoc. Prof. Dr. Sengdeuane Wayakone |
| 19) Culture | Asst.Prof.Dr. Sulak Sriburi | Mr Bounma Molakhasouk |
| 20) Public Consultation | Mr. Satien Rujiravanich | Videth Visounnarath |
| 21) Laws and Regulations | Assoc. Prof. Dr. Mattaya Jittirat | Assoc. Prof. Dr. Sengdeuane Wayakone |
| 22) GIS and Mapping | Dr. Ornprapa Pummakarnchana | Dr. Inthavy Akkharath |
| 23) Environmental Management Plan | Assoc. Prof. Dr. Thavivongse sriburi | - |

Project Director: Assoc. Prof. Dr. Thavivongse Sriburi

Project Manager: Mr. Luechai Kroutnoi
Dr. Kallaya Suntornvongsagul

Project Editor: Mr. Satien Rujiravanich
Dr. Kallaya Suntornvongsagul

International Expert: Dr. Charles B. Mehl

## 1.7 STRUCTURE OF THE REPORT

This EIA generally conforms to the preferred outline for environmental assessment. The Environmental Assessment Overview document, which is prepared as a separate document, provides a general overview of issues taken from each of the chapters of the EIA. It constitutes a reliable synopsis of the contents of the EIA. There are 9 chapters in this EIA:

**Chapter 1 – Introduction**: provides a brief description of the project, including background context of the Nam Ngiep 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.

**Chapter 2 – Project Description**: presents the project features in detail. This chapter enables the reader can obtain a clear understanding of the project. A description is presented of the study areas that were identified to evaluate the project impacts.

**Chapter 3 – Methodology**: provides details about the objective, scope and methods.

**Chapter 4 – Legal Aspects for EIA**: provides the policy, legal and administrative framework for the project. It contains a description of the implementation framework proposed by Nam Ngiep 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 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 – Study of Alternatives**: provides a detailed description of the project alternatives and justification for the proposals put forth by Project team.

**Chapter 7 – 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 implement during construction and operation period.

**Chapter 8 – Nam Ngiep Watershed Management Plan:** A draft plan for management of the Nam Ngiep watershed is presented. This program should be initiated by the GOL, with appropriate technical and financial support from the NNHP-1 Project, other hydropower projects in the watershed, and any other projects that affect the watershed's resources.

**Chapter 9 – Public Consultation**: 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 10 – Conclusions and Recommendation**: provides a summary of project information as well as the major findings and key recommendations from the environmental assessment of the proposed project.

**References**

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

# CHAPTER 2

# PROJECT DESCRIPTION

## 2.1 PROJECT BACKGROUND

The Lao PDR expects that its hydropower resources are to be a primary source of income for the future, selling electricity to Thailand and other neighbors. The foreign exchange earned from sale of hydropower will in turn spur other 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 NNHP-1, several pre-feasibility studies have been done. The JICA-F/S which has been done in 2000 and 2002 was implemented environmental impact assessments and technical feasibility studies. The JICA-F/S stated that the Nam Ngiep1 project has been planned to help cope with peaks or intermediate peaks in the load curve. It can maintain price competitiveness among other power sources.

NNHP-1 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 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.

A company, in future to be named the Nam Ngiep1 Power Co., Ltd., will be established under a shareholder agreement in order to sign loan agreements with lenders and start work on the project. The sponsors of the Nam Ngiep1 Power Co., Ltd., 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. Detailed designs, construction plans, commissioning, operations and maintenance are all 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 would be around 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 ( ) million USD.

## 2.2 PROJECT LOCATION

The site of the main dam is located on the Nam Ngiep River some 145 km north-east to Vientiane or about 40 km north to Pakxan as shown in Figure 2-1.

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

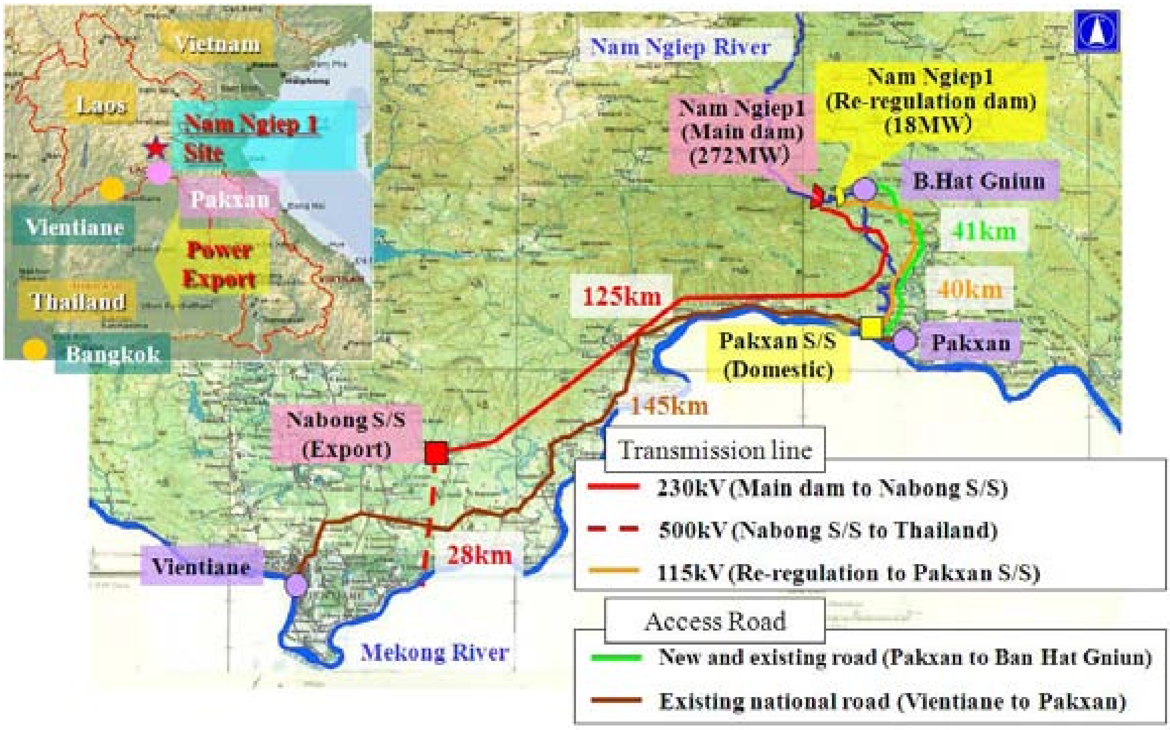



Figure 2-1 Project location.

## 2.3 GENERAL LAYOUT AND INFRASTRUCTURE

Extending over three provinces of Bolikhamxay, Vientiane, and Xieng Khouang located in central Lao PDR, the NNHP-1 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 1,515 GWh at substation, together with a re-regulation power station, located downstream of the main power station, having 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 sees nearly double the rainfall than the northern part of the river basin. The catchment area at the dam site is estimated to be 3,700 km$^2$ with average annual inflow of 148.4 m$^3$/s or 4.68 billion m$^3$.

The main features of the project are presented in Table 2-1 and Figure 2-2.

Table 2-1 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 |
| | | mill.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$^3$ | 2,245 (to be revised) |
| | 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 |

| Facility | Items | Unit | Specifications |
|---|---|---|---|
| Penstock | Type | - | Exposed and embedded |
| | Number | - | 2 |
| | Length | m | 185.0 |
| | 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 |
| | Gross head | m | 132.7 |
| | Effective head | m | 130.9 |
| | Type of turbine | - | Francis |
| | Rated output | MW | 272 (at Substation) (to be revised) |
| | Annual power generation | GWh | 1,515 (at Substation) (to be revised) |
| Transmission line | Voltage | kV | 230 |
| | Distance | km | 130 |
| | Connecting point | - | Nabong S/S |
| 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 | 185.2 |
| | Dam volume | $10^3\ m^3$ | 15.5 |
| | 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 | - | Concrete facing rock fill dam |
| | Crest length | m | 508.0 |
| | Dam height | m | 15.1 |
| Spillway | Gate type | - | Ungate spillway |
| | Design flood | $m^3/s$ | 5,210 (1,000-year) |
| Intake | Type | - | Open |
| | Number | - | 1 |
| | Discharge capacity | $m^3/s$ | 160.0 |

| Facility | Items | Unit | Specifications |
|---|---|---|---|
| Powerhouse | Type | - | Semi-underground |
| | Length | m | 62.5 |
| | Width | m | 25.0 |
| | Height | m | 47.2 |
| Turbine and Generator | Maximum plant discharge | $m^3/s$ | 160.0 |
| | Gross head | m | 13.1 |
| | Effective head | m | 12.7 |
| | Type of water turbine | - | Bulb |
| | Rated output | MW | 18 (at Substation) (to be revised) |
| | Annual power generation | GWh | 105 (at Substation) (to be revised) |
| Transmission line | Voltage | kV | 115 |
| | Distance | km | 40 |
| | Connecting point | - | Pakxan S/S |

Source: Technical Report on Nam Ngiep1 Hydropower Project Kansai, 2011

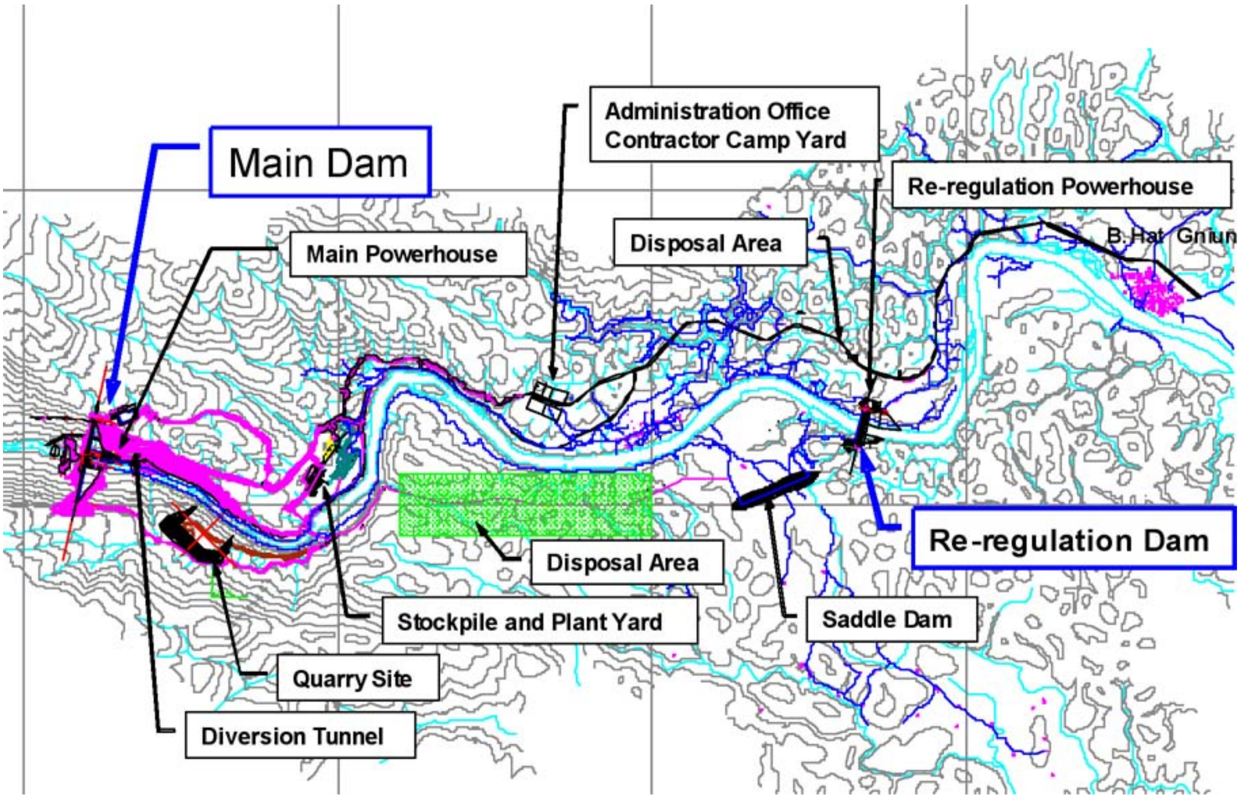


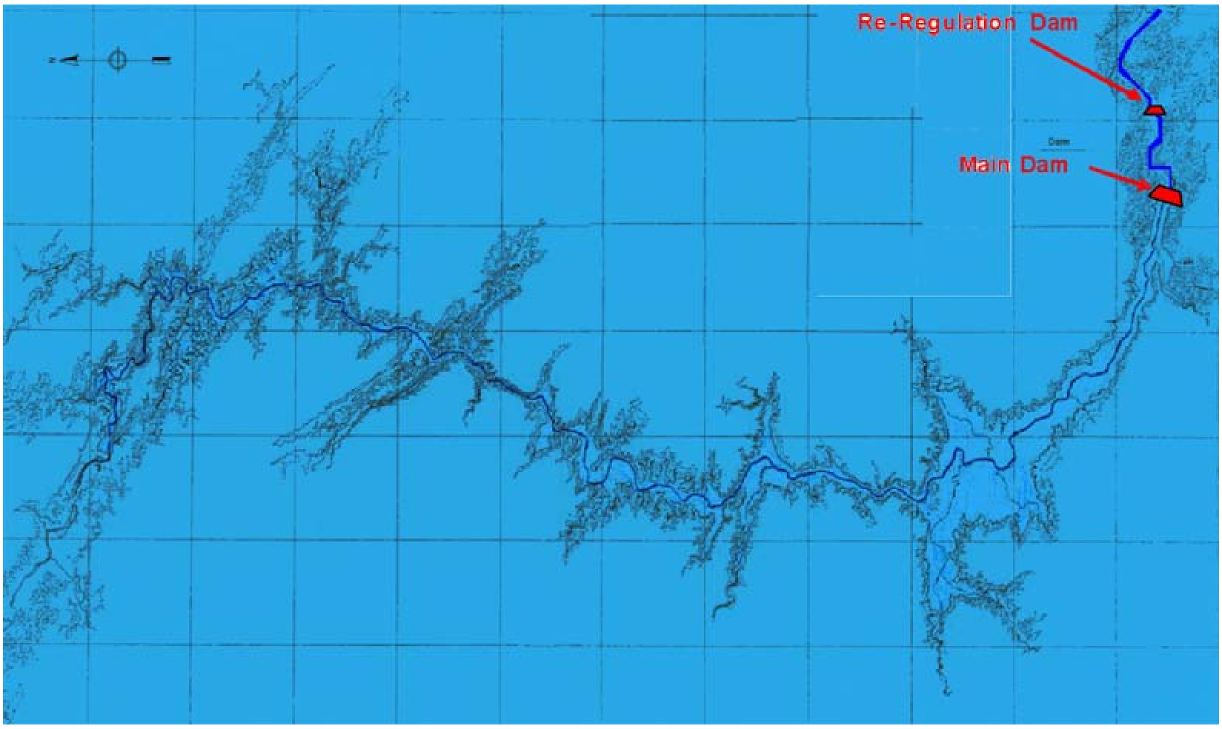

Figure 2-2 Location of main features of the Nam Ngiep 1 Hydropower Project.

## 2.4 MAIN DAM AND RELATED FACILITIES

### 2.4.1 MAIN DAM SITE RESERVOIR

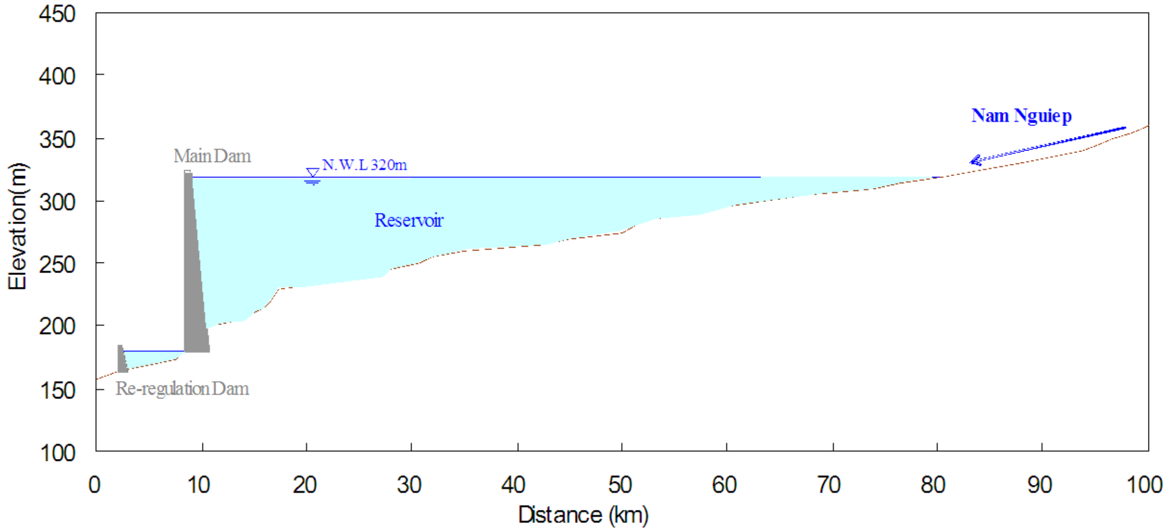
The dam location is planned to be 1.7 km upstream from the end of the narrow gorge, and 9.4 km from Ban Hat Gniun. The main dam reservoir with the effective storage capacity of

1,192 $Mm^3$ at NWL of EL 320 m and 70 km length is shown in the Figure 2-3. The reservoir is quite narrow along most of its length, and will cover an area of 66.9 $km^2$, with most of the area to be inundated within the first 20 km upstream from the main dam.




Source: Kansai and EGAT, Technical Report, 2011

Figure 2-3 Main dam reservoir map with the effective storage capacity of 1,192 $Mm^3$ at NWL of EL 320 m.




Source: Kansai and EGAT, Technical Report, 2011

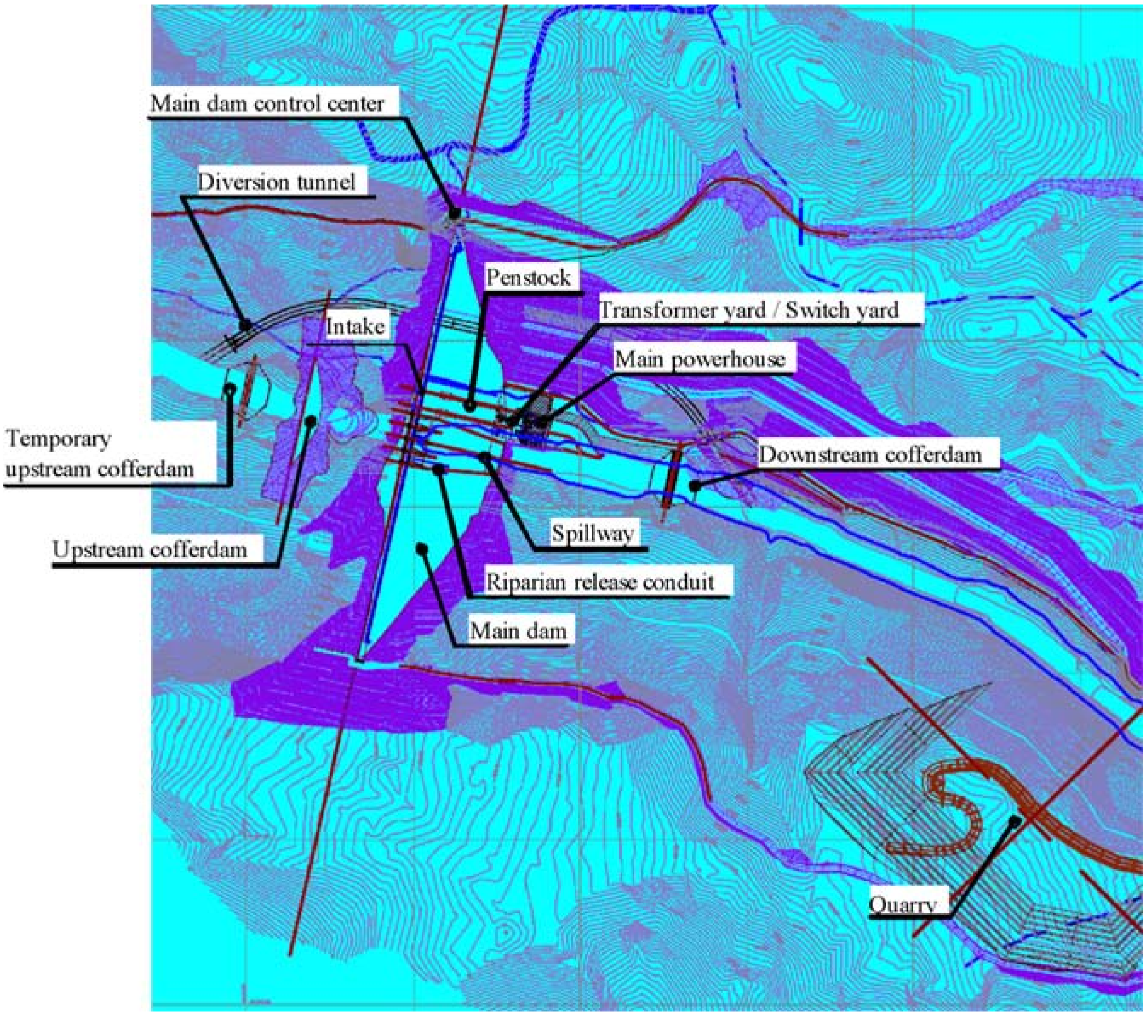
Figure 2-4 Longitudinal profile of the main reservoir.

As seen in Figure 2-4, where the main dam will be constructed the river floor is at EL 180 m. The reservoir depth at the deepest point just behind the dam is equal to the dam height, about 140m. The average depth would be about 70 m starting at 140 m at the dam site and decreasing as it goes farther upstream to only few m at about 70 km from the dam.

## 2.4.2 MAIN DAM

### 2.4.2.1 Layout

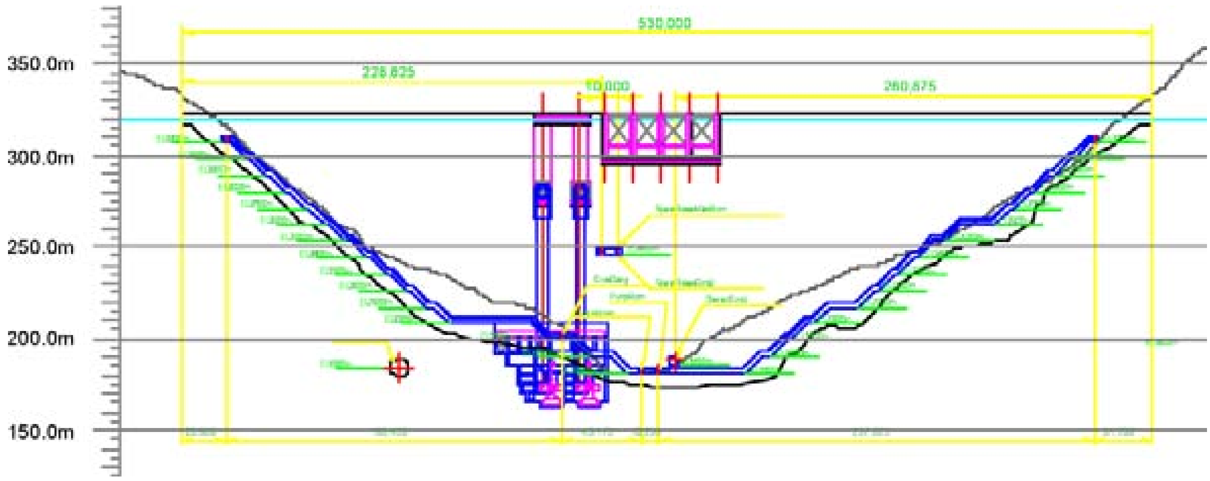
The structures will consist of a single lane river diversion with an intake/outlet, cofferdams located in upstream/downstream of the diversion tunnel, the main power station, and a tailrace are to be laid near the main dam. Intakes, penstocks, and a spillway, a riparian release conduit and valve are to be located in the main dam body. Figure 2-5 shows the layout plan in the periphery of the main dam.




Source: Kansai and EGAT, Technical Report on Nam Ngiep Hydropower Project, 2011

Figure 2-5 Dam periphery layout plan.

The main dam facilities will be located on the left bank 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 of the junction where the Nam Katha River joins the Nam Ngiep River, formed by the construction of 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 provable maximum flood. Grouting is also planned to improve the water cut-off effect of the dam foundation. (Figure 2-6)




Source: Kansai and EGAT, Technical Report on Nam Ngiep Hydropower Project, 2011

Figure 2-6 Upstream cross-section of the main dam.

#### 2.4.2.2 Main dam type

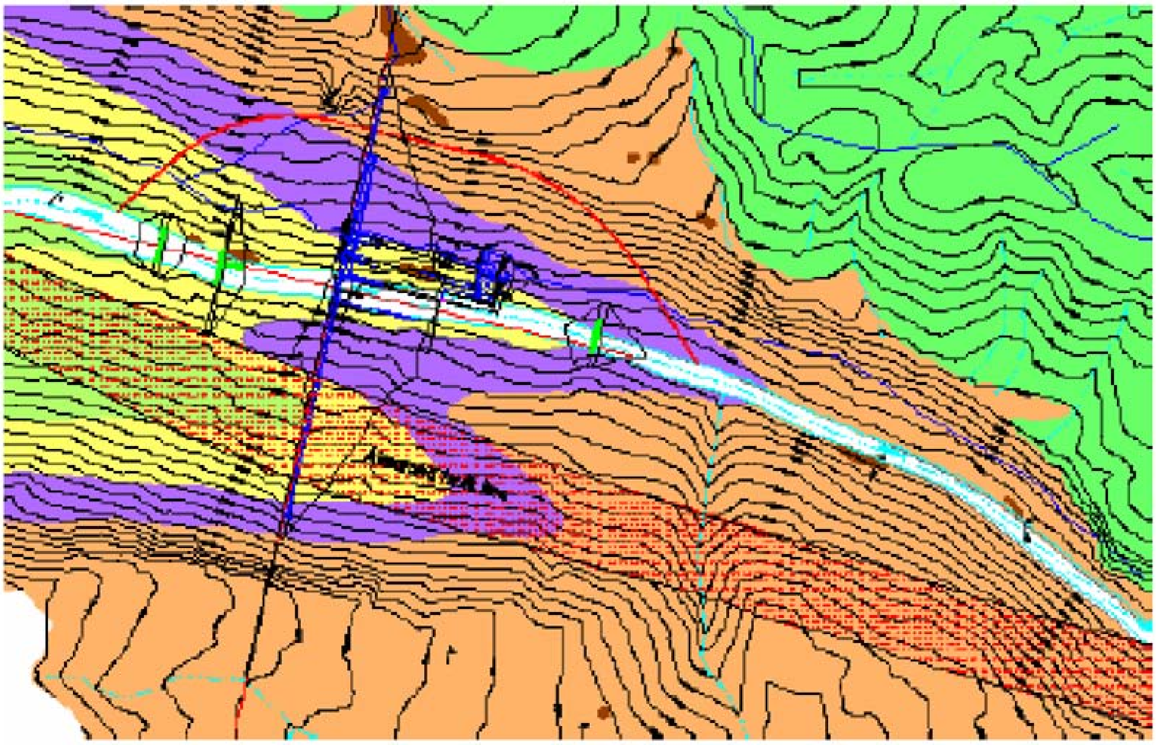
The dam axis has been set by considering the topography and geology. An RCC dam type of 148 m height has been selected as the most economical of the options; there would be considerable difficulties in the arrangement of a spillway and the procurement of materials such as core or asphalt/concrete, as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

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

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

### 2.4.3 RIVER DIVERSION

The river profile at dam site is a V-shape with 30−40 m width of riverbed. Therefore, a tunnel construction method is recommended. The left bank route is 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 2-7).



Source: Kansai and EGAT, Technical Report on Nam Ngiep Hydropower Project, 2011

Figure 2-7 River diversion tunnel layout.

The river diversion is to be a single-row water pressure tunnel with inner diameter of 10.0 m and 653 m long and horseshoe cross-section, and structurally capable of passing 1.5-year probable flood discharge of 1,000 $m^3/s$. The tunnel would be concrete lined with 0.7 m thickness for the intake section, outlet section and the plug section, and 0.3 m thickness for the rest. The tunnel would be blocked up at two sections, the intake section and the section below the dam axis.

### 2.4.4 SPILLWAY

The spillway is considered the necessity of direct water spillage to the Nam Ngiep River as well as the necessity of some elongation from the power station considered. It is designed for four (4) radial gates, each to be 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 is selected to be in accordance with the spill design flood discharge at NWL. A spillway chute and its energy dissipater are set to mitigate downstream impacts of the main dam.

The crest and chute of the spillway are to 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 energy dissipater, was set at EL 206.4 m, by considering the flood level of EL 192.1 m derived by non-uniform flow computation from the re-regulation dam using Design (8,050 $m^3/s$), plus some allowance.

### 2.4.5 INTAKE

Intakes are located on the upstream surface of the main dam. The sill level of the intake is set at EL. 275.500 m which is above the assumed sedimentation level of EL. 233.000 m. Intake structure is designed to minimize water head loss and to avoid harmful hydraulic phenomena of air bubbles generation, vortexes generation. Considering these conditions, now the intake location has enough water depth from the minimum operation level of EL296.0 m, generally two times as much as the inlet diameter is required, is considered in the power intake design. Further to minimize head loss, bell mouth inlet is applied.

### 2.4.6 PENSTOCK

Two rows of penstocks are planned to be near the center of the river. Diameter is 6.76 m at the beginning point and gradually reduced to 5.20 m and rapidly reduced to 3.7 m at just upstream of the inlet valve. The penstocks are exposed rather than buried for less impact on overall dam construction work as well as ease of inspection and maintenance.

### 2.4.7 CONDUIT FOR RIPARIAN RELEASE

A conduit is planned for riparian release for environmental protection of the downstream area. Water velocity inside the pipe has to be set at 20 m/sec, because 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, one (1) row of 0.8 m diameter discharge pipe and two (2) sluice valves, each 1.1 m in diameter, are installed inside the dam body.

The upstream slide valve is for back-up. The sill level of the gate chamber is set at EL. 244.600 m, which is lower than MOL 296.0m and higher than the assumed sedimentation level of EL. 233.0 m. The discharge is designed for a 5.5 $m^3/s$ discharge of riparian release.

### 2.4.8 MAIN POWER STATION

The layout of 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. (Table 2-2)

Table 2-2 Turbine Technical Data

| | Main Power Station |
|---|---|
| Type of turbines | Francis turbine Vertical shaft |
| Number of turbines | 2 (synchronous) |
| Nominal rotational speed | 214 rpm |
| Nominal capacity at substation | 272.0 MW (to be revised) |
| Generator terminal voltage | 16.5 kV |
| Transformer | Special three-phase Set-up to 230 kV |

All generating units will be isolated and protected from the pressurized water supply by inlet valves within the main power station. Draft tube gates of 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.

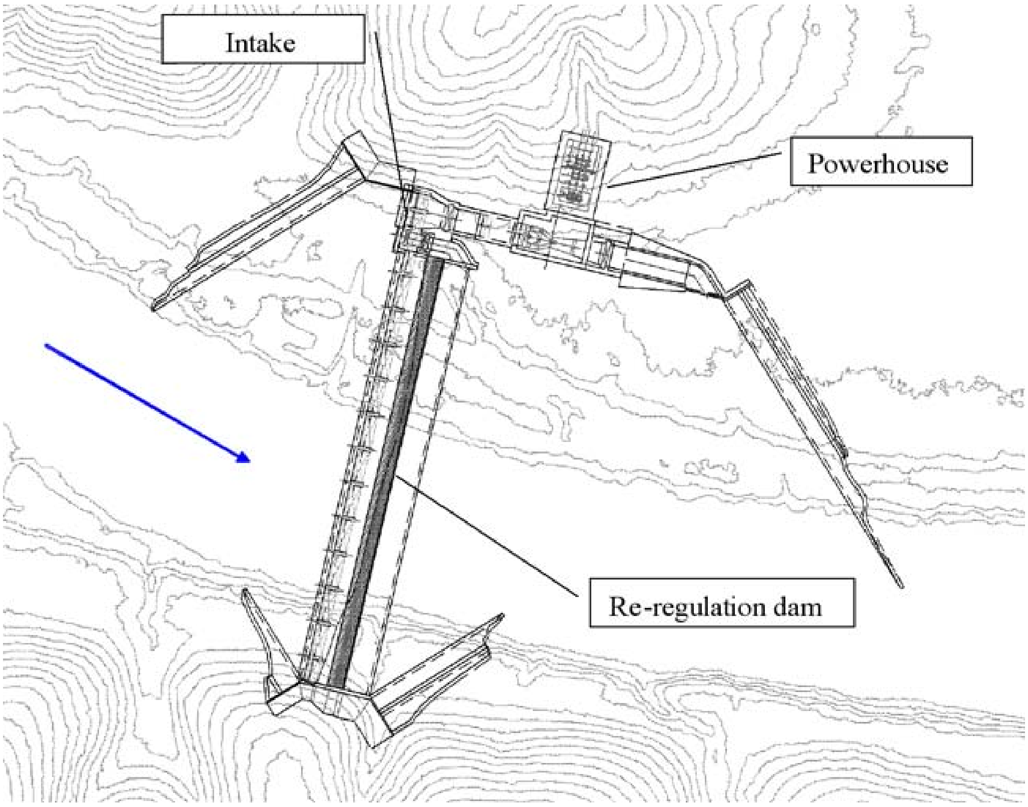
A Supervisory Control and Data Acquisition (SCADA) system will enable to monitor, supervise and control the power stations and substations. This system will enable analysis of power station conditions. All relevant information will be transmitted to EGAT's national and regional control centers. The SCADA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

## 2.5 RE-REGULATION DAM AND RELATED FACILITIES

### 2.5.1 RE-REGULATION DAM

A re-regulation dam is planned to be at the site 1.3 km downstream from Ban Hatsaykham or 3.2 km upstream from Ban Hat Gniun. The dam site is hilly at EL 163 m. The hills along the riverbanks are about EL 200 m. On the left bank there is a 90 m wide terrace plain 5-10 m above the river surface. The proposed dam crest elevation in the non-overflow section is indicated at about 187 m to discharge design flood.

The layout of the main facilities for the re-regulation dam is shown the figure below (Figure 2-8).




Source: Kansai, Technical Report on Nam Ngiep 1 Hydropower Project; 2011

Figure 2-8 Re-regulation dam layout.

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

The re-regulation dam will be formed by concrete gravity dam (CVC), with a crest length of approximately 185.2 m and a crest height of 20.6 m. Dam crest elevation will be EL 187.0 m.

### 2.5.2 RIVER DIVERSION

To secure five-year probable flood discharge (1,590 m3/s), the height of the cofferdam at EL 173 m is required at 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 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 the facilities, upstream and downstream cofferdams will be removed.

The primary diversion system:

- Cofferdam elevation: EL 173.0 m

The secondary diversion system:

- Cofferdam elevation: EL 182.0 m (upstream side), EL 174m (downstream side)
- Re-regulation gate discharge: Q = 230 $m^3$/s (10-year flood during dry season)

### 2.5.3 SPILLWAY

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

### 2.5.4 INTAKE

The intake is designed to accommodate the maximum plant discharge of 160 $m^3/s$ at any water level between NWL and MOL. The dimension of the intake bell-mouth is determined so as to avoid vortexes at any water level between NWL and MOL.

### 2.5.5 RE-REGULATION GATE

One (1) fixed wheel gate shall be 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.

### 2.5.6 RE-REGULATION POWER STATION

The re-regulation powerhouse has a length of 62.5 m, a width of 25.0 m and a height of 47.2 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 68.5 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. A bulb turbine unit will generate energy for delivery to EdL, the re-regulation power station, the administration office and the operator's village (Table 2-3).

Table 2-3 Turbine Technical Data

| | Re-regulation Power Station |
|---|---|
| Type of turbine | Bulb turbine Horizontal shaft |
| Number of turbine | 1 (synchronous) |
| Nominal rotational speed | 125 rpm |
| Nominal capacity at substation | 18 MW (to be revised) |
| Generator terminal voltage | 6.6 kV |
| Transformer | Special three-phase Set-up to 115 kV |

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

A Supervisory Control and Data Acquisition (SCADA) system will enable to monitor, supervise and control the power stations and substations. This system will 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.

### 2.5.7 SADDLE DAM

For the purpose of securing an effective storage capacity of NWL EL 179.0 m as well as preventing leakage, a saddle dam is built on the right bank, and the area behind it is utilized for the resettlement area. The saddle dam will be a formed concrete facing rock fill dam (CFRD), with a crest length of approximately 508 m and a dam height of 15.1 m.

## 2.6 OPERATION & MAINTENANCE

### 2.6.1 OPERATION OF PROJECT FACILITIES

The main power station with the maximum power output of 272 MW 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 by a 145 km long 230kV transmission line that will be owned by the project owner, and by a 27 km long shared-ownership 500kV transmission line beyond the substation at Ban Nabong. 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.

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 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 re-regulation reservoir is operated between a maximum reservoir elevation of EL 179.0 and the minimum operating level of EL 174.0 m. The re-regulation reservoir is to store water discharged from the main dam for 16-hour peak power generation, re-use it for power generation and release it downstream evenly on a 24-hour basis on weekdays and Saturday.

This will regulate the downstream flow for environmental reasons, 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 2-9, giving two duration curves of monthly flow data for 30 years. Operations of both the main dam and re-regulation dam could create a typical flow pattern with more decreased discharge in the rainy season and augmented flow in the dry season than there is for the natural river flow.

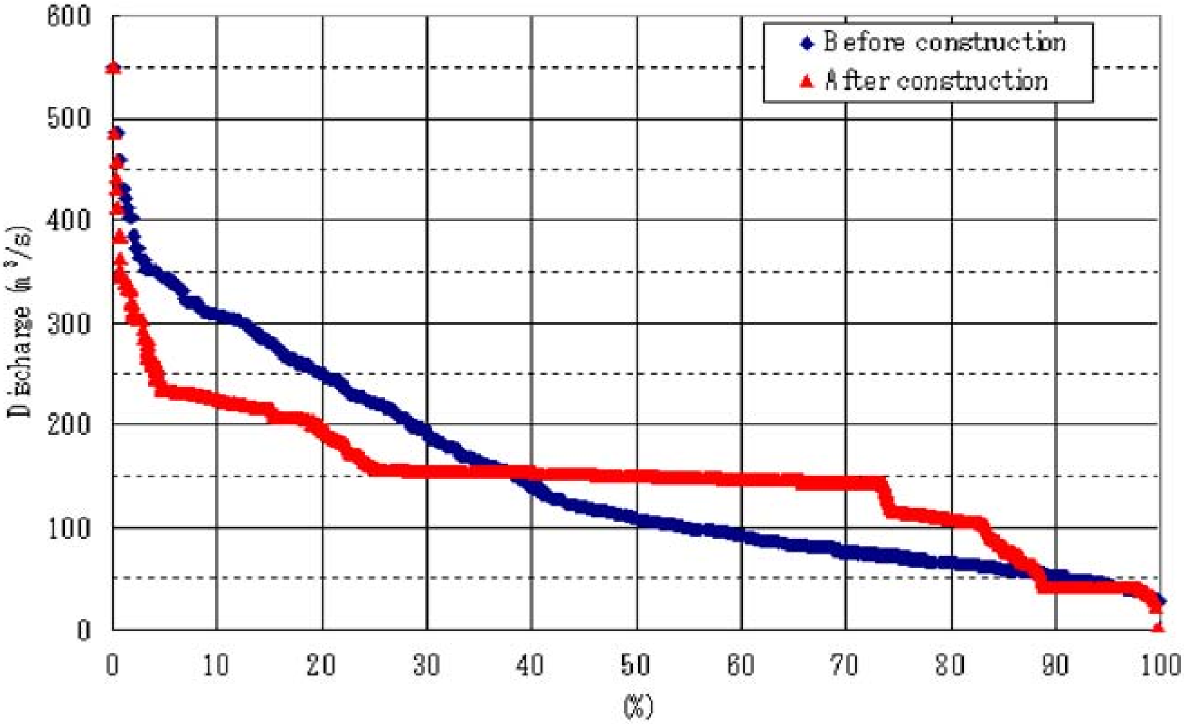



Figure 2-9 Discharge of the re-regulation dam.

The discharge of 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. Typical operation case is shown in Figure 2-10. The discharge from the main dam would be stored in the re-regulation reservoir.

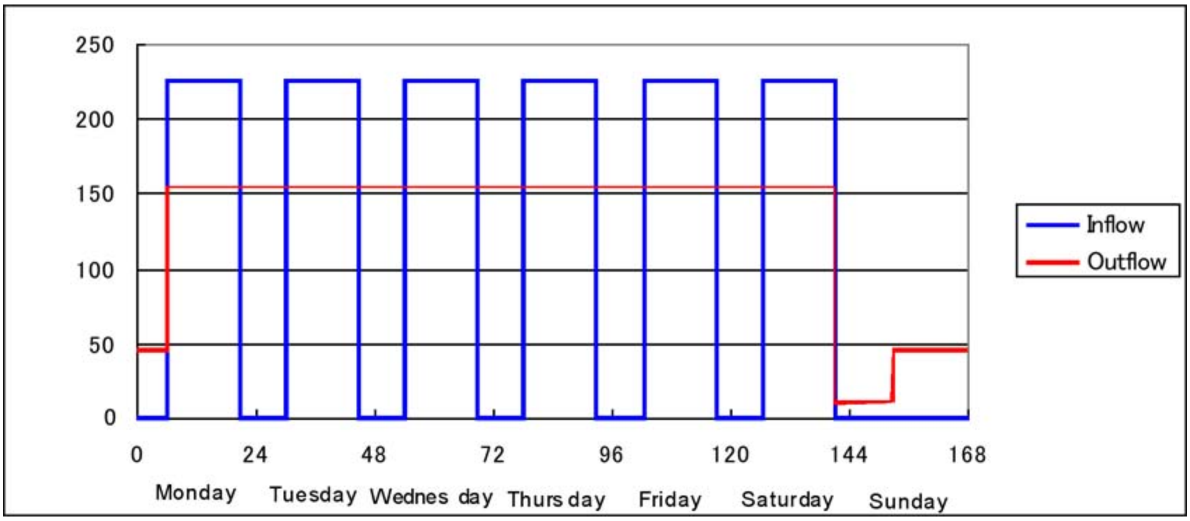



Figure 2-10 Typical Operation case of 230 $m^3/s$ 16-hour peak generation at the main power station.

Operation of the main dam would intentionally release water downstream during emergency events such as drought or flooding when both turbines are unable to release water because of those unforeseen events. 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.

### 2.6.2 OPERATION OF MAIN POWER STATION

#### (1) Plant Discharge

The NWL and MOL of the main dam will be at EL320.0 m and EL 296.0 m respectively. Drawdown of the reservoir will normally occur during the dry season, with filling occurring during the rainy season as shown in Figure 2-11. When the reservoir water level reaches NWL during floods, the spillway gates will be operated.

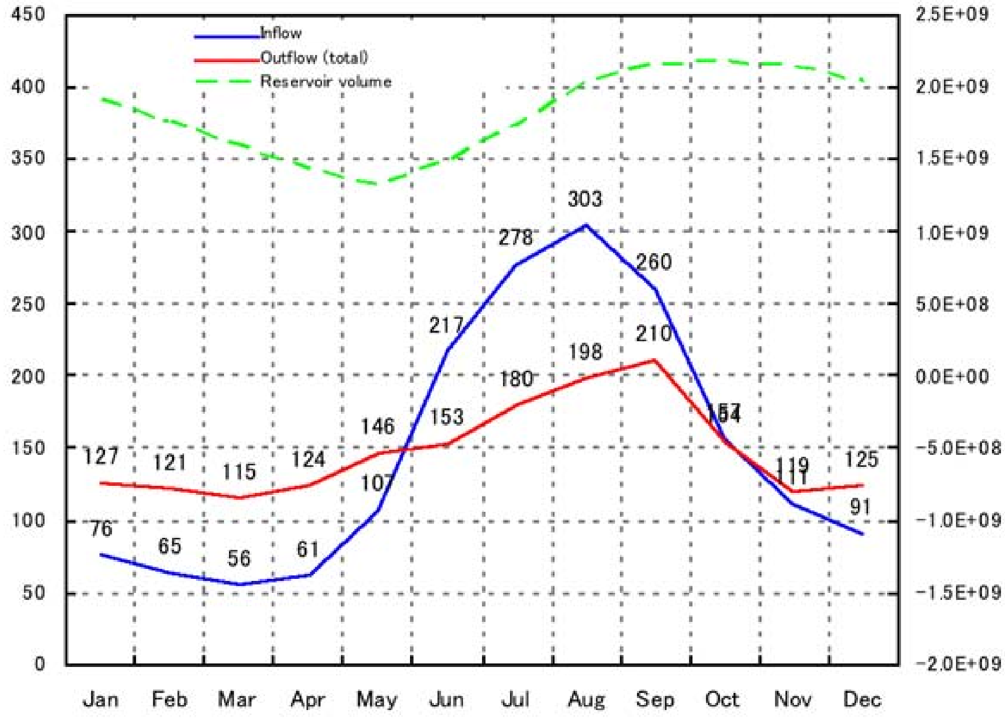



Figure 2-11 Seasonal inflow and outflow of the main reservoir and changes in reservoir volume.

### (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 Ngiep1 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 2-4.

Case 1:

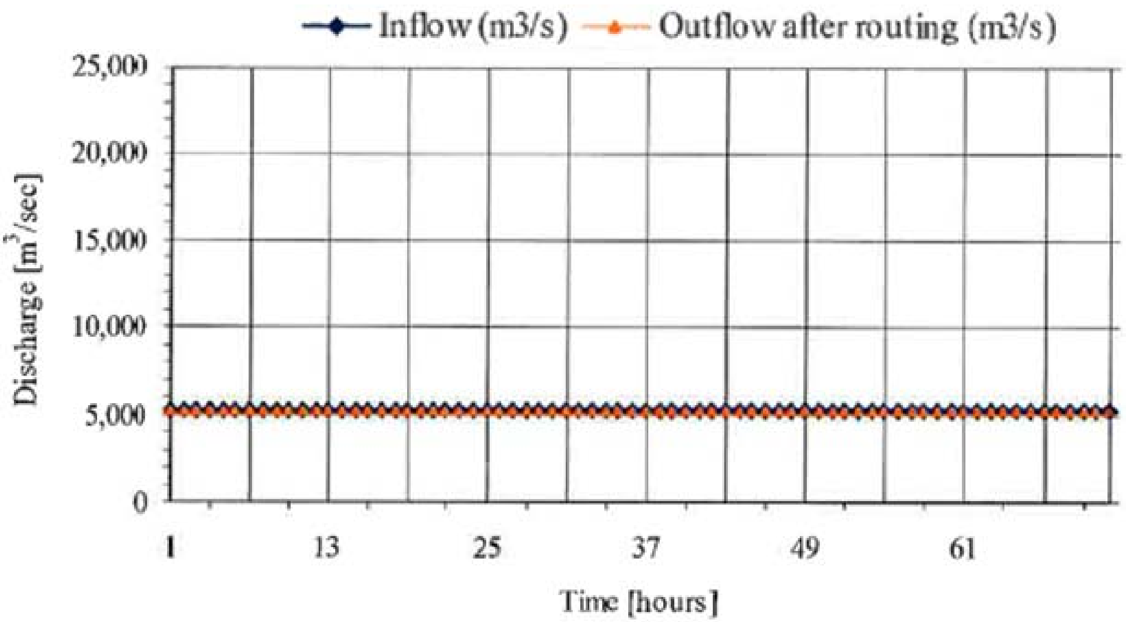
Whenever the WL is lower than NWL, the spillway gates will not be operated and all the river inflow will be stored in the main reservoir until the WL reaches NWL unless there is any requirement for preparation of flooding routine and/or required by laws, regulations or the Concession Agreement. Such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

Table 2-4 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 | $Q_{in}$ | $Q_{out} = 0$<br>Note: the spillway gates will not be operated. River inflow will be stored in the main reservoir until the WL rises up to NWL. |
| Case 2 | WL = NWL | $Q_{in}$ < = 5,210 $m^3/s$ (design flood) | $Q_{out} = Q_{in}$<br>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. |

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. The water amount to be discharged through the spillway gates will be performed by the gate opening/closing in order that $Q_{out}$ could be equal to $Q_{in}$. Under the condition that the spillway gates are full-opened or a free-flow condition, the spillway gates will be capable of discharging water amount of 5,210 $m^3/s$ corresponding to 1,000-year probable flood defined as the design flood. Thus, in the event of 1,000-year probable flood, the WL could not exceed NWL of EL 320 m as shown Figure 2-12.




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

Figure 2-12 Hydrograph at dam-site.

In the highly unlikely case that floods 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 the appropriate manners.

### 2.6.3 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 constructing the re-regulation dam.

The main power station will operate only 16 hours on w eekdays (from Monday to Saturday) and will often halt operation for the remaining 8 hour s 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, and thus mitigating environmental impacts caused by the Project.

#### (2) Plant Discharge

The re-regulation reservoir will be operated between NWL of EL179.0 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 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 it downstream on two steps from Saturday to Monday. Inflow and plant discharge pattern is as shown in Figure 2-13.

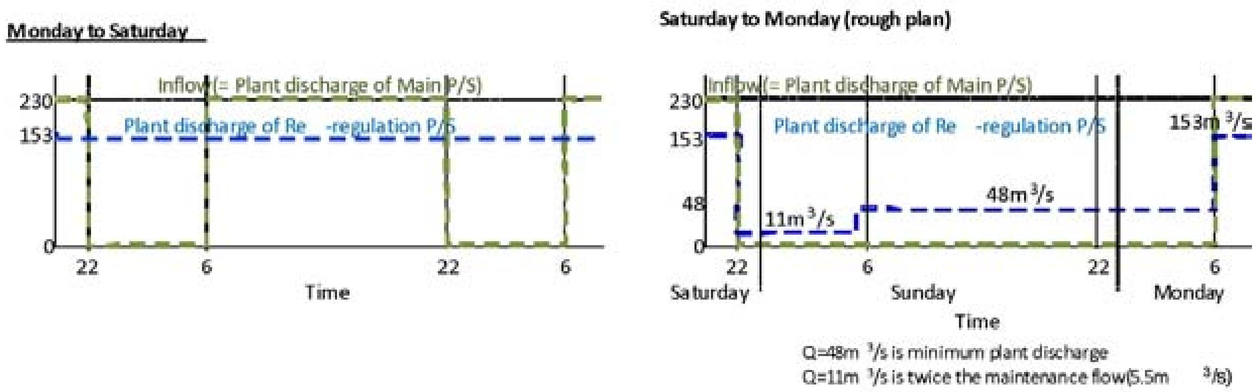



Figure 2-13 Inflow and plant discharge pattern in the re-regulation reservoir water level.

The operation to change the amount of released water 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 EL179 m. After that, the water from the main reservoir will be spilled 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.

## 2.7 ANCILLARY WORKS

### 2.7.1 QUARRY SITE

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

### 2.7.2 ACCESS ROAD

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

The most promising transportation route for these imported equipment and materials would be through Thailand. They would first be discharged at either the Bangkok Port or the Laem Chabang Port in Thailand; then taken by road to Vientiane, Lao PDR via the Friendship Bridge. From Vientiane, equipment and materials will be taken by Route 13 south to Pakxan, then to the north on a provincial road to Ban Nonsomboun before turning left onto the access road to the dam site.

### 2.7.2.1 Improvement of the Existing Access Road

With reference to the IEE reported in Annex D, the transportation distance and road conditions for each section of the route between Vientiane and Ban Hat Gniun are shown in Table 2-5. Since all the equipment and materials will be transported, during the construction period, through the route mentioned in Figure 2-14, widening the existing road, constructing bridges or culverts at stream (marsh area) crossings, and stabilization work of the roadbed will need to be done as appropriate.

Table 2-5 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)<br>* Currently conducting asphalt paving and constructing a PC bridge |
| 3 | Ban Nonsomboun–Ban Thahuea | 18.3 | Dirt, Width: 3.5 m |
| 4 | Ban Thahuea–Ban Hat Gniun | 2.6 | Dirt, Width 1.5–2.0 m |
| | Total | 202.5 | |

Source: Technical Report, 2011


Figure 2-14 General layout of existing road between Paksan and Ban Hat Gniun.

#### 2.7.2.2 Construction of Access Road

A temporary road now 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 JICA-F/S. For access to the left bank of the dam site, this temporary road will be upgraded and used as a construction road during the construction period. However, because of the mitigation of detour route which would not be economical to use for permanent access. A new permanent access road is proposed to 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 be adjacent the access road, branching off from the existing line at Nonsomboon, to provide electricity during construction. The road route plan is shown in Figure 2-15.

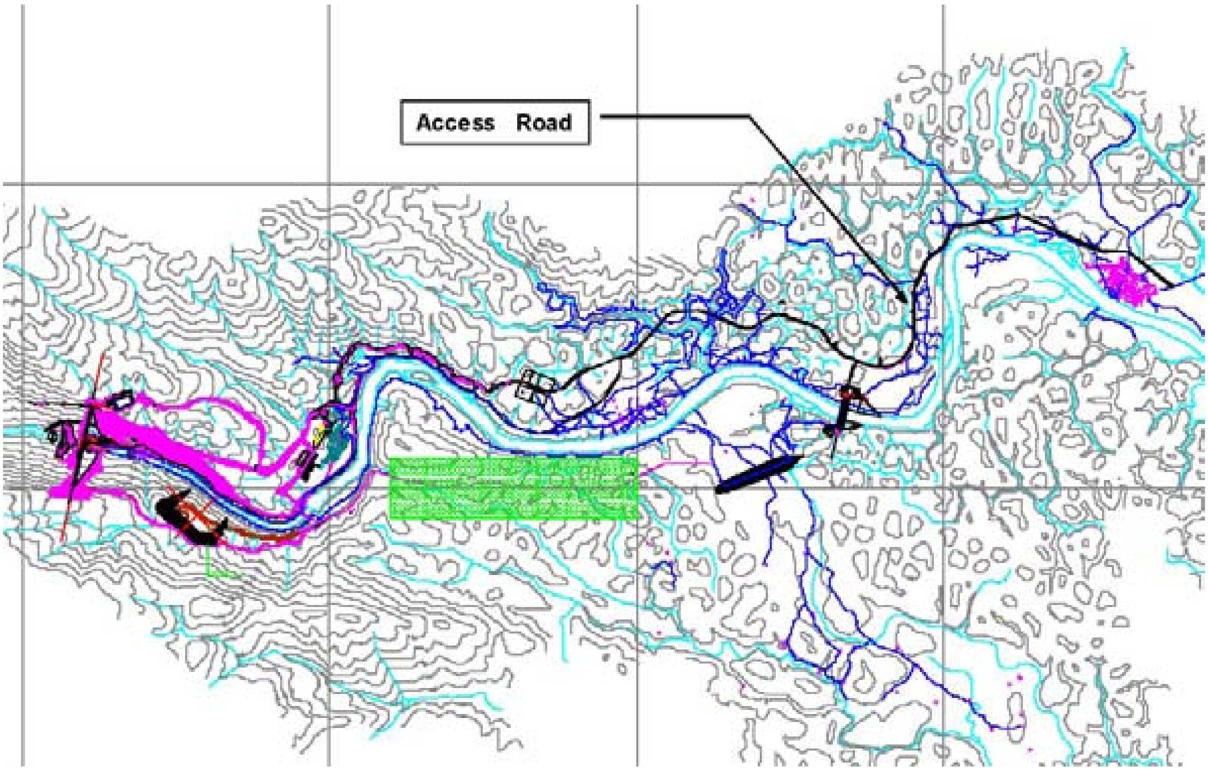



Figure 2-15 Road route plan.

## 2.8 TRANSMISSION LINE

There are two transmission lines for the Nam Ngiep Project, a 230 kV line from the power station at the main dam and a 115 kV from the power station at the re-regulation dam. The 230 kV line is proposed to run for about 130 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 is proposed to run 40 kilometers, starting at the re-regulation dam and ending at the Pakxan substation, providing domestic power supply.

# 2.9 CONSTRUCTION PLAN

## 2.9.1 METHOD OF CONSTRUCTION

Construction procedures of the main power facility would be in this 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

### 2.9.2 FUNCTIONAL AREA

Sites for project activities should be prepared during early phases of construction. Areas that need to be cleared are for the main and re-regulation dams, cofferdams, diversion tunnels, power houses, quarry areas, temporary yards, access roads, disposal areas, office, worker camps, waste storage, chemical storage, and waste treatment and disposal systems. Sizes of functional areas are presented in Table 2-6. Location of various components were shown in Figure 2-5.

Table 2-6 Sizes of Functional Areas during Construction Phase

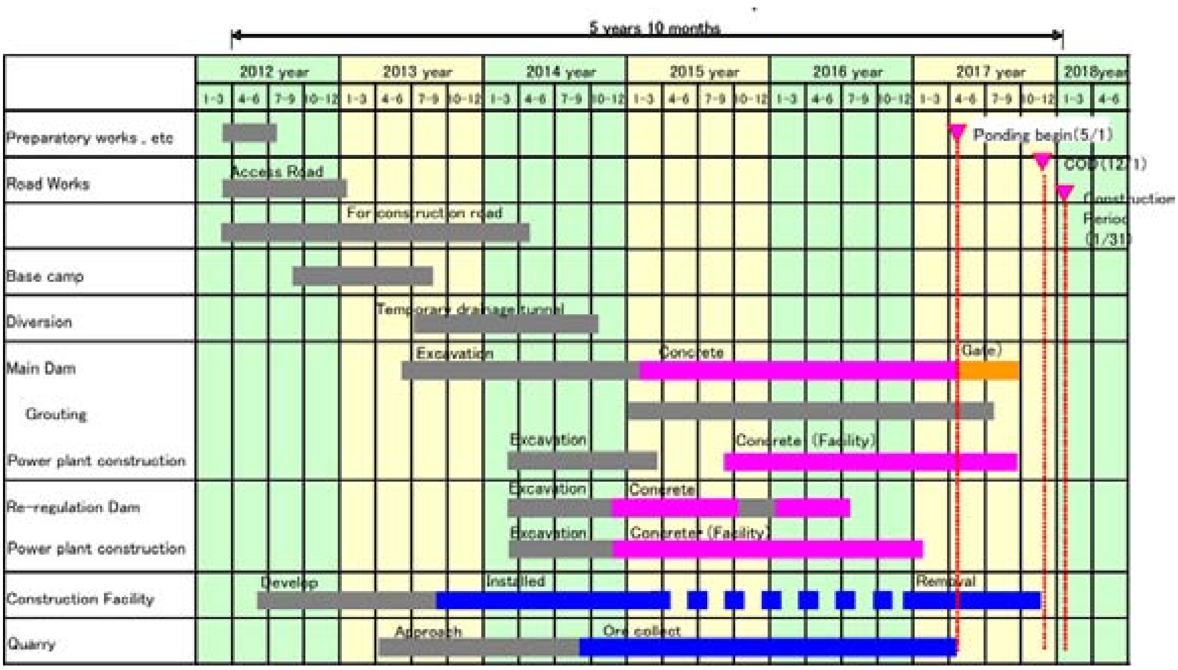
| Functional area | Size | | Length (m) | Permanent Use |
|---|---|---|---|---|
| | (ha) | ($m^2$) | | Yes |
| Main dam | 4.32 | 43,200 | | Yes |
| Re-regulation dam | 1.60 | 16,000 | | Yes |
| Cofferdams | 0.67 | 6,700 | | Yes |
| Diversion tunnels | 0.62 | 6,240 | | Yes |
| Main dam powerhouse | 0.15 | 1,470 | | Yes |
| Re-regulation dam powerhouse | 0.06 | 570 | | Yes |
| Quarry areas | 9.12 | 91,200 | | No |
| Temporary yards | 16.81 | 168,100 | | No |
| Switch yard | 0.24 | 2,400 | | Yes |
| Access Road | - | - | 23 | Yes |
| Disposal areas | 25.10 | 251,000 | | No |
| Office | 1.60 | 16,000 | | Yes |
| Worker camps | 12.00 | 120,000 | | No |

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

### 2.9.3 CONSTRUCTION SCHEDULE

A tentative schedule for the construction is presented in Table 2-7. Construction schedule is planned at the total 70 months.

Table 2-7 Schedule for Construction



# CHAPTER 3

# METHODOLOGY

The study components are organized into two main categories according to their general environmental aspects:

**1. Physical Environment**

1) Topography
2) Meteorology
3) Geology, Landforms, Seismology
4) Soils
5) Erosion and Sedimentation
6) Surface Water and Groundwater Quality
7) Mineral Resources
8) Noise and Vibration
9) Air Quality
10) Potential Contaminated Sites
11) Hydrology

**2. Biological Environment**

1) Terrestrial Ecology / Wildlife
2) Forests, Vegetation Cover
3) Aquatic Biota
4) Wetland

Analysis of the Socio-Economic and Cultural Environment is in the Social Impact Assessment report.

# 3.1 PHYSICAL ENVIRONMENT

## 3.1.1 TOPOGRAPHY

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

### 3.1.2.1 Objectives of Study

To study topography changes expected with the project and provide information of possible impacts for further assessment in the other study components.

### 3.1.2.2 Method of Study

(1) Study topographical data around the project site by reviewing existing works, in particular the previous feasibility studies, and data provided by the project developer.

(2) Study project details on water level dynamics (during fill up and operation periods), civil structures, and construction access routes. The study will focus on the activities involving modification of landscape.

(3) Prepare maps depicting the modified topography and recommended mitigation measure to minimize negative impacts.

## 3.1.2 METEOROLOGY

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

#### 3.1.2.1 Objective of Study

(1) To determine base meteorological data of the study area

(2) To suggest mitigation measures and action plans if required.

#### 3.1.2.2 Method of Study

Meteorological data including atmospheric pressure, air temperature, relative humidity, precipitation, wind speed and direction were collected from primary sources such as the Department of Meteorological.

### 3.1.3 GEOLOGY, LANDFORMS AND SEISMOLOGY

Geology is the most crucial fundamental for dam construction. The geological information including regional structure and rock formation is most useful for indicating potentials of mineral deposits and geohazards (e.g., seismic risks, rock falls and landslides). The geohazards may cause enormous 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 are considered for the potential of rock falls, flows and landslides. The geological information is also used for assessing the vulnerable and geologically risky areas, which are indicated for 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.

#### 3.1.3.1 Objectives of Study

(1) To compile and integrate geological data (e.g., rock formation, structure and tectonic) of the project area and regional area.

(2) To assess seismic hazards affecting the project site and adjoining areas.

(3) To propose solutions and alternatives if any potential problems are found.

#### 3.1.3.2 Method of Study

Results of the study in the previous Feasibility Study were investigated to determine the geological setting of the area. In addition, the following tasks were carried out.

(1) Compile information on regional geology and seismic source zones from Lao and international literature.

(2) Delineate geological features of the regional project area from satellite images.

(3) Review field surveys conducted around the project dam site to confirm and enhance the interpretations of the previous studies

(4) In case potential problems are found, develop appropriate measures to minimize the impacts.

## 3.1.4 SOILS

The dam development could lead to 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 soil fertility study is to evaluate whether or not the areas provided for resettlement allow people to continue their traditional agricultural practices. Additional soil analysis is 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.

### 3.1.4.1 Objectives of Study

(1) 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 sites, especially resettlement sites.

(2) To assess the probable effects and impacts from the project on soil fertility and suitability during construction and operation phases.

(3) To develop mitigation measures and monitoring plans for possible adverse effects.

### 3.1.4.2 Method of Study

(1) Investigated soil types and chemistry of the resettlement sites and project area.

(2) Conducted field survey and soil sampling at 2 different depths 0-15 cm and 15-30 cm by composite sampling method.

(3) Soil samples were prepared and analyzed for chemical and physical properties:

- Soil samples were air dried, under shade, crushed and sieved through 2 mm sieve.

- 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)

(4) Collected data were assessed for the impacts on soil fertility and to determine mitigation measures wherever necessary.

### 3.1.5 EROSION AND SEDIMENTATION

The amount 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 pa rticularly violent storm. Under such conditions, a river may carry as much sediment as it would in several normal years. Mudslides can also have a dramatic and unpredictable effect on reservoir sedimentation.

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

#### 3.1.5.1 Objectives of Study

(1) To determine sedimentation and erosion of the Nam Ngiep river from the existing flow

(2) To assess possible impacts of the NNHP-1 project on sedimentation and erosion

(3) To develop a plan to ensure minimum and controllable impacts of the dam on sedimentation and erosion

#### 3.1.5.2 Method of Study

There was no systematic collection of data on erosion patterns and sediment discharge in the river for any of the preliminary studies. This makes it extremely difficult, if not impossible, to estimate accurately how the dam will affect erosion and sedimentation. Since erosion patterns and sediment flows vary widely seasonally as well as from year to year, determining these factors require a long run of data. In theory, statistical data should be available for a period equal to at least half the projected lifetime of the dam for an accurate assessment. Using data on erosion and sedimentation collected over a short period is extremely prone to error. With insufficient data from the project area, it was considered more desirable and likely to be more accurate to use data from similar catchments in the region for the assessment.

### 3.1.6 SURFACE WATER AND GROUNDWATER QUALITY

A range of impacts on water quality will be identified in different stages of project construction and operation. 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 results in impoundment of the water body, w hich 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 consequently affect a broad spectrum of water quality parameters impounded water and the water released downstream.

#### 3.1.6.1 Objectives of Study

(1) To forecast the impacts on existing water quality of the Nam Ngiep River that could be caused by project activities.

(2) To propose mitigation measures and monitoring plans to prevent or mitigate the impact on water quality.

#### 3.1.6.2 Method of Study

The assessment of water quality of Nam Ngiep River was conducted by:

(1) Reviewing discharge sources and other relevant data water quality of the Nam Ngiep River, focusing on the segment passing through Xieng Khuang, and down to the Mekong River.

(2) Locating 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 map (Table 3-1 and Figure 3-1).

Table 3-1 Location of Water Sampling Station

| 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 Somseun | 18°30'17.54'' | 103°39'31.81'' |
| 10 .Nam Ngiep Bridge | 18°25'03.77'' | 103°36'11.30'' |

(3) Sampling the surface water twice to compare late hot and dry season (low flow) and late rainy season (high flow) conditions. The first sampling was collected on 24 April 2007 toward the end of the hot season, while the second sample was collected on 17 October 2007 in the later part of the rainy season. Groundwater quality was observed on 17 October 2007 at Ban Somseun and Ban Hat Gniun; however, only the well-water of Ban Somseun was collected.

(4) Sampling methods taken extensively and over a wide area; sampling procedures were done to prevent of sample cross contamination and water parameters especially trace elements. Grab sampling was conducted by using a water sampler dropped down to around 1 meter under the water surface. Samples were cooled to 4 de grees Celsius and hand carried to the laboratory for further analysis. Temperature, pH, conductivity, salinity, turbidity, and DO were measured at the field sites, whereas other characteristics were analyzed in a laboratory at the National University of Lao

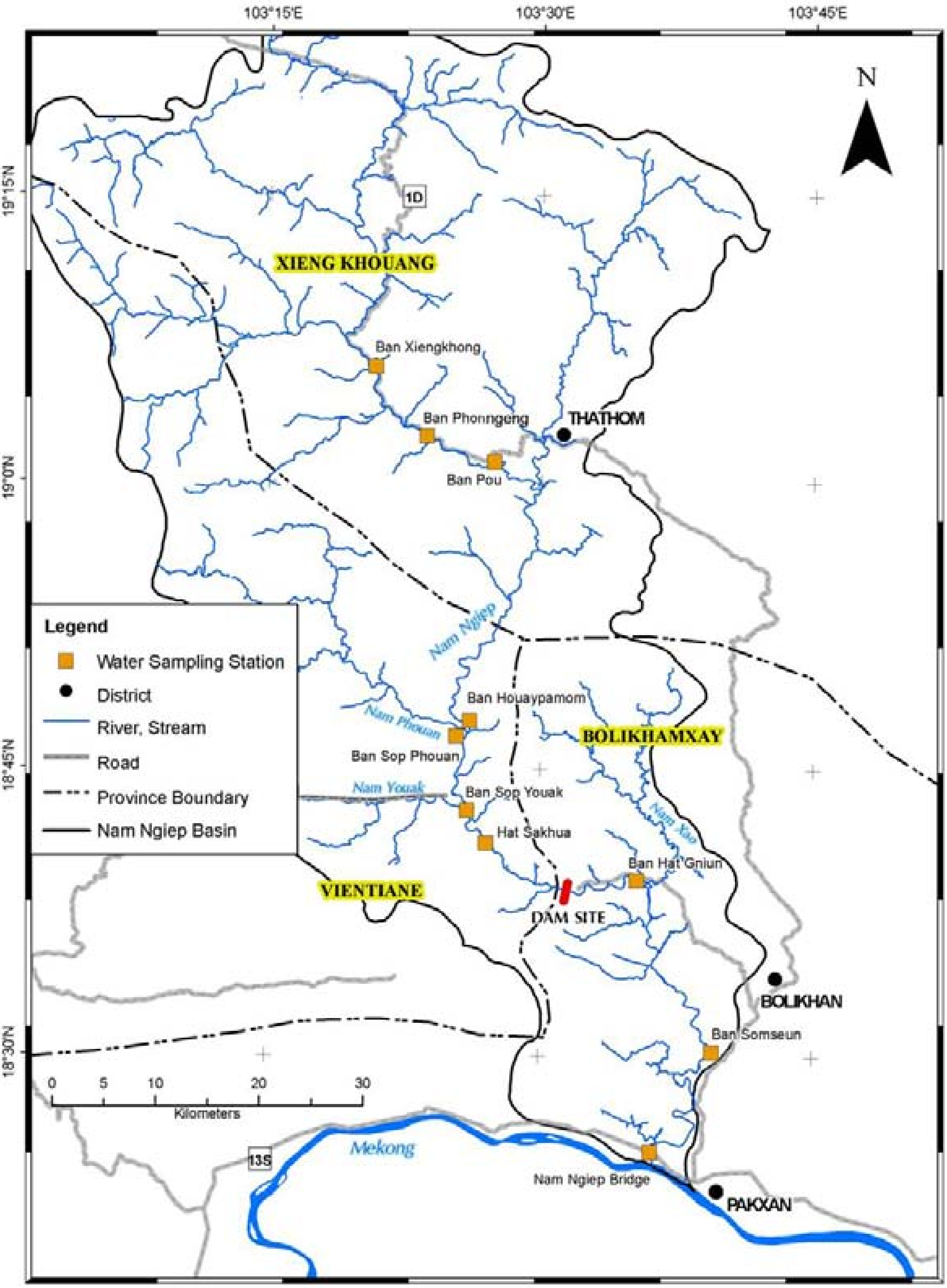



Figure 3-1 Location of surface water sampling stations.

(5) Analyzing the water quality. Parameters of interest included physical and chemical water qualities (temperature, pH, conductivity, salinity, hardness, alkalinity, turbidity, suspended solid, total dissolved solid, oil and grease), biological water qualities (DO, COD, $BOD_5$, P, $PO_4^{3-}$, N, $NO_3^-$, $NH_3$), bacteriological water quality (total coliform and feacal coliform), and other chemicals and trace elements (Cd, Cu, Fe, Hg, Mn, Ni, Pb Zn and As). Their analytical methods were indicated following the Standard Methods for the Examination of Water and Wastewater, 19th edition, 1995, e dited by Andrew Egton, Lenore Clesceri and Ashold Greenberg (Table 3-2)

Table 3-2 Analytical Methods of Water Quality

| Parameters | Unit | Methods |
|---|---|---|
| Temperature | $^oC$ | Thermometer |
| pH | | pH meter |
| Alkalinity | meq/L | Microtitration |
| DO | mg/L | Azide modification |
| $BOD_5$ | mg/L | Azide modification |
| Oil and Grease | mg/L | Partition gravimetric |
| Turbidity | FTU | Turbidity meter |
| Suspended solids | mg/L | at 180 ºC |
| TDS | mg/L | at 105 ºC |
| Hardness | mg/L | EDTA |
| Conductivity | µS/cm | Conductivity meter |
| Phosphate-P | mg/L | Vanadomolybdophosphoric acid |
| Total P | mg/L | Simultaneous oxidation of phosphorus cpds with persulphate |
| Ammonium-N | mg/L | Nesslization |
| 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 |

(6) The ambient water standards of the Lao PDR were used for analysis (Table 3-3) The surface water standards of Thailand (Table 3-4) were also used for analysis, because it includes several levels of water quality, indicating whether the water is appropriate for drinking, agriculture, or other uses. In

addition, Groundwater Standards for Drinking Purposes of Lao PDR were used (Table 3-5).

Table 3-3 Ambient Water Standards of Lao PDR

| Parameter | Unit | Standard |
|---|---|---|
| pH | | 5-9 |
| Dissolved Oxygen | mg/l | >5.0 |
| $BOD_5$ | mg/l | 1.5 |
| COD | mg/l | 5.0 |
| Nitrogen as nitrate ($N\text{-}NO_3$) | mg/l | 5.0 |
| Nitrogen as ammonia ($N\text{-}NH_3$) | mg/l | 0.2 |
| Sulfate | mg/l | 500 |
| Total coliform bacteria | MPN/ml | 5,000 |
| Total faecal coliform | MPN/ml | 1,000 |
| Phenols | mg/l | 0.005 |
| Arsenic (As) | mg/l | 0.01 |
| Cadmium (Cd) $CaCO_3 \leq 100$ mg/l | mg/l | 0.005 |
| Cadmium (Cd) $CaCO_3 \geq 100$ mg/l | mg/l | 0.05 |
| Chromium (VI) ($Cr^{6+}$) | mg/l | 0.05 |
| Copper (Cu) | mg/l | 0.1 |
| Cyanide | mg/l | 0.005 |
| Lead (Pb) | mg/l | 0.05 |
| Mercury (Hg) | mg/l | 0.002 |
| Nickel (Ni) | mg/l | 0.1 |
| Zinc (Zn) | mg/l | 1.0 |
| Manganese (Mn) | mg/l | 1.0 |
| Alpha ¬Radioactivity | Becquerel/l | 0.1 |
| Beta ¬ Radioactivity | Becquerel/l | 1.0 |
| Total Organochlorine | mg/l | 0.05 |
| DDT | mg/l | 1.0 |
| Alpha-BHC | mg/l | 0.02 |
| Dieldrin | mg/l | 0.1 |
| Aldrin | mg/l | 0.1 |
| Heptachlor and Heptachlor Epoxide | mg/l | 0.2 |
| Endrin | mg/l | 0 |

Source: MONRE, GOL

Table 3-4 Thailand's Surface Water Quality

| Parameter | Units | Statistics | Standard Value for Class | | | | | Methods for Examination |
|---|---|---|---|---|---|---|---|---|
| | | | Class 1 | Class 2 | Class 3 | Class 4 | Class 5 | |
| Temperature | $C^o$ | | 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 |

| Parameter | Units | Statistics | Standard Value for Class | | | | | Methods for Examination |
|---|---|---|---|---|---|---|---|---|
| | | | Class 1 | Class 2 | Class 3 | Class 4 | Class 5 | |
| $BOD_5$ | mg/L | P80 | n | 1.5 | 2.0 | 4.0 | - | Azide Modification at 20 °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*<br>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 :<br>1. conservation not necessary pass through water treatment process require only ordinary process for pathogenic destruction<br>2. ecosystem conservation where basic organisms can breed naturally |
| Class 2 | Very clean fresh surface water resources used for :<br>1. consumption which requires ordinary water treatment process before use<br>2. aquatic organism of conservation<br>3. fisheries<br>4. recreation |
| Class 3 | Medium clean fresh surface water resources used for :<br>1. consumption, but passing through an ordinary treatment process before using<br>2. agriculture |
| Class 4 | Fairly clean fresh surface water resources used for :<br>1. consumption, but requires special water treatment process before using<br>2. industry |
| Class 5 | The sources which are not classification in class 1-4 and used for navigation |

Remark :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 3-4 Ground Water Standards for Drinking Purposes of Lao PDR

| Characteristics | Parameters | Symbol | Unit | Permitted Standard Value | |
|---|---|---|---|---|---|
| | | | | Suitable | Maximum |
| Physical | 1. Colour | - | Platinum-Cobalt | 5 | 15 |
| | 2. Turbidity | - | JTU | 5 | 20 |
| | 14. Total solids | TS | mg/l | ≤600 | 1,200 |
| Chemical | 3. Acidity | pH | - | 7.0-8.5 | 6.5-9.2 |
| | 4. Iron | Fe | mg/l | ≤0.5 | 1 |
| | 5. Manganese | $Mn^{2+}$ | mg/l | ≤0.3 | 0.5 |
| | 6. Copper | $Cu^{2+}$ | mg/l | ≤1.0 | 1.5 |
| | 7. Zinc | $Zn^{2+}$ | mg/l | ≤5.0 | 15 |
| | 8. Sulphate | $SO_4^{2-}$ | mg/l | ≤200 | 250 |
| | 9. Chloride | $Cl^-$ | mg/l | ≤250 | 600 |
| | 10. Fluoride | $F^-$ | mg/l | ≤0.7 | 1 |
| | 11.Nitrate | $NO_3^-$ | mg/l | ≤15 | 45 |
| | 12. Total Hardness | Total | mg/l | ≤300 | 500 |
| | 13.Non-carbonate | Non | mg/l | ≤200 | 250 |
| | 15. Arsenic | $As^{3+}$, $As^{5+}$ | mg/l | None | 0.05 |
| | 16. Cyanide | $CN^-$ | mg/l | None | 0.1 |
| | 17. Lead | $Pb^{2+}$ | mg/l | None | 0.05 |
| | 18. Mercury | Hg | mg/l | None | 0.001 |
| | 19. Cadmium | $Cd^{3+}$ | mg/l | None | 0.01 |
| | 20. Selenium | Se | mg/l | None | 0.01 |
| Bacteria | 21. Coliform | Coliform | MPN/100 ml | <2.2 | <2.2 |
| | 22. E. coli bacteria | E. coli | MPN/100 ml | None | None |
| | 23. Standard plate | - | Colonies/ml | ≤500 | - |

Source: MONRE, GOL

(7) Assessed potential water quality impact from project implementation. The water standards together with results of water quality models conducted by Kansai Electric Power Co., Inc were integrated for the evaluation of:

- 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.

(8) Suggested mitigation measures and monitoring plans for impacts expected from project construction and operation.

### 3.1.7 MINERAL RESOURCES

Before the establishment of the Lao PDR in 1975, a number of foreign countries and international corporations conducted geological surveys to determine the potential mineral resources of the country. After the Lao PDR opened for foreign investment in mineral resources, these surveys were disclosed. They revealed that Laos has considerable potential of 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 attempts 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, particular of heavy metals that might occur within a mineral deposit, would also need to be reported.

#### 3.1.7.1 Objectives of Study

(1) To review the potential occurrence of economic mineral deposits, and to estimate the size and value of those deposits.

(2) To indicate if any toxic elements could accumulate within particular mineral deposits found the project area.

#### 3.1.7.2 Method of Study

(1) Compile information on regional geology and mineral resources from Lao and international literatures.

(2) Collect data collection on mineral occurrences, mining history, and other appropriate geological data to indicate prospective sites of economic minerals.

(3) Conduct field interviews to verify secondary data and resolve any problematic or conflicting information.

### 3.1.8 NOISE AND VIBRATION

The NNHP-1 Project is located in an area that still has much of its natural habitat. Project activities, both during construction and in normal operation, will changes patterns and amplitude of noise and vibration. This will disturb animal life as well as affect 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 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.

#### 3.1.8.1 Objectives of Study:

(1) To determine the potential noise and vibration sources during construction and operation.

(2) To determine the levels of noise and vibration generated from dam construction activities at the dam site.

(3) To assess the potential noise and vibration impacts due to other construction and operation of the proposed project.

(4) To recommend mitigation measures to maintain the noise and vibration levels within appropriate international standards.

(5) To recommend an appropriate noise and vibration monitoring program for the proposed project.

#### 3.1.8.2 Method of Study

(1) Review project description concerning noise and vibration created by equipment used during construction and operation phases.

(2) Investigate sensitive areas such as schools, temples and clinics in residential areas.

(3) Assess potential noise impacts associated with grading and construction using methodology developed by FTA and integrating with Guidelines for Community Noise of WHO.

(4) Selecting appropriate parameters to evaluate noise and vibration impacts on local people and workers. These are:

Noise parameters

- $L_{eq\ 24\ hr}$

Vibration parameters

- Frequency
- Peak Particle Velocities (PPV)
- Displacement

(5) Propose appropriate mitigation measures and monitoring programs for the construction phase.

### 3.1.9 AIR QUALITY

Dust from construction activities is expected to be the potential impact on air quality. Air sensitive receivers were identified for use for this study to enable measurement of existing ambient air quality; however, the use of these receivers was not possible for the study, because the permits required for the receivers were not yet granted.

Emissions from vehicles and equipment used for construction of the NNHP-1 and its infrastructure might affect air quality. Also, dust from unpaved roads and working areas should be controlled. Burning of waste or burning during clearing of biomass can cause significant effect to air quality. Thus, all significant parameters on air quality are studied and examined. An appropriate dust and emissions control plan is recommended.

#### 3.1.9.1 Objectives of Study

Suggest measures to mitigate air pollutants especially dust produced at construction sites. . Of greatest concern for the construction of the dam will be the creation of particulate matter ($PM_{10}$) to the atmosphere. Because Lao PDR has not yet adopted national ambient air quality standards, international measures are used for the analysis.

The WHO annual standards for particulate matter ($PM_{10}$) are now set at 0.20 $\mu g/m^3$, while those of Thailand are 0.50 $\mu g/m^3$. According to European Union directives 1999/30/EC and 96/62/EC, the annual standards for EU nations from 2005 was set at 0.40 $\mu g/m^3$, while from 2010 they will be 0.20 $\mu g/m^3$.

#### 3.1.9.2 Method of Study

(1) Preliminary study

- Conduct field survey to indicate potentially sensitive sites for dust and other emissions.

(2) Methodology

- 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 this reason, the study had to rely on presentation of and comparison between the ambient air qualities found in similar land uses.

### 3.1.10 POTENTIAL CONTAMINATED SITE

Several hazardous substances such as fuels, oils, paints, solvents, and pesticides will be used during the construction and operation of the NNHP-1 dam. Consequently, the construction site as well as nearby areas will have high potential for contamination. To protect the health of workers and nearby residents and to protect the ecosystems, the study investigated potential contaminated sites. Moreover, there will be potential impacts associated with handling, storage, use and disposal of chemicals during construction. Relevant mitigation measures and chemical waste and spillage management plans are prepared.

#### 3.1.10.1 Objectives of Study

(1) To investigate the sources and activities during construction and operation of the NNHP-1 dam that could lead to environmental contamination.

(2) To assess potential contaminated sites and the potentil extent of contamination.

(3) To prepared chemical waste and spillage management plan, site remediation plan, and chemical monitoring plan.

#### 3.1.10.2 Method of Study

(1) Acquire both primary and secondary data to evaluate present conditions and use of hazardous substances.

(2) Identify the project activities that may lead to site contamination.

(3) Evaluate the types of waste that could be generated during construction and operation of the dam.

(4) Determine the areas that might be contaminated and its potential spread to the environment.

(5) Prepare protection and mitigation measures and propose monitoring plans.

### 3.1.11 HYDROLOGY

Hydrological impact caused by the dam is a major concern for a hydropower project because the existing hydrological condition of the Nam Ngiep River will be controlled 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].

#### 3.1.11.1 Objectives of Study

(1) Evaluate the impacts due to the change of hydrological phenomena during project construction and operation.

(2) Suggest mitigation measures to minimize the impacts on the environment and local people.

#### 3.1.11.2 Method of Study

(1) Review the collection of hydrological data that show the project conditions

(2) Evaluate hydrological changes due to the project development regarding to existing natural condition & resources, people and their living

(3) Recommend mitigation measures.

[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.

## 3.2 BIOLOGICAL ENVIRONMENT

### 3.2.1 TERRESTRIAL ECOLOGY/WILDLIFE

Blockage in a waterway to create a large reservoir as well as other activities associated with the construction and operation of a large dam like the NNHP-1 can cause abrupt changes in the environment. It may affect plants and animals in either positive or negative ways. Some animals may respond positively to the changes, hence increasing their populations. Other animals may not be able to withstand the abrupt changes and must either seek a new place to live or die out.

#### 3.2.1.1 Objectives of Study

(1) Investigate the diversity, abundance, and distribution of wildlife in the project area, and any use of the wildlife by local residents.

(2) Assess environmental impacts that the proposed project may have on wildlife, their food sources, and their habitat.

(3) Draw up appropriate mitigating measures to protect against probable negative impacts on wildlife.

#### 3.2.1.2 Method of Study

The surveyed area is broadly defined as the area north of the dam site extending to the northern margin of the reservoir, covering the proposed reservoir area. The surveys were conducted to provide 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.

After a review of available literature, a field survey was conducted in both wet (October 2007) and dry (March 2007) seasons to collect primary field data concerning all wildlife species including mammals, reptiles, amphibians and birds.

Within and around the survey areas, wildlife conditions were surveyed and assessed by visual inspection and interviews with villagers, as well as from secondary data and information gathered from available sources such as authorities concerned with wildlife. Local villagers within and around the project area were interviewed regarding wildlife conditions within and around their villages. Additionally, wildlife within circular sample plots for forest collection were recorded, such as the sighted animals, foot-prints, nests, burrows, hair or feathers, molts, sounds and any other evidence.

Status of the wildlife species is then assessed according to the current IUCN classification (IUCN, 2009):

- CR = Critically Endangered
- EN = Endangered
- VU = Vulnerable
- NT = Near Threatened
- LC = Least Concern
- DD = Data Deficient

(IUCN 2009. IUCN Red List of Threatened Species. Version 2009.1. <www.iucnredlist.org>. Downloaded on 09 June 2009.)

### 3.2.2 FOREST, VEGETATION COVER

The Nam Ngiep Hydropower Project will affect forest resources and ecosystems by clearing some forest to be replaced by the dam and reservoir.

#### 3.2.2.1 Objectives of Study

(1) Study forest characteristics particularly tree species, density, and timber volume as well as saplings and seedlings in the reservoir area and in the resettlement area.

(2) Assess the economic value of timber to be cut in the reservoir and the resettlement areas.

(3) Evaluate impacts on forest resources that may be caused by the project.

(4) Recommend mitigating measures to minimize impacts on forest resources and ecosystems.

#### 3.2.2.2 Method of Study

The surveyed area is broadly defined as the area north of the dam site extending to the northern margin of the reservoir, covering the proposed reservoir area. The surveys were conducted to provide baseline information on the distribution of forest types and vegetation to determine likely impacts of the project on such flora and to assess how any such impacts might be mitigated through appropriate interventions.

The methodology involved in assessing the forest and vegetation cover was to compile maps and available literature on the land and water resources of the region and in particular the survey area. Based on these maps and literature, the field survey was conducted in October 2007 to collect primary data concerning tree and vegetation species, density and estimated volume per hectare for big tree species with diameter at breast height (DBH) of more than 10 centimeters.

The main method used in this survey is similar to that used for the wildlife survey including interviews with villagers, especially senior persons who have experience with the types of vegetation and non-timber forest products in their vicinity. The villagers were questioned on land use as well as lists of vegetation and NTFPs.

Primary data was collected from 35 temporary sample plots that were set in the form of line plot system covering the reservoir area according to land use, geographic conditions and forest types. The sample plots were set in the dominant area or good sample areas located where the reservoir will be located. There were 3 types of temporary sample plots, and the data collected depended on their shapes and size:

(1) A circular sample plots with a radius of 17.85 meters (0.1 hectare total area) from which data on trees of DBH equal to and above 10 centimeter were collected. Other significant information recorded included tree species, their diameter and height, and bamboo types, including number of clumps and stems per clump found in the plot.

(2) Square plots of 5x5 meters (25 square meters) was established in the middle of the circular plots. Information on small trees and/or saplings (trees whose DBH is less than 10 centimeters and whose height exceeds 1.3 meters), tree species, number of tree and their average height as well as NTFP species was recorded from these plots.

(3) Square plots of 2x2 meters were established within the larger square plots of 5x5 meters. Data concerning plants and vegetation including sapling or seedlings (all undergrowth vegetation), focusing on species of trees or seedlings of each species as well as NTFPs were recorded in these plots. The main concern was on the diversity of plants and NTFPs species, not the numbers or density of the

saplings and seedling or plants, since the time available for field data collection was limited, and also since some of the data, especially that on NTFPs were being collected through interviews with villagers.

#### 3.2.2.1 Forest and Vegetation Classification

Several forest classification schemes have been proposed for the Lao PDR. The classification of forest types for this study is based on the classification used by the Forest Inventory and Planning Division, Department of Forestry since 1982, and the preliminary national forest record. Box 1 shows the classification and definition of each forest or land use type.

Box 1 Definition of Land Use and Forest Types

1. **<u>Current Forest</u>:**

   ***Current Forest includes natural forests and plantation forests. It is used to refer to land with a tree canopy cover of more than 20% and area of more than 0.5 ha. The trees should be able to reach a minimum height of 5 m.*** The basis for the distinction between forest and other land use groups is the crown density. Natural forests are classified into forest types, which are Upper and Lower Dry Evergreen Forests, Upper and Lower Mixed Deciduous Forests, Gallery Forest, Coniferous Forest, Mixed Broadleafed and Coniferous Forest, and Dry Dipterocarp Forest.

- ***<u>Dry Evergreen Forest (DE)</u>:*** The Dry Evergreen Forest type has a lower proportion of evergreen trees than the Evergreen type, 50% -80%. Except in disturbed stands there is very little bamboo. Soil is usually deep. The forest consists of a considerable number of species, of which 2 to 3 species tend to be predominant.
- ***<u>Mixed Deciduous Forest (MD)</u>:*** In the Mixed Deciduous Forest, deciduous tree species represent more than 50% of the stand. The forest storeys are not as dense as those of evergreen types and most of the seedlings and saplings are deciduous trees. Bamboo often occurs in this type of forest.

  i) ***Upper Mixed Deciduous Forest (UMD)**:* This type of forest is located at an altitude above 200 m. In moist areas there might be many climbers, and it could be difficult to distinguish this forest from the Dry Evergreen type. In dry regions the difference can be clearly seen. This forest type appears quite open with a considerable amount of bamboo and undergrowth.

  ii) ***Lower Mixed Deciduous Forest (LMD)**:* This type of forest is located at an altitude below 200 m.

- ***Dry Dipterocarp Forest (DD):*** This type of forest occurs in open stands. The tree diameter is comparably small and the height of the stand varies from 8 to 25 m. The crowns do not spread out widely. It is normally found in places with shallow soil, where the hard pan emerges above the ground, and on latirized soil. On the most poor and shallow soils the trees are crooked and do not exceed 10 m in height: If the crown cover is less than 20% and the stand is undisturbed the vegetation type should be classified as Savannah.

  Many species characteristic for the Dry Dipterocarp forests are fire resistant and have a thick bark. Mai Sabeng *(Dipterocarpus intricatus)*, Mai Chick *(Shorea obtusa)*, Mai Sat *(Dipterocarpus obtusifolius)*, Mai Seuak *(Terminalia tomentosa)* and Mai Hang *(Shorea siamensis)* are among these species.

- ***Coniferous Forest (S):*** The Coniferous Forest is usually single storied and open but the young growth may sometimes form a dense second storey. This forest type occurs in higher elevations with a cool climate. The characteristic species of this type are pines (Pinus kesiya or Pinus merkusii) but other coniferous trees such as i.e. Cunninghammia may also be predominant.

- ***Mixed Broadleaved and Coniferous Forest (MS):*** The MS Forest is a transition type between the coniferous and the broadleaved forest types. The coniferous trees could be mixed with either deciduous or evergreen trees. It is also found in higher elevations.

**2. Potential Forest:**

***Previous forest areas where the crown cover has been reduced below 20% (whether from logging or shifting cultivation) are classified as Potential Forest.*** The potential forest includes Bamboo, old shifting cultivation areas (young secondary forests) and Temporary Unstocked areas. Potential Forest is consisted of Unstocked, Bamboo and *Ray*.

- ***Unstocked Forest (T):*** Unstocked Forest Areas are previous forest areas in which the crown density has been reduced to less than 20% because of logging, shifting cultivation or other heavy disturbance. If the area is left to grow undisturbed it becomes forest again. Abandoned *ray* and disturbed stands with a crown density less than 20% should be classified as Unstocked Forest Areas. Old *ray* in which seedlings, sapling and trees cover more than 20% of the area should be classified as some type of Current Forest.

- ***Bamboo (B):*** If an area is covered with bamboo and the over storey has a crown cover less than 5% it should be classified as Bamboo Forest.

- ***Swidden* (Ray) *(RA):*** *Ray* is an area where the forest has been cut and burnt for temporary cultivation of rice and other crops. The area should be classified as *Ray* from the time it is clear cut until one year after it has been abandoned. Areas being prepared but not yet clear-cut and areas that have been abandoned for more than 1 year should not be classified as *Ray*.

**3. Other Land Use Types:**

- ***Savannah (SH):*** is an area where the soil conditions are unsuitable for tree growth as well as for agriculture production. The tree cover in the Savannah should be at least 1% but not more than 20%. The trees are drought resistant and mostly short with graminaceous and herbaceous plants forming an under storey. Savannahs should not be confused those grass covered areas that sometimes occur after shifting cultivation. Normally, the Savannah does not occur on steep slopes but in plains.
- ***Scrub Forest (SR):*** This is an area covered with scrub and stunted trees. The soil is shallow and rocky.
- ***Barren Land and Rock (R):*** Unfertile or seriously degraded land on shallow soil and rocky areas on which neither trees nor grasses can grow.
- ***Grassland (G):*** 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. One reason for the absence of trees could be that larger areas have been deforested and the seed supply from surrounding forest has ceased. Areas burnt every year to grow fodder or for hunting purposes could also be classified as Grassland. That type of Grassland can be found on higher elevations in the Northern part of Laos. Grassland can also occur on deep sand with a high moisture content.
- ***Swamp (SW):*** Swamps are 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 a high ecological or environmental value and the flora and fauna may be rich.

  The typical tree species found in the Swamps are trees which can grow in water, such as *Adina cordifolia, Rhus succedanea* and *Barringtonia acutangula.*

**4. *Other Agricultural Land (OA):***

Land being used for agricultural purposes other than crop cultivation, such as cattle grazing, should be classified as Other Agricultural Land, unless the tree cover exceeds 20%. In that case it should be classified as some type of Current Forest depending on the tree species composition.

- ***Rice Paddy (RP):*** Areas permanently being used for rice cultivation. Old paddy that has been abandoned and not in use for more than one year should not be classified as Rice Paddy.

Source: Report on the Assessment of Forest Cover and Land Use (MAF, DOF, July 2005)

### 3.2.3 AQUATIC BIOTA

Reservoir impoundment and effluent discharge from the power plant and from other activities during construction and operation will affect the surrounding water bodies, including aquatic life in local canals and rivers. Therefore, a study on aquatic biota and habitats is necessary to asses present conditions and possible project impacts, and as a basis for possible plans for future utilization or development of their aquatic resources by local communities.

#### 3.2.3.1 Objectives of Study

(1) Review secondary data of aquatic biota and habitats from preliminary reports and the collect primary data from the field.

(2) Assess potential impacts on aquatic biota in the project area and downstream.

(3) Recommend mitigation measures, including monitoring programs.

#### 3.2.3.2 Method of Study

**(1) Sampling station**

Dry season survey along Nam Ngiep River was conducted in January 2008 at ten stations: six located downstream from the proposed dam and the other four located upstream (Table 3-6 and Figure 3-2).

Table 3-5 Fish and Fisheries Survey Locations along the Nam Ngiep River

| No. | Name | Location | | | Coordinate | |
|---|---|---|---|---|---|---|
| | | Village | District | Province | N | E |
| 1 | Station 1 | Piengta | Thathom | Xieng Khouang | 19°01'33.6" | 103°25'09.6" |
| 2 | Station 2 | Hatsamkhone | Thathom | Xieng Khouang | 19°00'46.0" | 103°26'40.3" |
| 3 | Station 3 | Pou | Thathom | Xieng Khouang | 19°00'52.5" | 103°27'37.7" |
| 4 | Station 4 | Houypamom | Hom | Vientiane | 18°59'32.6" | 103°30'10.5" |
| 5 | Station 5 | Sopphuane | Hom | Vientiane | 18°50'01.9" | 103°26'19.9" |
| 6 | Station 6 | Sopyouak | Hom | Vientiane | 18°42'53.7" | 103°26'40.9" |
| 7 | Station 7 | Hatsaykham | Bolikhan | Bolikhamxay | 18°38'41.1" | 103°33'17.4" |
| 8 | Station 8 | Hat Gniun | Bolikhan | Bolikhamxay | 18°39'23.6" | 103°35'03.6" |
| 9 | Station 9 | Somseun | Bolikhan | Bolikhamxay | 18°25'03.5" | 103°36'22.6" |
| 10 | Station 10 | Pak Ngiep | Pakxan | Bolikhamxay | 18°31'58.8" | 103°38'48.3" |

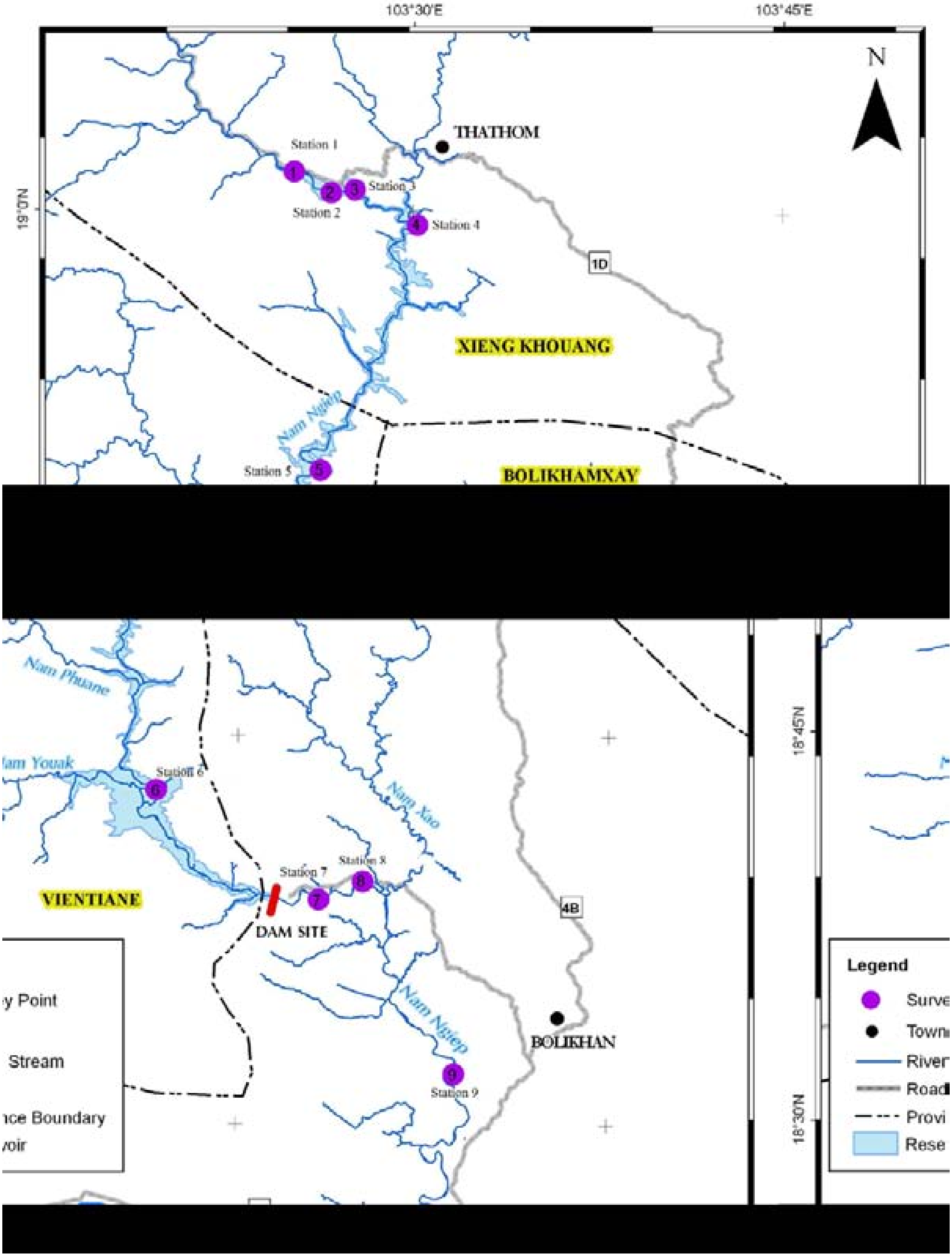



Figure 3-2 Fish and fisheries survey locations along the Nam Ngiep River.

Examination of aquatic fauna and flora included distribution of indigenous fish species and their abundance in particular areas of the river. Plankton, benthos and aquatic plants, which provide nutrients to young fish, were also examined.

The aim of the survey was mainly to determine the existence of aquatic life in the river. Study results and other relevant data (hydrology, water quality) were used to predict possible changes in aquatic life after project development and its effect on peoples' livelihood.

**(2) Fish sampling**

Fish were collected using sampling seine net with the size of 430 x 160 cm with 5 mm mesh size. At the site, the seine net was equipped with bamboo pole at each end that was at least equal to the height of the net. Haul seine was operated and fished parallel to the river bank. Fish samples were preserved in a plastic bottle or a jar containing 10% formalin solution. The bottle was labeled with information such as date of sampling, station code, name of collector and time of collection. The samples were sent to a laboratory for species identification. In the laboratory, fish sampled from each station were identified by using a magnifier, a dissection microscope and classification guidance books (Kottelat, 2001 and Rainboth, 1996). Their productivity in the river was recorded

**(3) Plankton sampling**

Plankton sampled from those stations was conducted using a plankton net of 70 µm mesh size and a 2-litter beaker (Gajaseni, 1993). Sampling depth of water was taken at 30 cm below the water surface. Ten litters of sample were preserved in a plastic bottle containing 5% formalin solution. Information such as the code of sampling station and date were marked on the bottle. The specimens were sent to a laboratory for species identification as well as their density.

**(4) Benthic sampling**

Benthic fauna at each station was sampling using an Ekman dredge (Gajaseni, 1993). The samples were sieved by using a 1 m-mesh sieve. Each specimen was preserved in a separate bottle containing 7% formalin solution. Necessary information was labeled on the bottle. They were delivered to a laboratory for specie identification and density assessment.

### 3.2.4 WETLAND

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 W etlands for the protection of wetlands of international importance as of March 2009, it well recognizes 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.

#### 3.2.4.1 Objectives of Study

(1) Identify location and pattern of wetlands found in the project area. This information serves as baseline data for future comparison of land cover changes or wetland habitat losses due to the project.

(2) Detect changes of location and patterns of wetlands and the impacts of project development on wetlands. This is useful for assessment of impact on t he wetlands after project development.

(3) Propose mitigation measures to reduce adverse impacts on w etlands. The proposed measures are helpful to establish future rehabilitation and restoration programs for damaged wetlands during and after the project development.

#### 3.2.4.2 Method of Study

(1) Compile information on wetlands from Lao and international literatures.

(2) Acquire both primary and secondary data to evaluate wetlands in the project area.

(3) Assess possible impacts of the project on identified wetlands.

(4) Prepare protection and mitigation measures and propose monitoring plans

# CHAPTER 4

# LEGAL ASPECTS FOR EIA

One of the main principles of the Nam Ngiep 1 Hydropower Project (NNHP-1) 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 also is to conform to international treaties to which the Lao PDR is signatory, and to standards and safeguard policies of the Asian Development Bank (ADB) and to the Equator Principles. Where there are legal gaps in terms of standards, the ADB or other international standards or other relevant local standards will be used, whichever is strictest.

## 4.1 NATIONAL LAWS AND DECREES

The key laws and decrees relevant to environment assessment and protection issues for NNHP-1 are:

1) The Law on Environmental Protection (1999),
2) The Law on Water and Water Resources (1996),
3) The Forestry Law (2007),
4) The Wildlife and Aquatic Law (2007),
5) The Land Law (2003),
6) The Electricity Law (2008),
7) The Road Law (1999),
8) The Decree on Environmental Impact Assessment (2010),
9) The Decree on State Land Lease or Concession (2009),

10) The Decree on Compensation and Resettlement of People Affected by Development Projects (2006),

11) The Technical Guidelines on Compensation and Resettlement of People Affected by Development Projects,

12) The Regulation on EIA for Road Projects (2004),

13) The Decree on the Environmental Protection Fund

### 4.1.1 ENVIRONMENTAL PROTECTION LAW (1999)

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

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

### 4.1.2 LAW ON WATER AND WATER RESOURCES (1996)

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

### 4.1.3 AMENDED LAO FORESTRY LAW (NO. 06/NA-DEC.2007)

The Amended Forestry Law, No 06/NA (Dec. 2007) stipulates the basic principles, regulations and measures concerning forest conservation, management, and use. It aims to make the forests and forestland a stable source of livelihood and use for the people, by ensuring sustainable preservation of water sources, preventing of 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. 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 more than 100 ha to 1,000 ha of degraded forestland per activity and of more than 200 ha to 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).

### 4.1.4 WILDLIFE AND AQUATIC LAW, NO 07/NA (2007)

The Wildlife and Aquatic Law restricts 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.

### 4.1.5 LAND LAW (2003)

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

### 4.1.6 ELECTRICITY LAW (2008)

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

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

### 4.1.7 ROAD LAW (1999)

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

### 4.1.8 PRIME MINISTERIAL DECREE NO. 112/PM ON ENVIRONMENTAL IMPACT ASSESSMENT (2010)

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

### 4.1.9 DECREE ON STATE LAND LEASE OR CONCESSION (2009)

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

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

### 4.1.10 DECREE ON COMPENSATION AND RESETTLEMENT OF PEOPLE AFFECTED BY DEVELOPMENT PROJECTS (2006)

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

### 4.1.11 TECHNICAL GUIDELINES ON COMPENSATION AND RESETTLEMENT OF PEOPLE AFFECTED BY DEVELOPMENT PROJECTS (2005)

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

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

### 4.1.12 REGULATION ON EIA OF ROAD PROJECTS IN LAO PDR (2004)

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

### 4.1.13 DECREE ON THE ENVIRONMENT PROTECTION FUND (2005)

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

### 4.1.14 KEY PROVISIONS OF LAO PDR LAWS AND DECREES PERTINENT TO ENVIRONMENTAL ASPECTS OF THE NNHP-1 PROJECT

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

Table 4-1 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.<br>Socio-economic development planning must include planning for environmental protection |

| Law or Decree | Article | Relating To | Content |
|---|---|---|---|
| Environmental Protection Law (1999) | Article 8 | EIA Process | MONRE is main agency to issue regulations for EIA.<br>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 |
| | 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 |

| Law or Decree | Article | Relating To | Content |
|---|---|---|---|
| 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 forestland | Stipulates that forestland can be converted to other land type if it brings a high level of benefits to the nation and to livelihoods of the people, and is included in the national development plan |
| | Article 71 | Types of converted forestland | Stipulates that for uses such as dam construction, the timber and forest resources to be harvested in those areas are property of the State |
| Wildlife and Aquatic Law (2007) | Article 31 | Use for Household purposes | Allows use by village households of wildlife and aquatic species in the common and general category list in particular seasons or permitted areas, using tools or equipment that do not adversely affect habitats or compromise the species population. |
| | Article 32 | Customary Use | Allows use of wildlife or aquatic species in the common and general category list by village households for "necessary cultural beliefs." |
| | Article 52 | Prohibitions | Prohibits taking of wildlife, including parts of the animals, from their habitats; tormenting wildlife and aquatics; illegal catching, hunting, trading and possession; catching aquatic and hunting in conservation zones, in breeding season, or when pregnant; devastation of habitats and feeding zones. |

| Law or Decree | Article | Relating To | Content |
|---|---|---|---|
| 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 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 |

## 4.2 INTERNATIONAL TREATIES

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

### 4.2.1 CONVENTION ON BIOLOGICAL DIVERSITY

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

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

- Watershed management and protection is currently inadequate.
- Hydropower development often results in reduced forest cover, wildlife habitats and biodiversity resources.
- Dam construction has a direct impact on fisheries and local income, especially in downstream areas.
- Some hydropower construction has occurred without prior detailed studies
- The resettlement of the local people can have a direct and indirect impact on biodiversity.

- Dam construction changes the natural water flow.
- The compensation schemes for lost land and property are not clearly defined according to different scale.[1]

The report recommends addressing these issues through several options:

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

### 4.2.2 CONVENTION ON CLIMATE CHANGE

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

### 4.2.3 AGREEMENT ON THE COOPERATION FOR SUSTAINABLE DEVELOPMENT OF THE MEKONG RIVER BASIN

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

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

[2] Ibid.

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)

### 4.2.4 CONVENTION ON INTERNATIONAL TRADE IN ENDANGERED SPECIES OF WILD FAUNA AND FLORA (CITES)

The Lao PDR joined the Convention on International Trade in Endangered Species of Wild Fauna and Flora (or CITES) in March 2004, with it coming into force on 30 May 2004. The

Wildlife and Aquatics Law of 2007 includes provisions that meet the obligations of the Lao PDR to CITES.

### 4.2.5 INTER-GOVERNMENTAL AGREEMENT ON REGIONAL POWER TRADE IN THE GREATER MEKONG SUB-REGION

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

i) Cooperation: That issues related to regional interconnection be handled in a spirit of cooperation and mutual benefit, that the Parties have equal rights and obligations, act in solidarity, and refrain from taking advantage of one another;

ii) Gradualism: That the Parties consider the progressive development of regional electricity trade; and

ii) Environmentally Sustainable Development: That regional electricity trade is operated within a framework of respect for the environment. (Article 2, Paragraph 2.2)

## 4.3 ADB ENVIRONMENTAL SAFEGUARD POLICIES

With funding expected from the Asian Development Bank (ADB), the key environmental safeguard policies of the ADB that should be addressed by this project are noted in this section. Social safeguard policies are presented in the volume on Social Impact Assessment.

The Asian Development Bank 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.

Hydropower projects are immediately classified as Category A projects, which require full environmental assessments of the potential negative and positive impacts and assessments of alternatives, recommended mitigation measures, and extensive participation of the 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. T o 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."[3]

The ADB also requires that the borrow 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 carries out at least twice: once early states of the EIA field work to be able to incorporate the views of and views of the affected people, and then again after the draft EIA is prepared and before the loan appraisal by the ADB.[4]

Among the key environmental concerns of the ADB noted in its policy that need to be addressed in the NNHP-1 project EIA are: deforestation and land degradation, biodiversity loss, aquatic resources, water pollution, and climate change.

## 4.4 EQUATOR PRINCIPLES

Private banks now do a large amount of the lending for international development. Initiated by several of the world's largest banks, the Equator Principles were established to assure that borrowers from the private banks for development projects abide by similar environmental and social standards as those applied by the World Bank, the ADB and other international financial institutions. The Equator Principles incorporate the International Finance Corporation's Environmental and Social Performance Standards. Of particular relevance to the environmental aspects of the NNHP-1 project are the need and means for biodiversity conservation and sustainable natural resource management, and pollution prevention and

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

[4] Ibid, p. 18

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. T hese 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 NNHP-1 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.[5]

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

[5] 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.

# CHAPTER 5

# EXISTING ENVIRONMENT

## 5.1 PHYSICAL ENVIRONMENT

### 5.1.1 TOPOGRAPHY

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

#### 5.1.1.1 Upstream of the main dam

The main dam of the NNHP-1 Project is located on the Nam Ngiep River at the latitude of 18$^{o}$ 39' N and the longitude of 103$^{o}$ 30' E at a ground elevation is 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 the 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 downsream 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 of the villagers.

**(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 Viet Nam. 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 $5^oC$ to $40^oC$ depending on the altitude. Humidity is generally high (in the 70 to 80% range).

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

The NNHP-1 project area generally experiences better weather conditions than elsewhere in the Lao PDR, with less extremes of temperature. The EIA study found that for the months of March to the end of May, temperatures ranged from 17$^{o}$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, emperature 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. Table 5-1 shows climate data at Pakxan station, Bolikhamxay province.

Table 5-1 Climate Data at Pakxan Station, Bolikhamxay Province

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

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

#### 5.1.2.2 Rainfall

The 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 evaluated.

Average annual rainfall in Lao PDR in select locations in the country is:

- 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. T he study concluded that there was average rainfall of 1,870 mm/year between 1971 and 2000. The detailed information about rainfall is presented below in section 5.1.11 on hydrology.

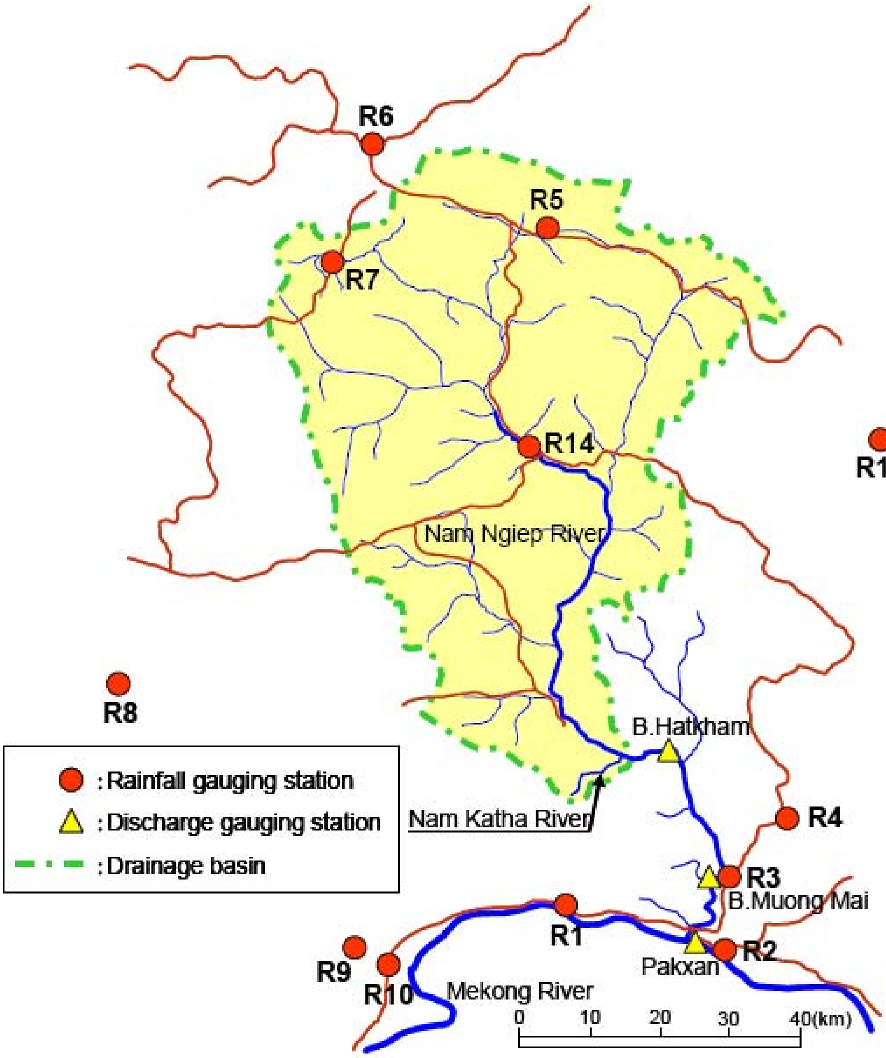



Figure 5-1 Location of hydrological gauging locations within and peripheral to the Project basin area.

Table 5-2 List of Hydrological Gauging Stations within and Peripheral to the Project Basin Area

| Gauging Station | | Elevation (m) |
|---|---|---|
| Rainfall | | |
| R1 | B. Nakham (B. Pakthouei) | 159 |
| R2 | Pakxan | 155 |
| R3 | Muong Mai | 158 |
| R4 | Muong Kao (Bolikhan) | 158 |
| R5 | M. Khoun (B. Thoun) | 1,110 |
| R6 | Xieng Khouang | 1,050 |
| R7 | M. Phaxay (B.Hokai) | 1,100 |

| Gauging Station | | Elevation (m) |
|---|---|---|
| R8 | B. Naluang | 460 |
| R9 | Houayleuk (Tadleuk) | 220 |
| R10 | B. Thabok | 160 |
| R11 | Vientiane | 170 |
| R12 | Vangvieng | 215 |
| R13 | Muong Mork | 900 |
| R14 | B. Thaviang | 370 |
| Discharge/River water level | | |
| | B. Hat Gniun | - |
| | Muong Mai | 153 |
| River water level | | |
| | Pakxan | 142 |

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

### 5.1.3 GEOLOGY, LANDFORMS AND SEISMOLOGY

Although seismic events in the project area have been rare, and the area where the dam and reservoir are located are classified as being of only moderate risk (level VI) on the Modified Mercalli Intensity Scale, geological structures in the region seem to indicate joints and fractures of rock formations, which suggest seismic activity in the past. Therefore, detailed mapping and coring explorations has 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 2.3.7) for project design. During the past 20 years, there has been no record of an earthquake in the area exceeding magnitude of 5. It can be concluded that the investigated region is characterized by a geological structure with good stability and that seismic activities in the Nam Ngiep river basin are rare. This conclusion is supported by the report on “Lao PDR: Natural Hazard

Risks", edited by the OCHA Regional Office for Asia Pacific, issued on 08 March 2007.[1] As shown in Figure 5-2, the entire area of the Nam Ngiep 1 Hydropower Project is located in an area with earthquake intensity of I to V and VI on a Modified Mercalli Intensity Scale. The dam and reservoir area are located in the area which is shown as having an earthquake possible at level VI intensity, which is considered of only moderate risk with possibility of only slight camage. 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.

Available regional geological information shows that earthquake evens in the project area and adjoining areas have been rare. Structural geology indicats 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 sometime in the past. ***In order to assure utmost safety in the design of the dam, it is strongly recommended that detailed mapping and coring explorations should be carried out prior to detailed design and dam construction.***

The Nam Ngiep basin is located in central Lao PDR. The proposed dam site is surrounded mainly by Mesozoic-Palaeogene flat formation. Outcrops are usually found along high cliffs in the area. Older rock formations, mostly grouped as Palaeozoic rocks, are also found in the region, which was controlled by geological structures of significant folding and faulting. Lineaments were observed along NW-SE, W-E and NE-SW directions, but these are believed restrict to and relate to the old geological structure and tectonic movements. Active faults have never been reported within this area (see Figure 5-3).

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

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

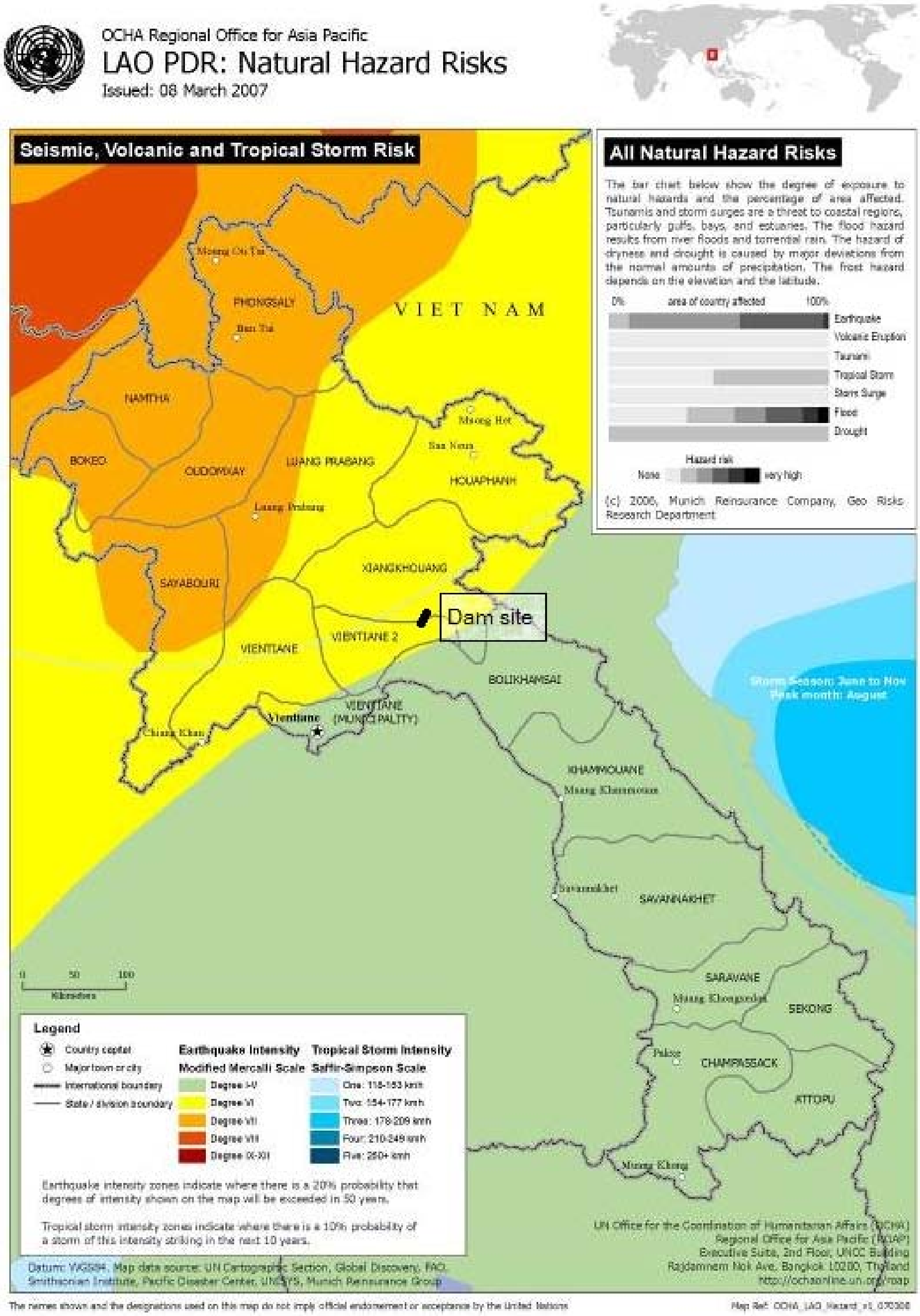



Figure 5-2 Map of natural hazard risks in the Lao PDR, 2007.

#### 5.1.3.2 Sedimentary sequences

1) 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.

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

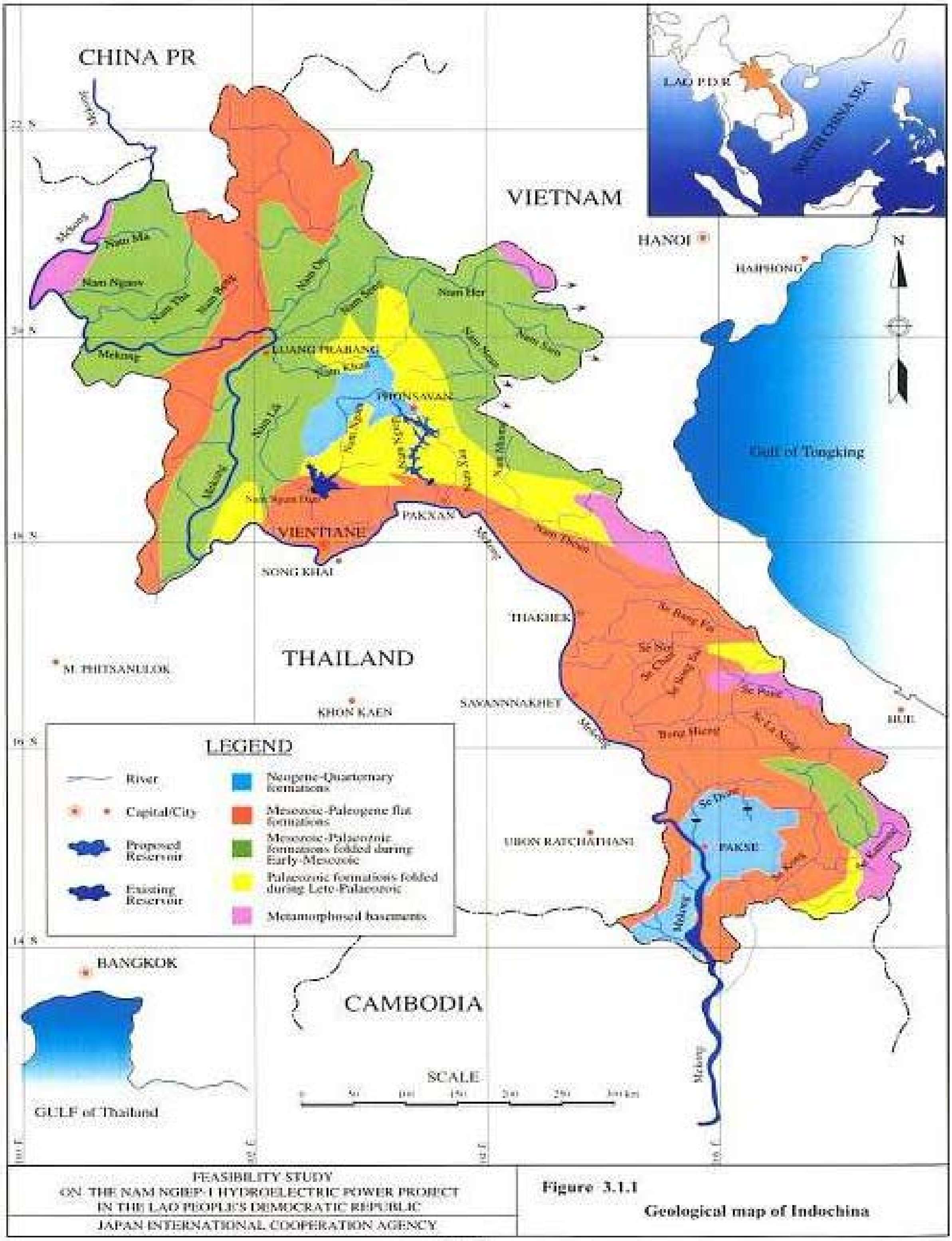
3) Masozoic (Jurassic to Cretaceous) flat formations contain sandstones, conglomerates and mudstones which are located around the proposed dam site and the lower part of the reservoir area. Massive beds of sandstones and conglomerates are found homogeneously on t he upper formations. Besides, mudstones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

4) Quaternary sediments are characterized by river deposits and talus deposits. They are young unc onsolidated 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 in 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 t he 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.




Source: JICA-F/S, 2002

Figure 5-3 Geological map of Lao PDR.

### 5.1.4 SOILS

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

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

#### 5.1.4.1 Soil type in the Nam Ngiep watershed

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

- Lithosols (shallow soils) occur on steeply sloping rock outcrops where soil formation is limited by natural erosion processes.
- Ferralsols and acrisols (lateritic type soils) form on the upper ridge slopes of the escarpment and plateau areas. The soils are derived from weathered weak sandstone. These soils are characterized by a dark red loamy clay surface horizon overlying a slightly bleached horizon. Clay content is found to increase with depth. Their properties are moderately acidic, low fertility and poor internal drainage. Due to their low inherent fertility their proper properties last for only one or two years.
- 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 aluminium in the former subsoil kill off new growth. All exposed soils erode at a faster rate, increasing the risk and adverse impact of greater sediment discharge rates into local waterways.

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

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

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

#### 5.1.4.3 Soil 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. 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 medium in texture.

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 the ESIA teams, 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 Sopphuane, Ban Sopyouak and Ban Namyouak; and the Hat Gniun area for the APs of Ban Hatsaykham.

**(1) Soil Properties for agriculture in the Hat Gniun area**

Hat Gniun village: soil in this village was very strong 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 and high 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, loam, clay loam and sandy clay loam soil were found in this village.

Table 5-3 Physical Soil Properties of Four Villages for Initial Site Selection

| No. Lab | Sample station (No. Profile) | Soil Unit | Province | District | Village | Soil Texture (%) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Coarse Sand | Sand | Silt | Clay | Texture |
| Ban Hat Gniun | | | | | | | | | | |
| 91 | 1 | èéÌÌà | Bolikhamxay | Bolikhan | Hat Gniun | 0.41 | 34.29 | 32.65 | 32.65 | Clay loam |
| 92 | 2 | èéÌÝàÍÑÞÃ | Bolikhamxay | Bolikhan | Hat Gniun | 1.02 | 54.22 | 24.42 | 20.35 | Sandy clay loam |
| 93 | 3 | èéÌÛïÍ | Bolikhamxay | Bolikhan | Hat Gniun | 2.55 | 56.72 | 28.51 | 12.22 | Sandy clay loam |
| 94 | 4 | èéÌäÌÌÙ‹ÜÇÌ²Ã | Bolikhamxay | Bolikhan | Hat Gniun | 1.93 | 41.04 | 36.66 | 20.37 | Clay loam |
| 95 | 5 | èéÌäÌÌ | Bolikhamxay | Bolikhan | Hat Gniun | 1.63 | 37.27 | 36.66 | 24.44 | Clay loam |
| 96 | 6 | èéÌÝàÍÑÞÃ | Bolikhamxay | Bolikhan | Hat Gniun | 1.12 | 53.89 | 16.36 | 28.63 | Sandy loam |
| 97 | 7 | èéÌÂ‹ÜÇæèÌ | Bolikhamxay | Bolikhan | Hat Gniun | 3.58 | 47.40 | 28.60 | 20.43 | Sandy clay loam |
| 98 | 8 | èéÌ éŠáÂîè | Bolikhamxay | Bolikhan | Hat Gniun | 3.83 | 76.01 | 8.06 | 12.10 | Sandy loam |
| 99 | 9 | èéÌÝàÍÑÞÃ | Bolikhamxay | Bolikhan | Hat Gniun | 4.49 | 38.43 | 24.46 | 32.62 | Loam |
| 100 | 10 | èéÌÝàÍÑÞÃ | Bolikhamxay | Bolikhan | Hat Gniun | 1.94 | 40.80 | 28.63 | 28.63 | Clay loam |
| 101 | 11 | èéÌÝàÍÑÞÃ | Bolikhamxay | Bolikhan | Hat Gniun | 1.84 | 10.78 | 28.69 | 28.69 | Clay loam |
| 102 | 12 | èéÌÝàÍÑÞÃ | Bolikhamxay | Bolikhan | Hat Gniun | 0.62 | 33.54 | 32.92 | 32.92 | Clay loam |
| 103 | 13 | èéÌÝàÍÑÞÃ | Bolikhamxay | Bolikhan | Hat Gniun | 1.85 | 32.30 | 28.81 | 37.04 | Clay loam |
| 104 | 14 | èéÌäÌÌ | Bolikhamxay | Bolikhan | Hat Gniun | 1.63 | 61.71 | 20.37 | 16.29 | Sandy clay loam |
| 105 | 15 | èéÌÂèÌÑï | Bolikhamxay | Bolikhan | Hat Gniun | 4.65 | 41.63 | 33.06 | 20.66 | Sandy clay loam |

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

Table 5-4 Chemical Soil Properties of Four Villages for Initial Site Selection

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

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

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

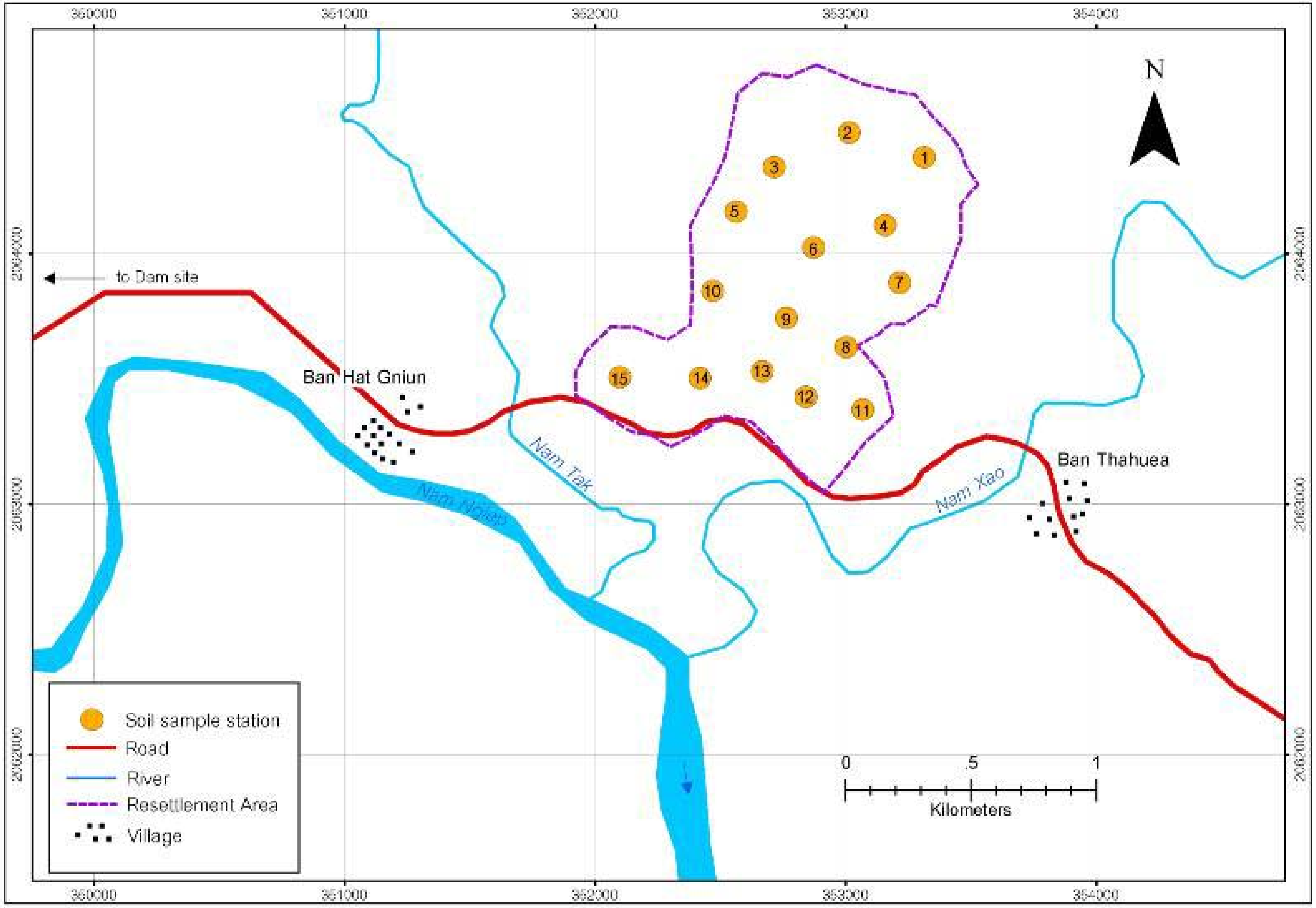



Figure 5-4 Soil sampling locations at Hat Gniun area, Bolikhan District, Bolikhamxay Province. Conducted in December 2007.

**(2) Soil Properties for agriculture of the area** on the right bank of the re-regulation dam and upstream area of the dam site

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

The field survey and soil physico-chemical analysis data of the resettlement site on the right bank of the re-regulation dam found that most areas are extremely acid to very strong acid (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 pose a problem for agricultural production Soil characteristics are shown in Table 5-5 and Table 5-6, while Figure 5-5 and Figure 5-6 show the location of the samples.

**Soil profile HY P01:**

This soil profile have a medium organic matter (%OM) content of 2.02% in topsoil layer, medium in % base saturation (42.72%), very low exchangeable potassium (0.05 Exch-k meq/100g soil), low in % total phosphorous content (0.04%), soil reaction is an extremely acid with pH value equals to 4.4, 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). When considered together all these chemical and physical properties, this soil profile is rated as marginal to moderate suitable for rice cultivation. Exchangeable potassium and soil pH make this soil generally less suited to cultivation and limit their use if without soil improvement application. Special attention should be paid to improve soil acidity that is why 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 in % 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 acid 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. When considered all elements together this soil is rated as marginally to moderately suitable due to low indigenous soil potassium supply and high acid. 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 soil profile mentioned above (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 an extremely acid with pH value of less than 4.4. This soil show sandy loam textured 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 in % 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 an extremely acid with pH value equals to 4.45. These soils are limiting in its use for rice cultivation due to low in soil fertility and strong acid 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 have a 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 a minor input, the improvement of soil fertility particularly indigenous phosphorous supplies from soils and soil acidity is needed due to both elements are considerate as the limiting factors affect on 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, which 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 show 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 $day^{-1}$). When all physical and chemical are combined, 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 having high clay content (23.96%) which characterized as high field water stored due to low downward water movement (estimated percolation is 0.6 mm/day). This soil shows extremely acid which requires a major input of liming and the improvement of soil fertility particularly potassium supplies from chemical fertilizer are needed due to both elements are considerate as the limiting factors affect on 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 acid with pH value of less than 4.14. This soil show sandy loam textured 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(PLEASE TRANSLATE THE LAO LANGUAGES TO ENGLISH)

ສາທາລະນະລັດ ປະຊາທິປະໄຕ ປະຊາຊົນລາວ

ສັນຕິພາບ ເອກະລາດ ປະຊາທິປະໄຕ ເອກະພາບ ວັດທະນະຖາວອນ

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ສະຖາບັນຄົ້ນຄວ້າ ກະສິກຳ ແລະ ປ່າໄມ້ ແຫ່ງຊາດ

ສູນຄົ້ນຄວ້າການນຳໃຊ້ທີ່ດິນ ກະສິກຳ ແລະ ປ່າໄມ້ ນະຄອນຫຼວງວຽງຈັນ, ວັນທີ..../..../........

ຜົນວິໄຈດິນຂອງໂຄງການນ້ຳງຽບ 1 ຈຳນວນ 24 ຕົວຢ່າງ

| 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 |

ຫົວໜ້າສູນຄົ້ນຄ້ວາການນຳໃຊ້ທີ່ດິນກະສິກຳ ແລະ ປ່າໄມ້ ຫົວໜ້າໜ່ວຍງານວິໄຈດິນ

Table 5-5 Soil Texture of Proposed Area on the Right Bank of Re-regulation dam, Ban Sopyouak and Ban Namyouak, in July 2011(Continued)

| 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 |

ຫົວໜ້າສູນຄົ້ນຄ້ວາການນຳໃຊ້ທີ່ດິນກະສິກຳ ແລະ ປ່າໄມ້ ຫົວໜ້າໜ່ວຍງານວິໄຈດິນ

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

ສາທາລະນະລັດ ປະຊາທິປະໄຕ ປະຊາຊົນລາວ

ສັນຕິພາບ ເອກະລາດ ປະຊາທິປະໄຕ ເອກະພາບ ວັດທະນາຖາວອນ

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ສະຖາບັນຄົ້ນຄວ້າ ກະສິກຳ ແລະ ປ່າໄມ້ ແຫ່ງຊາດ

ສູນຄົ້ນຄວ້າການນຳໃຊ້ທີ່ດິນ ກະສິກຳ ແລະ ປ່າໄມ້ ນະຄອນຫຼວງວຽງຈັນ,ວັນທີ......./......./.......

ຜົນວິໄຈດິນຂອງໂຄງການນ້ຳງຽບ 1 ຈຳນວນ 24 ຕົວຢ່າງ

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

ຫົວໜ້າສູນຄົ້ນຄ້ວາການນຳໃຊ້ທີ່ດິນກະສິກຳ ແລະ ປ່າໄມ້ ຫົວໜ້າໜ່ວຍງານວິໄຈດິນ

ສາທາລະນະລັດ ປະຊາທິປະໄຕ ປະຊາຊົນລາວ

ສັນຕິພາບ ເອກະລາດ ປະຊາທິປະໄຕ ເອກະພາບ ວັດທະນາຖາວອນ

=====000=====

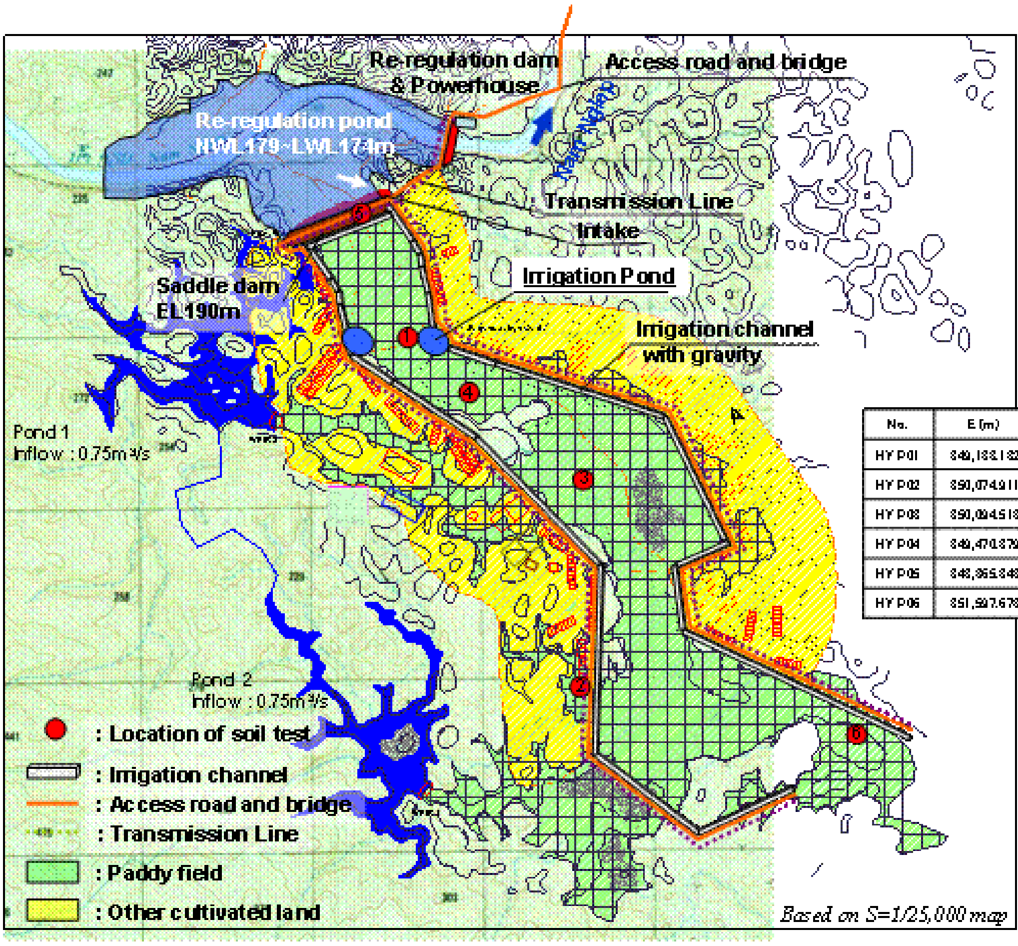
ສະຖາບັນຄົ້ນຄວ້າ ກະສິກຳ ແລະ ປ່າໄມ້ ແຫ່ງຊາດ

ສູນຄົ້ນຄວ້າການນຳໃຊ້ທີ່ດິນ ກະສິກຳ ແລະ ປ່າໄມ້ ນະຄອນຫຼວງວຽງຈັນ,ວັນທີ......./......./.......

ຜົນວິໄຈດິນຂອງໂຄງການນ້ຳງຽບ 1 ຈຳນວນ 8 ຕົວຢ່າງ

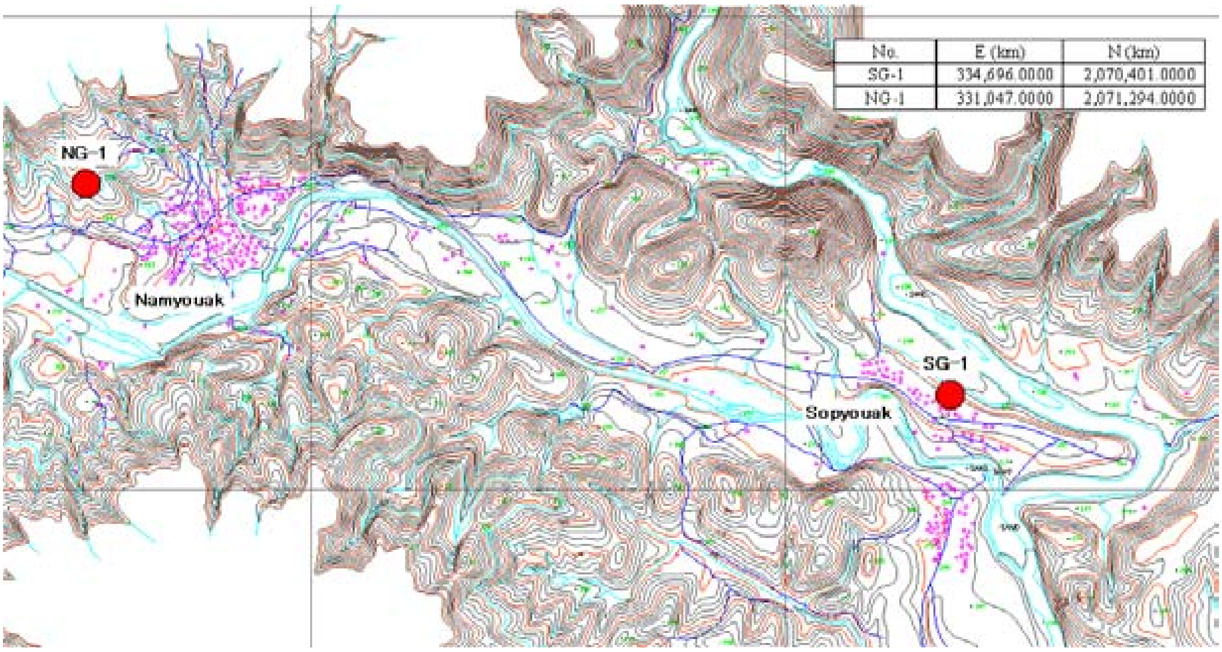
| N/N | No.Lab. | Profile | Layer | Date | pH | | OM | $NH_4^+$ | $NO_3^-$ | $P_2O_5$ | CEC | Exchangeable cation(meq/100g) | | | | BS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | $H_2O$ | KCl | % | mg/kg | mg/kg | % | cmol/kg | $Ca^{+2}$ | $Mg^{+2}$ | $K^+$ | $Na^+$ | % |
| 1 | 3308 | SG-1 | 0-10 | 26-07-11 | 4.4 | 4.04 | 15.82 | 14.00 | 5.60 | 0.054 | 15.04 | 1.36 | 0.64 | 0.02 | 0.10 | 14.10 |
| 2 | 3309 | SG-1 | 30-40 | 26-07-11 | 4.36 | 3.99 | 8.75 | 15.40 | 7.00 | 0.065 | 3.12 | 0.96 | 0.84 | 0.01 | 0.12 | 61.81 |
| 3 | 3310 | SG-1 | 60-70 | 26-07-11 | 4.34 | 4.09 | 3.75 | 10.50 | 3.50 | 0.059 | 6.52 | 0.36 | 0.84 | 0.03 | 0.07 | 19.87 |
| 4 | 3311 | SG-1 | 80-90 | 26-07-11 | 4.09 | 3.98 | 4.96 | 11.90 | 4.90 | 0.063 | 2.80 | 0.76 | 0.64 | 0.02 | 0.09 | 53.69 |
| 5 | 3312 | NG-1 | 0-10 | 26-07-11 | 4.14 | 3.99 | 10.99 | 17.50 | 10.50 | 0.058 | 36.86 | 0.76 | 0.64 | 0.01 | 0.03 | 3.91 |
| 6 | 3313 | NG-1 | 30-40 | 26-07-11 | 4.2 | 4.06 | 9.96 | 20.30 | 11.20 | 0.063 | 15.32 | 0.36 | 1.24 | 0.03 | 0.09 | 11.18 |
| 7 | 3314 | NG-1 | 60-70 | 26-07-11 | 4.14 | 4.03 | 5.39 | 14.00 | 5.60 | 0.064 | 23.80 | 0.56 | 0.64 | 0.02 | 0.01 | 5.18 |
| 8 | 3315 | NG-1 | 80-90 | 26-07-11 | 4.39 | 4.12 | 5.82 | 10.50 | 3.50 | 0.069 | 22.16 | 0.36 | 0.64 | 0.03 | 0.07 | 4.95 |

ຫົວໜ້າສູນຄົ້ນຄ້ວາການນຳໃຊ້ທີ່ດິນກະສິກຳ ແລະ ປ່າໄມ້ ຫົວໜ້າໜ່ວຍງານວິໄຈດິນ




| No. | E (m) | N (m) |
|---|---|---|
| HY P01 | 349,188.182 | 2,061,420.620 |
| HY P02 | 350,074.911 | 2,059,508.992 |
| HY P03 | 350,094.518 | 2,060,646.165 |
| HY P04 | 349,470.879 | 2,061,119.988 |
| HY P05 | 348,355.348 | 2,062,108.577 |
| HY P06 | 351,597.678 | 2,059,241.088 |

Figure 5-5 Soil sampling locations at proposed area on the right bank of re-regulation dam during the final resettlement site selection.




| No. | E (km) | N (km) |
|---|---|---|
| SG-1 | 334,696.0000 | 2,070,401.0000 |
| NG-1 | 331,047.0000 | 2,071,294.0000 |

Figure 5-6 Soil sampling locations of Ban Sopyouak and Ban Namyouak.

## 5.1.5 EROSION AND SEDIMENTATION

### 5.1.5.1 Soil erodibility and texture

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

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

- STP steep slope complex where the topography is very steep, the slope is more than 55%, and the soil is relatively fragile and easy to erode.
- Humid ACRISOLS: consists of fertile organic matter, A Umbric or A mollic layers present, soil in 0-75 cm in depth is Loam (LL) and Clayed loam (CL), slope ranges from moderately steep 16-30% to steep of 30 to 55% (Table 5-7 and Table 5-8).

Table 5-7 Soil Erodibility for Humic ACRISOLS

| Soil texture (T) | Soil depth (D) | Slope (S) | Erodibility (E) | Soil fertile (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) | | | | |

(EEE: very serious potential erodibility)

Table 5-8 Soil Texture

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

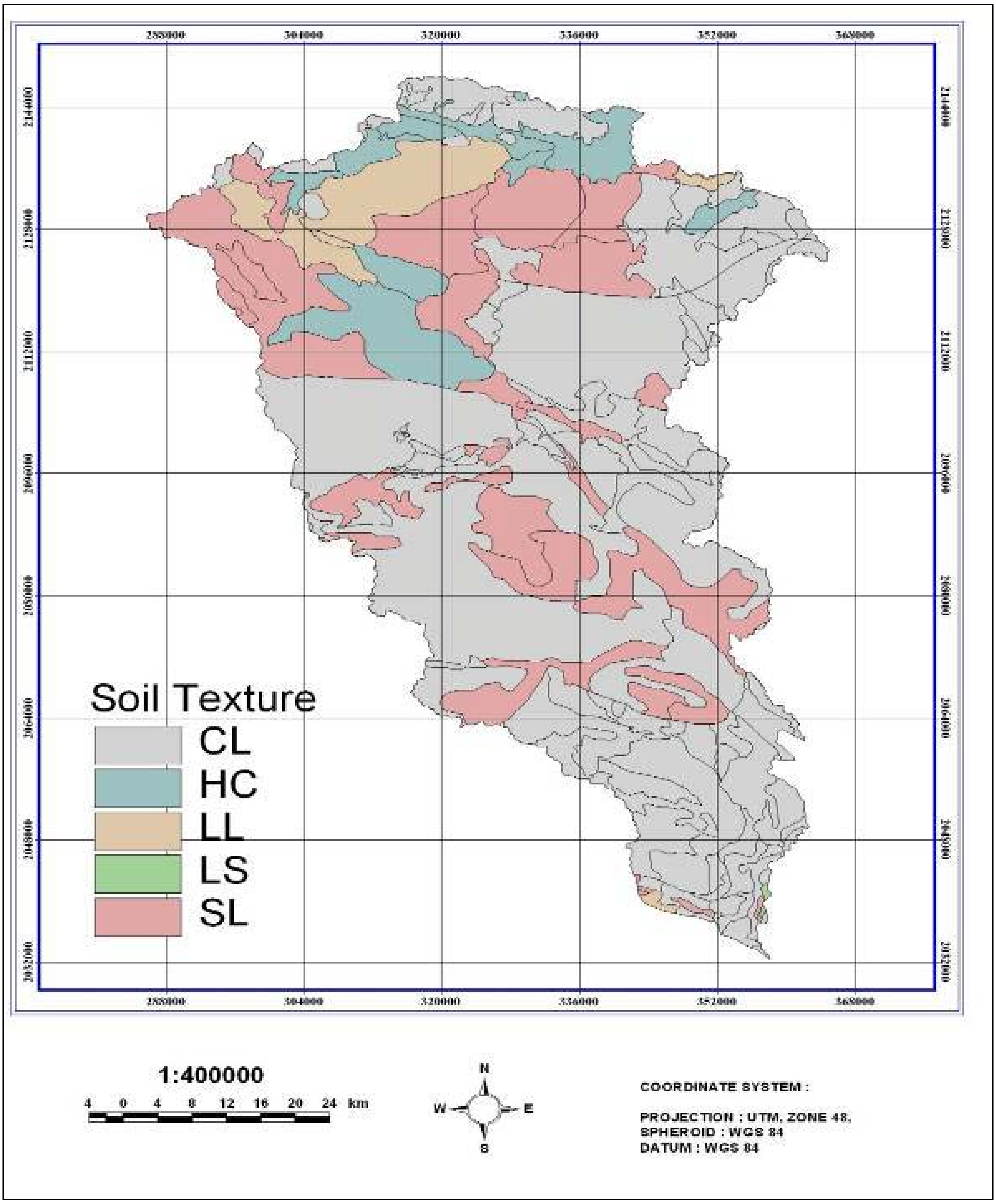



Figure 5-7 Soil texture map of the Nam Ngiep watershed.

#### 5.1.5.2 Location of water sampling stations

There are presently ten water-sampling stations in the project area. Seven are situated inside the controlled watershed (Nos. 1 to 7) and the other three stations situated downstream from the Dam site (Nos. 8 to 10) (Figure 3-1). The location of the ten stations by their coordinates is given in Table 5-9.

Table 5-9 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 Sopphuane | 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 Somsuen | 18°30'17.54'' | 103°39'31.81'' |
| 10. Nam Ngiep Bridge | 18°25'03.77'' | 103°36'11.30'' |

#### 5.1.5.3 Water sampling collection

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. They were analyzed to determine the suspended sediment concentration only, addressed in mg/l.

#### 5.1.5.4 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 r ecord of sediment data, it 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 listed here and as noted in Table 5-10.

- 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 5-10 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 hour s. 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:<br><br>Suspended solids (mg/l) = $\frac{A_1 - B}{V} X\ 10^6$<br><br>Where; $A_1$ is the weight of residue on filter paper + p.c (g)<br>B is the weight of filter paper + p.c (g)<br>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:<br><br>Suspended sediment (mg/l) = $\frac{A_2 - A_1}{V} X\ 10^6$<br><br>Where; $A_2$ is the weight of ignited residue + p.c (g)<br>$A_1$ is the weight of residue on filter paper + p.c (g)<br>V is the volume of water sample (ml) |

Source: Inthavy, 2005

#### 5.1.5.5 Erosion and sedimentation in the Nam Ngiep watershed

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

The study on erosion and sedimentation from river basins is important for many reasons. Sediment deposits in a reservoir reduces its capacity and power generation. Use of forestland, logging in particular, has often been a cause for concern, because it reduced 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.

The laboratory procedure was adopted and the calculations expressing suspended sediment concentrations in milligram per liter (mg/l) are summarized in Table 5-11 for the dry season and Table 5-12 for the rainy season. The volume of water sampled which was colledted in Ban Hat Gniun by the gravimetric analysis was usually 1,000 ml.

Table 5-11 Results of Erosion and Sedimentation Monitoring on Dry Day 2010

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

Preliminary assessment found suspended sediment concentration highest during the rainy season, ranging from 14.10 mg/l at the site farthest downstream to 532.60 mg/l at Ban Hat Gniun, with the water level at about 1-3m. During the dry season, the maximum suspended sediment concentration was 42.50 mg/l at Ban Hat Gniun and the minimum was 5.20 mg/l. It is a common phenomenon in the tropics that storms are usually of high intensity of sedimentation but 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 5-12 Results of Erosion and Sedimentation Monitoring during Rainy Season 2010

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

#### 5.1.5.6 Sediment load and yield

To control further adverse developments in the entire watershed area and avoid increasing sedimentation, it is recommended that a comprehensive watershed management study be conducted.

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 the most suitable procedure. In the absence of sedimentation survey information for the Nam Ngiep River, reservoir sedimentation is estimated based on t he suspended sediment concentration and discharge at a lognormal distribution.

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

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

, where Qs: Suspended Sediment (m$^3$/sec)

Q : Discharge (m$^3$/sec)

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

$$Vy=Vy_s+Vy_b$$

$$Vy_S = R\times\frac{1}{\gamma}\times\frac{1}{(1-n_s)},\quad Vy_b = R\times0.2\times\frac{1}{\gamma}\times\frac{1}{(1-n_b)}$$

R= Suspended load curve × $D_h$

,where

| | |
|---|---|
| $V_y$ : | Annual sediment yield ($m^3$/yr) |
| $Vy_S$, $Vy_b$ : | Sediment yield of suspended load, bed load ($m^3$/yr) |
| R : | Sediment weight (kg) |
| γ: | Specific gravity (2,650 kg/$m^3$) |
| $n_s$, $n_b$: | Void content; Suspended load: 0.7, Bed load: 0.4 |
| $D_h$ : | Discharge of duration curve (sec) |

Based on t he above equation to estimate suspended sediment the results of annual sediment yield produced from the Nam Ngiep watershed is 178 ton/km$^2$/year. Table 5-13 provides a comparison of this estimated annual sediment yield to that of other major watersheds in Lao PDR.

Table 5-13 Comparison of Annual Sediment Yields Estimates at Major Hydropower Project Sites in Lao PDR

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

Source: Technical Report, 2011

### 5.1.6 SURFACE WATER AND GROUNDWATER QUALITY

Surface water quality in the project area is generally moderately good t o good qua lity, depending on the level of human activity near the site where the water was tested. Where there is more human activity, the quality of water is lower. There is also evidence that water quality is deteriorating.

#### 5.1.6.1 Environment affecting water conditions

A World Bank[2] 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.

##### (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 a catchment of water courses. The level of oxygen was high while the nutrient concentration was low[3]. However, water quality was deteriorating. In urban areas, pollutants from roads, commercial and industrial areas, and private properties washed 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 5-8.


Figure 5-8 Open dump of solid waste in a city.

Residential development and agriculture cultivation have contributed to sediment and nutrient loads in the rivers. Urban drainage such as industrial discharges and septic tank seepage also worsened water quality. To determine the quality of water supply in the project

[2] World Bank. 2006. Lao PDR Environmental Monitoring Report.

[3] ADB. 1998. Water Sector Study.

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 Khuang 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. M any more villages are found, especially in the lowland plains of Pakxan district near the Mekong River. The villagers along the Nam Ngiep River use it 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 5-9 to Figure 5-11), 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 even more the case farther downstream, particularly in the relatively densely populated plains of Pakxan (Figure 5-12). Garbage was 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 5-13). Their waste can mix with runoff and flow through the riverbank down to the river.

Figure 5-9 Three-canopy forest located near the proposed dam site.

Figure 5-10 Stake marking the dam site.

Figure 5-11 Forest at the proposed dam site.

Figure 5-12 Disturbed forest from grazing near Ban Somseun.


Figure 5-13 Residential areas divided for activities such as washing, waste dumping and animal feeding.

After observing activities that could load pollutants into the river, ten locations were determined for surface water sampling to cover four zones.

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

The photos of the ten sampling locations are presented in Figure 5-14. The water quality at these sites is shown in Table 5-14.

Station 1: Ban Xiengkhong

Station 2: Ban Phonngeng

Station 3: Ban Pou

Station 4: Ban Houypamom

Station 5: Ban Sopphuane

Station 6: Ban Namyouak

Station 7: Hatsakhua

Station 8: Hat Gniun

Station 9: Ban Somsuen

Station 10: Nam Ngiep Bridge

Figure 5-14 Ten locations of surface water sampled in April 2007.

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 | April | Oct. | April | Oct. | April | Oct. | April | Oct. | April | Oct. | Oct. | April | Oct. | April | Oct. |
| Temperature | °C | 26.4 | 24.2 | 28.8 | 24.5 | 28.5 | 24.5 | 27.0 | 28.5 | 27.6 | 29.9 | 25.9 | 31.1 | 26.3 | 27.4 | 29.5 | 25.3 | 28.2 | 27.9 | 27.7 | 26.5 |
| pH | - | 8.06 | 6.87 | 8.17 | 7.16 | 8.20 | 7.24 | 7.03 | 7.85 | 7.21 | 7.78 | 7.35 | 8.13 | 7.25 | 7.79 | 7.09 | 7.09 | 8.18 | 7.34 | 7.58 | 7.17 |
| Alkalinity | meq/L | NA | 0.14 | NA | 0.23 | NA | NA | 0.28 | NA | 0.26 | NA | 0.21 | NA | 0.29 | NA | 0.26 | 0.14 | NA | 0.29 | NA | 0.27 |
| DO | mg/L | 7.80 | 6.90 | 8.00 | 7.12 | 8.10 | 7.30 | 6.87 | 7.80 | 7.11 | 6.60 | 8.10 | 7.20 | 7.20 | 6.40 | 7.21 | 7.23 | 7.60 | 7.47 | 7.20 | 6.97 |
| $BOD_5$ | mg/L | 2.6 | 1.1 | 3.0 | 0.9 | 2.8 | 3.4 | 1.3 | 2.4 | 1.3 | 2.1 | 1.2 | 2.5 | 1.1 | 2.1 | 1.4 | 1.2 | 2.6 | 1.1 | 3.3 | 1.1 |
| Oil and Grease | mg/L | NA | <0.01 | NA | <0.01 | NA | NA | <0.01 | NA | <0.01 | NA | <0.01 | NA | <0.01 | NA | <0.01 | <0.01 | NA | <0.01 | NA | <0.01 |
| Turbidity | FTU | 24.7 | 13.3 | 31.4 | 12.4 | 31.4 | 57.2 | 19.4 | 59.1 | 12.0 | 12.9 | 18.2 | 21.1 | 16.9 | 9.1 | 17.9 | 16.2 | 47.9 | 15.7 | 32.9 | 17.3 |
| Suspended solids | mg/L | 100.0 | 21.6 | 78.0 | 19.2 | 94.0 | 246.0 | 18.7 | 69.0 | 19.0 | 72.0 | 23.8 | 74.0 | 21.5 | 80.0 | 21.4 | 22.1 | 112.0 | 17.9 | 72.0 | 21.2 |
| TDS | mg/L | 100.0 | 18.2 | 110.0 | 17.4 | 90.0 | 70.0 | 33.9 | 110.0 | 37.8 | 110.0 | 22.4 | 50.0 | 29.6 | 30.0 | 33.1 | 19.7 | 100.0 | 21.2 | 93.0 | 31.6 |
| Hardness | mg/L | 124.0 | 71.5 | 90.0 | 66.2 | 136.0 | 140.0 | 77.4 | 78.0 | 69.3 | 100.0 | 83.2 | 130.0 | 86.4 | 140.0 | 78.0 | 73.0 | 184.0 | 84.0 | 118.0 | 76.0 |
| Conductivity | µS/cm | 92.4 | 47.7 | 94.4 | 49.8 | 104.8 | 56.60 | 58.00 | 89.40 | 49.80 | 147.00 | 56.88 | 85.10 | 61.04 | 82.40 | 60.56 | 48.9 | 88.5 | 72.0 | 94.5 | 74.1 |
| Phosphate-P | mg/L | 0.05 | 0.21 | 0.98 | 0.31 | 0.03 | 0.11 | 0.21 | 0.20 | 0.18 | 0.20 | 0.25 | 0.09 | 0.38 | 0.19 | 0.48 | 0.10 | 0.14 | 0.20 | 0.16 | 0.12 |
| Total P | mg/L | 0.35 | 0.09 | 0.31 | 0.06 | 0.11 | 0.34 | 0.07 | 0.36 | 0.06 | 0.29 | 0.09 | 0.33 | 0.09 | 0.29 | 0.11 | 0.04 | 0.27 | 0.09 | 0.32 | 0.04 |
| Ammonium-N | mg/L | 0.01 | 0.02 | 0.01 | 0.02 | 0.01 | 0.01 | 0.02 | 0.01 | 0.05 | 0.01 | 0.04 | 0.01 | 0.04 | 0.01 | 0.05 | 0.02 | 0.01 | 0.04 | ND | 0.04 |
| Nitrate-N | mg/L | 0.16 | 0.12 | 0.23 | 0.15 | 0.18 | 0.26 | 0.12 | 0.27 | 0.14 | 0.34 | 0.14 | 0.29 | 0.16 | 0.20 | 0.14 | 0.21 | 0.17 | 0.10 | 0.20 | 0.09 |
| Total N | mg/L | NA | 0.05 | NA | 0.06 | NA | NA | 0.02 | NA | 0.05 | NA | 0.05 | NA | 0.07 | NA | 0.07 | 0.05 | NA | 0.07 | NA | 0.03 |
| Total coliform | MPN/100 | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Fecal coliform | MPN/100 | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Cadmium, Cd | mg/L | 0.01 | <0.001 | 0.03 | <0.001 | <0.001 | <0.001 | <0.001 | 0.02 | <0.001 | 0.01 | <0.001 | 0.01 | <0.001 | <0.001 | <0.001 | <0.001 | 0.06 | <0.001 | 0.05 | <0.001 |
| Mercury, Hg | mg/L | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 |
| Copper, Cu | mg/L | <0.10 | <0.10 | <0.10 | <0.10 | <0.10 | <0.10 | <0.10 | <0.10 | <0.10 | <0.10 | <0.10 | <0.10 | <0.10 | <0.10 | <0.10 | <0.10 | <0.10 | <0.10 | <0.10 | <0.10 |
| Iron, Fe | mg/L | <0.10 | 0.31 | <0.10 | 0.34 | <0.10 | <0.10 | 0.24 | <0.10 | 0.99 | <0.10 | 0.31 | <0.10 | 0.20 | <0.10 | 0.22 | 0.20 | <0.10 | 0.10 | <0.10 | 0.11 |
| Manganese, Mn | mg/L | 0.50 | 0.10 | 0.34 | 0.10 | 0.70 | 0.28 | 0.20 | 0.31 | 0.14 | 1.67 | 0.10 | 1.97 | 0.17 | 2.03 | 0.18 | 0.11 | 0.76 | 0.13 | 0.70 | <0.10 |
| Nikel, Ni | mg/L | NA | <0.10 | NA | <0.10 | NA | NA | <0.10 | NA | <0.10 | NA | <0.10 | NA | <0.10 | NA | <0.10 | <0.10 | NA | <0.10 | NA | <0.10 |
| Lead, Pb | mg/L | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | 0.16 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 |
| Zinc, Zn | mg/L | 0.03 | <0.02 | 0.02 | <0.02 | <0.02 | <0.02 | <0.02 | <0.02 | <0.02 | <0.02 | <0.02 | <0.02 | <0.02 | <0.02 | <0.02 | <0.02 | 0.02 | <0.02 | <0.02 | <0.02 |
| Arsenic, As | mg/L | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 |

Note: NA = Not available

Quality of water sources is normally affected by residential and agricultural activities. Therefore the water samples were collected along river to cover all types of existing land uses including natural areas, agriculture lands, residential areas, and other types of discharges that can change or lead to a deterioration in water quality. The water parameters found in this sampling 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 already started when the second sample was taken in October.

The study 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 natural as those showing good freshwater and less disturbed forest in the upper catchment. 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. Its average value was about 83 ppm in April and 17 ppm in October.

Regarding to the biological water qualities, DO concentrations were 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 ni trate-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 seaso, into the river during the early rainy season.

Since data of total coliform and fecal coliform was not available, there was no microbiological parameter for the water samples. The WHO/UNICEF Joint Monitoring Programme in its Country, Regional and Global Estimate on Water and Sanitation gave a 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 be able to contribute to those contaminants, especially the high amount of coliform, a parameter revealed in the poor sanitation of communities.

Because Lao PDR does not yet have its own water quality standards, the quality of surface water was evaluated using the classification of the Surface Water Standards (Table 3-3) of Thailand and of the Surface Water Quality Guidelines and Standards by International Organizations and Countries (Table 3-5). These then help provide the general guidelines to determine proper water management.

In general, the water quality of water 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 appropriate for aquatic organism 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. The increase of $BOD_5$ was caused by the nutrients flushed from the agricultural lands and residential areas into the river during the start of the rainy season.

**(2) Groundwater quality**

Although there is a well at Ban Hat Gniun, the villagers do not use it and dump trash in the well. Spring water from a gravity-flow system built under Action Contre la Faim (ACF) and the Nam Ngiep River are the main water sources that supplied water to the village. Residents of Ban Somseun, however, do use water from a well and also from the river. The well was about 12 m deep (Figure 5-15 to Figure 5-17). Table 5-15 shows the groundwater quality at Ban Somseun.


Figure 5-15 Ground water sampling at Ban Somseun.

Figure 5-16 The well at Ban Hat Gniun.

Figure 5-17 Spring water gravity flow system in Ban Hat Gniun

Table 5-15 Ground water Quality of Ban Somseun Collected on 17 October 2007

| Parameters | Unit | Somseun | STD value | |
|---|---|---|---|---|
| | | | Suitable allowance | Maximum allowable |
| Temperature | $^oC$ | 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 |

| Parameters | Unit | Somseun | STD value | |
|---|---|---|---|---|
| | | | Suitable allowance | Maximum allowable |
| 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 |

Note: NA = "Not Available"

- = Not indicated

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

### 5.1.7 MINERAL RESOURCES

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

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

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

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

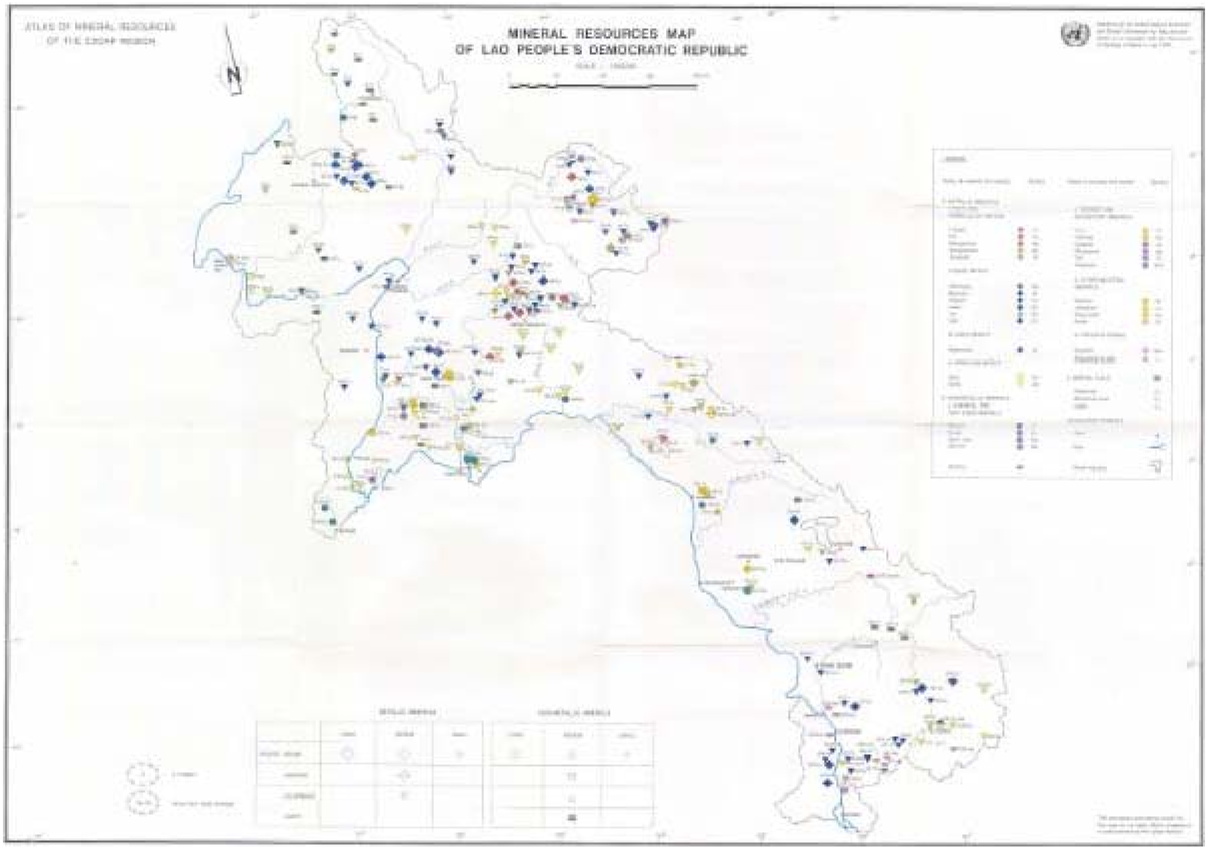



Figure 5-18 Mineral resource map of Lao PDR.

Only medium occurrence of metallic and non-metallic mineral reserves was found in Xieng Khouang, Vientaine, 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 as a potential source of copper according to a geological study conducted by Lao-Fuda Co., Ltd in March 2007, but this site in Houixiat Village, Hom District, Vientiane Province is also far from the project and so should not have any impact on the project.

### 5.1.8 NOISE AND VIBRATION

Only one community, Ban Hat Gnuin, about 3 km from the construction site, is close enough to the dam site to be affected by noises and vibrations during construction or operation.

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 hear sounds between 20 Hz and 20,000 Hz. Frequency is also related to pitch, with the higher pitches having higher frequencies. Sound intensity is measure 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 NNHP-1 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 NNHP-1 Project also work on the field research for the ESIA of the Hutgyi Hydropower Project. They found that the two sites have many similarities in noise and vibration sources and impacts. Variables that were considered for comparison were similarities of local agricultural activities of sensitive communities, of other land uses that could contribute to noises and vibrations, and other noise and vibration sources.

#### 5.1.8.1 Sensitive receptors

Field surveys were conducted for identification of sensitive areas. Only Ban Hat Gnuin, a village located about 3 km from the construction site (Figure 2-3), 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 5-19), a school (Figure 5-20) and a temple (Figure 5-21). 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 5-19 Houses at Ban Hat Gnuin.

Figure 5-20 School at Ban Hat Gnuin.

Figure 5-21 Temple at Ban Hat Gnuin.

#### 5.1.8.2 Noise and vibration sources

The village area is generally quiet. However, some agricultural activities produce sounds that interfere with activities of nearby people. This sound could become a disturbing noise, especially in the evening and during normal sleeping hours. The main noise source of the village is the hand tractor, a popular form of local transport. It has two wheels, with the driver walking behind to plough rice fields. It is also used to pull a cart to transport things including agricultural products such as bagged rice and bamboo, materials for house construction, and people (Figure 5-22). The acoustic environment normally consists of natural sounds such as wind blowing through trees, birds, and pets.

Figure 5-22 Two-wheel tractor pulling a cart.

#### 5.1.8.3 Background sound level

The intensity of sound is measured in dB. The Ministry of Agriculture Food and Rural Affairs of the Government of Ontario provided common sound levels including agricultural activities (Table 5-16). Most of the common sounds listed are in fact found in everyday life (whisper, leaves, conversation, 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 NNHP-1 with regard to noise and vibration sources and their impacts. For example, its location is in a remote and mountainous area similar to Nam

Ngiep 1. Equipment and techniques of construction were generally similar, and community sizes near the dam site also small.

Table 5-16 Decibel Levels of Common Sounds

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

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

Figure 5-23 Ban Hat Gniun.

### 5.1.9 AIR QUALITY

Air quality in the project area is still considered generally good quality.

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

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

The Lao PDR has not adopted its own ambient air standards, so generally accepted international standards are used instead. "The Lao PDR Environment Monitor 2005" of the World Bank showed that overall air quality is currently at acceptable levels in both urban and rural areas in Lao PDR. It is therefore quite reasonable to expect that the air quality in the project area falls well within the standards presented in Table 5-17.

Table 5-17 Ambient Air Standards Applied to the NNHP-1 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 |

| Parameter | Average Time | | | | | Method of Measurement |
|---|---|---|---|---|---|---|
| | 1 hr Av | 8 hr Av | 24 hr Av | 1 Month Av | 1 Year Av | |
| 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:

WHO, 1987. 'WHO Ambient Air Quality Guideline',
URL: http://w3.whosea.org/techinfo/air.htm ,(21/6/06)

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)

Ministry of Environment, Government of Japan, 1973. 'Environmental Quality Standards in Japan: Air Quality', URL: http://www.env.go.jp/en/air/aq/aq.html (18/7/06)

### 5.1.10 POTENTIAL CONTAMINATED SITES

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

Potential contaminated sites were assessed, 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 was no contaminated site from minerals or mineral extraction that could cause hazardous contamination in the project area. There is also no industrial activity within or immediately adjacent the Nam Ngiep River basin, so industrial activity would also not be a source of hazardous contamination, at least for the present.

Thus, 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 NNHP-1 dam. The chemicals that must be used for the project during construction and operation were reviewed to predict the potential site contamination. The project materials that would be storaged 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 and wiers, near offices and parking areas.

Non-harzardous substances that could contiminate the project site would be from the generation of solid waste and wastewater during 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 daily for six years; thus creating solid waste of about 800 kg to 1,500 kg/days. 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 and plant year, the potential quarry site near the river, and other sites where project activities will be carried out that could run the risk of contamination are shown Figure 2-3.

### 5.1.11 HYDROLOGY

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

#### 5.1.11.1 Geography along the Nam Ngiep River

For most of its 160 km length, the Nam Ngiep flows through mountainous regions in a south to southeastern direction. After a turn to the east, it passes through a narrow gorge of some 7 km between Mt. Huasua (elevation 1,538m) to the northeast and Mt. Katha (elevation 2,071 m to the southewest. T he 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 segmet of the gorge has a river gradient as steep as 1/100. The planned dam site is in this segment of the gorge about 1.2 km downstream from the confluence of the Nam Katha River. The entire basin for the dam has an area of about 3,700 km$^2$.

#### 5.1.11.2 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 5-18. Other meteorological data such as air temperature, relative humidity, barometric pressure, solar radiation, sunshine hours, evaporation, 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 measurementw were taken at the same location until March 2000. Discharge rating curve was shown in Figure 5-24.

Table 5-18 Basic Hydrological Data

| Gausing 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.Pakthousi) | 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 | | | | | | | | | | | | | | | | | | | △ | ● | ● | ● | ● | ● | ● | ● | ● | △ | ● | △ | ● | ● |

● : Fully available Δ : Partly avalible

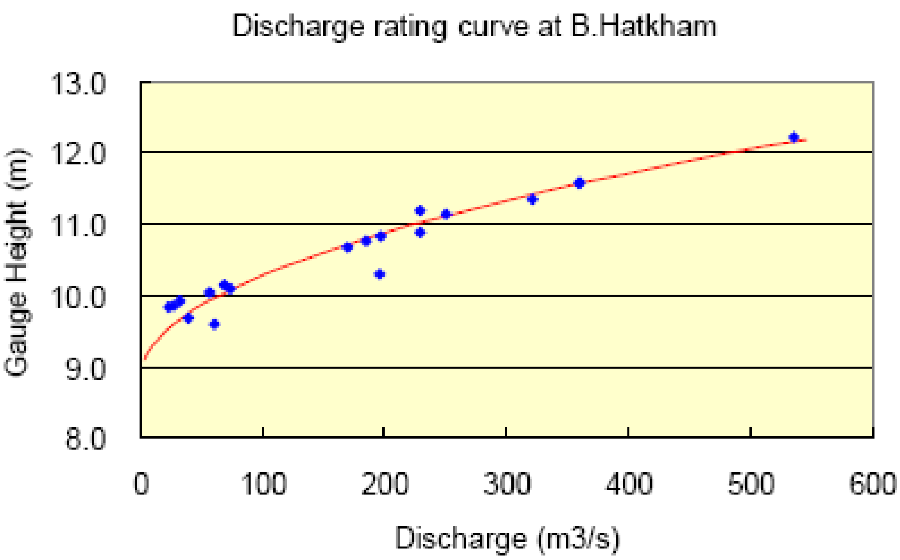



Figure 5-24 Discharge rating curve.

### (3) Hydrological study

This 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 topographical maps of 1/10,000 derived from aerial photo.

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

#### 5.1.11.3 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 was shown in Table 5-19.

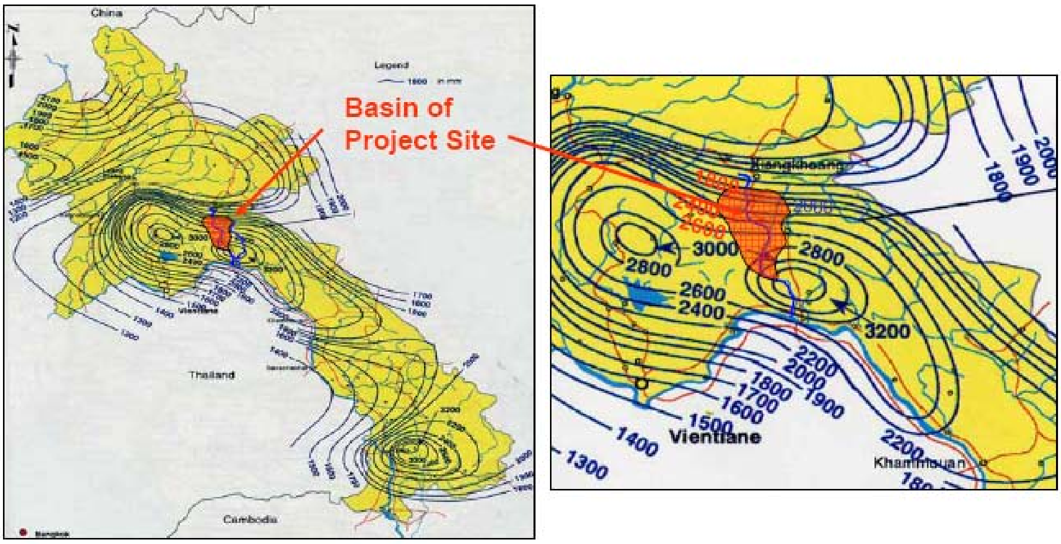
Table 5-19 Assumed Mean Basin Rainfall (1971-2000)

(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 |

| Year | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1997 | 9 | 4 | 85 | 220 | 250 | 302 | 485 | 416 | 243 | 94 | 4 | 0 | 2,111 |
| 1998 | 0 | 11 | 17 | 86 | 231 | 295 | 364 | 282 | 156 | 45 | 9 | 8 | 1,503 |
| 1999 | 7 | 3 | 60 | 119 | 521 | 426 | 320 | 537 | 293 | 125 | 26 | 8 | 2,445 |
| 2000 | 4 | 46 | 7 | 178 | 296 | 359 | 293 | 382 | 312 | 93 | 2 | 0 | 1,972 |
| Av. | 8 | 17 | 38 | 104 | 231 | 361 | 402 | 380 | 230 | 86 | 13 | 4 | 1,873 |

The mean rainfall of the basin of 1,870 mm/year was finally selected after considering the Isohyetal Map (Figure 5-25). The mean rainfall of Nam Ngiep River basin was assumed at 1,870 mm/year, which 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.




Source: Ministry of Mines and Energy, Lao PDR

Figure 5-25 Isohyetal map.

Based on the 14-year actual measurement of discharge at the Moung Mai station and the measured discharge at Ban Hat Gniun, 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 $m^3/s$.

The annual average discharge assumed this time (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 confirmed values of runoff coefficient and the specific yield (Table 5-20).

Table 5-20 Comparison of Hydrological Characteristics with other Projects in North and Middle of Laos

| Project | Source | Year | Catchment Area km$^2$ | Annual average rainfall mm/year | Annual average dischage m$^3$/s | Specific yield m$^3$/s/100km$^2$ | Runoff coefficient |
|---|---|---|---|---|---|---|---|
| Nam Ngiep 1 | KANSAI Update F/S | 2007 | 3,700 | 1,874 | 148.4 | 4.01 | 0.67 |
| | Feasibility Study on the NAM NGIEP 1 Project (Phase II)<br><br>Final Report: volume1 Main Report (JICA) | 2002 | 3,700 | 1,874 | 147.2 | 3.98 | 0.67 |
| Nam Ngum 2 | Hydropower Development Strategy for LAO Draft Final Report (LAHMEYER) | 2000 | 5,640 | 2,166 | 200.6 | 3.56 | 0.52 |
| Nam Ngum 3 | | | 3,873 | 2,166 | 106.2 | 2.74 | 0.40 |
| Nam Ngum 5 | | | 483 | 1,944 | 22.7 | 4.70 | 0.76 |
| Nam Theun 3 | | | 2,338 | - | 110.00 | 4.70 | - |
| Nam Theun 2 | Water Management Plan for the NAM THEUN Final Report (NORPLAN A.S.) | 1997 | 4,013 | 2,250 | 233.0 | 5.81 | 0.81 |
| Nam Ngum 1 | Nam Ngum5 Hydropower Project Feasibility Study (LAHMEYER) | 1997 | 8,460 | - | 308.0 | 3.64 | - |
| Nam Ngum 5 | | | 483 | 2,200 | 22.8 | 4.72 | 0.68 |
| Nam Ngum 1 | NAM NGUM1 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 |

### 5.1.11.4 Flood analysis

The hourly rainfall data for the Nam Ngiep basin was prepared by the automatic rainfall recorder installed at B. Thaviang, near the center of the basin (Sep, 1998 to Dec, 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 5-26).

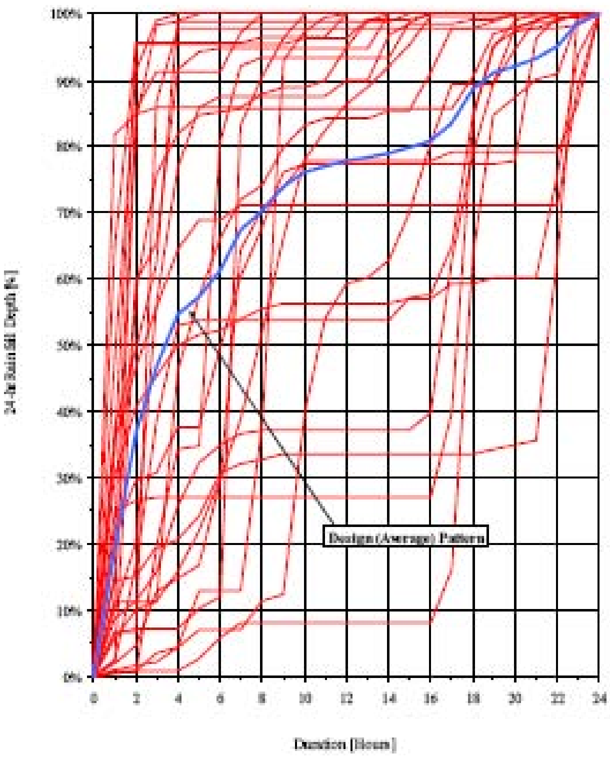



Figure 5-26 Accumulated hourly rainfall curves.

### (1) Base flow

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

### (2) Runoff coefficient

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

### (3) Unit hydrograph

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

### (4) Probable flood discharge estimation

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

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

**(5) Flood analysis result**

It was likely that actual discharge measurement at Moung Mai station was more reliable than the rainfall data estimated by Thiessen method. Thus, 5,210 $m^3/s$ of probable flood discharge in 1,000 years was adopted for designing the dam (Table 5-21).

Table 5-21 Flood Analysis Result

($m^3/s$)

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

**(6) Riparian Release**

Riparian release was included into the calculation. Cases of specific discharge of 0.15 $m^3/s/km^2$ for Nam Ngiep1 (Table 5-22) is adopted, and the minimum discharge after the initial impounding should be 5.5 $m^3/s$.

Table 5-22 Flow of Riparian Release

| Condition | Cases | Flow rate ($m^3/s$) |
|---|---|---|
| Without Dam | Min. monthly river flow in 30 yr (1971-2000) | 26 |
| With Dam | Min. monthly river flow in 30 yr (1971-2000) | 0 |
| | The release included specific discharge of 0.15 m3/s/km2 | 5.5 |

The operation of the main dam would intentionally have the riparian release into the downstream to maintain normal functions of the river.

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 about 26 m3/s as the minimum monthly river flow during 30 years (1971-2000).

#### 5.1.11.5 Impacts of Flow Variations on Riparian Communities

Like most tropical monsoon communities, the life of the people living along the Nam Ngiep River and its tributaries flows 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, a verage annual maximum flow was 1,046.76 $m^3$/sec, while the average annual minimum flow as 29.72 $m^3$/sec. 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.

With the exception of one community in Zone 2LR, Houayphamom, and the sub-village in Zone 3, Hatsaykham, all villages in the affected area of the project, from Zone 1 upstream to Zone 4 do wnstream, get 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. Only those two communities mentioned above depend entirely on the Nam Ngiep and nearby tributaries for all their water.

For most of its course, the Nam Ngiep passes through valleys with steep embankments. Even farther downstream, where the topography is less mountainous, the river flows through a valley between higher hills. Nearly all the agricultural fields are on lands well above the river. The main agriculture production – lowland rice, upland crops, and tree crops – depends upon rainfall rather than river water. A few areas are irrigated, but these use water from streams flowing down toward the Nam Ngiep from the mountains. Farmers use river water only for 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.

## 5.2 BIOLOGICAL ENVIRONMENT

### 5.2.1 TERRESTRIAL ECOLOGY/ WILDLIFE

The construction of the Nam Ngiep Hydropower Project will not have a significant impact on wildlife in the area. At present, the only remaining viable wildlife habitats are on the steep and relatively inaccessible slopes of undisturbed forests outside the project area. These areas will not be affected by the reservoir, resettlement, or other project-related activities. ***The areas of the reservoir, dam, and re-regulation dam are not significant for wildlife migration, breeding, or feeding.*** Whatever remaining wildlife found in the project area lives mostly in the higher elelvations, and these have been and are still being indiscriminately and extensively hunted and captured.

The definition of wildlife used for the purpose of this study consists of 4 gr oups of animals: mammals, birds, reptiles, and amphibians. Forests are the dominant habitat of wildlife in Lao PDR. Much of what had been forest in the project area has long since been cleared for shifting cultivation. Shifting cultivation is practiced widely near the Nam Ngiep River and the dam sites. Official forest classification for most of the project area is largely (1) unstocked forest that is part of the cycle of slash and burn agriculture and (2) mixed forest that is located either on areas of steep land where the forest is inaccessible or on poor soils unsuitable for upland rice and other crop production.

Lao PDR is still rich in wildlife, when compared with many other countries, including it 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;[4] 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, a nd consequently the wildlife population has declined dramatically throughout the country.

Threatened species recorded in Lao PDR, based upon N ovember 1998 da ta from the Word Conservation Monitoring Centre of UNEP, included 220 plants and 150 animals. The purpose of this assessment was to determine what if any threatened species live in or near the

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

project area, in particular in or near the areas directly affected by the project (the dam and reservoir), and whether the project will affect their habitats or not.

The surveyed or project area is broadly defined as the area north of the dam site extending to the northern m argin of the reservoir, covring the proposed reservoir area. Within and around the Project Area (PLEASE DEFINE THE AREA COVERAGE OF 'AROUND THE SURVEY AREAS"), 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 field survey was conducted in both wet (October 2007) and dry (March 2007) seasons to collect primary field data concerning all wildlife species including mammals, reptiles, amphibians and birds. (NOTES:

- PLEASE DISCUSS IF ANY CRITICAL HABITATS (AS DEFINED IN ADB'S SPS) HAVE FOUND WITHIN THE SURVEYED AREAS.
- PLEASE CONFIRM IF WILDLIFE SURVEY ACTIVITIES HAVE ALSO BEEN DONE DOWNSTREAM OF THE RE-REGULATING DAM.
- PLEASE PROVIDE MAP SHOWING THE SURVEYED AREAS ON THE TERRESTRIAL ECOLOGY/WILDLIFE AS RELATED TO THE LOCATIONS OF TRIBUTARIES (PHU KENG, PHU NGOU TO PHU PHA MELA, NAM PHA AND NAM TEK)
- PLEASE CLARIFY IF THE SURVEYED AREAS FOR THE TERRESTRIAL ECOLOGY/WILDLIFE HAVE COVERED THE : (1) DOWNSTREAM OF THE MAIN DAM I.E. BETWEEN THE MAIN DAM AND THE RE-REGULATING DAM (6.5 KM) AND (II) DOWNSTREAM OF THE RE-REGULATING DAM TO THE NEXT MAJOR TRIBUTARY, AND IF SO, COVERING UP TO HOW MANAY KILOMETERS.

#### 5.2.1.1 Mammals within and around the Project Area

Data on mammal species were collected in interviews and field surveys in March and October 2007. Villagers described that in years past there was considerable mammal wildlife in the project area, both in number of species and in higher populations. However, at present, after the forests in the river valley have mostly been cleared and the surrounding areas also cleared and/or extensively hunted or captured, most of these species are no longer seen or only rarely seen in the areas where the dam and reservoir are located. If the species are still found in the project area, they are in the less accessible, higher elevations where some forest still remains. Some of the more agile animals go at night down the steep slopes to the river to drink, and this will still be possible for them after the dam is built.

The remaining pockets of virgin forest that exist in the region are home to some species on the IUCN Red List of 2009. These are:

- EN (endangered) 7 species: Cuon alpinus, Pygathrix nemaeus, Trachypithecus phayrei, Manis javanica, Prionailurus viverrinus, Panthera tigris and Elephas maximus,
- VU (vulnerable) 11 species, including Capricornis milneedwardsi, Bos gaurus, Macaca arctoides and Rusa unicolor,
- NT (near threatenedNT) 5 species: Macaca assamensis, Pardofelis temminckii, Arctonyx collaris, Lutra lutra and Viverra zibetha,
- LC (least concern LC) 27 species, among them Muntiacus muntjak, Prionailurus bengalensis and Hystrix brachyuran, and
- DD (those for which data is deficient) 2 species: Tragulus javanicus and Melogal personata.

Table 5-23 provides the list of mammal species and the method of reporting their presence or absence in or near the project area.

#### 5.2.1.2 Reptiles and Amphibians within and around the Project Area

Reptiles and Amphibians (herpetofauna) have always been abundant in Lao PDR. Earlier reports on herpetofauna (Gressitt 1970, Salter 1993s) have been reviewed and re-edited recently (Wildlife in Lao PDR 1999), with at least 166 species of reptiles and amphibians recorded, most verified with pictures.

Table 5-24 presents the reptile and ambhibian species recorded in the interviews. These included turtles, tortoises, monitors, Varanus spp., Python spp., and king cobra. Provisionally at-risk species that were recorded as present from the surveys include the Reticulated Python and the Water Monitor. None of the reptiles are on the IUCN Red List (2009). Only 5 of the amphibians are lists. These are:

- NT (Near Threatened) 3 s pecies: Rhacophorus calcaneus, Rhacophorus reinwardtii and Amolops cremnobatus,
- LC (Least Concern) 1 species: Microhyla berdmorei and
- DD (Data Deficient) 1 species: *Annandia delacouri*.

The project is not expected to have a detrimental impact to the reptile and ambhibious species in the area.

#### 5.2.1.3 Key Species of Birds within and around Project Area

Data on bird species data was gathered during interviews and field surveys in March 2007 and October 2007 a nd then compared with the list of species found in Lao PDR. Some species in this list are derived from authoritative sources in Lao PDR, however, not all species listed have adequate supporting evidence. They may have been mentioned in interviews, but no evidence of their actual presence was found during the field surveys.

As with the mammal species, the number of bird species and their populations declined significantly because of habitat loss, hunting, as capture as pets. Also as with the mammal species, there are no s ignificant breeding or migratory sites for birds where the dam and reservoir will be located, mainly because of the lack of viable forest cover. It is therefore expected that the project will not have a significant impact on these species.

Table 5-25 also provides the list of avian species and the method of reporting their presence or absence in or near the project area. The national risk status categories are based upon “The conservation status of Birds in Laos: a review of key species” (Thewlis *et al.* 1998) and *A Field Guide to the Birds in Lao PDR* 2003. Two species identified during interviews that are globally threatened vulnerable species are the green peafowl and the Rufous-neck hornbill (*Aceros nipalensis*). Species in the IUCN Red List (2009) found in or near the project area or identified through interviews were:

- CR (Critically Endangered) 1 species: *Gyps bengalensis*,
- EN (Endangered) 2 species: *Cairina scutulata* and *Arborophila davidi*,

- VU (Vulnerable) 2 species: *Aceros nipalensis* and *Aquila heliaca*,
- NT (Near Threatened) 9 species: *Anhinga melanogaster*, *Megalaima rafflesii*, *Rhinoplax vigil*, *Chloropsis cyanopogon*, *Arborophila charltonii*, *Lophura diardi*, *Lophura diardi*, *Pycnonotus eutilotus* and *Harpactes duvaucelii*, and
- LC (Least Concern) 84 species, among them *Antracoceros albirostris*, *Ducula badia* and *Columba pulchricollis*.

Table 5-23 Wildlife Conditions within and around the Project Area: Mammals (NOTE: PLEASE DEFINE THE SCOPE AND E XTENT OF COVERAGE OF THE “WITHIN PROJECT AREA” AND ALSO THE “OUTSIDE PROJECT AREA”)

| English (Lao) Name (Common Name) | Scientific Name | Within Project Area | Outside Project Area | Classification and Status | Identification of Sites Survey within the project Area | | IUCN Red List Status |
|---|---|---|---|---|---|---|---|
| | | | | | Reservoir area | Dam site | |
| **Mammal Species:** | | | | | | | |
| **Bovidae** | | | | | | | |
| Gaur (Meuey) | *Bos gaurus* | S | S | | | | VU |
| Chinese Serow (Nheuang) | *Capricornis milneedwardsi* | A | A | Prohibited List 1 | R2 | R2 | VU |
| **Canidae** | | | | | | | |
| Asiatic Jackal (Ma Jork) | *Canis aureus* | S | S | | | | LC |
| Asian Wild Dog (Ma Nai) | *Cuon alpinus* | S | S | | | | EN |
| **Cercopithecidae** | | | | | | | |
| Stump-Tailed Macacque (Ling Kung) | *Macaca arctoides* | S | S | | | | VU |
| Asamese Macaque (Ling Sehn) | *Macaca assamensis* | S | S | | | | NT |
| Rhesus Macacque (Ling Vork) | *Macaca mulatta* | S | S | | | | LC |
| Monkey (Ling) | *Macaca* spp. | A | A | Managed List 2 | R1 | R2 | |
| Red-shanked Douc Langur (Khadeng) | *Pygathrix nemaeus* | D | A | Prohibited List 1 | | | EN |
| Phayre’s Langur | *Trachypithecus phayrei* | S | S | | | | EN |
| **Cervidae** | | | | | | | |
| Sambar Deer (Kouang) | *Rusa unicolor* | A | A | Managed List 2 | R2 | R2 | VU |
| Barking Deer (Fan) | *Muntiacus muntjak* | A | A | Managed List 2 | R1/[] | R1 | LC |
| **Cynocephalidae** | | | | | | | |
| Colugo (Malayan Flying Lemur) (Bahng Hog) (Bahng Nai)) | *Galeopterus variegatus* | S | S | | | | LC |
| **Elephantidae** | | | | | | | |
| Asistic Elephant (Xang) | *Elephas maximus* | S | S | | | | EN |
| **Felidae** | | | | | | | |
| Asian Golden Cat (Seua Fai (Seua Daeng)) | *Pardofelis temminckii* | D | A | Prohibited List 1 | | | NT |
| Fishing cat (Seua Pa) | *Prionailurus viverrinus* | S | S | | | | EN |
| Marbled Cat (Seua Maeo) | *Pardofelis marmorata* | S | S | | | | VU |
| Tiger (Seua Khong) | *Panthera tigris* | S | S | | | | EN |
| Wildcat/Leopard cat (Seua Meo) | *Prionailurus bengalensis* | A | A | Prohibited List 1 | R2 | - | LC |
| **Hylobatidae** | | | | | | | |
| Whitecheeked crested gibbon (Thany) | *Hoolock leuconedys* | D | A | Prohibited List 1 | | | VU |
| **Hystricidae** | | | | | | | |
| Porcupine (Men) | *Hystrix brachyura* | A | A | Managed List 2 | R2 | R1 | LC |
| Asiatic Brush-tailed Porcupine (Hone) | *Atherurus macrourus* | A | A | - | R2 | R1 | LC |
| **Lorisaadea** | | | | | | | |
| Asian Slow Loris (Ling Lom) | *Nycticebus bengalensis* | S | S | | | | VU |
| Pygmy Loris | *Nycticebus pygmaeus* | S | S | | | | VU |
| **Manidae** | | | | | | | |
| Pangolin (Liin) | *Manis javanica* | A | A | Managed List 2 | R2 | R2 | EN |

| English (Lao) Name (Common Name) | Scientific Name | Within Project Area | Outside Project Area | Classification and Status | Identification of Sites Survey within the project Area | | IUCN Red List Status |
|---|---|---|---|---|---|---|---|
| | | | | | Reservoir area | Dam site | |
| **Mustelidae** | | | | | | | |
| Hog Badger (Mu Leung) | *Arctonyx collaris* | S | S | | | | NT |
| Common Otter (Nahk) | *Lutra lutra* | S | S | | | | NT |
| Large-toothed Ferret-Badger (Ma Leung) | *Melogale personata* | S | S | | | | DD |
| Back Striped Weasel (Phung Porn) | *Mustela strigidorsa* | S | S | | | | LC |
| **Pteropodidae** | | | | | | | |
| Greater Short-Nosed Fruit Bat | *Cynopterus sphinx* | S | S | | | | LC |
| Geoffroy's Rousettle | *Rousettus amplexicaudatus* | S | S | | | | LC |
| **Rhinolophidae** | | | | | | | |
| Horseshoe Bat | *UNIDENTIFIED* | S | S | | | | |
| **Rhizomyidae** | | | | | | | |
| Horay Bamboo Rat (Onn Khaem) | *Rhizomys pruinosus* | S | S | | R1 | R1 | LC |
| Large Bamboo Rat (Onn Hok) | *Rhizomys sumatrensis* | S | S | | R1 | R1 | LC |
| **Sciuridae** | | | | | | | |
| Variable Squirrel (Ka Hok Lark Sy) | *Callosciurus finlaysonii* | S | S | | R1/F | R1 | LC |
| Grey-Bellied Squirrel | *Callosciurus caniceps caniceps* | S | S | | | | LC |
| Red-Cheeked Squirrel | *Dremomys rufigenis* | S | S | | | | LC |
| Phayre's Flying Squirrel | *Hylopetes phayrei* | S | S | | | | LC |
| Lesser Giant Flying Squirrel (Bahng Lua) | *Petaurista elegans* | S | S | | | | LC |
| Red Giant Flying Squirrel (Bahng Lua) | *Petaurista petaurista* | S | S | | | | LC |
| Flying squirrel (Baang) | Subfamily Sciurinae, Tribe Pteromyini | D | A | Prohibited List 1 | | | |
| **Suidae** | | | | | | | |
| Wild boar (Mou Paa) | *Sus scrofa* | A | A | - | R1/[] | R1 | LC |
| **Talpidae** | | | | | | | |
| Kloss's Mole (Teung) | *Euroscaptor klossi* | S | S | | | | LC |
| **Tragulidae** | | | | | | | |
| Lesser Mouse Deer (Kaay) | *Tragulus javanicus* | A | A | Managed List 2 | R1 | R1 | DD |
| **Tupaiidae** | | | | | | | |
| Northern Treeshrew (Ka Tae) | *Tupaia belangeri* | S | S | | R1 | R1 | LC |
| **Ursidae** | | | | | | | |
| Malayan Sun Bear (Mee Born) | *Helarctos malayanus* | D | A | Prohibited List 1 | | | VU |
| Asian Black Bear (Meuey) | *Ursus thibetanus* | S | S | | R1 | R1 | VU |
| **Viverridae** | | | | | | | |
| Binturong (Ngen Hang Kho) | *Arctictis binturong* | S | S | | | | VU |
| Three Striped Palm Civet (Ngen Omm Na Daen) | *Arctogalidia trivirgata* | S | S | | | | LC |
| Javan Mongoose (Phung Porn) | *Herpestes javanicus* | S | S | | | | LC |
| Masked Palm Civet (Ngen Kheua Khow) | *Paguma Iarvata* | S | S | | | | LC |
| Common Palm Civet (Ngen Omm Tin Tam) | *Paradoxurus hermaphroditus* | S | S | | R2 | R1 | LC |
| Small Indian Civet (Ngen Faeng) | *Viverricula indica* | S | S | | | | LC |
| Three-Striped Palm Civet | *Viverra zibetha* | S | S | | | | NT |
| Common palm civet (Ngen Om) | *Paradoxurus hermaphroditus* | A | A | - | | | LC |

Table 5-24 Wildlife Conditions within and around the Project Area: Reptiles and Amphibians

| English (Lao) Name (Common Name) | Scientific Name | Within Project Area | Outside Project Area | Classification and Status | Identification of Sites Survey within the project Area | | IUCN Red List status |
|---|---|---|---|---|---|---|---|
| | | | | | Reservoir area | Dam site | |
| ***Reptile Species:*** | | | | | | | |
| **Agamidae** | | | | | | | |
| Asian Water Dragon (Kathang) | *Physignathus cocincinus* | A | A | Managed List 2 | R1 | R1 | - |

| English (Lao) Name (Common Name) | Scientific Name | Within Project Area | Outside Project Area | Classification and Status | Identification of Sites Survey within the project Area | | IUCN Red List status |
|---|---|---|---|---|---|---|---|
| | | | | | Reservoir area | Dam site | |
| **Serpentes** | | | | | | | |
| **Colubridae** | | | | | | | |
| Indochinese Sand Snake (Ngou Xeuak Phat) | *Psammophis condanarrus* | A | A | - | R1 | R1 | - |
| Common Ratsnake (Ngou Sing) | *Ptyas mucosus* | A | A | - | R1 | R1 | - |
| Black Rat Snake | *Ptyas carinatus* | S | S | | | | - |
| Red-Necked Keelback Snake | *Rhabdopsis subminiatus* | S | S | | | | - |
| **Elapidae** | | | | | | | |
| King Cobra | *Ophiophagus hanah* | S | S | | | | - |
| **Naja** | | | | | | | |
| Monocled cobra (Ngou Haou) | *Naja kaouthia* | A | A | Managed List 2 | R2 | R2 | - |
| **Pythonidae** | | | | | | | |
| Reticulated Python (Gnou Leuam) | *Python reticulates* | A | A | Prohibited List 1 | R2 | R2 | - |
| **Not Clearly Identified** | | | | | | | |
| Green Snake (Ngou Khieo) | - | A | A | - | R2 | R2 | - |
| **Scincidae** | | | | | | | |
| Sun Skink | *Mabuya multifasciata* | S | S | | | | - |
| **Testudinidae** | | | | | | | |
| Tortoises (Tau) | *Testudo* spp. | A | A | Managed List 2 | R2 | R2 | - |
| **Varanidae** | | | | | | | |
| Water monitor (Hiaa) | *Varanus salvattor* | A | A | Managed List 2 | R1 | R1 | - |
| Jellow Tree Monitor (Len) | *Varanus bengalensis* | A | A | - | R1 | R1 | - |
| ***Amphibian Species:*** | | | | | | | |
| **Dicroglossidae** | | | | | | | |
| (Kob Hin/Kob Dong) | *Annandia delacouri* | A | A | - | | | DD |
| **Microhylidae** | | | | | | | |
| (Khiet Leuang) | *Microhyla berdmorei* | A | A | - | | | LC |
| **Ranidae** | | | | | | | |
| (Khiet Lai/Hin) | *Amolops cremnobatus* | A | A | - | | | NT |
| **Rachophoridae** | | | | | | | |
| (Khiet Ta Pat Leuang) | *Rhacophorus calcaneus* | A | A | - | | | NT |
| (Khiet Ta Pat Tong) | *Rhacophorus reinwardtii* | A | A | - | | | NT |

## Table 5-25 Wildlife Conditions within and around the Project Area: Birds (Avian)

| English (Lao) Name (Common Name) | Scientific Name | Within Project Area | Outside Project Area | Classification and Status | Identification of Sites Survey within the project Area | | IUCN status |
|---|---|---|---|---|---|---|---|
| | | | | | Reservoir area | Dam site | |
| ***Birds Species:*** | | | | | | | |
| **Accipitridae** | | | | | | | |
| Imperial Eagle (Leo) | *Aquila heliaca* | A | A | Managed List 2 | R1/F | R1/F | VU |
| White backed vulture (Heng Khorkham) | *Gyps bengalensis* | D | A | Prohibited List 1 | | | CR |
| **Anatidae** | | | | | | | |
| White winged duck (Nok Pet Nam) | *Cairina scutulata* | D | A | Managed List 2 | | | EN |
| **Anhingidae** | | | | | | | |
| Oriental Darter (Nok Khor Gnou) | *Anhinga melanogaster* | D | A | Managed List 2 | | | NT |
| **Apodidae** | | | | | | | |
| Himalayan Swiftlet (Nok En) | *Collocalia brevirostris* | | | | F | | LC |
| **Ardeidae** | | | | | | | |
| Intermediate egret (Nok Nhang Noy) | *Mesophoyx intermedia* | D | A | - | | | LC |
| Blue Throated barbet | *Megalaima asiatica* | S | S | | | | LC |
| Blue Eared barbet | *Megalaima asiatica* | S | S | | | | LC |
| Gold Whiskered barbet | *Megalaima chrysopogon* | S | S | | | | LC |
| Green Eared Barbet | *Megalaima faiostricta* | S | S | | | | LC |
| Golden Throated Barbet | *Megalaima franklinii* | S | S | | | | LC |

| English (Lao) Name (Common Name) | Scientific Name | Within Project Area | Outside Project Area | Classification and Status | Identification of Sites Survey within the project Area | | IUCN status |
|---|---|---|---|---|---|---|---|
| | | | | | Reservoir area | Dam site | |
| ***Birds Species:*** | | | | | | | |
| Coppersmith Barbet | *Megalaima haemacephala* | S | S | | | | LC |
| Moustached Barbet | *Megalaima incognita* | S | S | | | | LC |
| Red Crowned Barbet | *Megalaima rafflesii* | S | S | | | | NT |
| **Bucerotidae** | | | | | | | |
| Oriental Pied Hornbill (Nok Keng) | *Antracoceros albirostris* | D | A | Managed List 2 | R2 | | LC |
| Helmeted Hornbill Nok kok | *Rhinoplax vigil* | S | S | | | | NT |
| Rufous-necked Hornbill (Nokkok kho-kham) | *Aceros nipalensis* | D | A | Prohibited List 1 | | | VU |
| **Caprimulgidae** | | | | | | | |
| Grey Nightjar | *Caprimulgus indicus* | S | S | | | | LC |
| **Chloropseidae** | | | | | | | |
| Blue Winged Leaf Bird | *Chloropsis cyanopogon* | S | S | | | | NT |
| **Columbidae** | | | | | | | |
| Green Winged Pigeon | *Chalcophaps indica* | S | S | | | | LC |
| Mountain Imperial Pigeon (Nok Moum) | *Ducula badia* | A | A | - | R2 | | LC |
| Oriental Turtle Dove | *Streptopelia orientalis* | S | S | | F | F | LC |
| Spotted Dove (Nok Kao) | *Streptopelia tranquebarica* | S | S | | R1/F | R1 | LC |
| Orange Breasted Pigeon (Nok Pao) | *Treron bicincta* | S | S | | | | LC |
| Thick Billed Pigeon | *Treron curvirostra* | S | S | | | | LC |
| Pink Necked Pigeon | *Treron vernans* | S | S | | | | LC |
| Green Pigeon (Nok Paao) | *Columba pulchricollis* | A | A | - | R1 | R1 | LC |
| Spotted necked dove (Nok Khao) | *Streptopelia tranquebarica* | A | A | Managed List 2 | | | LC |
| **Corvidae** | | | | | | | |
| Large-Billed Crow | *Corvus macrorhynchos* | S | S | | | | LC |
| Black-Billed Magpie | *Pica pica* | S | S | | | | LC |
| Rufos Treepie | *Dendrocitta vagabunda* | S | S | | | | LC |
| Racket-Tailed Treepie | *Crrpsirina temia* | S | S | | | | |
| **Cuculidae** | | | | | | | |
| Green-Billed Malkoha | *Phaenicophaeus tristis* | S | S | | | | LC |
| Lesser Coucal | *Centropus bengalensis* | S | S | | | | LC |
| Greater Coucal (Nok Kot) | *Centropus sinensis* | A | A | - | R1/F | R1/F | LC |
| **Dicruridae** | | | | | | | |
| Bronzed Drongo | *Dicrurus aeneus* | S | S | | | | LC |
| Black Drongo | *Dicrurus macrocercus* | S | S | | R1 | R1 | LC |
| Greater Racket Tailed Drongo | *Dicrurus paradiseus* | S | S | | | | LC |
| Lesser Racket Tailed Drongo | *Dicrurus remifer* | S | S | | | | LC |
| **Estrildidae** | | | | | | | |
| Scaly-Breasted Munia (Nok Ka Pid) | *Lonchura punctulata* | | | | R1/C | R1 | LC |
| **Eurylaimidae** | | | | | | | |
| Long Tailed Broadbill | *Psarisomus dalhousiae* | S | S | | | | LC |
| **Hirundinidae** | | | | | | | |
| Asian house Martin | *Delichon dasypus* | S | S | | | | LC |
| Barn Swallow | *Hirundo rustica* | S | S | | | | LC |
| **Motacillidae** | | | | | | | |
| Grey Wagtail | *Motacilla cinerea* | S | S | | | | LC |
| Forest Wagtail | *Dendronanthus indicus* | S | S | | F | | LC |
| **Muscicapidae** | | | | | | | |
| Pale Blue Flycatcher | *Cyornis unicolor* | S | S | | | | LC |
| **Nectariniidae** | | | | | | | |
| Crimson Sunbird | *Aethopyga siparaja* | S | S | | | | LC |
| Purple Sunbird | *Nectarinia asiatica* | S | S | | | | LC |
| **Oriolidae** | | | | | | | |
| Asian Fairy Blue Bird | *Irena puella* | S | S | | | | LC |
| **Phasianidae** | | | | | | | |
| Bar-Backed Partidge | *Arborophila brunneopectus* | S | S | | | | LC |
| Scaly-breasted Partridge (Nok Kho) | *Arborophila charltonii* | S | S | | | | NT |
| Chinese Francolin | *Francolinus pintadeanus* | S | S | | | | LC |
| Red Jungle Fowl (Kay Paa) | *Gallus gallus* | A | A | - | R1/O | R1/O | LC |
| Siamese Fireback (Kay Khoua) | *Lophura diardi* | A | A | Prohibited List 1 | | | NT |
| Silver Pheasant (Kay Khoua | *Lophura nycthemera* | A | A | Prohibited List 1 | R1 | R1 | LC |

| English (Lao) Name (Common Name) | Scientific Name | Within Project Area | Outside Project Area | Classification and Status | Identification of Sites Survey within the project Area | | IUCN status |
|---|---|---|---|---|---|---|---|
| | | | | | Reservoir area | Dam site | |
| ***Birds Species:*** | | | | | | | |
| Luang) | | | | | | | |
| Grey Peacock Pheasant (Nok Kang Kort) | *Polyplectron bicalcaratum* | A | A | Managed List 2 | | | LC |
| **Pittidae** | | | | | | | |
| Eared Pitta | *Pitta phayrei* | S | S | | | | LC |
| Blue Pitta | *Pitta cyanea* | S | S | | | | LC |
| **Psittacidae** | | | | | | | |
| Red Breasted Parakeet | *Psittacula alexandri* | S | S | | | | LC |
| Alexandrine Parakeet | *Psittacula eupatria* | S | S | | | | LC |
| Grey Headed Parakeet | *Psittacula finschii* | S | S | | | | LC |
| Bossom Headed Parakeet | *Psittacula roseata* | S | S | | | | LC |
| Parakeets (Nok Keo) | *Psittacula* spp. | A | A | Managed List 2 | R1 | | |
| Upupidae | | | | | R1/F | R1 | |
| Common Hoopoe (Nok Hone) | *Upupa epops* | | | | | | LC |
| **Pycnonotidae** | | | | | | | |
| White-Headed Bulbul | *Hypsipetes thompsoni* | S | S | | | | LC |
| Puff-Throated Bulbul | *Alophoixus pallidus* | S | S | | | | LC |
| Ashy Bulbul | *Hemixos flavala* | S | S | | | | LC |
| Black-Headed Bulbul | *Pycnonotus atriceps* | S | S | | | | LC |
| Puff Backed Bulbul | *Pycnonotus eutilotus* | S | S | | | | NT |
| Stripe Throated Bulbul | *Pycnonotus finlaysoni* | S | S | | | | LC |
| Flavescent Bulbul | *Pycnonotus flavescens* | S | S | | | | LC |
| Red Whiskered Bulbul | *Pycnonotus jocosus* | S | S | | | | LC |
| Black Crested Bulbul | *Pycnonotus melanicterus* | S | S | | | | LC |
| Cream Vented bulbul | *Pycnonotus simplex* | S | S | | | | LC |
| **Rallidae** | | | | | | | |
| White Breasted Waterhen | *Amaurornis phoenicurus* | S | S | | | | LC |
| Ruddy-breasted Crake (Nok Kay Na) | *Porzana fusca* | A | A | - | R1/F | R1 | LC |
| **Rostratulidae** | | | | | | | |
| Greater Painted Snipe | *Rostratula benghalensis* | S | S | | | | LC |
| **Strigiformes** | | | S | | | | |
| Brown Hawk Owl | *Ninox scutulata* | S | S | | | | LC |
| Common Scops Owl | *Otus scops* | S | S | | | | LC |
| Mountain scops Owl | *Otus spilocephalus* | S | S | | | | LC |
| Asian Barred Owls (Nok Khaow) | *Glaucidium cuculoides* | A | A | Prohibited List 1 | RI/F | R1/O | LC |
| **Sturnidae** | | | | | | | |
| Hill Myna (Nok Sa Li Ka) | *Gracula religiosa* | A | A | Managed List 2 | | | LC |
| White-Vented Myna (Nok Ieng Mong) | *Acridotheres grandis* | | | | F | | LC |
| **Sylviidae** | | | | | | | |
| White-Tailed Leaf-Warble | *Phylloscopus davisoni* | S | S | | | | LC |
| Golden Spectacled Warbler | *Seicercus burkii* | S | S | | | | LC |
| White-rumped Shama (Nok Tem Poun) | *Copsychus malabaricus* | A | A | - | R2 | | LC |
| **Timaliidae** | | | | | | | |
| White Headed Babbler | *Gampsorhynchus rufulus* | S | S | | | | LC |
| White-Crested Laughingthrush | *Garrulax leucolophus* | S | S | | | | LC |
| **Trogonidae** | | | | | | | |
| Scarlet Rumped Trogon | *Harpactes duvaucelii* | S | S | | | | NT |
| **Turdidae** | | | | | | | |
| White Rumped Shama | *Copsychus malabaricus* | S | S | | | | LC |
| Blue Whistling Thrush | *Myophonus caeruleus* | S | S | | | | LC |
| Cark-Sided Thrush | *Zoothera marginata* | S | S | | | | LC |
| **Turnicidae** | | | | | | | |
| Barred Buttonquail | *Turnix Suscitator* | S | S | | | | LC |
| Yellow Legged Buttonquail | *Turnix tanki* | S | S | | | | LC |

Source: Interviews and field surveys, March and October 2007; and Nippon Koei Co., Ltd. (2000): *Final Report (Vol. 1).*

Note: A = Indicates "Appearance" according to survey of villagers. D = Indicates "Disappearance" according to survey of villages. S = Indicates the information is based on Secondary Data, from the "Feasibility study on the Nam Ngiep-I hydroelectric power project in the LAO People's Democratic Republic, 2000"

- The classification and status of wildlife based on the Regulation of the Ministry of Agriculture and Forestry No. 0360/MAF, dated 8th Dec. 2003:

  C = Common: seen daily, often in large numbers, in favored habitat

  F = Frequent: see on most days favored habitat is visited, but not usually in large number

  P = Present: abundance was not assessed

  R = Reports: information gathered from villager's interview

  - R1: Always seen
  - R2: Sometime found

  O = Occasional: seen on fewer than haft the days

  H = Remains of the species were found, usually in a village or with a hunting party.

  [ ] = Indicates a provisional identification

  NA: Not Available

- The classification of wildlife according to the IUCN Red List (2009)

  - CR = Critically Endangered
  - EN = Endangered
  - VU = Vulnerable
  - NT = Near Threatened
  - LC = Least Concern
  - DD = Data Deficient

Lao name: Ka Hork

English name: Nonflying Squirrel

Scientific name: *Sciuridae*

Lao name: Nok Khaow

English name: Owls

Scientific name: *Glaucidiun spp.*

Lao name: Kaay

English name: Lesser Mouse Deer

Scientific name: *Tragulas javanicus*

Lao name: Ngou Sing

English name: Common Ratsnake

Scientific name: *Ptyas mucosus*

Figure 5-27 Typical animals found in the project area.

### 5.2.2 FORESTS, 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.

The surveyed area is broadly defined as the area north of the dam site extending to the northern margin of the reservoir, covering the proposed reservoir area. The surveys were conducted to provide baseline information on the distribution of forest types and vegetation to determine likely impacts of the project on such flora and to assess how any such impacts might be mitigated through appropriate intervention. The field survey was conducted on October 2007 to collect primary data concerning tree and vegetation species, density and estimated volume per hectare for big tree species with a diameter at breast height (DBH) of more than 10 centimeters. The main method used in this survey is similar to that used for the wildlife survey including interviews with villagers, especially senior persons who have experience with the types of vegetation and non-timber forest products in their vicinity. The villagers were questioned on land use as well as lists of vegetation and NTFPs. Detailed methodology for conducting primary data collection is discussed in Section 3.2.2 F orest, Vegetation Cover.

#### 5.2.2.1 General Conditions in the Provinces Affected by the Project

According to the Report on the Assessment of Forest Cover and Land Use during 1992-2002, (Department of Forestry, July 2005) for the Northern Part of Lao PDR (including the project area), 28% of the total land area is covered by the Current Forest[5], while 66.5% is covered by Potential Forest[6], approximately 1% is other wooded area, 1.5% is permanent agricultural land, and 3% other land uses. For Xieng Khouang Province, 38.6% of the total land area of the province was Current Forest, while 49% was Potential Forest, 0.4% other wooded area, 3% is permanent agricultural land and 9% other land uses. A reported 24.3% of Vientiane Province was covered by Current Forest, and 60.6% covered by Potential Forest, 1.8% other wooded area, 4.7% is permanent agricultural land and 8.5% other land uses.

#### 5.2.2.2 Forest and Vegetation Cover within the Project Area

The definition of the project area used for this section refers only those lands covered by the proposed reservoir, the dam sites and powerhouse. The Lao landscape has historically been dominated by dense forest and, despite more recent clearance, still 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,

[5] ***Current Forest includes natural forests and plantation forests. It is used to refer to land with a tree canopy cover of more than 20% and area of more than 0.5 ha. The trees should be able to reach a minimum height of 5 m.*** The basis for the distinction between forest and other land use groups is the crow density. In this study the natural forests are classified into forest types which composed of Upper and Lower Dry Evergreen Forests, Upper and Lower Mixed Deciduous Forests, Gallery Forest, Coniferous Forest, Mixed Broadleaved and Coniferous Forest, and Dry Dipterocarp.

[6] ***Previous forest areas where the crown cover has been reduced below 20% for some reason (logging or shifting cultivation) are classified as Potential Forest.*** The potential forest includes Bamboo, old shifting cultivation areas (young secondary forests) and Temporary Unstocked areas.

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.

Based on a review of the 2002 Land Use and Forest Cover maps for the regions in which the Nam Ngiep 1 Hydropower will be constructed, and from the interviews with villagers, as well as observations made during the field survey, the following observations were made regarding the conditions of forests and land use within the project area.

Based on the 320 MSL full supply level (Full Reservoir Load), slightly more than 7,700 ha will be directly affected. The Land Use and Forest Types Map of this area shows that inundated lands will consist of about 1.62% Dry Evergreen Forest and approximately 40% Mixed Deciduous, while the largest portion of the reservoir area (almost 46%) is covered by Unstocked Forest and Scrub and about 2% Bamboo forest. Apart from these, some agricultural land[7] will be affected: 3.3% of the area is swidden or shifting cultivation and 7% is rice paddy fields. Based on the study, the landuses in the immediate project area (the reservoir) are presented in Table 5-26, with a comparison to the area of similar landuses in the entire catchment area. The forest cover distribution will be updated in the dry season 2012-2013 or prior to reservoir impoundment. (TO BE CONFIRMED BY THE PROJECT SPONSOR)

Table 5-26 Land Use and Forest Types in the Reservoir Area with FSL 320 MSL

| Forest Category | Land Use and Forest Types | Area (ha) | Percent in total Reservoir (%) | Area of this landuse in entire catchment (ha) | Proportion of landuse in reservoir to same landuse in entire catchment to be affected (%) |
|---|---|---|---|---|---|
| Current Forest | Dry Evergreen Forest (DE) | 125 | 1.62 | 23,690 | 0.53 |
| | Mixed Deciduous (UMD) | 3,089 | 40.00 | 101,420 | 3.05 |
| Potential Forest | Unstocked Forest (T) | 3,551 | 45.99 | 209,725 | 1.69 |
| | Bamboo (B) | 158 | 2.05 | 852 | 18.54 |
| | Swidden (Ray, RA) | 255 | 3.30 | 3,383 | 7.54 |
| Permanent Agriculture Land | Rice Paddy Field (RP) | 544 | 7.04 | 11,777 | 4.62 |
| | Other Agricultural Land (OA) | 0 | 0.0 | 0 | 0.0 |
| | Total | 7,722 | 100 | 350,847 | 2.2 |

Note: Focusing on the inundated areas of the reservoir.

[7] This includes permanent and non permanent cultivation areas.

Land uses for the entire catchment area are presented in Table 5-27. Unstocked forest is even more predominant in the entire area (over 53%), while Mixed Deciduous was the main type of current forest (over 25%).

Table 5-27 Land Use and Forest Types in the NNHP-1 Catchment Area

| Category | Land Use and Forest Types | Area (ha) | Percent (%) |
|---|---|---|---|
| Current Forest | Dry Evergreen Forest (DE) | 23,690 | 6.0 |
| | Mixed Deciduous (MD) | 101,420 | 25.8 |
| | Coniferous Forest (S) | 821 | 0.2 |
| | Mixed Coniferous and Broad-Leaved (MS) | 5,922 | 1.5 |
| Potential Forest | Unstocked Forest (T) | 209,725 | 53.4 |
| | Bamboo (B) | 852 | 0.2 |
| | Swidden (Ray, RA) | 3,383 | 0.9 |
| Other Wooded Area | Savannah/Open Woodland (SH) | 2,751 | 0.7 |
| | Scrub (SR) | 851 | 0.2 |
| Permanent Agriculture Land | Rice Paddy Field (RP) | 11,777 | 3.0 |
| | Other Agricultural Land (OA) | 0 | 0.0 |
| Other Non-Forested Areas | Barren Land and Rock (R) | 30 | 8.0 |
| | Grassland (G) | 31,303 | 0.0 |
| | Swamp (SW) | 13 | 6.0 |
| | Total | 392,537 | 100 |

Note: The Land use and Forest Types in the Table are included the reservoir area.

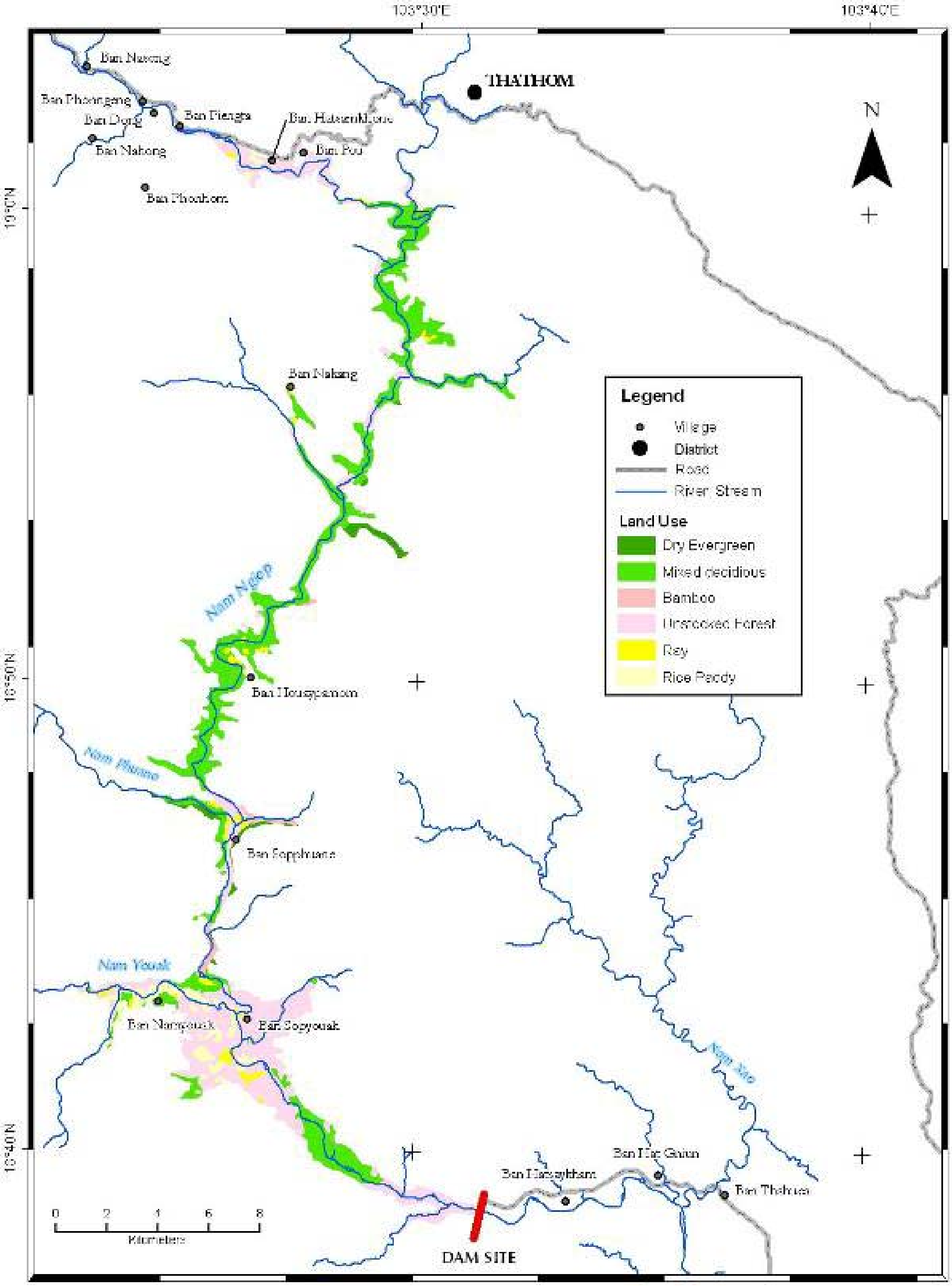



Figure 5-28 Land use and forest types in the proposed NNHP-1 reservoir.

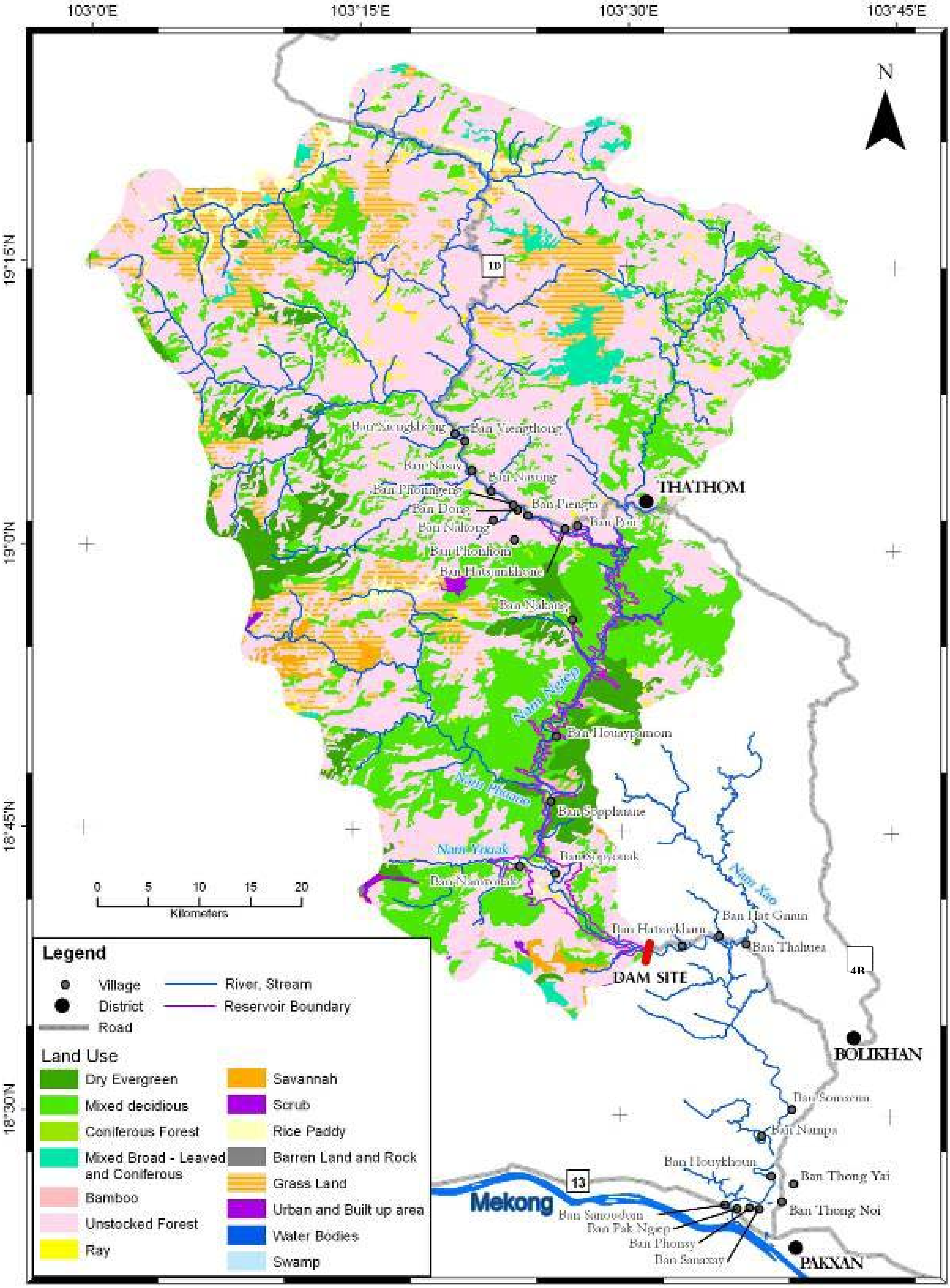



Figure 5-29 Land use and forest types in the NNHP-1 catchment area.

### 5.2.2.3 The Main Tree Species (with DBH ≥ 10 cm)

All tree species were recorded in the sample plots set-up during the field survey. The forest types are classified according to the classification and definition of Forest Inventory and Planning Division, Department of Forestry (see Box 1, Chapter 3). In addition to the broad categorization of vegetation according to the land use planning classification system, a closer identification of plant communities was undertaken for the areas likely to be most affected by the proposed hydropower development.

A vegetation map has been produced based on analysis of satellite imagery and aerial photographs. According to the field reconnaissance survey and interviews, a larger portion of the project area was already significantly disturbed years ago by conversion of forest land into other land use types, mostly agriculture, but also burning forests for hunting and illegal logging within and near the proposed reservoir and dam site. The land is a medley of vegetation communities, with local agricultural practices heavily impacting on species composition and maturity. Three main forest types are found in the area of the Nam Ngiep 1 Hydropower Project, with the dominant species shown in Table 5-28 below:

Table 5-28 Forest Types and Main Tree Species found in the Project Area

| No | Forest Types | Scientific Name | Lao Name | Classification |
|---|---|---|---|---|
| 1 | Dry Evergreen Forest | 1) *Cinnamomum liseafolium* | May Chuang | Special List |
| | | 2) *Hopea odorata* | May Khen Heua | Special List |
| | | 3) *Lagerstroemia florribunda* | May Peuay Khao | Managed List 1 |
| | | 4) *Ailanthus fauveliana* | May Nhom Pha | Managed List 1 |
| | | 5) *Vatica cineria* | May Xi Dong | Managed List 1 |
| | | 6) *Duabanga sonneratioides* | May Ten | Managed List 1 |
| | | 7) *Dipterocarpus turbinatus* | May Nhang Dong | Managed List 1 |
| | | 8) *Pentacme siamensis* | May Hang | Managed List 1 |
| | | 9) *Vatica astrotricha* | May Khen Phai | Managed List 1 |
| | | 10) *Dipterocarpus tuberculatus* | May Kung (Tong Kung) | Managed List 2 |
| | | 11) *Albissia codoratisima* | May Houa Lon | Managed List 2 |
| | | 12) *Pentace burmanica* | May Si Siet | Managed List 2 |
| | | 13) *Vitex altisima* | May Khi Ngen | Managed List 2 |
| | | 14) *Castanopsis hystrix* | May Kor (Nam) | Managed List 2 |
| | | 15) *Castanopsis annamonsis* | May Kor Khi Mou | Managed List 2 |
| | | 16) *Tetramaleles nudiflora* | May Phung | Managed List 2 |
| | | 17) *Cinnamomum iners* | May Sikhay Ton | Managed List 2 |
| | | 18) *Peperomia pellusida* | May Ka Xang | Managed List 2 |
| | | 19) *Dialium indum* | May Kham Phep | Managed List 2 |
| | | 20) *Carallia lucida* | May Bong Nang | Managed List 3 |
| | | 21) *Vitex pinnata* | May Tin Nok | Managed List 3 |

| No | Forest Types | Scientific Name | Lao Name | Classification |
|---|---|---|---|---|
| 1 | | *22) Steeospermum Spp* | May Khe (Deng) | Managed List 3 |
| | | *23) Canarium kerrii* | May Kok Leuam | Managed List 3 |
| | | *24) Cassia siamea* | May Khi Lek | Managed List 3 |
| | | *25) Holarrhaena antidysenterica* | May Mouk | Managed List 3 |
| | | *26) Bombax anceps* | May Ngew Paa | Managed List 3 |
| | | *27) Anogeissus acuminata* | May Ben Mon | Managed List 3 |
| | | *28) Sterculia villosa* | May Por | Managed List 3 |
| | | *29) Baccaurea Oxycarpa Gagnepain* | May Mak Fay | - |
| | | *30) -* | May Deua Pong | - |
| | | *31) -* | May Meuat | - |

| No | Forest Types | Scientific Name | Lao Name | Classification |
|---|---|---|---|---|
| 2 | Mixed Deciduous Forest | *1) Pterocarpus pedatus* | May Dou | Special List |
| | | *2) Cinnamomum liseafolium* | May Chuang | Special List |
| | | *3) Hopea odorata* | May Khen Heua | Special List |
| | | *4) Xylia kerrii* | May Deng | Special List |
| | | *5) Hopea ferrea* | May Khen Hin | Managed List 1 |
| | | *6) Lagerstroemia florribunda* | May Peuay | Managed List 1 |
| | | *7) Ailanthus fauveliana* | May Nhom Paa | Managed List 1 |
| | | *8) Vatica cineria* | May Xi Dong | Managed List 1 |
| | | *9) Sindora cochinchinensis* | May Tae Hor | Managed List 1 |
| | | *10) Duabanga sonneratioides* | May Ten | Managed List 1 |
| | | *11) Dipterocarpus turbinatus* | May Nhang Dong | Managed List 1 |
| | | *12) Pentacme siamensis* | May Hang | Managed List 1 |
| | | *13) Vatica astrotricha* | May Khen Phai | Managed List 1 |
| | | *14) Dipterocarpus tuberculatus* | May Kung (Tong Kung) | Managed List 2 |
| | | *15) Dialium indum* | May Kham Phep | Managed List 2 |
| | | *16) Albissia codoratisima* | May Houa Lon | Managed List 2 |
| | | *17) Pelthopholum dasyrhachis* | May Sa Fang (Sa Kham) | Managed List 2 |
| | | *18) Dialium cochinchinensis* | May Kheng | Managed List 2 |
| | | *19) Pentace burmanica* | May Si Siet | Managed List 2 |
| | | *20) Irvingia cambodiana* | May Bok | Managed List 2 |
| | | *21) Vitex altisima* | May Khi Ngen | Managed List 2 |
| | | *22) Castanopsis hystrix* | May Kor (Nam) | Managed List 2 |
| | | *23) Castanopsis annamonsis* | May Kor Khi Mou | Managed List 2 |
| | | *24) Tetramaleles nudiflora* | May Phung | Managed List 2 |
| | | *25) Peperomia pellusida* | May Ka Xang | Managed List 2 |
| | | *26) Terminalia chebula vancitrina* | May Som Mor | Managed List 2 |
| | | *27) -* | May Nam Pheung | - |
| | | *28) Baccaurea Oxycarpa Gagnepain* | May Mak Fay | - |
| | | *29) Phyllanthus emblica L.* | May Kham Pom | - |
| | | *30) -* | May Phay | - |
| | | *31) -* | May Keo | - |
| | | *32) -* | May Bia | - |
| | | *33) -* | May Kong Sy | - |
| | | *34) -* | May Tong Khok | - |

| No | Forest Types | *Scientific Name* | Lao Name | Classification |
|---|---|---|---|---|
| 3 | Unstocked Forest | *1. Pterocarpus macrocarpus* | May Dou | Special List |
| | | *2. Aquilaris Sp.* | May Por Heuang | Special List |
| | | *3. Cinnamomum liseafolium* | May Chuang | Special List |
| | | *4. Hopea odorata* | May Khen Heua | Special List |
| | | *5. Xylia kerrii* | May Deng | Special List |
| | | *6. Vatica cineria* | May Xi | Managed List 1 |
| | | *7. Lagerstroemia florribunda* | May Peuay | Managed List 1 |
| | | *8. Duabanga sonneratioides* | May Ten | Managed List 1 |
| | | *9. Dipterocarpus turbinatus* | May Nhang | Managed List 1 |
| | | *10. Ailanthus fauveliana* | May Nhom | Managed List 1 |
| | | *11. Sindora cochinchinensis* | May Tae Hor | Managed List 1 |
| | | *12. Hopea ferrea* | May Khen | Managed List 1 |
| | | *13. Hopea ferrea* | May Khen Hin | Managed List 1 |
| | | *14. Pelthopholum dasyrhachis* | May Sa Fang | Managed List 2 |
| | | *15. Dipterocarpus tuberculatus* | May Tong Kung | Managed List 2 |
| | | *16. Dialium cochinchinensis* | May Kheng | Managed List 2 |
| | | *17. Pentace burmanica* | May Si Siet | Managed List 2 |
| | | *18. Irvingia cambodiana* | May Bok | Managed List 2 |
| | | *19. Sinnamomum iners* | May Si Khay (Ton) | Managed List 2 |
| | | *20. Dipterocarpus tuberculatus* | May Tong Kung | Managed List 2 |
| | | *21. Cratexylon prunifolium* | May Tiew | Managed List 2 |
| | | *22. Holarrhaena antidysenterica* | May Mouk | Managed List 2 |
| | | *23. Tetramaleles nudiflora* | May Phung | Managed List 2 |
| | | *24. Castanopsis annamonsis* | May Kor Khi Mou | Managed List 2 |
| | | *25. Vitex pinnata* | May Tin Nok | Managed List 2 |
| | | *26. Helicteres viscida Blume* | May Khi On | - |
| | | *27. Streblus ilicifolius (Vidal) Corner* | May Khi Het | - |
| | | *28. -* | May Ka Thang | - |
| | | *29. -* | May Por Mim | - |
| | | *30. Baccaurea Oxycarpa Gagnepain* | May Mak Fay | - |
| | | *31. Ziziphus cambodiana Pierre* | May Khom | - |
| | | *32. -* | May Khab | - |
| | | *33. -* | May Hou Xang | - |
| | | *34. -* | May Bong | - |
| | | *35. -* | May Nam Pheung | - |

Note: - Classification of the tree species is based on the Instruction of the Ministry of Agriculture and Forestry No. 0116/MAF.07, dated 17th May 2007.

- The tree species are only those with DBH equal to or more than 10 cm.

#### 5.2.2.4 The Average Number and Volume of stand Trees (with DBH ≥ 10 cm)

The number of trees and average volume for each tree species per one hectare of stand trees with DBH equal to or greater than 10 cm were calculated, by the different types of forests as shown in Table 5-29.

Table 5-29 Average Number and Volume of Tree Species per Hectare, of Trees with DBH ≥ 10 cm

| No | Forest Types | Scientific Name | Lao Name | No. of Tree per Hectare | Average Volume per Hectare ($m^3$) |
|---|---|---|---|---|---|
| 1 | Dry Evergreen Forest | 1) *Cinnamomum liseafolium* | May Chuang | 5.4 | 8.631 |
| | | 2) *Hopea odorata* | May Khen Heua | 15.8 | 13.465 |
| | | 3) *Lagerstroemia florribunda* | May Peuay Khao | 19.7 | 9.024 |
| | | 4) *Ailanthus fauveliana* | May Nhom Pha | 14.2 | 8.534 |
| | | 5) *Vatica cineria* | May Xi Dong | 8.5 | 6.935 |
| | | 6) *Duabanga sonneratioides* | May Ten | 6.3 | 3.420 |
| | | 7) *Dipterocarpus turbinatus* | May Nhang Dong | 7.4 | 5.028 |
| | | 8) *Pentacme siamensis* | May Hang | 11.3 | 8.057 |
| | | 9) *Vatica astrotricha* | May Khen Phai | 9.3 | 8.925 |
| | | 10) *Dipterocarpus tuberculatus* | May Kung (Tong Kung) | 8.2 | 4.476 |
| | | 11) *Albissia codoratisima* | May Houa Lon | 6.7 | 2.768 |
| | | 12) *Pentace burmanica* | May Si Siet | 3.5 | 2.967 |
| | | 13) *Vitex altisima* | May Khi Ngen | 8.6 | 3.452 |
| | | 14) *Castanopsis hystrix* | May Kor (Nam) | 12.8 | 7.142 |
| | | 15) *Castanopsis annamonsis* | May Kor Khi Mou | 16.4 | 8.382 |
| | | 16) *Tetramaleles nudiflora* | May Phung | 7.2 | 5.964 |
| | | 17) *Cinnamomum iners* | May Sikhay Ton | 1.8 | 3.543 |
| | | 18) *Peperomia pellusida* | May Ka Xang | 12.1 | 4.632 |
| | | 19) *Dialium indum* | May Kham Phep | 4.2 | 2.086 |
| | | 20) *Carallia lucida* | May Bong Nang | 5.7 | 0.872 |
| | | 21) *Vitex pinnata* | May Tin Nok | 6.9 | 2.654 |
| | | 22) *Steeospermum Spp* | May Khe (Deng) | 13.2 | 3.347 |
| | | 23) *Canarium kerrii* | May Kok Leuam | 3.7 | 2.763 |
| | | 24) *Cassia siamea* | May Khi Lek | 4.2 | 0.534 |
| | | 25) *Holarrhaena antidysenterica* | May Mouk | 11.1 | 3.675 |
| | | 26) *Bombax anceps* | May Ngew Paa | 3.2 | 2.875 |
| | | 27) *Anogeissus acuminata* | May Ben Mon | 4.5 | 0.134 |
| | | 28) *Sterculia villosa* | May Por | 13.8 | 2.573 |
| | | 29) *Baccaurea Oxycarpa Gagnepain* | May Mak Fay | 12.1 | 1.675 |
| | | 30) - | May Deua Pong | 15.2 | 1.241 |
| | | 31) - | May Meuat | 7.7 | 2.756 |
| | *Average Number and Volume of Trees per Hectare for DE Forest* | | | 280.7 | 142.530 |
| 2 | Mixed Deciduous Forest | 1) *Pterocarpus pedatus* | May Dou | 8.6 | 3.671 |
| | | 2) *Cinnamomum liseafolium* | May Chuang | 4.3 | 4.657 |
| | | 3) *Hopea odorata* | May Khen Heua | 4.9 | 4.097 |
| | | 4) *Xylia kerrii* | May Deng | 2.9 | 1.643 |
| | | 5) *Hopea ferrea* | May Khen Hin | 3.0 | 2.363 |
| | | 6) *Lagerstroemia florribunda* | May Peuay | 11.7 | 8.790 |
| | | 7) *Ailanthus fauveliana* | May Nhom Paa | 8.6 | 3.086 |
| | | 8) *Vatica cineria* | May Xi Dong | 5.1 | 5.296 |

| No | Forest Types | Scientific Name | Lao Name | No. of Tree per Hectare | Average Volume per Hectare ($m^3$) |
|---|---|---|---|---|---|
| 2 | | 9) *Sindora cochinchinensis* | May Tae Hor | 5.7 | 2.956 |
| | | 10) *Duabanga sonneratioides* | May Ten | 8.6 | 4.149 |
| | | 11) *Dipterocarpus turbinatus* | May Nhang Dong | 5.9 | 5.784 |
| | | 12) *Pentacme siamensis* | May Hang | 7.9 | 2.366 |
| | | 13) *Vatica astrotricha* | May Khen Phai | 8.6 | 5.593 |
| | | 14) *Dipterocarpus tuberculatus* | May Kung (Tong Kung) | 11.4 | 3.470 |
| | | 15) *Dialium indum* | May Kham Phep | 7.9 | 3.910 |
| | | 16) *Albissia codoratisima* | May Houa Lon | 3.4 | 1.119 |
| | | 17) *Pelthopholum dasyrhachis* | May Sa Fang (Sa Kham) | 13.3 | 1.900 |
| | | 18) *Dialium cochinchinensis* | May Kheng | 1.4 | 3.451 |
| | | 19) *Pentace burmanica* | May Si Siet | 3.9 | 2.649 |
| | | 20) *Irvingia cambodiana* | May Bok | 4.3 | 6.833 |
| | | 21) *Vitex altisima* | May Khi Ngen | 2.9 | 2.089 |
| | | 22) *Castanopsis hystrix* | May Kor (Nam) | 4.0 | 1.367 |
| | | 23) *Castanopsis annamonsis* | May Kor Khi Mou | 2.9 | 1.443 |
| | | 24) *Tetramaleles nudiflora* | May Phung | 5.7 | 10.441 |
| | | 25) *Peperomia pellusida* | May Ka Xang | 4.0 | 3.238 |
| | | 26) *Terminalia chebula vancitrina* | May Som Mor | 1.4 | 1.814 |
| | | 27) - | May Nam Pheung | 1.4 | 2.833 |
| | | 28) *Baccaurea Oxycarpa Gagnepain* | May Mak Fay | 3.7 | 0.037 |
| | | 29) *Phyllanthus emblica L.* | May Kham Pom | 2.9 | 1.120 |
| | | 30) - | May Phay | 8.4 | 0.440 |
| | | 31) - | May Keo | 7.9 | 0.661 |
| | | 32) - | May Bia | 5.4 | 0.554 |
| | | 33) - | May Kong Sy | 4.3 | 1.331 |
| | | 34) - | May Tong Khok | 12.9 | 1.807 |
| *Average Number and Volume of Trees per one Hectare for MD Forest* | | | | *199.2* | *106.958* |
| 3 | Unstocked Forest | 1) *Pterocarpus macrocarpus* | May Dou | 2.0 | 2.542 |
| | | 2) *Aquilaris Sp.* | May Por Heuang | 8.0 | 0.574 |
| | | 3) *Cinnamomum liseafolium* | May Chuang | 8.0 | 1.524 |
| | | 4) *Hopea odorata* | May Khen Heua | 6.0 | 6.128 |
| | | 5) *Xylia kerrii* | May Deng | 2.0 | 5.216 |
| | | 6) *Vatica cineria* | May Xi | 6.0 | 4.542 |
| | | 7) *Lagerstroemia florribunda* | May Peuay | 9.0 | 5.108 |
| | | 8) *Duabanga sonneratioides* | May Ten | 8.0 | 3.920 |
| | | 9) *Dipterocarpus turbinatus* | May Nhang | 10.0 | 3.881 |
| | | 10) *Ailanthus fauveliana* | May Nhom | 8.0 | 2.602 |
| | | 11) *Sindora cochinchinensis* | May Tae Hor | 10.0 | 3.192 |
| | | 12) *Hopea ferrea* | May Khen | 6.0 | 0.152 |
| | | 13) *Hopea ferrea* | May Khen Hin | 2.0 | 1.566 |
| | | 14) *Pelthopholum dasyrhachis* | May Sa Fang | 12.0 | 3.456 |
| | | 15) *Dipterocarpus tuberculatus* | May Tong Khok | 4.0 | 1.068 |

| No | Forest Types | Scientific Name | Lao Name | No. of Tree per Hectare | Average Volume per Hectare ($m^3$) |
|---|---|---|---|---|---|
| 3 | | *16) Dialium cochinchinensis* | May Kheng | 4.0 | 1.102 |
| | | *17) Pentace burmanica* | May Si Siet | 7.0 | 3.146 |
| | | *18) Irvingia cambodiana* | May Bok | 2.0 | 2.198 |
| | | *19) Sinnamomum iners* | May Si Khay (Ton) | 4.0 | 2.842 |
| | | *20) Dipterocarpus tuberculatus* | May Tong Kung | 8.0 | 2.278 |
| | | *21) Cratexylon prunifolium* | May Tiew | 2.0 | 0.682 |
| | | *22) Holarrhaena antidysenterica* | May Mouk | 6.0 | 2.982 |
| | | *23) Tetramaleles nudiflora* | May Phung | 5.0 | 7.108 |
| | | *24) Castanopsis annamonsis* | May Kor Khi Mou | 6.0 | 1.376 |
| | | *25) Vitex altissima L.f.* | May Khi Nok | 2.0 | 0.068 |
| | | *26) Helicteres viscida Blume* | May Khi On | 4.0 | 0.162 |
| | | *27) Streblus ilicifolius (Vidal) Corner* | May Khi Het | 4.0 | 0.122 |
| | | *28) -* | May Ka Thang | 6.0 | 3.508 |
| | | *29) -* | May Por Mim | 6.0 | 0.247 |
| | | *30) Baccaurea Oxycarpa Gagnepain* | May Mak Fay | 4.0 | 0.104 |
| | | *31) Ziziphus cambodiana Pierre* | May Khom | 4.0 | 0.079 |
| | | *32) -* | May Khab | 8.0 | 0.073 |
| | | *33) -* | May Hou Xang | 6.0 | 0.166 |
| | | *34) -* | May Bong | 2.0 | 0.074 |
| | | *35) -* | May Nam Pheung | 4.0 | 3.75 |
| *Average Number and Volume of Trees per Hectare for Unstocked Forest* | | | | *193* | *74.996* |

Note: The average Number and Volume of the tree species per one hectare are for stand trees with DBH equal to or more than 10 cm.

#### 5.2.2.5 Average Number of Tree Species (with DBH <10 cm and >1.3 meters of height)

A survey was also made of tree species with DBH of less than 10 centimeters and height of more than 1.3 meters, with the results shown in Table 5-30.

Table 5-30 Main Tree Species and Average Number of Trees per Hectare, of trees less than 10 cm DBH and height above 1.3 m

| No | Forest Types | Scientific Name | Lao Name | No of Tree per Hectare |
|---|---|---|---|---|
| 1 | Dry Evergreen Forest | *1) Ailanthus fauveliana* | May Nhom Pha | 4.3 |
| | | *2) Hopea odorata* | May Khen Heua | 5.6 |
| | | *3) Lagerstroemia florribunda* | May Peuay Khao | 9.5 |
| | | *4) Cinnamomum liseafolium* | May Chuang | 1.3 |
| | | *5) Vatica cineria* | May Xi Dong | 2.5 |
| | | *6) Duabanga sonneratioides* | May Ten | 1.3 |
| | | *7) Dipterocarpus turbinatus* | May Nhang Dong | 2.6 |
| | | *8) Albissia codoratisima* | May Houa Lon | 2.8 |

| No | Forest Types | Scientific Name | Lao Name | No of Tree per Hectare |
|---|---|---|---|---|
| 1 | | 9) *Vatica astrotricha* | May Khen Phai | 3.9 |
| | | 10) *Dipterocarpus tuberculatus* | May Kung (Tong Kung) | 7.2 |
| | | 11) *Vitex pinnata* | May Tin Nok | 2.9 |
| | | 12) *Pentace burmanica* | May Si Siet | 2.5 |
| | | 13) *Cinnamomum iners* | May Sikhay Ton | 1.3 |
| | | 14) *Carallia lucida* | May Bong Nang | 1.7 |
| | | 15) *Vitex altisima* | May Khi Ngen | 4.2 |
| | | 16) *Pentacme siamensis* | May Hang | 1.9 |
| | | 17) *Castanopsis annamonsis* | May Kor Khi Mou | 7.5 |
| | | 18) *Peperomia pellusida* | May Ka Xang | 2.1 |
| | | 19) *Castanopsis hystrix* | May Kor (Nam) | 6.2 |
| | | 20) *Tetramaleles nudiflora* | May Phung | 3.5 |
| | | 21) *Holarrhaena antidysenterica* | May Mouk | 13.1 |
| | | 22) *Canarium kerrii* | May Mak Kok | 0.7 |
| | | 23) *Cassia siamea* | May Khi Lek | 7.2 |
| | | 24) *Sterculia villosa* | May Por | 3.8 |
| | | 25) *Baccaurea Oxycarpa Gagnepain* | May Mak Fay | 3.2 |
| | | 26) - | May Deua Pong | 5.1 |
| | | 27) - | May Meuat | 1.6 |
| *Average Number of All Trees per Hectare for MD Forest* | | | | *109.5* |
| 2 | Mixed Deciduous Forest | 1) *Pterocarpus pedatus* | May Dou | 5.7 |
| | | 2) *Cinnamomum liseafolium* | May Chuang | 8.6 |
| | | 3) *Hopea odorata* | May Khen Heua | 8.5 |
| | | 4) *Shorea harmandii* | May Khen | 4.3 |
| | | 5) *Hopea ferrea* | May Khen Hin | 11.4 |
| | | 6) *Lagerstroemia florribunda* | May Peuay | 17.1 |
| | | 7) - | May Leuad | 10.0 |
| | | 8) *Vatica cineria* | May Xi Dong | 5.7 |
| | | 9) *Sindora cochinchinensis* | May Tae Hor | 1.4 |
| | | 10) *Duabanga sonneratioides* | May Ten | 1.4 |
| | | 11) *Holarrhaena antidysenterica* | May Mouk | 4.3 |
| | | 12) *Vitex altissima L.f.* | May Khi Nok | 5.7 |
| | | 13) *Vatica astrotricha* | May Khen Phai | 4.3 |
| | | 14) *Dipterocarpus tuberculatus* | May Kung (Tong Kung) | 1.4 |
| | | 15) *Dialium indum* | May Kham Phep | 1.4 |
| | | 16) *Helicteres viscida Blume* | May Khi On | 5.7 |
| | | 17) *Streblus ilicifolius (Vidal) Corner* | May Khi Haet | 1.4 |
| | | 18) *Dialium cochinchinensis* | May Kheng | 5.7 |
| | | 19) *Pentace burmanica* | May Si Siet | 1.4 |
| | | 20) *Irvingia cambodiana* | May Bok | 2.8 |
| | | 21) - | May Cham | 1.4 |
| | | 22) *Castanopsis hystrix* | May Kor | 2.8 |
| | | 23) *Fokinia chinensis* | May Hing | 1.4 |
| | | 24) *Tetramaleles nudiflora* | May Phung | 1.4 |
| | | 25) *Peperomia pellusida* | May Ka Xang | 1.4 |
| | | 26) *Terminalia chebula vancitrina* | May Som Mor | 2.8 |
| | | 27) - | May Nam Pheung | 2.8 |
| | | 28) *Baccaurea Oxycarpa Gagnepain* | May Mak Fay | 7.1 |
| | | 29) *Lacticum* | May Lam Yay Paa | 1.4 |
| | | 30) - | May Kong | 4.3 |
| | | 31) - | May Keo | 2.8 |

| No | Forest Types | Scientific Name | Lao Name | No of Tree per Hectare |
|---|---|---|---|---|
| 2 | | *32) Sinnamomum iners*<br>*33) -*<br>*34) Mangifera indica* | May Si Khay<br>May Ka Bong<br>May Muang Paa | 1.4<br>1.4<br>1.4 |
| *Average Number of All Trees per Hectare for MD Forest* | | | | *142.9* |
| 3 | Unstocked Forest | *1) Pterocarpus macrocarpus*<br>*2) Aquilaris Sp.*<br>*3) Cinnamomum liseafolium*<br>*4) Lagerstroemia florribunda*<br>*5) Sindora cochinchinensis*<br>*6) Hopea ferrea*<br>*7) Pelthopholum dasyrhachis*<br>*8) Dipterocarpus tuberculatus*<br>*9) Steroespermum Spp*<br>*10) -*<br>*11) Sinnamomum iners*<br>*12) Castanea Castanopsis (quercus)*<br>*13) Cratexylon prunifolium*<br>*14) Holarrhaena antidysenterica*<br>*15) Tetramaleles nudiflora*<br>*16) Castanopsis annamonsis*<br>*17) -*<br>*18) -*<br>*19) Baccaurea Oxycarpa Gagnepain*<br>*20) -*<br>*21) -*<br>*22) -*<br>*23) -* | May Dou<br>May Por Heuang<br>May Chuang<br>May Peuay<br>May Tae Hor<br>May Khen<br>May Sa Fang<br>May Tong Kung<br>May Mak Khe<br>May Mak Khor<br>May Si Khay (Ton)<br>May Kor<br>May Tiew<br>May Mouk<br>May Phung<br>May Kor Khi Mou<br>May Ka Thang<br>May Por Mim<br>May Mak Fay<br>May Khab<br>May Hou Xang<br>May Lin May<br>May Tin Cham | 2<br>4<br>8<br>12<br>4<br>10<br>18<br>4<br>2<br>2<br>2<br>2<br>4<br>6<br>4<br>6<br>4<br>2<br>10<br>10<br>4<br>8<br>2 |
| *Average Number of All Trees per Hectare for Unstocked Forest* | | | | *132* |

Note: The average Number of tree species per one hectare focused on trees with DBH of less than 10 centimeters and height of more than 1.3 meters.

#### 5.2.2.6 Other Plants and Non-timber Forest Products (NTFPs)

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

**The main NTFPs found in the project area are:**

**Bamboos and Bamboo Shoots:** Four species of bamboo found in the project area, mostly in Mixed Deciduous and Unstocked Forests, are used by local residents. May Lay (Gigantochloa albociliata Munro Kurz) provides bamboo shoots that are an important food source in the rainy season (June to September). May Hia (Dendrocalamus longispathus Kurz), May Xang (Dendrocalamus *membranaceus Munro), and* May Xort *(Oxytenanthera parvifolia Br.)* are used as temporary housing material, material for fencing, and to make looms for weaving. They are distributed along the streams and up to the hills, widespread throughout the study area. The distribution of these species is shown in Table 5-31.

Table 5-31 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 | | | |
| *For the 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 in DE Forest* | | | *27.9* | | *740.7* |
| *For the 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 in MD Forest* | | | *43.5* | | *1,342* |
| *For the 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 apecies in Unstocked Forest* | | | *72.7* | | *2,677* |

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

**Mushrooms:** Mushrooms grow well in Unstocked and Mixed Deciduous Forests in the early rainy season. Villagers reported the main mushroom species they collected for food were:

Het Puak (Termitomycetes species, Agaricus integer Loureiro), Het Pheung (Boletus sp.), Het Hu Nou (Auricularia polytricha-Montagne-Saccardo), Het Khao (Lentinus sp.), Het La Ngok (Auricularia sp.), Het Bot (Lentinus kurzianus Curr., L. praerigidus), and Het Khon Kong (Hiatula sp., Lepiota sp.).

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

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

Table 5-32 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* |
| 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* |

| No | Dry Evergreen and Mixed Deciduous Forest | | Unstocked Forest | |
|---|---|---|---|---|
| | Lao Name | Scientific Name | Lao Name | Scientific Name |
| 15 | Ka Pouk | | Mak Maou | *Antidesma bunius sprengel* |
| 16 | Phak Wan | *Melientha Suavis Pierre* | Mak Huat | *Lepisanthes rubiginosa (Roxburgh) Leenh* |
| 17 | Dok Pheung | | Kheua Hang Kuang | *Ancistrocladus tectorius (Loureiro)Merrill* |
| 18 | Phak Ii Leud | *Piper albospicum DC,P.lotot C.* | Koud Paa | *Cythea spinulosa wall* |
| 19 | Khem (Bloom grass) | | Ya Nang | *Limacia traindia Mers* |
| 20 | Het Khao (Mushroom) | *Lentinus.sp* | Phak Wan | *Melientha Suavis Pierre* |
| 21 | Het Tan (Mushroom) | *Auricularia sp* | Het Khao (Mushroom) | *Lentinus.sp* |
| 22 | Het Bot (Mushroom) | *Lentinus kurzianus curr* | Het Ka Tan(Mushroom) | *Auricularia sp* |
| 23 | Het Ka Dang (Mushroom) | | Het Bot (Mushroom) | *Lentinus kurzianus curr* |
| 24 | Het Man (Mushroom) | | Dok Ka Chieo | *Curcuma singularis Gagnepain* |
| 25 | Phak Kud Paa | *Cythea spinulosa wall* | Het Puak (Mushroom) | *Temitomycetes species,Agaricus* |
| 26 | Ya Nang | *Limacia traindia Mers* | Het Puak Kay Noy (Mushroom) | |
| 27 | Dok Ka Chieo | *Curcuma singularis Gagnepain* | Wai (Rattan) | *Rattans generally* |
| 28 | Palm | | Man Paa (Groundnut) | |
| 29 | Kheua Haem (Beberin) | *Coscinium fenestratum(Gaertner)* | Palm | |
| 30 | Kheua Kadongtipok | | Phak Ii Leud | *Piper albospicum DC,P.lotot C.* |
| 31 | Teuy | *Pandanus species generally* | Mak Nat Paa | *Ananas comosus(L) Merrill* |
| 32 | Kheua Makkhibe | *Murraya Koenigii(L) Sprengel* | Kuay Paa | *Musa acuminata colla,M paradisiaca L* |
| 33 | Mak Khi Ma | *Aerva Sanguinolenta(L) Blume* | San | *Rhapis species generally* |
| 34 | San | *Rhapis species generally* | | |

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

#### 5.2.2.7 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.

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 Khoauy and Nam Ka Ding, are in Vientiane and Bolikhamxay provinces. However, both NBCAs are located far from the project area. ***The project does not pose any direct threat to an NBCA or major protected forest.***

However, although the project area is not near any NBCAs, it still does contain some important forests, including village conservation forests and special spirit pool forests at Namyouak, Sopyouak and Sopphuane Villages, Hom District and at Hatsaykham Village, Bolikhan District (Table 5-34). These are on quite steep terrains, on lands relatively inaccessible to humans, allowing the vegetation to remain relatively intact and keeping the areas as viable sites for a number of species. ***It should be stressed that these forests are at elevations above the flood level of the reservoir***.

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 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 less hunting in these places.

Table 5-33 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).

Table 5-34 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.Sopphuane, 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, Bolikhamxay District |

Source: Discussions with village leaders

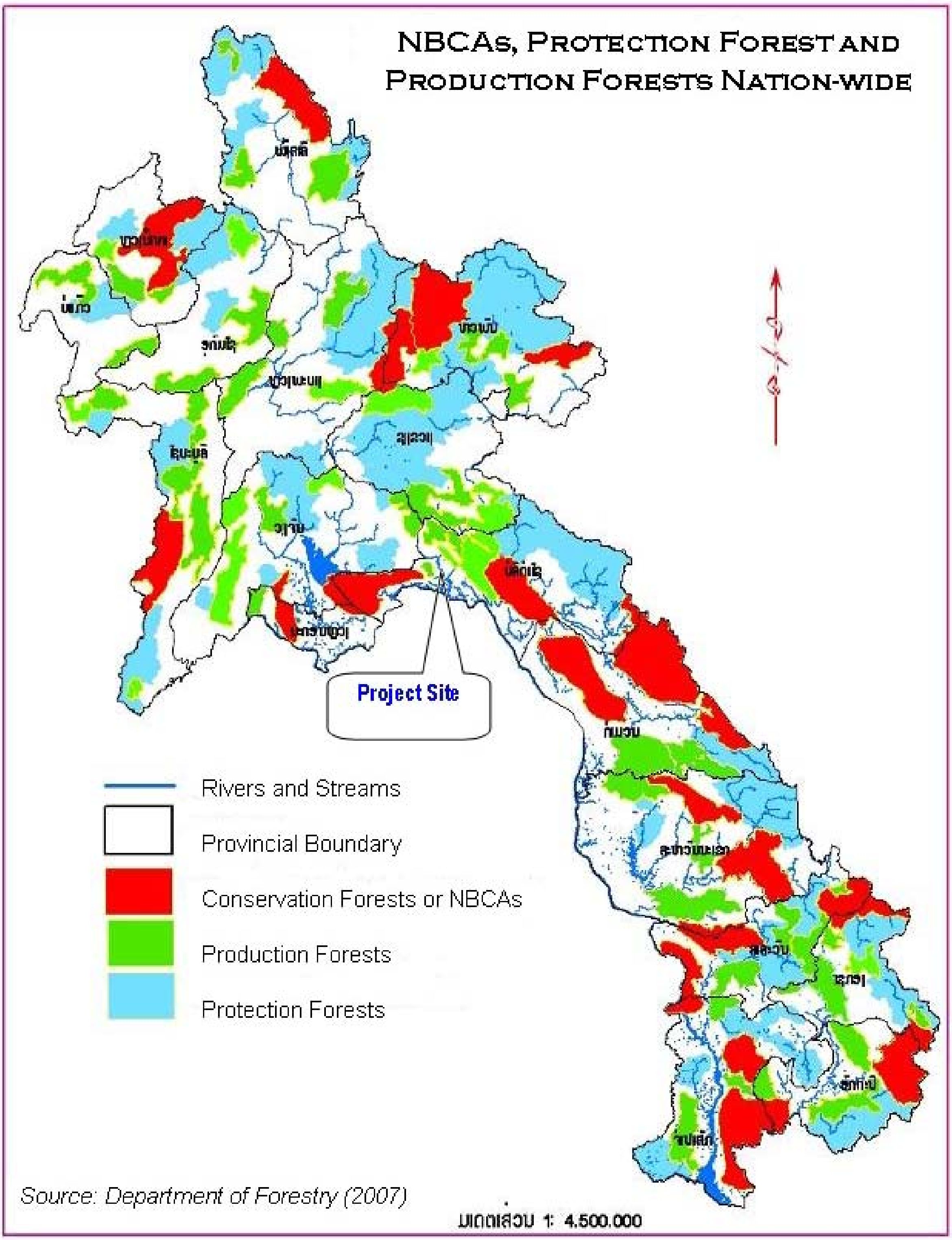



Figure 5-30 Map shows the location of three forest categories nationwide.

### 5.2.3 AQUATIC BIOTA

The Nam Ngiep River is the eleventh longest tributary of the Mekong River in the Lao PDR (Phanthaba et al. 2005). The total flow contributed by these rivers is about 35% of the entire flow of the Mekong River Basin. The Nam Ngiep River accounts for 1.5% of the flow of the Mekong River (Hori 2000).

Because the Nam Ngiep River passes different habitats with elevations ranging from 1,300 m at the source to 200 m above the mean sea level (MSL) at its convergence with the Mekong, it supports a large variety of aquatic biota.

#### 5.2.3.1 Results

Dry season survey along the Nam Ngiep River was conducted in January 2008 at ten aquatic sampling stations: six located downstream from the proposed dam and the other four located upstream (shown in Figure 3-2) to determine the existence of aquatic life in the river. The number and location of each station were: station 1 ( Ban Piengta); station 2 ( Ban Hatsamkhone); station 3 (Ban Pou); station 4 (Ban Houypamom); station 5 (Ban Sopphuane); station 6 (Ban Sopyouak); station 7 (Ban Hatsaykham); station 8 (Ban Hat Gniun); station 9 (Ban Somseun); and, station 10 (Ban Pak Ngiep). Fish and fisheries survey locations along the Nam Ngiep River is also presented in Table 3-5.

Examination of aquatic fauna and flora included distribution of indigenous fish species and their abundance in particular areas of the river. Plankton, benthos and aquatic plants, which provide nutrients to young fish, were also studied. Study resulsts and other relevant data (hydrology, water quality) were used to predict possible changes in aquatic life after project development and its effect on peoples' livelihood. Detailed methodologies for fish, plankton and benthic sampling are discussed in Section 3.2.32- Method of Study.

**(1) Fish communities**

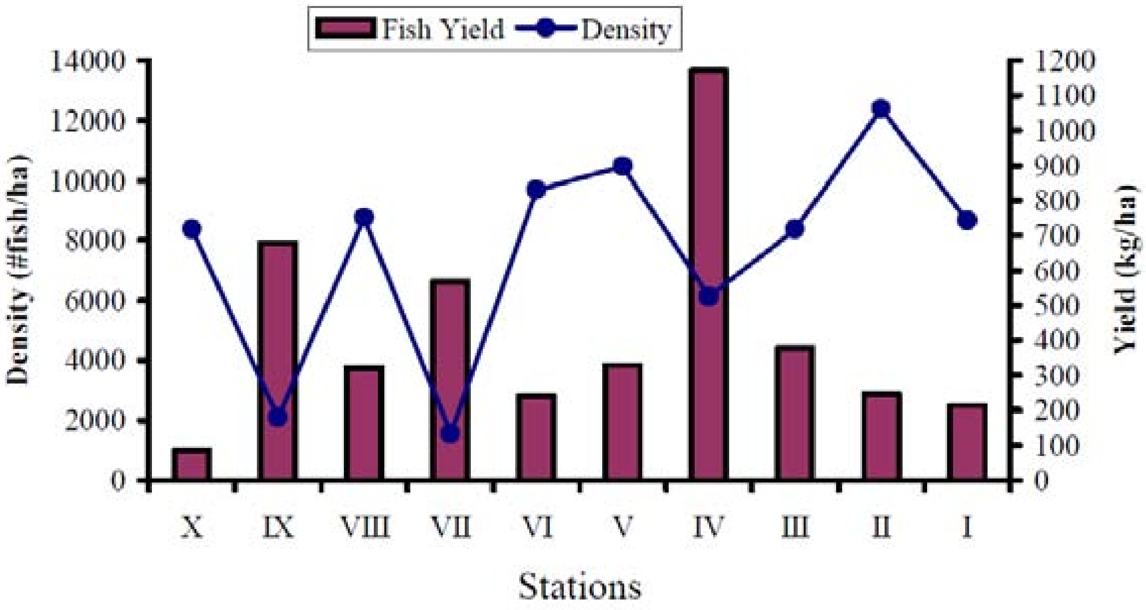
The survey found 42 fish species along the Nam Ngiep River, a part of the project areas. They are common species that can be found in other water bodies in Lao PDR (Annex B) and are not categorized as Red List species by the IUCN (2009). Many species are caught almost daily and sold at local fresh markets. Most fish sold at the markets were juveniles while the bigger sizes of certain species especially expensive fish were sold at some markets.

Cyprinidae accounted for 24 species. The other species were in the Bagridae family (3). The other families, such as Notopteridae family and Siluridae were represented by only 1 or species each.

**(2) Fish density**

The density and yield distribution of the fish varied considerably from station to station. Station 2 has the highest density (12,384) of fish by all species, followed by station 5 (10,465), station 6 (9,690), station 8 (8,753) and station 10 (8,372) (Figure 5-31). Cyprinidae were dominant in each station, especially the juvenile stage: *Opsarius pulchellus* followed in numbers by *Puntius brevis*, *Rasbora borapetensis*, *Rasbora danioconius*, *Raiamas guttatus* and *Poropuntius* spp.

The numbers of fish does not directly correlate with yield. Station 4 had fewer but larger fish in its catch, hence higher yield. The most common fish at station 4 were *Bagarius yarrelli, Neolissochilos blanci, Cirrhinus molitorella,* and *Hemibagrus wyckioides.* Some of the larger fish caught at stations 9 and 7 were: *Hypsibarbus wetmorei, Hypsibarbus vernayi, Helicophagus waandersii, Barbodes gonionotus* and *Scanphognathops stejnegeri*.




Note: The line graph represents density of fish. The bar graph represents fish yield.

Figure 5-31 Illustration of fish density and their yield at sampling stations.

The 42 fish species caught in the project area can also be classified into three groups according to their feeding habits, whether surface feeders, bottom feeders, or mid-water (column) feeders (Table 5-36). The column feeders (mid-water) comprised the largest proportion, accounting for 38.10% of the total, followed by both surface feeders and bottom feeders, each accounting for 30.95% of the total. Most of the surface and mid water fish were cyprinids, accounting for over half to the total fish population in the river (54.8 %).

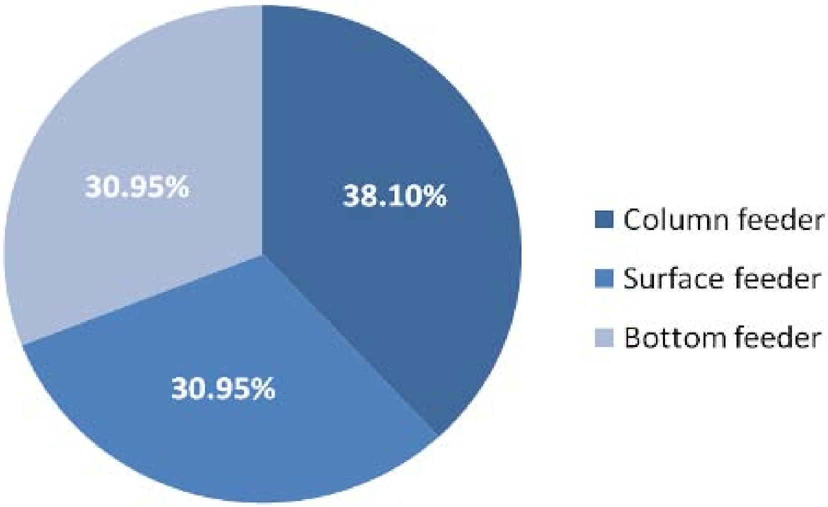



Figure 5-32 Proportional composition of feeding types of fish in the Nam Ngiep River.

### (3) Plankton communities

The Nam Ngiep River has a great diversity of plankton species. About 104 species were found in the project sites, of which 64 were phytoplanktons and the other 40 species were zooplanktons (Annex B). The highest density of planktons were found at the site closest to the mouth of the river at station 10 (1,215.379 x $10^3$), followed by station 6 (811.058 x $10^3$), station 7 (786.181 x $10^3$) and station 8 (775.084 x $10^3$). The most common species of phytoplankton found in the river were *Anabena helicoidea*, *Chlorella ellipsoidea* and *Closteriopsis longissima.* Zooplankton occurrence in the water varied according to the sampling station. The highest density of zooplankton were found at station 5 (227.33 x $10^3$) followed by stations 3 (216.59 x $10^3$) and 9 (91.2 x $10^3$). The most common zooplankton species found in the river were *Cephalodella gibba, Haraella thomassoni, Spirostromum spp.*, *Stenosemella ventricosa* and *Trichocerca rosea.*

### (4) Benthic communities

Twelve species of benthic fauna were found in Nam Ngiep project area (Annex B). The most abundant species were earthworms. They were found at a density of 12,000/$m^2$ at station 9, 1,320/$m^2$ at station 10, and 120/$m^2$ at stations 1 and 8. The next most abundant species was the Damselfly Nymph, found mostly at stations 6 (720/$m^2$) and 4 (520/$m^2$), and much less at stations 2, 5, and 7. Other species found mostly in the mid-part of the river that will be most affected by the project are the Mayfly Nymph (found at stations 3, 5, 6, and 8, mostly at stations 6 and 8) and the Stonefly Nymph (found at stations 3, 4, 6, and 8, mostly at stations 3 and 4). The remaining 8 invertebrate species were found at much lower density.

#### 5.2.3.2 Discussion of Fish and Fisheries in the Nam Ngiep River

##### (1) Fish communities

The Nam Ngiep River does not host as many fish species as most other Mekong tributaries. Furthermore, the fish are all common species that can be found in other water bodies Small cyprinidae, the dominant species in the river, can adapt to the different environments in the various sections of the river.

Some species are typical rocky bottom feeders that show a preference to specific habitats. The largest numbers of species were found at stations 3 and 1 in the river, which will be part of the new reservoir. Bigger species of fish, such as *Bagarius yarrelli, Cirrhinus molitorella, Hemibagrus wyckioides* and *Labeo erythropterus* were found at station 4. Many of these larger fish, particularly *Cirrhinus molitorella, Hemibagrus wyckioides* and *Labeo erythropterus* are migratory species of the lower Mekong basin that swim upstream along the river and its tributaries during the wet season for spawning (Poulsen *et.al.* 2004). While these species have been found split into different subpopulations along the Mekong River, it is not certain if this is the case for these species in the Nam Ngiep River. A number of species were found the Nam Ngiep River in their juvenile stage: *Opsarius pulchellus, Puntius brevis, Rasbora borapetersis, Rasbora danioconius, Raimas guttatus* and *Poropuntius spp.* This shows that the Nam Ngiep River serves as other tributaries of the Mekong in providing safe habitats for the young fish, to ensure maximum number of survivors into maturity (Lowe-McConnell 1995).

During the first survey trip to Nam Ngiep project area, it was reported that eels (*Anguilla* sp.) had been caught a few years earlier in the middle zone of the river. One caught by gill net before 1999 was 1.60 m long and weighed 18 kg. Another caught in 1999 weighed over 26 kg and was about 2.00 m long. The villagers reported that when this fish was caught, it was then distributed among all the fishing families in the community. Another specimen approximately 2.00 m long is preserved in a glass container at the Bolikhamxay Fisheries and Veterinary Office. Because of their size, these eel are probably *Anguilla marmorata*, or the giant mottled eel. This kind of eel is reported elsewhere in tributaries of the Mekong, and migrates to the sea to spawn in deep gullies, returning to the rivers as adults.

#### (2) Planktons communities

The Nam Ngiep River is host to many species of planktons. During the dry season, most of the river becomes shallow, so that light can penetrate into the water for longer periods and with higher light intensity. This can accelerate photosynthesis for the planktons and algae to grow. The relative richness of plankton species is due to substantial variations in ecosystems, caused by the range of climatic and geological conditions of the Nam Ngiep River.

#### (3) Benthos communities

The higher density of earthworms in stations 9 and 10 indicate the soils around these areas are in a virgin or near virgin stage. Earthworms and other insects are excellent food for many kinds of local fish. Some species of benthic invertebrates are very sensitive to environment, such as water temperature, turbidity, and flow pattern.

### 5.2.4 WETLANDS

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.

# CHAPTER 6

# STUDY OF 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. Alternative fuels sources are also considered.

## 6.1 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 NNHP-1 project, the reservoir will be narrow but long, so the

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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.

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.

## 6.2 PROJECT DESIGN ALTERNATIVES

### 6.2.1 HYDROPOWER ALTERNATIVE

Another alternative some suggest would be 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

### 6.2.2 PROJECT LOCATION

The project site (Main dam site) is located on the Nam Ngiep River some 145 km northeast from Vientiane or about 50 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 Phonsavan 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 goes 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 goes 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.

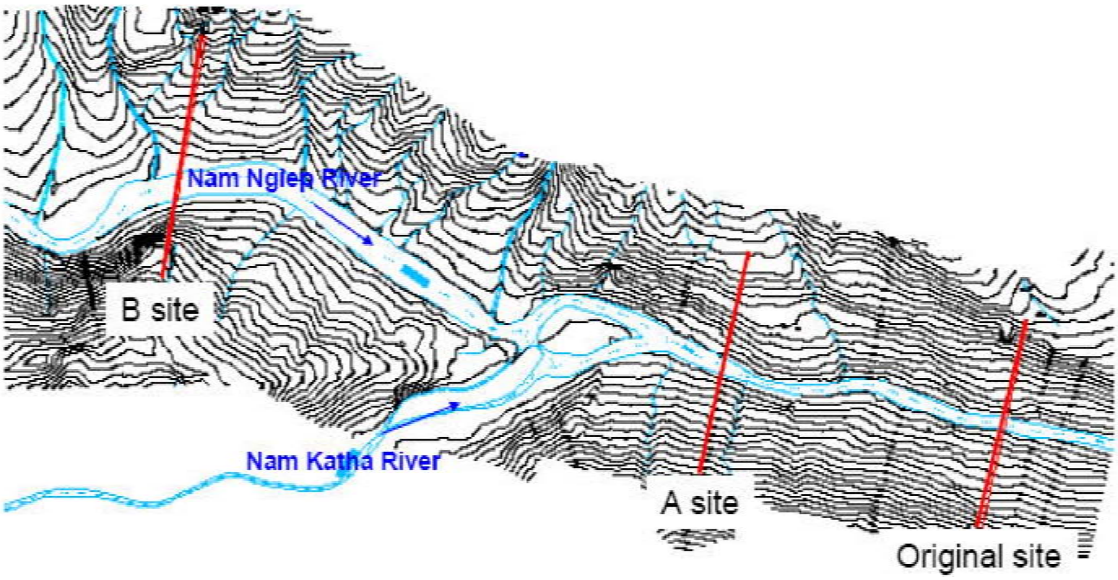
### 6.2.3 ALTERNATIVE DAM SITES

#### 6.2.3.1 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 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 6-1 shows the alternative locations of each dam site. (The KANSAI Electric Power Co., Inc., 2011)

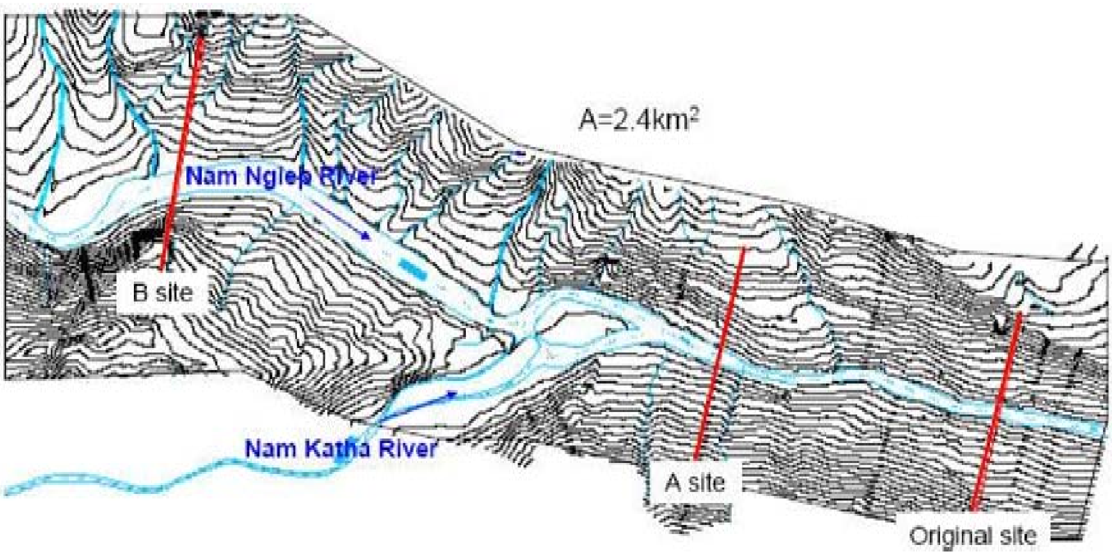



Source: Technical Report, 2011

Figure 6-1 Alternative location of each dam site.

#### 6.2.3.2 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 is approximately 2.4 $km^2$, to include the original site, the A site, and the B site, as shown in Figure 6-2. 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)




Source: Technical Report, 2007

Figure 6-2 Topographical survey coverage.

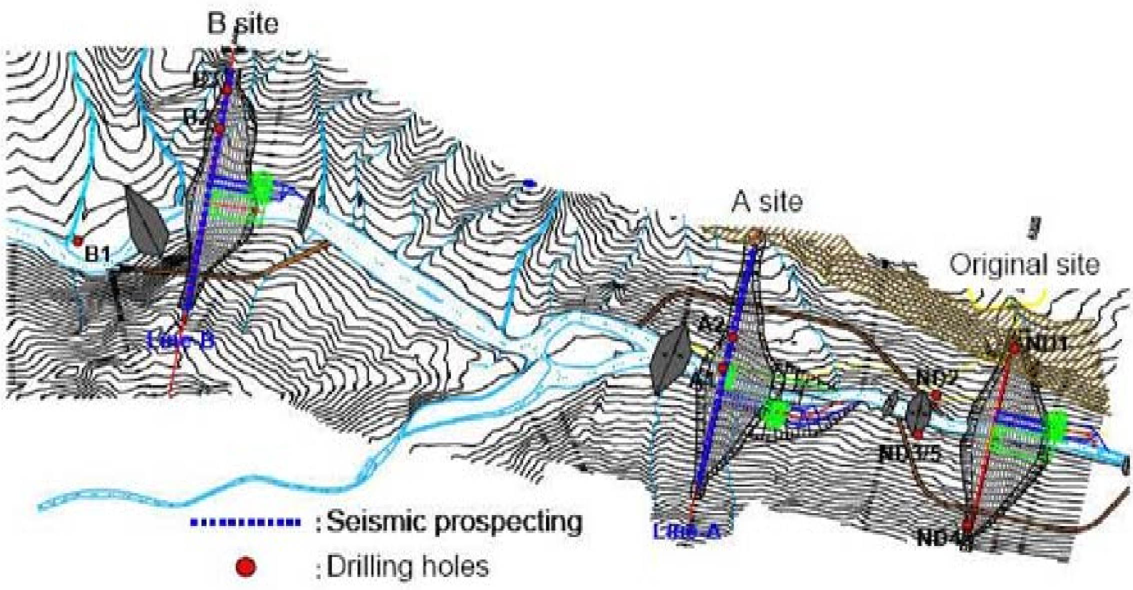
### 6.2.3.3 Geological survey

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 6-1. Figure 6-3 shows the survey location plan. Data from the original site were already in JICA-F/S. (The KANSAI Electric Power Co., Inc., 2007)

Table 6-1 Geological Survey Quantities

| Item | B site | A site | Original site |
|---|---|---|---|
| Seismic wave prospecting | 1 traverse line<br>(L = 800 m) | 1 traverse line<br>(L = 800 m) | - |
| Drilling survey | B1: 75 m<br>B2: 50 m<br>B3: 50 m<br>-<br>- | A1: 75 m<br>A2: 50 m<br>-<br>-<br>- | ND1: 150 m<br>ND2: 100 m<br>ND3: 100 m<br>ND4: 150 m<br>ND5: 100 m<br>(Incline) |
| Total | 3 holes, 175 m | 2 holes, 125 m | 5 holes, 600 m |




Source: Technical Report, 2007

Figure 6-3 Geological survey plan.

Table 6-2 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 6-2 Comparison of Dam-sites

| Dam-site | Topographic features | Geologic conditions |
|---|---|---|
| Original site | • Location: 1.2 km downstream from the Nam Khata River<br>• River channel: 30-40 m wide (dry season), forming a rapid<br>• Topographic profile:<br>- Both banks: steep about 30º, covered with big boulder | • Rock kinds: Alternation of sandstone, conglomerate, mudstone but sandstone and conglomerate predominant<br>• Geologic structure: Beds dipping downstream-ward with 10-15º and a fold zone running in the same direction of river on the lower portion of right bank<br>• Foundation: Generally good<br>- River deposit: 15 m in thickness<br>- Talus deposit: thickly (20-22 m) covered from the shoreline to the middle of slope on both banks<br>• Excavation depth: 20 m at the river channel, 15-45 m on both banks<br>• Permeability: generally small of 5 Lu or less under the excavation line |
| A site | • Location: 0.5 km downstream from the Nam Khata River<br>• River channel: 30-40 m wide (dry season), forming a rapid<br>• Topographic profile:<br>- Both banks: about 30º up to dam crest level (EL. 325 m), but after that 15º on the left bank<br>- Covered with big boulder exceeding 5 m in diameter<br>• A small topographic protrusion due to gushing out of slide debris exists on the downstream left bank. | • Alternation of sandstone and mudstone<br>• Foundation: Red mudstone lying under the river channel is deteriorated to 30 m in depth by a folding running along river channel<br>- River deposit: 11.2 m (drill hole A-1)<br>- Talus deposit: 10-15 m in thickness but 20 m at the dam crest on the left bank<br>• Excavation depth: 27-30 m at the river channel, 15-25 m on the slopes of both banks<br>• 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 Khata River.<br>• River channel: 60-70 m wide (dry season), forming a backwater<br>• Topographic profile is asymmetrical between the left and right banks.<br>- Left bank: gentle about 20º<br>- Right bank: steep 40-45º up to EL. 300 m and after that gentle 20º | • Rock kinds: Alternation of sandstone and mudstone<br>• Foundation: Generally good except following locations<br>- A fold zone passes on the middle of left bank<br>- A fractured zone is expected on the right bank upper portion.<br>- River deposit: 15-20 m in thickness (drill hole B-1)<br>- Talus deposit: less than 10 m on the right bank, while rocks crop out on the right bank<br>• Excavation depth: 20 m under the river channel, 15-30 m on the slopes of both banks<br>• 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

#### 6.2.3.4 Evaluation of dam sites and determination

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 6-3)

Table 6-3 Dam Site Comparative Evaluation Result

| Item | B site | A site | Original site |
|---|---|---|---|
| Topography | A | A | A |
| Geology | B | C | A |
| Workability | A | B | B |
| Economic efficiency | C | B | A |
| Comprehensive evaluation | B | C | A |

Source: Technical Report, 2007 A: Good, B: Fair, C: Poor

Workability of the original site was given an evaluation of B because blasting to crush boulders to small pieces may require time and cofferdams built on the boulder stratum may present technical difficulty to ensure water cut-off. This means that for detailed design and implementation, boulders should be handled with sufficient caution.

The environmental impact of these three alternatives did not differ much. 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.

### 6.2.4 ALTERNATIVE DAM TYPE

#### 6.2.3.1 Overview

In selecting the dam type, JICA-F/S compared CFRD and 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.

#### 6.2.3.2 Comparison of Preliminary Designs of CRRD 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 account of 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, as so 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.

#### 6.2.3.3 Comparison between CFRD and RCC

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 economical 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 6-4. 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 6-4 shows that the RCC type of dam is more preferable from economically.

The RCC dam is also preferable environmentally. 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 6-4 Comparison of RCC and CFRD Dam Types for NNHP-1

Note: Revised items/figures are in Italic.

| Factor | Items | Unit | Review Report | JICA F/S(Phase-II) |
|---|---|---|---|---|
| | | | Report in 2004 | 2002 |
| Catch. Area | Catchment area at dam site | $km^2$ | 3,700 | 3,700 |
| | Annual average basin rainfall | mm | 1,873 | 1,873 |
| | Average run-off coefficient | - | 0.67 | 0.67 |
| Reservoir | Probable maximum flood (PMF) | $m^3/s$ | 14,220 | 14,220 |
| | Mean annual sediment flow | $t/km^2/yr$ | 500 | 500 |
| | FSL (Full supply water level) | EL.m | 320 | 320 |
| | MOL (Minimum operation level) | EL.m | 296 | 296 |
| | Gross storage capacity | $mil.m^3$ | 2,241 | 2,241 |
| | Effective storage capacity | $mil.m^3$ | 1,192 | 1,192 |
| | Reservoir area at FSL | $km^2$ | 66.9 | 66.9 |
| Main dam | Dam type | - | ***RCC*** | CFRD |
| | Dam height, crest length | m | 151 | 151 |
| | Dam crest length | m | ***600*** | 513 |
| | Dam volume | $mil.m^3$ | ***2.6*** | 7.3 |
| Power plant | Design discharge | $m^3/s$ | 230 | 230 |
| | Annual mean runoff | $m^3/s$ | 147.2 | 147.2 |
| | Rated head | m | 127.7 | 136.2 |
| | Plant capacity | MW | 260 | 260 |
| | Annual output | GWh | 1,327 | 1,327 |
| Economic analysis | Total construction cost | US$ mil. | ***313*** | 344 |
| | Unit cost | US$/kW | ***1,204*** | 1,323 |
| | Economic internal rate of return (EIRR) | % | ***21.6*** | 19.5 |
| | Financial) internal rate of return (FIRR) | % | ***14.4*** | 13.1 |
| Required resettlement | Number of villages | Nos. | 4 | 4 |
| | Number of Households | H/H | 239 | 239 |
| | Population | People | 1,609 | 1,609 |

Note; (1) Revised project features in Review report are shown in italic/bold/red color.

(2) RCC (Roller Compacted Concrete Dam), CFRD (Concrete Faced Rockfill Dam)

Source: Review Report of the Feasibility Study by JICA, 2004.

#### 6.2.3.4 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 was 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)

### 6.2.5 PROJECT OPTIMIZATION STUDY OF THE MAIN POWER STATION

#### 6.2.5.1 Project optimization study of JICA-F/S

The main power station (peak operation time of 16 hour s) proposed in the project optimization study (optimum reservoir operation) of JICA F/S is shown in Table 6-5.

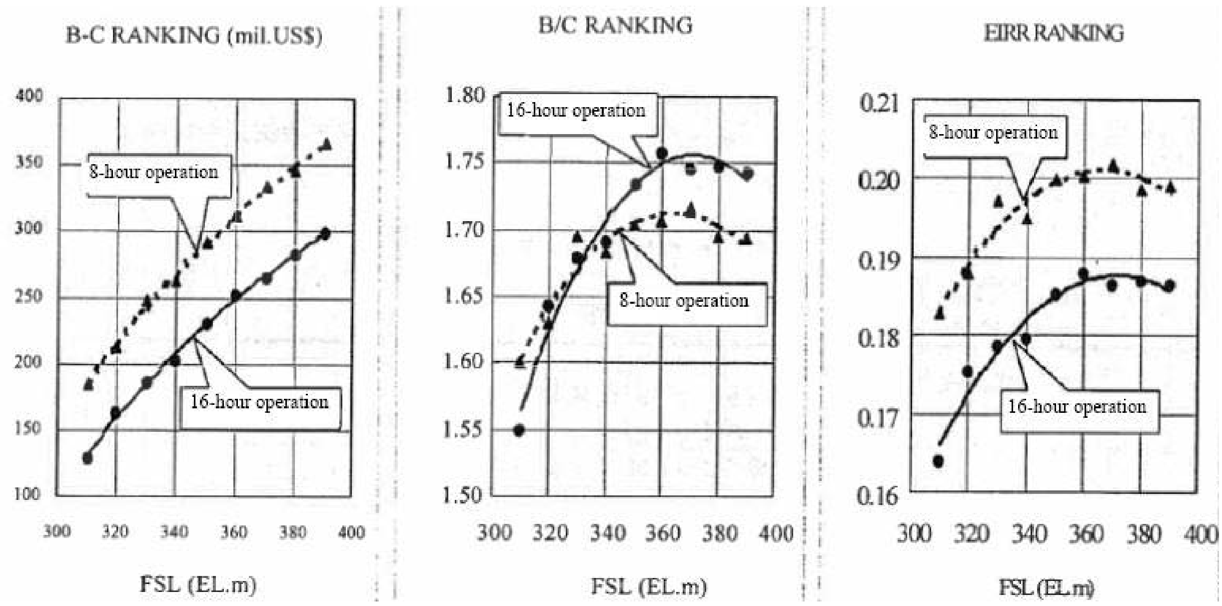
Table 6-5 Project Optimization Study of the Main Power Station (proposed by JICA)

| | |
|---|---|
| Flood Water Level (FWL) | EL. 320.0 m |
| Normal Water Level (NWL) | EL. 320.0 m |
| Rated Water Level (RWL) | EL. 312.0 m |
| Minimum Operation Water Level (MOL) | EL. 296.0 m |
| Maximum Plant Discharge | 230 $m^3/s$ |

Source: Technical Report, 2007

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

Setting the NWL at near EL. 370 m optimizes the economic efficiency of the project (Figure6-4), but it would also mean that 14 villages in the Thaviang area would be inundated. Analysis of the area show that if NWL is set at more than EL. 320 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.




Source: JICA-F/S, 2002.

Figure 6-4 Relation b/w NWL and economic efficiency of project.

The elevations of most vulnerable villages in the Thaviang area are shown in Table 6-6.

Table 6-6 Elevation of Villages Upstream of the Main Reservoir

| No. | Village Name | Lowest Elevation (m) of Village |
|---|---|---|
| 1 | B. Pou | 316 |
| 2 | B. Nakang | 324 |
| 3 | B. Hatsamkone | 326 |
| 4 | B. Phiengta | 321 |
| 5 | B. Dong | 326 to 330 |
| 6 | B. Phonngeng | 326 to 330 |
| 7 | B. Nasong | 330 |
| 8 | B. Nasay | 338 |
| 9 | B. Viengthong | 343 |

Source: Technical Report, 2007

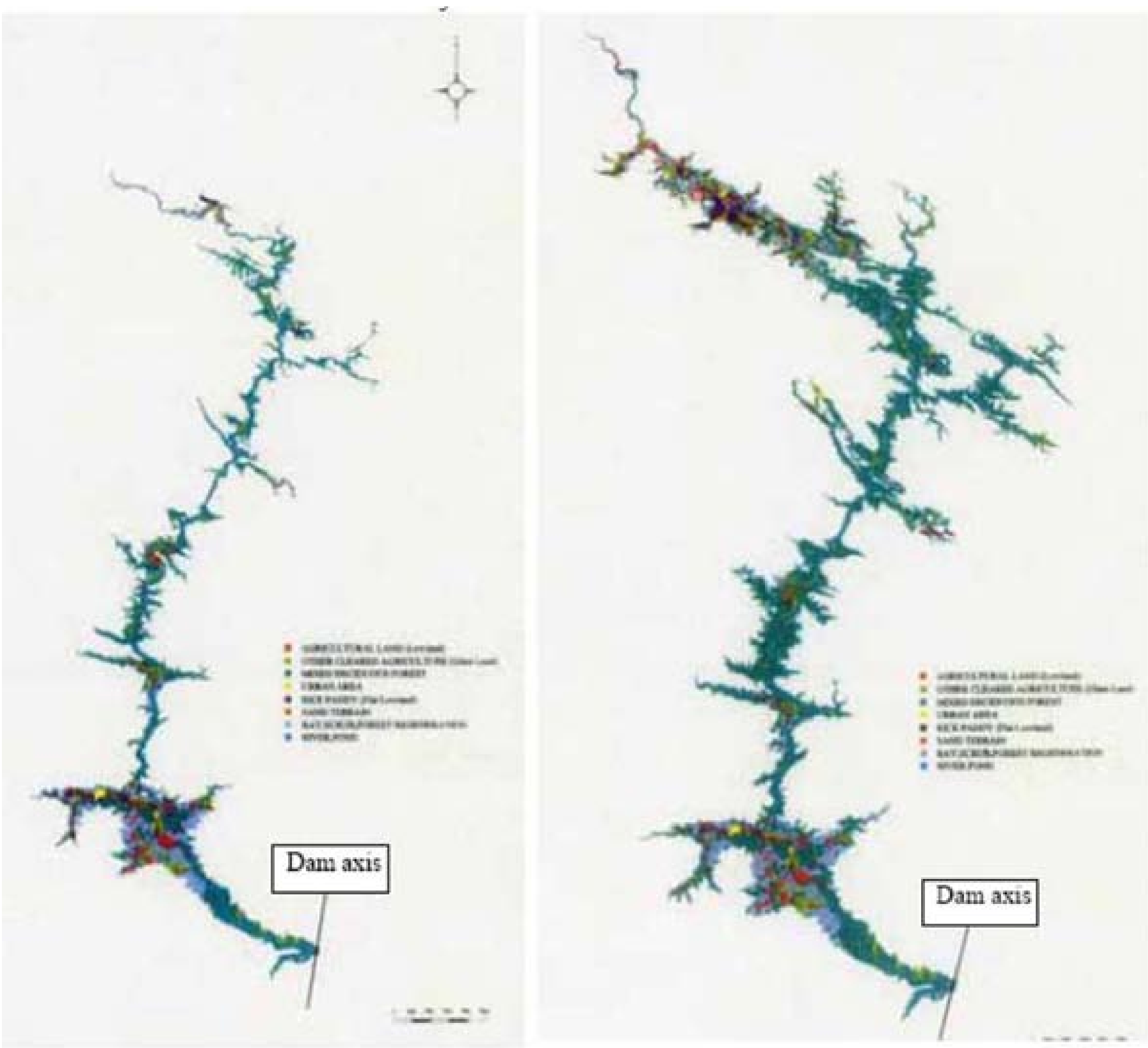
Land utilization distribution is compared for reservoir water level below EL 320 m and below EL 360 m in Figure 6-5. Summation of utilized land area for each elevation in Thaviang area is presented in Figure 6-6. The results of the surveys showed that at the dividing line of EL 320 m, the land utilization 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**

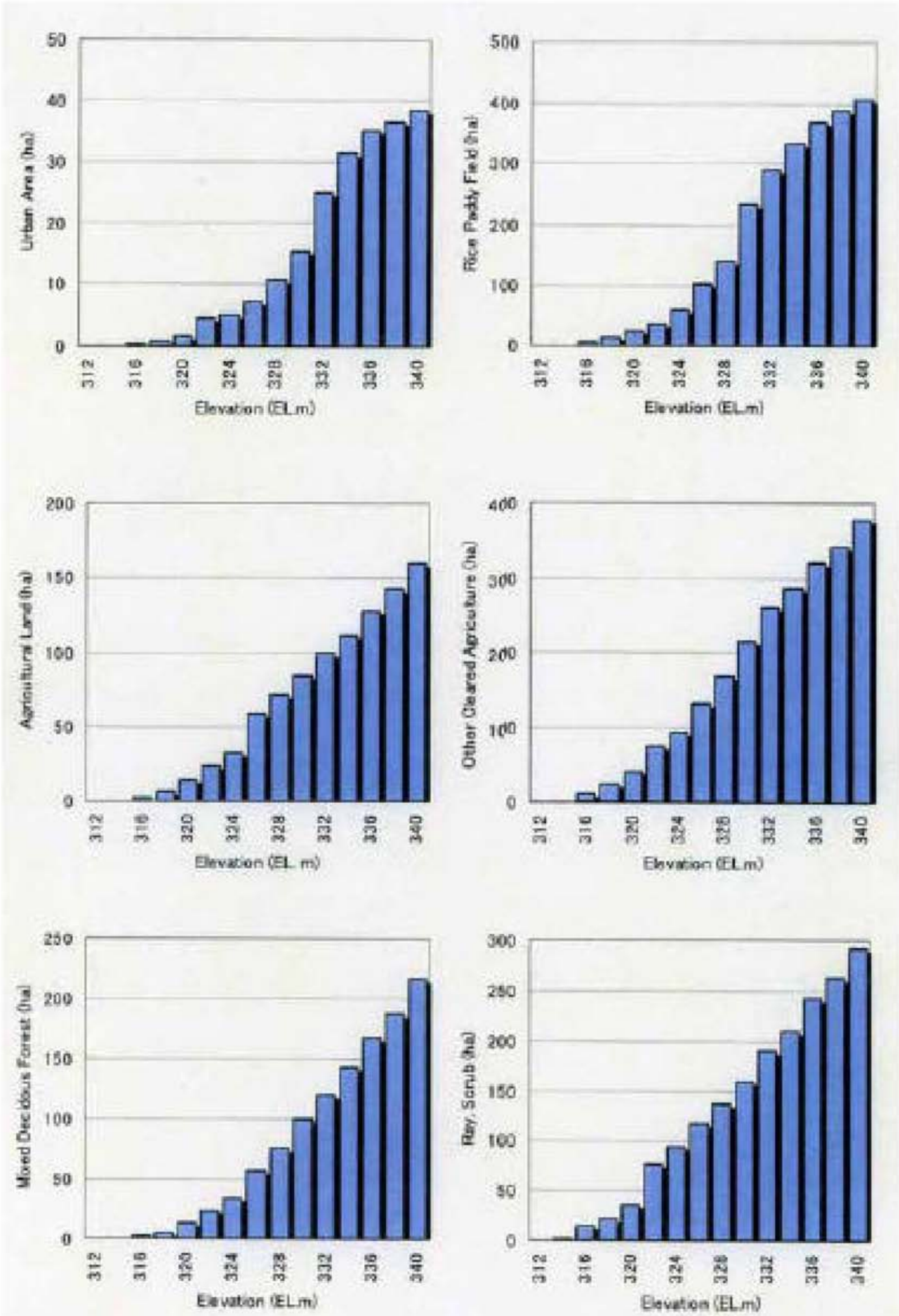
The maximum plant discharge was determined so that the annual peak energy for 95% dependability of the total analyzed period (30 years) should not fall below 80% of the annual average peak energy. The maximum plant discharge depended on the level set for NWL and MOL.




(a) NWL = EL. 320 m (b) NWL = EL. 360 m

Source: JICA-F/S, 2002

Figure 6-5 Land utilization of areas to be inundated at NWL 320 and 360 of the main reservoir.

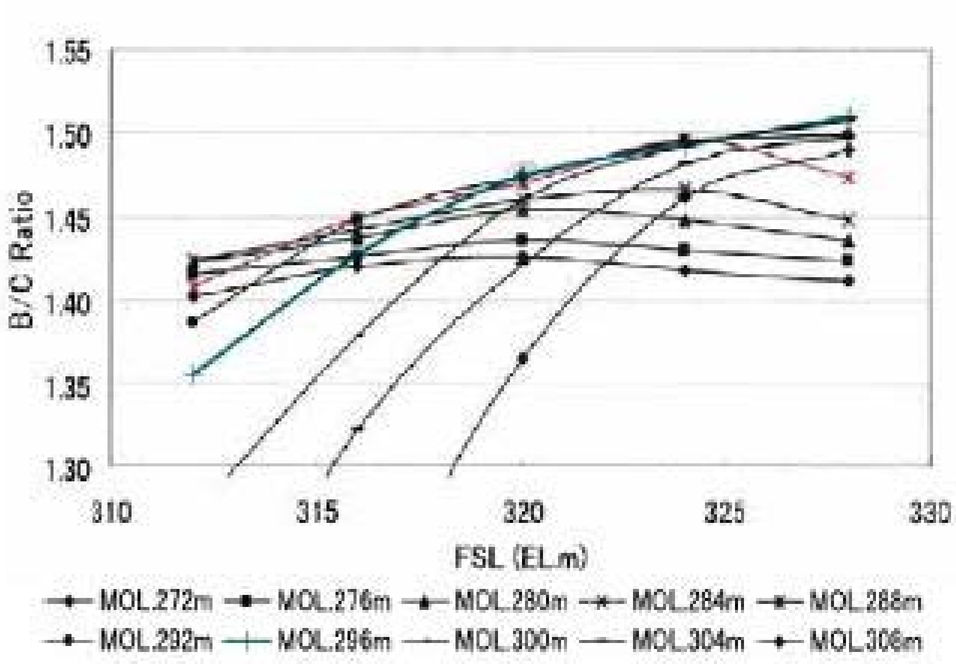



Source: JICA-F/S, 2002

Figure 6-6 Area of main types of land utilization per elevation in Thaviang area (excerpted from JICA-F/S).

### (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 6-7), with the least environmental and social impacts.




Source: JICA-F/S, 2002

Figure 6-7 Relation among NWL, MOL and economic efficiency (B/C) of project.

# CHAPTER 7

# ENVIRONMENTAL IMPACTS AND MITIGATION MEASURES

## 7.1 INTRODUCTION

The study of impacts identification and their mitigation that are likely to affect the environment is based on the period of

(i) Pre-construction and construction of project facilities, and

(ii) Operations of the two reservoirs and power plants

The environmental impacts are analyzed for two major elements, (1) the physical environment and (2) the biological environment.

Assessment of impacts caused by the access road is discussed separately in Appendix D. However, some of the main environmental issues concerning the access road are also briefly covered in this chapter.

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 and so on )
3) Main Dam
   - Diversion and cofferdams
   - Foundation excavation
   - Concrete placing

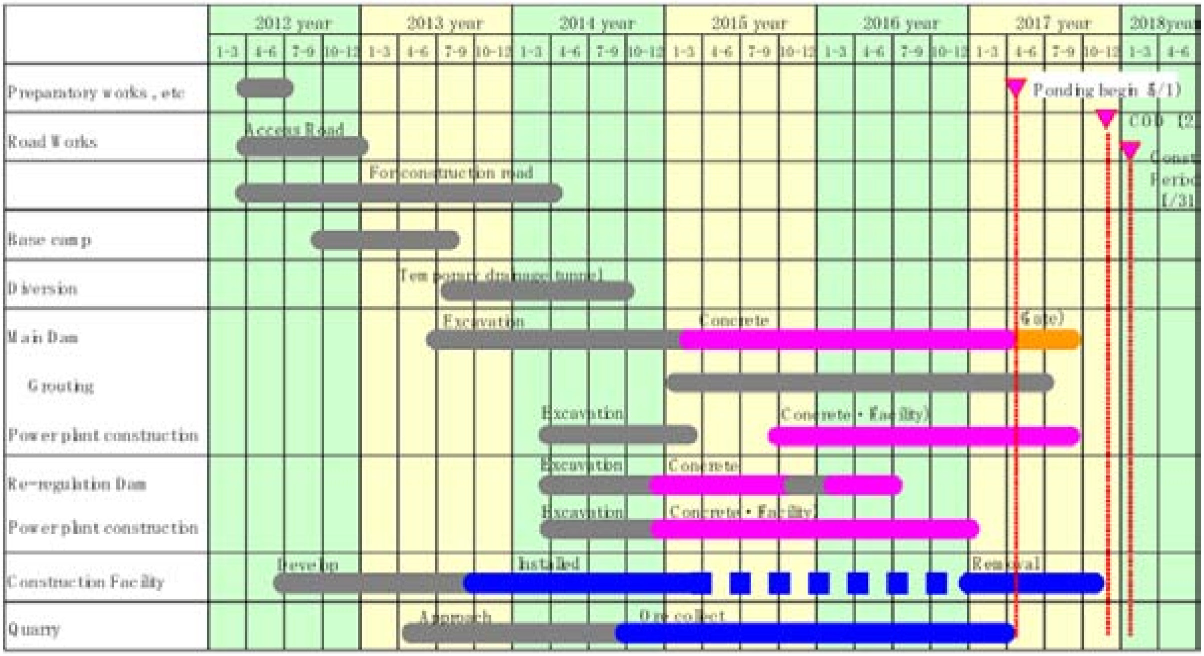
- Grouting works
- Spillway
- Main Powerhouse
- Transformer and Switchyard

4) Re-regulation Dam Construction
    - Diversion and cofferdams
    - Foundation excavation
    - Concrete placing
    - Grouting works
    - Saddle dams
    - Re-regulation Powerhouse
    - Transformer and Switchyard

5) Other
    - Disposal Area
    - Quarry Site
    - Transmission Line
    - Administration office (Owner's Base Camp)

These project components are planned to be complete at total 70 months as shown in Table 7-1.

Table 7-1 Tentative Schedule of Construction Activities




The main construction activities commence after the access roads have been completed and the contractor's facilities have been prepared. This is expected to take about 12 months. Construction commences with the excavation of the diversion tunnel, which is then followed by other activities until the powerhouse and dam are completed. During this time the reservoir and resettlement programs are also completed. Construction concludes 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 2.

The activities will involve the following;

- **Diversion of water around coffer dams**

The main construction activities on the dam foundation can only start after the river has been diverted through diversion tunnels and the river excluded from the site by coffer dams constructed above and below the dam site. There are likely to be temporary fluctuations in the flow regime in the river whilst this is going on, plus release of sediment associated with the diversion tunnel construction.

- **Movement of materials and equipment to site**

There will considerable movement of materials such as cement, fuel, construction materials, equipment and machinery along roads to the dam site and within the construction area, Residents living alongside access roads will experience impacts from increased traffic resulting in; noise, dust and reduced safety.

- **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.

- **Earth moving**

This is a major activities associated with the dam and is required for building internal and external access road, preparing sites for construction camps, dam foundation, opening quarries and for landscaping after completion of the dam site. Risks involved include; increased erosion of exposed surfaces, increase sediment loads in drainage lines, release of chemical contaminants into water, dust and noise.

- **Spoil disposal**

Proper design should maximize the re-use of spoil from excavation activities for road and foundation preparation. Spoil that is generated and is surplus to use will need to be safely disposed of to avoid erosion and destabilization of the spoil disposal area leading to sedimentation of water courses and release of chemicals in runoff.

- **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. 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.

- **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 safety and securely to prevent environmental damage.

- **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.

- **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.

- **Worker health and wildlife management**

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 as well as excessive use of scarce natural resources and hunting and trade in wildlife.

- **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 and hence water quality issues downstream. The methods for disposal of the vegetation can cause air pollution from burning etc. During filling, vegetation residues that float to the surface will need to be cleared to prevent clogging the dam intake structure.

- **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 c losing the diversion tunnel. Management of the downstream river flows will be a key task at this stage.

- **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 and the areas stabilized to minimize risks of release to the environment of toxic or polluting materials, All disturbed sites which are no longer being used will need to be rehabilitated and revegetated.

Based on ground survey conducted by the Project Owner, the main environmental impacts of NNHP-1 have been determined to be flooding of 6,690 ha will be flooded, of which about 3,200 ha are at present covered by forest. The resettlement sites will require clearing of additional forest land for agriculture. Given the changes in water flow, there is also expected to be some change in aquatic ecosystems.

With the project, mitigation measures are to be taken that will protect and enhance the remaining forests of the Nam Ngiep watershed. Fishery resources will be monitored and replenished as needed. Water quality will also be closely monitored. Agricultural production will be supported to become more sustainable.

Without the project, existing trends of forest, land, and water use can expect to continue. These are: 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 these resources will continue to be exploited at unsustainable levels. With the project, if the environmental monitoring system is in place and implemented effectively and if the recommended mitigation measures are implemented, it is likely there would be less environmental degradation than if the project was not implemented.

## 7.2 ANTICIPATED IMPACTS DURING PRE-CONSTRUCTION AND CONSTRUCTION PHASES

### 7.2.1 CONSTRUCTION IMPACTS ON PHYSICAL ENVIRONMENT

#### **7.2.1.1** Topography

The available topographic maps were of 1:250000, 1:50000 and 1:2000 scale. Additionally, more accurate information was obtained from visits to the proposed dam sites, as well as other documents.

During pre-construction and construction phases, the topography will necessarily change with the modification of the landscape with the construction of the dam and other civil works and the construction of access routes.

No mitigation measures are needed that relate solely to changes in topography. Possible impacts that are related to changes in topography, such as erosion or sedimentation, are considered separately. These issues are discussed in separate sections.

### 7.2.1.2 Meteorology

The impact of the project on climate is uncertain and not expected to be significant. 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 by Thiessen and Isohyetal methods were the most practical means for the project hydrological study. However, they may be not 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 done 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. Heavy rains will affect construction.

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 7-1). Both rains and wind would have effect on clearing.

Figure 7-1 Wet weather affecting the clearing process.

The available days 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 create dust that is dispersed downwind.

#### 7.2.1.3 Geology, Landforms and Seismology

Most of the geological information available for review was at the regional scale, some of the major geological impacts such as seismic events can also be assessed at the scale. Some geological ground surveys were conducted around the construction sites. The data obtained from these surveys was used for project design and can also used to assess the impact of geological patterns on riverbank erosion, landslide and ground leakages of the reservoir.

Based on regional geology of the project area and local geological data from the Technical Report, the potential for earthquake in the project area is determined to be low.

Landslides and rock movements are possible during construction. This potential is influenced by the Late Palaeozoic granites found intruded into Palaeozoic formations which were 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 the needs to be prevented or mitigated.

The geological information reveals only minor potential of seismic events, but the observed geological formations of fractures and deep weathering can lead to water leakage and to landslides and rock falls. To prevent these possible impacts, these 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 the appropriate properties. Ground geophysic 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.

#### 7.2.1.4 Erosion and Sedimentation

Most erosion from construction is 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, so that after the vegetation has been removed and catchment areas have been converted to other land uses (Brooks 1993), increased sediment discharges and associated adverse effects result and can persist for some time.

The proposed NNHP-1 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. Because there is as yet no detailed design of the construction site, and the locations of the workers' camp, landfill, and quarry are all still tentative, it is not possible to 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 will be essential that appropriate mitigation measures be implemented with the best management measures followed. Whenever feasible, construction, particularly land clearing activities should be conducted to the maximum amount possible 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 points in accordance with the requirements of a water quality monitoring plan.

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 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 area disturbed by construction activity will be, as far as reasonably possible, landscaped to reflect natural contours, restore suitable drainage paths and provide reasonable treatments.
- 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 dr ainage lines or in floodway zones 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.
- Waster 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 the construction sites as part of the site management plan for construction. It will include environmental management and pollution control techniques for all drainage measures. This will involve measures such as:

- Water management plans to 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 constructed watercourses. These structures will be constructed prior to commencement of earthwork 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 where appropriate depending upon the size of the catchment area, and other physical and environmental constraints.

The following measures are planned 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.

#### **7.2.1.5** Reservoir and River Water Quality

The impact assessment of water quality is considered with reference to the standards reviewed in Section 3.1.6 and water quality models developed by Kansai Electric Power Co., Inc (Annex C).

Because of 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 (the first 5 y ears of operation, including the time when the reservoir is first filled), and (3) long-term operations.

During construction phase, treated wastewater with remaining $BOD_5$ of less than 20 mg/L will be discharged from on-site wastewater treatment facility or a settling pond. When there is the peak of 1,800 workers, with estimated wastewater of 50 L/day/person, the project could produce a total of 90,000 L/day or $1.0 \times 10^{-3}$ $m^3/s$[1] 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 the rate of $1.0 \times 10^{-3}$ $m^3/s$ will not have a significant impact on water quality.

It is more likely that changes 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.

Figure 7-2 Water drainage channel provided along an elevated unpaved road.

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[1] Average wastewater 140 L/day/person were designed for the rural areas in Mahasarakham Province, Thailand. The average water use of rural Thai people was 45 liters/person/day. (www.spo.moph.go.th/). Water use of Nam Ngum 2 Hydroelectric Power Project was designed at 50-60 L/person/day.

Figure 7-3 Large sediment load due to unpaved road.

The area to be cleared for construction has been estimated to cover about 2.543 $km^2$ or 254.3 ha. This is based on estimates from spaces provided for the construction activities such as opened diversion channel, longitudinal cofferdam, foundation excavation, etc.

Main dam = 25.9 ha

Re-regulation dam = 14.3 ha

Access road (21.2 km length) = 42.4 ha

New access roads

Permanent road (12.5 km length x 10 m width) = 34.6 ha

Temporary road (20.9 km length x 6.5 m width) = 52.2 ha

Quarry site = 10.7 ha

Office = 10.2 ha

Disposal area = 64.0 ha

(*The above number is to be revised later by KANSAI due to detailed design)*

The study of soil erosion indicated that the specific sediment yield is conservatively set at 248 tons/$km^2$/year same level as that of Nam Ngum 1 Hydropower Project, which is more than that of annual sediment yield of NNHP-1 estimated 178 tons/$km^2$/year. During the wet season, the suspended solids could rise up to about 200 mg/L, compared to the much lower rate of about 20 mg/L in dry season. The erosion rate would also 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 in the river could affect downstream.

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 by runoff. The soil erosion during the rainy season that causes sedimentation downstream could occur during the five to six years of the construction period.

The main materials used for construction could also be a source of water contamination. Specification of the materials should indicate which substances would be potential contaminants, such as heavy metals. Some metal elements could leach from components used as the construction material or from the geochemistry of foundation rocks where anaerobic reaction occurs.

Potential cause of deterioration on water quality downstream is the 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 even at a very specific or limited location. 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 programs are suggested according to the types of project activities during construction are as follows.

***Program: Mitigation measures on water quality caused by project construction***

*Background*

The construction areas of the Project, including construction of the transmission line, will lead to deterioration of water quality downstream in two major ways: from storm water carrying sediment and from wastewater contaminated with nutrients from worker camps. Settling ponds can be an alternative method for improving the quality of final draining effluent from construction areas and worker camps. They can be installed to mitigate the impacts of water contamination.

*Objectives*

To control the release of sediment and other water nutrients downstream from the dam.

*Activities*

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 a space is available and able to trap sediments and other water pollutants that come along with the runoff or direct discharge, and construction costs are manageable.

Properly designed settling ponds retain water long enough for coarse suspended solids to settle. Water discharge from the settling ponds will be lower in suspended solids concentrations and concentrations of total nitrogen, total phosphorus, and biochemical oxygen demand than water entering them. 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 voluntary reward-based approach introduced. Workers should be educated on the proper use of sanitary toilets. They should be punished if open defecation is found.

Referring to OSHA 29 CFR 1910.141(c)(1)(i),it recommends toilet facilities that 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.

*Period of Practices*

The settling ponds should be provided when and where cut-and-fill operations are conducted and where bare areas occur during the construction period.

Table 7-2 Guideline for Toilet Facilities Providing 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]1 additional fixture for each additional 40 employees

Source: U.S. Department of Labor Occupational Safety and Health Administration

#### 7.2.1.6 Noise and Vibration

The impact assessment is made for only project construction while the impacts during normal operation of the dam will be negligible. The impacts due to noise and vibration levels are specific to major considerations such as the sources of noise and vibration, distance between sensitive receptors and those sources, exposure time and differences between day/night times.

The sensitive receptor of the project would be Ban Hat Gniun, which is located next to the proposed new access road and is near the re-regulation dam.

Impacts and their mitigation measures on the receptors during the construction activities are assessed as:

**(1) Noise pollution**

During the construction phase, activities that can cause noise impacts to the surrounding area include cutting and land excavation, and moving 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.

Potential noise impacts associated with grading and construction have been assessed using the methodology developed by FTA (Federal Transit Administration, 1995). Table 7-3 is a summary of noise levels generated from construction equipment (in terms of Leq) (Federal Transit Administration, 1995). Generally, construction equipment can be operated intermittently or fairly continuously, with multiple pieces of equipment operating concurrently. Typically, construction-site noise levels are about 80-90 dBA, measured 50 feet (15.24 m) from the activity. Ban Hat Gniun lies about 3 km, or nearly 9,900 feet, from the construction site, so the noise level would be less than 50 dBA.

Table 7-3 Noise Levels Generated from Construction Equipment

| Type of Equipment | Maximum Level (dBA at 50 feet) |
|---|---|
| 1. Grader | 85 |
| 2. Scrapers | 89 |
| 3. Bulldozers | 85 |
| 4. Heavy Trucks | 88 |
| 5. Backhoe | 80 |
| 6. Pneumatic Tools | 85 |
| 7. Concrete Pump | 82 |

Source: Federal Transit Administration,1995

To assess a typical reasonably foreseeable construction noise condition, a scenario in which a grader (85dBA) 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 worst case scenario, all construction equipment operates concurrently and continuously in the same area (whereas several activities might be operated at the same time) has been assessed. The combined sound level of all of equipment would be approximately 94.2 dBA at a distance of 50 f eet (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, the noise level would be approximately 48.3 dBA.

Due to 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 f eet (365 m) from active construction sites, the combined sound level of all of equipment would be approximately 66.6 dBA.

Table 7-4 indicated 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 indicated that the typical reasonable foreseeable construction noise could 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 dB A above the existing ambient sound level for the closest houses, and it will be negligible for most of the community, which lies nearly 10,000 feet from the nearest construction site.

Table 7-4 Estimated Grading–Related Construction Noise in the Project Area

| Distance Attenuation | |
|---|---|
| Distance to Receptor (feet) | Sound Level at Receptor (dBA) |
| 50 | 90 |
| 100 | 84 |
| 200 | 78 |
| 400 | 71 |
| 600 | 67 |
| 800 | 65 |
| 1 200 | 60 |
| 1,500 | 58 |
| 2,000 | 55 |
| 2,500 | 52 |
| 3,000 | 49 |
| 4,000 | 45 |
| 5,280 | 41 |
| 7,500 | 34 |

Based on the following assumptions:

| | | |
|---|---|---|
| Basic sound level drop-off rate: | 6.0 | dB per doubling of distance |
| Molecular absorption coefficient: | 0.7 | dB per 1,000 feet |
| Analogous excess attenuation: | 1.0 | dB per 1,000 feet |
| Reference sound level: | 90 | dBA |
| Distance for reference sound level: | 50 | Feet |

The report of the World Health Organization on "Guidelines for Community Noise" establishes health-based guideline values of noise exposure, for which no adverse effects of community noise exposure on hum an health would be expected. The guidelines provide guidance on va rious levels of risk on publ ic 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 7-5 Guideline Values for Community Noise in Specific Environments

| Specific environment | Critical health effect(s) | LAeq [dB(A)] | Time base [hours] | LAmax, fast [dB] |
|---|---|---|---|---|
| Outdoor living area | Serious annoyance, daytime and evening | 55 | 16 | - |
| | Moderate annoyance, daytime and evening | 50 | 16 | - |
| Dwelling, indoors | Speech intelligibility and moderate annoyance, daytime and evening | 35 | 16 | |
| Inside bedrooms | Sleep disturbance, night-time | 30 | 8 | 45 |
| Outside bedrooms | Sleep disturbance, window open (outdoor values) | 45 | 8 | 60 |
| School class rooms and pre-schools, indoors | Speech intelligibility, disturbance of information extraction, message communication | 35 | during class | - |
| Pre-school bedrooms, indoors | Sleep disturbance | 30 | sleepin g-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

These construction noise impacts can 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. 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, 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.

Since there is no residential community in the immediate vicinity of the project site, the only noise impact would be on t he workers and on s ome communities that have been proposed to be resettled by the riverside.

This shall include, at a minimum, the following measures:

- 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 devises that are provided on the equipment when new.
- 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.
- 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 controlled.

**(2) Vibration**

Vibration levels of different construction activities were also calculated. 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 showed that relatively peak particle velocity occurs between distance from explosive source and explosive mass Table 7-6.

Table 7-6 Peak Particle Velocities (PPV) from Explosion at Mae-Moh Coal Mine, Lampang Province, Thailand

| Distance from source (m) | Explosive mass (kg/d) | Vibration level | |
|---|---|---|---|
| | | 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 |

| Distance from source (m) | Explosive mass (kg/d) | Vibration level | |
|---|---|---|---|
| | | PPV (mm/s) | Freq (Hz) |
| 653 | 20 | 0.59 | 57 |
| 4,302 | 165 | <0.50 | 0 |
| 1,559 | 25 | <0.50 | 0 |
| 1,440 | 50 | <0.50 | 0 |
| 1,502 | 25 | <0.50 | 0 |
| 1,547 | 25 | <0.50 | 0 |
| 668 | 20 | 0.62 | 32 |
| 597 | 20 | 0.52 | 27 |
| 631 | 20 | 0.67 | 47 |
| 4,506 | 187 | <0.50 | 0 |
| 1,434 | 25 | <0.50 | 0 |
| N\R | N\R | N\R | N\R |
| 4,302 | 165 | <0.50 | 0 |
| 604 | 20 | 0.63 | 34 |
| 1,574 | 25 | <0.50 | 0 |
| 1,547 | 25 | <0.50 | 0 |
| 1,404 | 25 | <0.50 | 0 |
| 5,291 | 200 | <0.50 | 0 |
| 1,547 | 25 | <0.50 | 0 |
| 4,269 | 100 | <0.50 | 0 |
| 4,302 | 165 | <0.50 | 0 |
| 4,269 | 100 | <0.50 | 0 |
| 622 | 20 | 0.63 | 27 |
| 659 | 20 | 0.76 | 37 |
| 670 | 20 | 0.71 | 37 |
| 662 | 20 | 0.68 | 43 |
| 668 | 20 | 0.54 | 37 |
| 685 | 20 | 0.54 | 34 |
| 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 |

| Distance from source (m) | Explosive mass (kg/d) | Vibration level | |
|---|---|---|---|
| | | PPV (mm/s) | Freq (Hz) |
| 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), took the reference vibration amplitude (PPV ref) for a large bulldozer as 0.089 in/s at 25 feet distance, and assumed 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 amplitude at various distances was calculated and summarized in Table 7-7.

Table 7-7 Estimation of Vibration Amplitude Released from Large Bulldozer

| Distance (feet) | PPV (in/s) |
|---|---|
| 25 | 0.08900 |
| 50 | 0.03100 |
| 100 | 0.01100 |
| 200 | 0.00390 |
| 500 | 0.00100 |
| 1,000 | 0.00035 |
| 1,200 | 0.00027 |
| 2,000 | 0.00012 |

Blasting is required for the excavation of dam foundation and diversion tunnel. Noise and vibration generated by blasting was 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. 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 7-8 (Jones & Stokes 1999). Specifically, the data showed that the estimated air blast and ground-vibration values as a function of distance, based on a 293-pound charge under average normal confinement.

Table 7-8 Estimated Air Blast and Ground-Vibration Levels

| Distance (feet) | Peak Particle Velocity under Average Normal Confinement (in/s) | Probable Peak Air Overpressure (dB) |
|---|---|---|
| 250 | 1.400 | 130 |
| 500 | 0.460 | 123 |
| 750 | 0.240 | 119 |
| 1,000 | 0.150 | 116 |
| 1,250 | 0.110 | 114 |
| 1,500 | 0.080 | 112 |
| 1,850 | 0.057 | 110 |
| 2,000 | 0.050 | 109 |
| 2,250 | 0.042 | 108 |
| 3,450 | 0.021 | 103 |
| 4,400 | 0.014 | 101 |
| 5,150 | 0.011 | 99 |
| 6,200 | 0.008 | 97 |
| 7,200 | 0.009 | 96 |

Source: Jones & Stokes ,1999

The air blast could exceed the 130 dB USBM standard at a location within about 250 feet from a blast.

Employ measures to reduce air blast and vibration from blasting. 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.

#### **7.2.1.7** 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) need to be considered. 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 considerable high negative impacts on the air quality in the project site. However, these do not need to be significant and can be limited through good construction management practices. In addition, minor impacts are expected from upgrading and construction of new roads, including other infrastructure construction.

There are many dust and emission sources in the construction sites that can release a range of particles. Dust (all particulate matter up to 75 μm in diameter) and PM10 (airborne particles with an aerodynamic diameter of 10 microns or less).

The 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).

Most dust particles can cause eye, nose and throat irritation and lead to deposition on object surfaces while the PM10 can have greater effect to human health, such as causing breathing and respiratory problems. PM10 can be carried by wind to people who live and work in the area surrounding and near to 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 these 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.
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 if close to sensitive receptors
   - Loads entering and leaving the site should be covered if they are expected to contribute to creation of particles or dust.
   - The construction equipment emission as a result of diesel fuel combustion is 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.

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 for the shortest possible time

**7.2.1.8** Potential Contaminated Sites

The impact assessment and recommended mitigation measures for the construction phase are described as follows:

**(1) Chemical Use and Storage**

Some of the project construction materials that are classified as hazardous include explosive materials, fuel (diesel, LPG), lubricant oils, pesticides and paints. The improper transport, storage, use, and disposal of these materials could cause spills, leakage, fire, and site contamination. Besides hazardous materials, leachates from solid waste landfill and wastewater from campsites could pollute the river and soils by i ncreasing nutrient loads, heavy metals, and pathogens.

Activities that may cause the 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 being transported.

The receptors of those contaminants are likely to be the workers who are involved in chemical use, transport and storage, 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 hi gh slope surfaces would be increased. The cut-and-fill technique that is planned for application for the high slope can only retain the contamination. Stringent management of hazardous materials to prevent spills must be applied to the construction sites.

**(2) Quarry Site and Waste Disposal**

The proposed quarry site and the solid waste landfill near the river will require careful operation and must follow best practices. They can easily be sources of water contaminants mixing with overflow during heavy rain.

Recommended mitigation measures to minimize potential contaminations 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 follow up on 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.
- 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 material

- A hazardous waste storage area will be prepared.
- All workers will be informed of the stringent controls, and these controls will be advertised to all workers.
- Warning signs and rules must be located in the most 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.
- Probation and punishment should be applied to whoever avoids or breaks the rules.

4) Leachate of quarry site and landfill

- Appropriate measures to prevent the contaminated runoff from discharging to the river should be taken.

**7.2.1.9** Hydrology

The schedule for project construction is about 70 months or 5 years and 10 months. Water impoundment to meet the operation 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.

The tunnel construction method was recommended in the Technical Report. The tunnel with 10 m inner diameter, 660 m of length was proposed 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 then there is no plan for other uses. The flood discharge of 1.5 year probability was proposed at 1,000 $m^3/s$.

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 is at present very limited. This makes any assessment to evaluate or simulate to verify the results 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 equipments.

Although cofferdams will bank up the river with the 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.

Since the flood flow is fast and high volume, loose materials and equipment might be caught in the flow of the floodwaters downstream and cause damage to structures, campsites, roads, inhibit navigation, and can be hazardous to human and animal life. Construction materials and equipment must be firmly in place during flooding season.

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

During reservoir impoundment, even though upstream inflow has to be collected to meet water storage requirements before hydropower operations can commence, there is still need to maintain minimum flow downstream to mitigate environmental impacts as far as practical. Although water can discharged from the riparian release conduit at the elevation of 245 m, water cannot be discharged from the main dam immediately after the closure of the diversion conduit inside the main dam. Before the closure of diversion conduit, re-regulation reservoir should be filled with the water to release the water to downstream area until the water level of the main reservoir reach at the elevation of 245 m. 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.

Recommended mitigation measures to minimize the impacts on hydrology are provided 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 stored well during the

potential flooding season. To avoid any loose construction materials getting caught 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.

### 7.2.2 CONSTRUCTION IMPACTS ON BIOLOGICAL ENVIRONMENT

#### **7.2.2.1** Terrestrial Ecology/Wildlife

Based on the field survey and interviews with local residents, it is apparent that the only **significant remaining wildlife habitats are in the forested areas on the steep upper slopes or in the still abundant forests outside the project area**. There are still some wildlife habitats, though not as significant, within the proposed reservoir area where the mixed deciduous forest still remains. In the other more accessible lower and less steep slopes, the forests have been destroyed by indiscriminant logging, bush fires, and shifting cultivation, and the wildlife and wildlife habitats there have also been severely disturbed.

Most of the project components are located on the lower slopes of mountains or in the valleys. Although these used to be among the most important wildlife habitats, human activities have forced the wildlife into the higher and less accessible slopes, so that the proposed project activities are now located well below their remaining habitats. However, local residents also reported that some of the wildlife will come down to the river at night, then return to the comparative safety of the higher elevations during the day. It is thus of prime importance that the destruction of remaining habitat be kept to a minimum. Temporary access roads that go through forest areas must be closed permanently after construction is completed and the area rehabilitated to its original condition.

Although there remains some relatively undisturbed forest in the upper part of the proposed reservoir and near the dam site, these represent only a fraction of the surrounding forest. Construction of the dam and inundation of the reservoir will cause minimal disturbance to the wildlife in the area.

Loud noises from construction machinery may disturb the wildlife. Some restrictions may be necessary to keep noise disturbances to a minimum, such as restricting the times when loud machinery can be operated.

Another threat to local wildlife would be hunting of the animals by construction workers and other project staff. Prohibitions to hunting must be strictly enforced.

Tables 5.23, 5-24 and 5-25 present the list of species recorded during the baseline surveys undertaken in 2007 in the project area. The list will be updated during the biodiversity survey to identify the species that will be directly impacted by the project and unable to adapt to the new environment created by the impoundment of the reservoir and the modifications upstream and downstream.

Recommended mitigation measures to minimize the impacts on terrestrial ecology/wildlife during the construction phase is provided as follows:

- A wildlife protection team will be established to protect and rescue remaining wildlife in the proposed reservoir area.
- Wildlife specialists should be engaged to collect more updated and detailed data concerning the existing wildlife species (mammal,birds, reptile and amphibian species) in the project area prior to construction activities, and how these species will be affected during construction and operations.
- 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 breaks these rules and regulations.

- In the remaining forest areas in the catchment, and especially in those areas near the reservoir, a forest and wildlife conservation and management program needs to be implemented in order to protect the wildlife in the area.

#### 7.2.2.2 Forest, Vegetation Cover

**(1) Options and Design Consideration**

Unlike other types of infrastructure development such as roads or railways, the various components of hydroelectric power projects are much more limited by physical constraints of location, topographical features, the condition of river networks and of catchment areas. With need for extensive reservoirs and as well as other major components, the potential adverse impact to both the community and the environment could be enormous. Whatever benefits that may derive from technical aspects must be weighed against the adverse impacts on communities and the environment, in particular on forests.

Because the placement of access roads and transmission lines are much more flexible than the placement of the dam, powerhouse, and other structures, planning for the access roads and transmission lines should be sufficiently flexible to avoid as much as possible adverse environmental impacts. The project should:

- Where possible keep the access road and the transmission line alignments as straight as possible between the start and end points. For transmission lines, this will minimize the total number of towers, and for both the transmission lines and access roads, this will reduce the amount of materials that need to be imported, reduce construction costs, minimize the area that needs to be converted from other land uses and minimize the area of forest clearing. However, if there is a choice between a straight path going through a forest or a more circuitous route that avoids the forest, the more circuitous route should be selected, since it will minimize forest destruction.
- Minimize the need to expropriate valuable lands, particularly village holy forests, village cemeteries, and agriculture land.
- Avoid areas of mature forest and other environmentally sensitive areas including NBCAs, NPAs, and eco-tourism sites.
- Ensure adequate clearance between the transmission line and access road alignments and any significant cultural/historical monuments/sites.
- In addition, wherever possible considerations should be given in minimizing the extent of visual intrusion upon views considered as unique or valuable as tourist resources. This aspect however limited in so far as the technical

consideration of the dam is concern, it is still applicable in determining the visual aspect of the dam, the powerhouse as well as the operation villages.

From the field survey carried out as well as from the information available, the most favorable components were recommended and their selections based on the above principles. However it must be emphasized that these are subject to further detailed site survey and detailed design, and that these principles should be maintained for these more detailed works.

### (2) Impact on Forest, Vegetation and NTFPs

Generally, the clearance of vegetation within the dam site, powerhouse and reservoir can lead to fragmentation of already diminishing areas of natural forests and wildlife habitats. Overall, the existence value, as well as the ecological research value of the ecosystem will be diminished. Rare and/or threatened tree and plant species may also be affected by flooding. The permanently maintained access roads to the dam site and powerhouse during and after construction will eliminate the ability of the land on which the roads are located to regenerate to the original species-rich secondary forest.

Based on a nalysis of the land use and forest map and results of the field survey, as presented in Table 5-26, most of the forest and vegetation cover that will be affected within the immediate project area and in particular within the proposed reservoir is classified as Unstocked Forest and Scrub (3,551 ha) or 1.69% of the entire catchment area (refer to Figure 7-4).

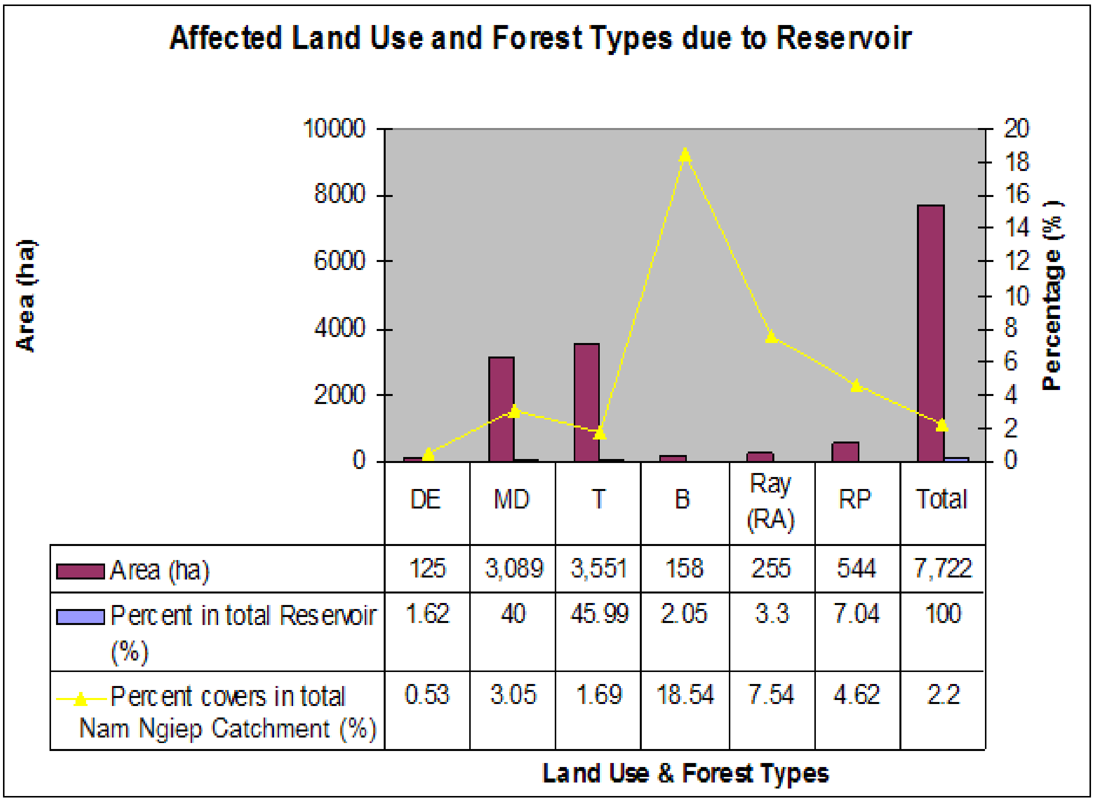
This is severely degraded forest, mostly from conversion to agricultural land. There are small patches of dry evergreen forest (125 ha) and bamboo forest (158 ha) and larger areas of mixed deciduous forest (3,089 ha). H owever, there are no ol d forests or environmentally unique areas, such as National Biodiversity Conservation Areas (NBCAs) and protection forests, within the project area. There are still some commercial tree species within the remaining three forest types. These commercially valuable tress should be removed prior to flooding. Some of these high value species are *Aquilaris Sp. (*May Por Heuang/May Ketsana*), Pterocarpus pedatus* (May Dou)*, Pterocarpus macrocarpus (*May Dou*), Cinnamomum liseafolium (*May Chuang*), Hopea odorata (*May Khen Heua*), Xylia kerrii (*May Deng*)* which belong to the “Special List”, identified by the Instruction of the Ministry of Agriculture and Forestry No. 0116/MAF.07, dated 17th May 2007.

In terms of the density and volume of the trees that will be directly affected by inundation, for trees with diameter at breast height (DBH) of equal to and more than 10 cm, an estimated 281 trees of approximately 143 $m^3$ per hectare (volume of stand tree) will be affected in the Dry Evergreen (DE). In the Mixed Deciduous (MD) Forest an average about 199 trees and 107 $m^3$ per hectare will be affected. For the Unstocked (T) Forest about 193 trees and approximately 75 $m^3$ per hectare will be affected. In addition, for trees with DBH of less than 10 cm and more than 1.3 meters of height, an average about 110 trees per hectare will be affected within DE Forest, approximately 143 trees per hectare will be inundated within the MD forest, and about 132 trees per hectare affected in the Unstocked Forest.

Apart from the loss of timber species, the submerged forest will reduce the total availability of non-timber forest products, but only to a relatively minor extent at the watershed scale. Some of the NTFPs (including medicinal plants, fruits, material, value for animals and conservation) that will be affected are listed in the Table 5-32. Some of the high value NTFP species found were medicinal plants or herbs such as cardamom *(Amomum Xathioides Wallich)*, Beberin *(Coscinium fenestratum-Gagnepain)*, *Neolourya pierrei Rod, Ziziphus attopoensus Pierre etc.,* while others are used as food, such as mushrooms, bamboo shoots, wild vegetables, and wild fruits.

Forest and NTFPs play an important role in the livelihood of many local people, especially the poor, who depend heavily on forests not only for timber for house construction and other purposes but also for food, fodder, fencing materials, medicines and condiments. Villagers also often derive cash income from sale of NFTPs and, in many areas, harvesting of forest resources is one of the few available economic activities. NTFP consumption and sales in some parts of the country can account for more than half of family income. However, in the project area, as is discussed in the Social Impact Assessment report, NTFP consumption and sales account for only a small portion of the total income of households in the NNHP-1 project area. Still, any project affected persons who lose income or livelihood from the loss of forest products or NTFPs should be compensated, as is discussed in the Resettlement Action Plan.

None of the reservoir area or other project area is situated on conservation forest or protected area, so that the overall impact of the removal and loss of the trees in this area can be considered relatively minor. Because the main means of access to land along the Nam Ngiep River is by boat, land adjacent to the river that is to be inundated by the reservoir is the most accessible and thus the most degraded.




DE = Dry Evergreen Forest; MD = Mixed Deciduous; T = Unstocked Forest; B= Bamboo; RP = Rice Paddy Field

Figure 7-4 Losses of different land uses and forest types from inundation of the reservoir.

(3) Pre-Impoundment Reservoir Preparation

In principle, four options for clearing the reservoir may be considered:

- Do nothing.
- Cut trees without removal.
- Cut trees and remove.
- Cut trees and burn.

Table 7-9 presents advantages and disadvantages of each option.

Table 7-9 Reservoir Clearing Options

| Strategy | Advantage | Disadvantage |
|---|---|---|
| *Do Nothing* | • Long term fish yield increased through increased nutrients.<br>• Standing trees provide:<br>o protection for several fish species.<br>o environment for algal growth.<br>• Very low cost. | • Rapid de-oxygenation of bottom water results in harmful to fish and production of hydrogen sulfide.<br>• High nutrient load can cause rapid growth of large floating macrophytes which can provide habitats for vectors for various diseases and also clog turbines.<br>• Navigation and gill net fishing hindered. |

| Strategy | Advantage | Disadvantage |
|---|---|---|
| | | • Re-oxygenation by wind mixing is hindered.<br>• Loss of valuable timber.<br>• Methane generation results in large greenhouse gas emissions. |
| *Cut trees Without removal* | • Long term fish yield increased through increased nutrients.<br>• Permits fishing and navigation. | • Rapid de-oxygenation results in harmful to fish and production of hydrogen sulfide.<br>• High nutrient load can cause rapid growth of large floating macrophytes which can provide habitats for vectors for various diseases and also clog turbines.<br>• Labor intensive.<br>• Promotes shoreline erosion through soil instability.<br>• Loss of potential fish habitats.<br>• Loss of valuable timber.<br>• Methane generation results in large greenhouse gas emissions. |
| *Cut Trees with Removal* | • Reduces oxygen demand and associated hydrogen sulfide production.<br>• Sale of timber can increase economic viability of project.<br>• Permits fishing and navigation.<br>• Reduces total greenhouse gas emissions. | • Very costly.<br>• Logistic problem in removing materials.<br>• Lower overall lake production.<br>• Promotes shoreline erosion through soil instability. |
| *Cut trees and burn* | • Reduced total greenhouse emission.<br>• Easier than hauling trees.<br>• Permits fishing and navigation.<br>• Reduces hydrogen sulfide production. | • Allows immediate solubilization of inorganic nutrients.<br>• Potential for explosive algal and macrophyte growth.<br>• Promotes shoreline erosion through soil instability.<br>• Loss of valuable timber. |

Based on these advantages and disadvantages, it is anticipated that timber logging and vegetation clearing is the preferred option. The objectives of the pre-impoundment preparation will be:

- To maximize income to the province from commercially viable timber;
- To minimize adverse impacts of high initial oxygen demand;
- To control nutrient concentrations and risk of eutrophication during initial filling;
- To create a suitable area for fish;
- To allow reservoir navigation and commercial fisheries;

- To create stable lake shorelines;
- To minimize greenhouse gas emissions.

Based on recent experience from similar projects, some preliminary principles for clearing may be proposed. These will have to be detailed during the preparation of a logging and clearing plan. The main recommendations and objectives may be summarized below:

- Removal of maximum commercially viable timber except in some designated buffer zones. The provincial authorities will be requested to adjust their provincial logging plan to give the commercial logging of the reservoir highest priority as soon as construction starts. All timber remaining thereafter will be offered to other contractors and the local community to be removed by a given date or to be burnt.
- All remaining timber after commercial and salvage logging operations have been completed will be cut as necessary and burnt. Experience from other projects show that the local population can be contracted to clear relatively large areas of land using their slash and burn techniques. The area that can be cleared by heavy equipment or by the local population will depend mainly on labor availability, but also on terrain. The task should take no more than two dry seasons. The area suitable for heavy machinery is limited because of the steep terrain. It is estimated that 200-300 workers would be required. If necessary, temporary migrant workers may be hired to undertake this task, however priority should be given to employing local residents. The cost of using local workers to clear small timber can cost a little less than the cost of using heavy machinery. For a similar project (Nam Lik) the average cost for manual labor and its supervision was about US$420/ha for clearing and burning. It can be expected that costs will be similar for the NNHP-1 project.
- Avoid removing stumps as disturbed soil may release far more nutrients in water – this requirement favors the use of manual labor, as heavy machinery tends to push over the standing timber and attached stumps.
- Maintain a 200 m wide buffer zone along the major creek channels or small streams to control sediment movement down the reservoir, and additionally to provide habitats for fish and to preserve the fish against commercial fisheries (since nets can hardly be used among all the tree branches).

- Preserve at least a 100 m wide vegetation strip around the perimeter of the reservoir so that the intact root structure of the trees will help bind the soil and reduce shoreline erosion and wave erosion. This will also provide a shelter for fish.

Calculation of biomass from DBH more than 10 cm could be conducted and the result is shown in Table 7-10.

Table 7-10 Estimation of Remaining Biomass on Each Main Forest Type in Reservoir Area

| Description | Dry Evergreen Forest (DE) | | Mixed Deciduous (MD) | | Unstocked Forest (T) | | Total Volume (m3) |
|---|---|---|---|---|---|---|---|
| | Density (trees/hectare) | Volume (m3/hectare) | Density (trees/hectare) | Volume (m3/hectare) | Density (trees/hectare) | Volume (m3/hectare) | |
| Diameter at breast height (DBH) of equal to and more than 10 cm | 281 | 143 | 199 | 107 | 193 | 75 | |
| Diameter at breast height (DBH) of lesse than 10 cm and more than 1.3 meters of height | 110 | n/a | 143 | n/a | 132 | n/a | |
| Total Area in Reservoir (ha) | 125 | | 3,089 | | 3,551 | | |
| Total Tree Volume (only DBH >= 10 cm), m3 | | | | | | | |
| - at 100% | 17,875 | | 330,523 | | 266,325 | | **614,723** |
| - at 90% remaining | 16,088 | | 297,471 | | 239,693 | | **553,251** |
| - at 80% remaining | 14,300 | | 264,418 | | 213,060 | | **491,778** |
| - at 70% remaining | 12,513 | | 231,366 | | 186,428 | | **430,306** |
| - at 60% remaining | 10,725 | | 198,314 | | 159,795 | | **368,834** |
| - at 50% remaining | 8,938 | | 165,262 | | 133,163 | | **307,362** |
| - at 40% remaining | 7,150 | | 132,209 | | 106,530 | | **245,889** |
| - at 30% remaining | 5,363 | | 99,157 | | 79,898 | | **184,417** |
| - at 20% remaining | 3,575 | | 66,105 | | 53,265 | | **122,945** |
| - at 10% remaining | 1,788 | | 33,052 | | 26,633 | | **61,472** |

These mitigation measures are including:

1) There are some commercial tree species that should be removed. However, a detailed survey needs to be conducted to determine which of the large commercial tree species should be logged. This will be overseen by Provincial and District Forestry Section (Unit) to ensure there is no illegal logging or destruction of trees outside the approved area. (As per Article 105 and 106 of Amended Forestry Law No. 06/NA-2007).

2) As per Article 70 ( Amended Forestry Law No. 06/NA-2007), funds could be provided to the relevant local government authorities to conduct the detailed survey for identification of location and boundary of the reservoir and/or affected areas as well as for a detailed estimate of timber for logging of the trees that will be affected, especially in the reservoir area. Funds could also be

provided to local authorities to promote the collection of all NTFPs from the reservoir area prior to clearing and burning. The local authorities will be asked to collaborate with the Provincial Environment and Social Management Committee (PESMC) to ensure that these operations are limited to the reservoir area.

3) Funds will be also provided by the developer to assist with a program of compensatory regenerating and planting as per Article 70 of the Amended Forestry Law (No. 06/NA-2007) especially for those areas where temporary access roads need to be constructed. The PESMC, which includes the PAFO, will have responsibility to monitor the implementation of the program. The areas for compensatory regeneration could constitute woodlot areas for the resettlement villages or areas of degraded forest such as unstocked forest or bamboo areas.

4) Logging and sale of log selling must comply with the Forestry Law and other laws and related regulations. A salvage logging committee (SLC) must be established in order to manage all of the logging process.

5) In order to reduce intrusion into the reservoir area by project workers, the reservoir area will be part of the designated buffer area from which all workers are excluded. The developer shall be responsible for dissemination of all regulations and related information to its staff and workers, and will also be responsible for any misconduct by its staff and workers.

6) Water quality of the reservoir, especially in the first years, is dependent on the quantity of biomass in the reservoir area that will be inundated. Given the amount of forest area and vegetation, including agricultural lands, that will be inundated in the case of the NNHP-1 Project, vegetation or biomass clearance in the reservoir area is needed.

7) Compensation is required for loss of land and livelihood in accordance decree 192/PM. These arrangements are discussed in the Resettlement Action Plan.

8) Compensation and consultation with local organization and villagers are needed before logging; traditional protocol and spiritual rituals must be observed. All commercial tree species that are cut in community lands belong to the community/village.

9) Forest protection and management including forest rehabilitation and tree plantation need to be carried out in the watershed area (or catchment area) by establishing Watershed Management Committee that is responsible for all related activities. This is discussed in the Watershed Management Plan.

10) A monitoring program will be implemented that involves the DAFO, other authorities concerned, village forest associations (VFA), and an independent third party, to audit the clearing operation and compensatory replanting operations.

#### **7.2.2.3** Aquatic Biota

During constructing period, moving of heavy equipment for cutting, soil leveling, digging and soil transport may produce dust and sediment adding to water turbidity. This turbid water can prohibit penetration of sunlight to deeper layers in the river, and reduce the population of plankton, consequently leading to a decrease of fish biomass. The distance of this turbidity will depend on the flow of the river and the amount of dust and sediment released. The greatest impact is likely on benthic species. The turbid water will run down to the distance short or long depending on rate of flow at that time.

To avoid pollution that can affect aquatic species, toilet, cooking, and other facilities must be well maintained and must avoid releasing waste or sediment into the river. Construction materials must be adequately stored to avoid leaching of pollutants from those materials.

These mitigation measures are including

- During construction, water turbidity and flow problems could be avoided by building cofferdam and diversion tunnels that would allow the water in the Nam Ngiep to continue to flow freely to the downstream, as it did prior to impoundment.
- Site clearing and other earth works should use appropriate method, to minimize release of dust and sediment into the river that would increase water turbidity.
- Sedimentation ponds should be constructed to gather all wastewater and turbid water in the construction area prior to discharge to an open area.
- Fishing around the construction area should be prohibited. Use of illegal fishing gear anywhere along the river should also be prohibited.

# 7.3 ANTICIPATED IMPACTS DURING OPERATION PHASES

## 7.3.1 OPERATION IMPACTS ON PHYSICAL ENVIRONMENT

### 7.3.1.1 Meteorology

The impact of the project on climate is uncertain and not expected to be significant. 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 by Thiessen and Isohyetal methods were the most practical means for the project hydrological study.

The creation of a reservoir and flooding of 66.94 km$^2$ of formerly forested and sometimes seasonally flooded land, including reservoir of re-regulation dam 1.42 km$^2$ 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 7-5), as well as result in increased down slope winds, and could result in cloud base creation or suppression.

Figure 7-5 Fog during rainy season.

The magnitude of the changes will be small, localized and not particularly noticeable because of the comparatively small size of the reservoir and forces created by this new waterbody in relation to the dominant climatic influence of the seasonal monsoons. The reservoir will likely only contribute to minor microclimatic changes. The forested lands in the catchment and in the project area will be important to help maintain and enhance localized climatic conditions.

The water quality simulations as shown in Annex C showed that downstream water temperatures could be significantly changed. The input factors of surface water temperature model were solar radiation, wind velocity, cloud amount and relative humidity. The average temperature of outflow from the dam would be about 4°C higher than the river water temperature.

#### **7.3.1.2** 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 where is 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 impacts that could contribute to the geohazards can be minor if suggested mitigation measures are implemented. During the operation phase, inspection of 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 solid and its chemical characteristics e.g. mercury should also be monitored annually as a baseline information

#### **7.3.1.3** Soils

The field survey and soil physico-chemical analysis data of the resettlement site on the right bank of Re-regulation dam in July 2011 found that most areas are extremely acid to very strong acid (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.

The 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 before after comparison study. The date shows that most area are extremely acid to very strong acid (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 area in the resettlement site are considered as 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 to 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), soils 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 any soil management problem in this study site, there are several best management practices to choose from or to use in combination. These include:

- Lime application on the sites which soil pH is very strong acid to extremely acid.
- Bio-char; easy, inexpensive, and without-cutting methods of soil improvement organic fertilizer, which is made of husk by burning and
- Organic fertilizer; composed of leftover food, animal dung, bacteria, and water
- Add limited amounts of chemical fertilizer, especially macronutrients such as N, P and K, in order to manage and balance plant nutrients in the soil.
- Infrastructure enhancement
  - Irrigation system; pond and water way
  - Saddle dam; protect new resettlement are from flood of Nam Ngiep


Source, Huay Sai Royal Development Study Center (Thailand)

Figure 7-6 Practices of bio-char in Thailand.


Source, Huay Sai Royal Development Study Center (Thailand)

Figure 7-7 Practices of organic fertilizer in Thailand.

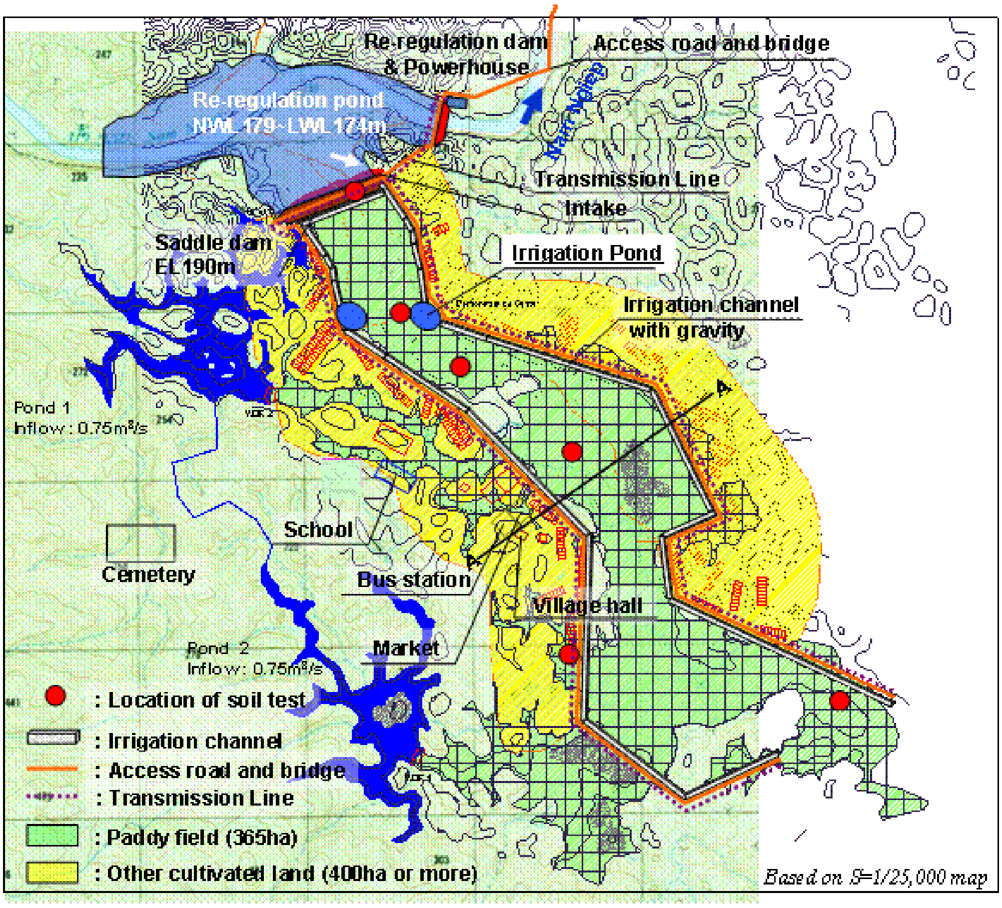



Figure 7-8 Infrastructure within the resettlement area.

- Sustainable lifecycle Management: The proper application of livestock manure can benefit soil by returning nutrients removed by crops, supplying organic matter to feed the soil biota, which in turn will help to improve soil structure. However, livestock manure must be handled properly to prevent pollution and to ensure the greatest economic benefit.

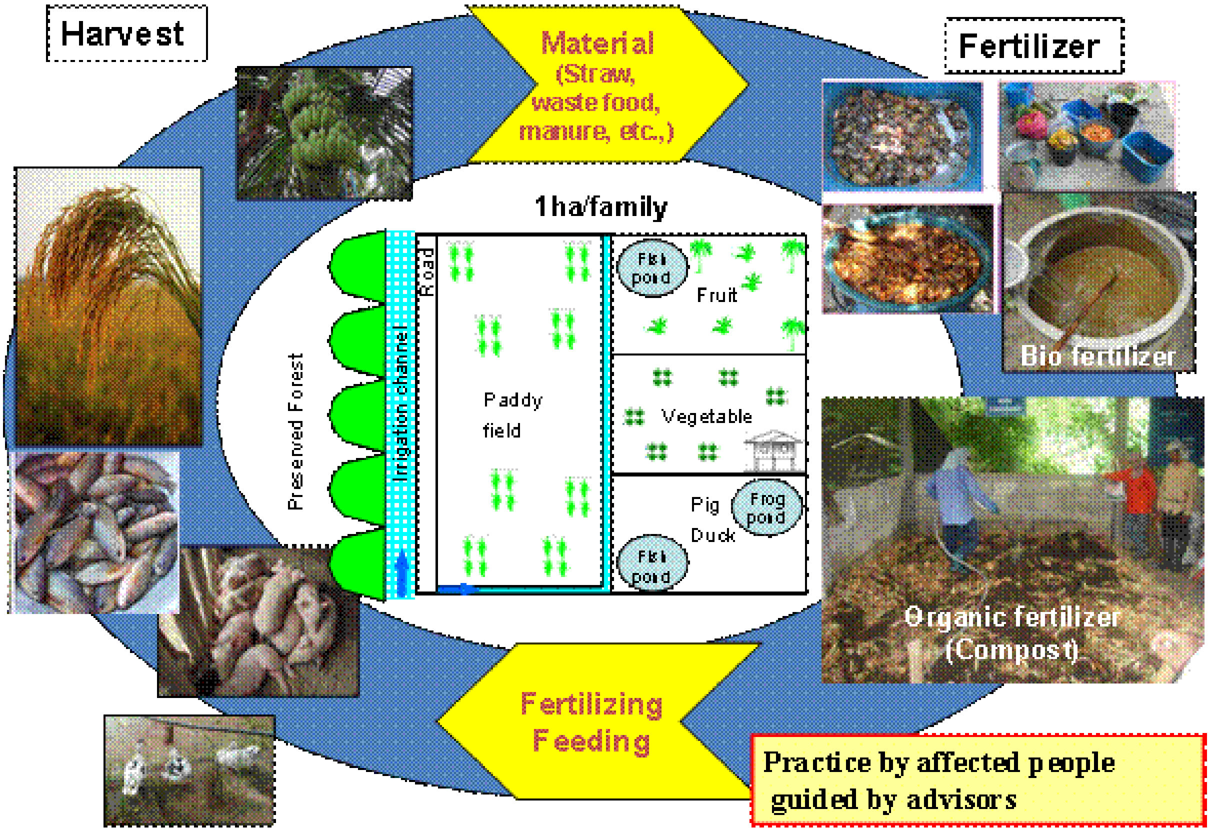



Figure 7-9 Sustainable lifecycle management.

- Crop management:
  - 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 a vetiver grass, which can prevent loss of soil nutrients and improve capture and efficient use of water.

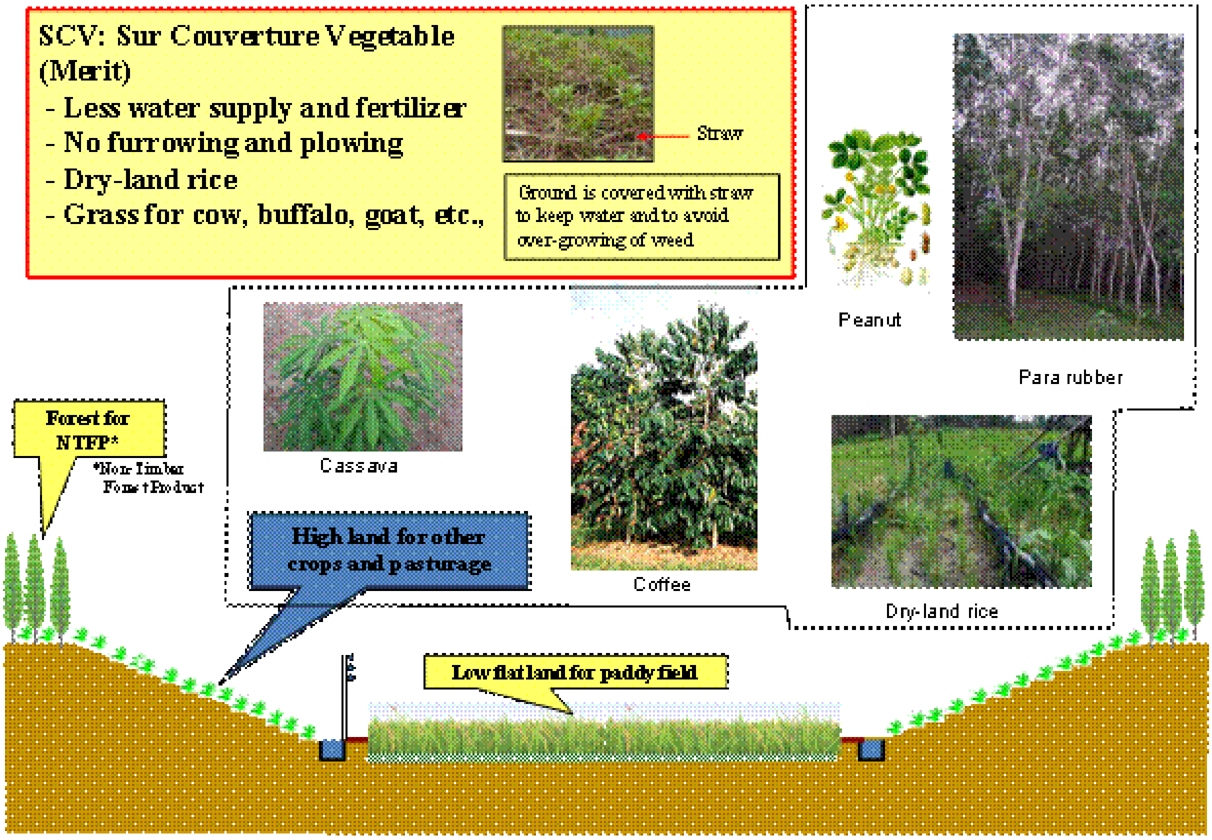



Figure 7-10 Crop management.

To achieve above mentioned mitigation measure, pilot plant will be constructed. Procedure for achieving sustainable life cycle is following.

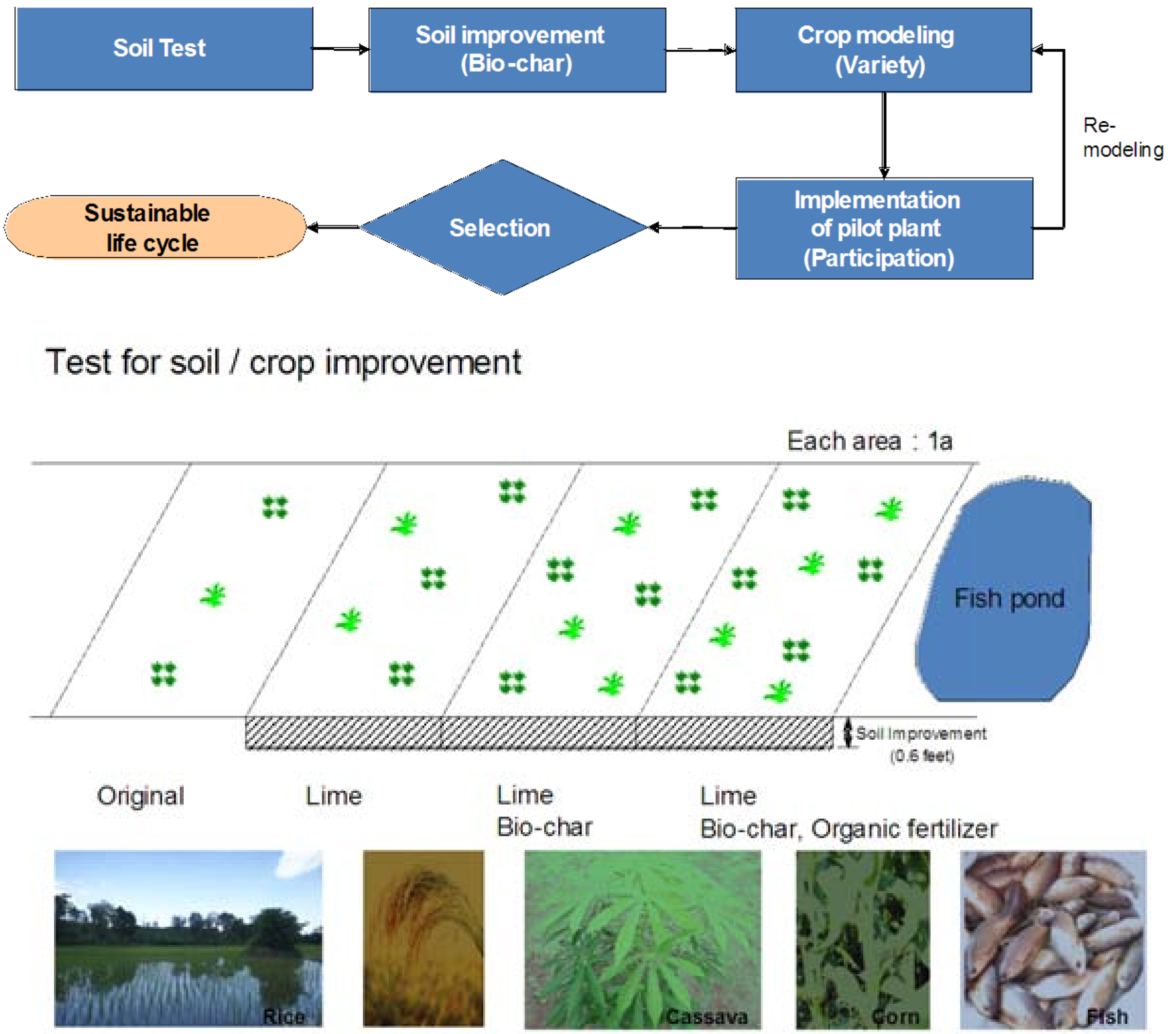



Figure 7-11 Pilot plant.

#### 7.3.1.4 Erosion and Sedimentation

The sediment yield from the catchment and in the reservoir should be taken into account during the design life of the project. The long-term protection of the catchment area is essential to insure 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.

Monitoring the recovery of the dam construction site after the construction work is needed for further impact to downstream. It will be of great importance to monitor the development and sediment output decrement with recovery. 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

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.

At Zone 2 (Reservoir), the creation of a large catchment Area of 3,700 $km^2$ should ensure that mitigation measures to control erosion and sedimentation in the reservoir are implemented and insure that sediment yield will remain at the current estimated low level. The issue is how to ensure that the reality is as close as possible to the predictions. The key to this is the management of activities in the watershed, particularly the steeper slopes. These areas are wholly in the catchment area and without management could be subject to logging and slash and burn agriculture. It is therefore important that prohibition of logging in the catchment area be enforced rigorously and that slash and burn activities be limited to and preferably reduced significantly from their current levels in watershed management plan.

At Zone 4 (Downstream), mitigation measures will be essential to prevent or minimize such adverse effects on aquatic habitat and associated species, particularly given the reliance of fish and other aquatic or riparian wildlife species as food sources and for commerce.

Areas downstream of the main dam site and re-regulation dam are expected to experience some erosion, particularly where soil properties comprise areas of instability that are sensitive to erosion. T he environmental assessment and management plan recommends that the situation should be periodically monitored by the ESMMU and measures taken to rectify the conditions if adverse impacts are found and identified.

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 control 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 in the downstream of Nam Ngiep. Both remedial mitigation measures and compensation for the loss or interference with villagers' livelihoods should be considered and the most appropriate measure or combination of measures applied on case-by-case basis.

#### 7.3.1.5 Reservoir and River Water Quality

The impact assessment of water quality is considered with reference to the standards reviewed in Section 3.1.6 and water quality models by Kansai Electric Power Co., Inc (Annex C).

**(1) Study Cases in South East Asia**

A large number of hydroelectric dams have been constructed throughout the Southeast Asia, which can help us understand the potential problems with the NNHP-1 project. Three major biophysical environmental issues have been found with these dams:

- Large rates of sedimentation, as found in the dams in the Brantas River Catchment, Indonesia
- Eutrophication and proliferation of exotic aquatic weeds
- Poor downstream water quality and changes in hydrological regime, as is found at the Bhumibol Dam, Nam Thuen 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.

In Thailand, the Bhumibol dam caused deterioration of water quality downstream for decades because of anaerobic organic degradation and stratification phenomena. The water quality in the reservoir was reported as Class 5[2] due to rapid depletion of DO with the

[2] Notification of the National Environmental Board of Thailand, 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).

discharge of the hypolimnion zone. Class 5 is the lowest surface water quality standard in Thailand, which is appropriate only for navigation and not for any other human use. However, it is not likely that similar problems will occur with the NNHP-1 project as with the Bhumibol dam in Thailand, since the reservoir of the Bhumibol dam covers a vast expanse of very deep water, while that of the NNHP-1 is long and relatively narrow.

Generally, the water quality of small reservoirs in Southeast Asia is not affected by the stratification effect. In Thailand, dams with about 10-15 meters water depth sometimes reported thermocline effects. However, the stratification depends on many factors including water body, environment, and polluted organic matter. Therefore, the designs of dams, especially the water head, usually include the aspects of stratification.

Even when the dam designs include prevention of stratification so as not to affect downstream water quality, low DO in the water can still occur from the high degradation rate of organic matter in the cleared topsoil of the upper reservoir and of remaining organic debris in the inundated area. However, in the longer-term operation of the dams, the water quality in reservoirs recovers. Moreover, colder temperatures, wind velocity and wave action during the cool season causes turnover, with the low-DO water in the hypolimnion layer naturally turning over and mixing with that of epilimnion zone, resulting in higher DO content in the hypolimnion zone which is discharged downstream.

In Thailand, Lao PDR and Vietnam, there are 17 hydro-power projects with stratified storage reservoirs which periodically release anaerobic water with highly toxic hydrogen sulfide that affects downstream aquatic ecology and fisheries. There were 18 irrigation reservoirs with a depth of more than 10 meters that potentially showed the same negative downstream effects on water quality, depending on the reservoir operation.

To date, these reservoirs have implemented few to no mitigation measures to improve downstream water quality. The Mekong River Commission is investigating destratification of reservoirs to improve downstream water quality and enhance fisheries production. They have recently reviewed a very successful destratification operation in water supply storage of comparable size to these reservoirs in Southeast Asia, such as one case in Brisbane, Australia. Technology transfer of this technique is underway via the Mekong River Commission.

**(2) Water Quality of the project**

Computer models were made 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. Annex C provides greater detail on the method of computation of water level fluctuation and water quality to the downstream.

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 is analyzed based on the measurement in 2011.

Other computerized output focusing on DO was 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.

Because of the varying impacts from different activities, that already mentioned in section 7.2.1.5, 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 (the first 5 years of operation, including the time when the reservoir is first filled), and (3) long-term operations. The long term operations are further divided into two phases: (3.1) from 5 to 10 years after start of operations and (3.2) after 10 years of operation. The different types of impacts during these phases and the various changes of water quality (sediment, DO, phosphorous and nitrogen concentrations) potentially have adverse effects downstream unless appropriate mitigation measures are taken.

While the dam structures have been designed to minimize changes in water flow, it is still likely that there will be changes in water quality during the first years of operation. The reservoir may also release stratified into thermocline and hypolimnion zones, and the water from these zones could be released from riparian release conduit, intake, or spillway.

**(2.1) Initial Operation phase**

Initial impounding plan will be prepared during 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 7-12) 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 (Reference: Water Quality in Hydroelectric Project: Consideration for Planning in Tropical Forest Regions, WB Technical Paper No.20, 1984). After that, the rate of leaching and degradation would become much lower, depending on amount of organic 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 7-12 Algal bloom and debris degradation during the early stage of water impoundment of a small reservoir in Feung.

After about ten years of water impoundment, the discharge quality may recover to Class 2 or Class 3 standard for surface water. Even so, water quality monitoring programs must be continued on a regular basis, because many external factors can affect water quality.

**(2.2) Normal Operation phase**

During routine operation, the direct impacts on the water body included 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 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 or nutrient loads from land uses in the river catchment will affect the quantitative and qualitative characteristics of the water. Natural forests, crops and communities are found throughout the catchment area. After the water has filled to the designed level, the stored water will inundate a large variety of terrestrial and riparian habitats, including natural plants and strips of crops along the shore. Water can continue to deteriorate from the dissolved components of these plants flowing into the reservoir, with runoff containing soil nutrients and sediment from the catchment settling in the reservoir.

Water quality models were calculated 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. Several factors, however, limited the quality of the model results. Normally, impacts on aquatic life would need to concentrate on hourly quality change rather than daily, weekly or monthly water quality values. Maximum and minimum values are also very important to indicate the tolerance of the biota to the fluctuations in quality. The database of water quality of the project did not include this information on hourly or even on maximum and minimum values, providing only average monthly water quality.

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 2011. The other study of correlation equation was conducted using both the observed water temperature in Tavieng and the air temperature in Vientiane. Extrapolation method was used to estimate missing water temperature data.

Monthly average solar radiation in Nongkhai (Thailand, 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 Nam Ngiep1 reservoir and discharge was carried out, based on the hydraulic data of eight (8) years (1991-1998).

The average daytime water temperature of reservoir surface close to the dam was the lowest (25.9°C) in January while the highest (30.1°C) was in May (Figure 7-13). 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.

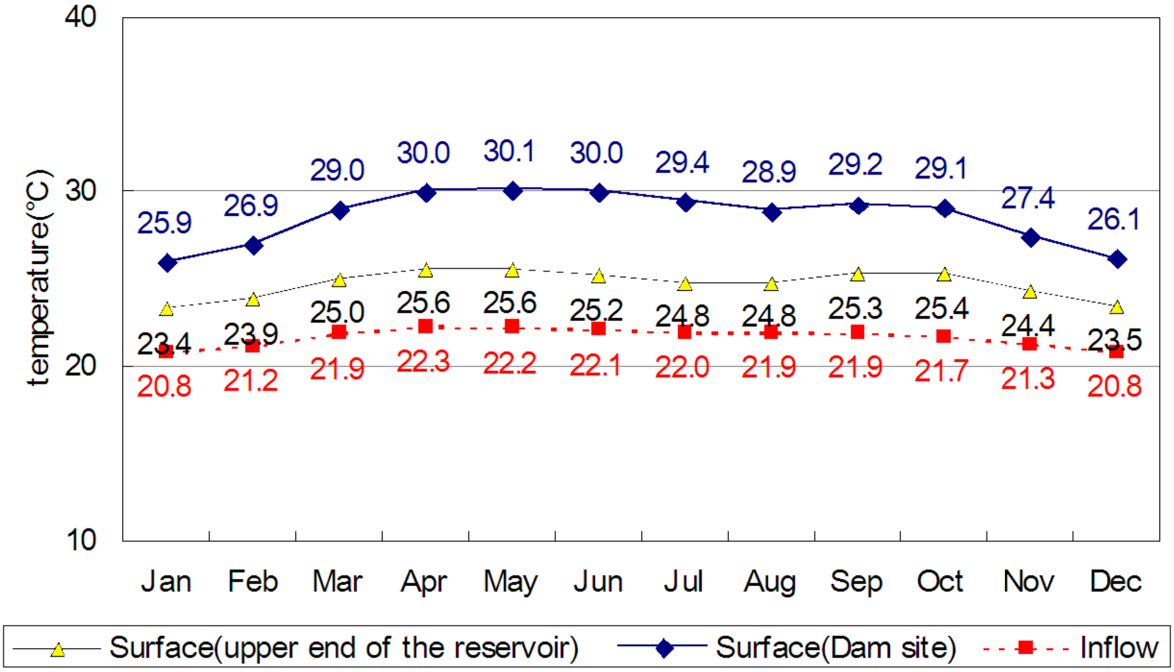



Figure 7-13 Monthly daytime water temperature in the reservoir.

- Daytime water temperature of discharged water

The water temperature of discharged water tends to be higher than that of the natural inflow (Figure 7-14). The temperature of the discharged water also tends to be lower than that of reservoir surface water close to the dam.

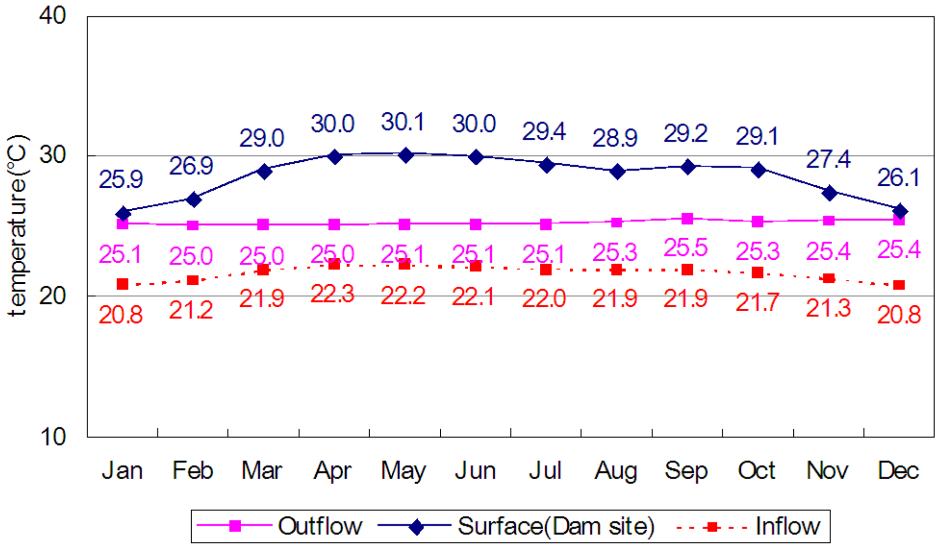



Figure 7-14 Comparison of inflow and outflow water temperatures of NNHP-1.

- 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 7-15).

The temperature of discharged water gradually changes as the water flows downstream and it gradually approaches the temperature of water before construction of the dam.

Due to the limits of available data on temperature, the impact assessment of water temperature on aquatic life in the project area had to be made was indirectly linking to the biochemical functions that is affected by temperature change. The change could affect to 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.[3] At the least, it can be expected that there will be changes in the community composition of macroinvertebrates in those areas downstream from the dam that will face the significant increases (up to 4°C) in temperature predicted.

The assessment of the temperature changes on aquatic organisms downstream is conducted by the results of temperature model. This makes it even more imperative that an effective and regular monitoring system be in place to determine the impact of the dam on downstream aquatic life during construction and throughout the operation of the dam.

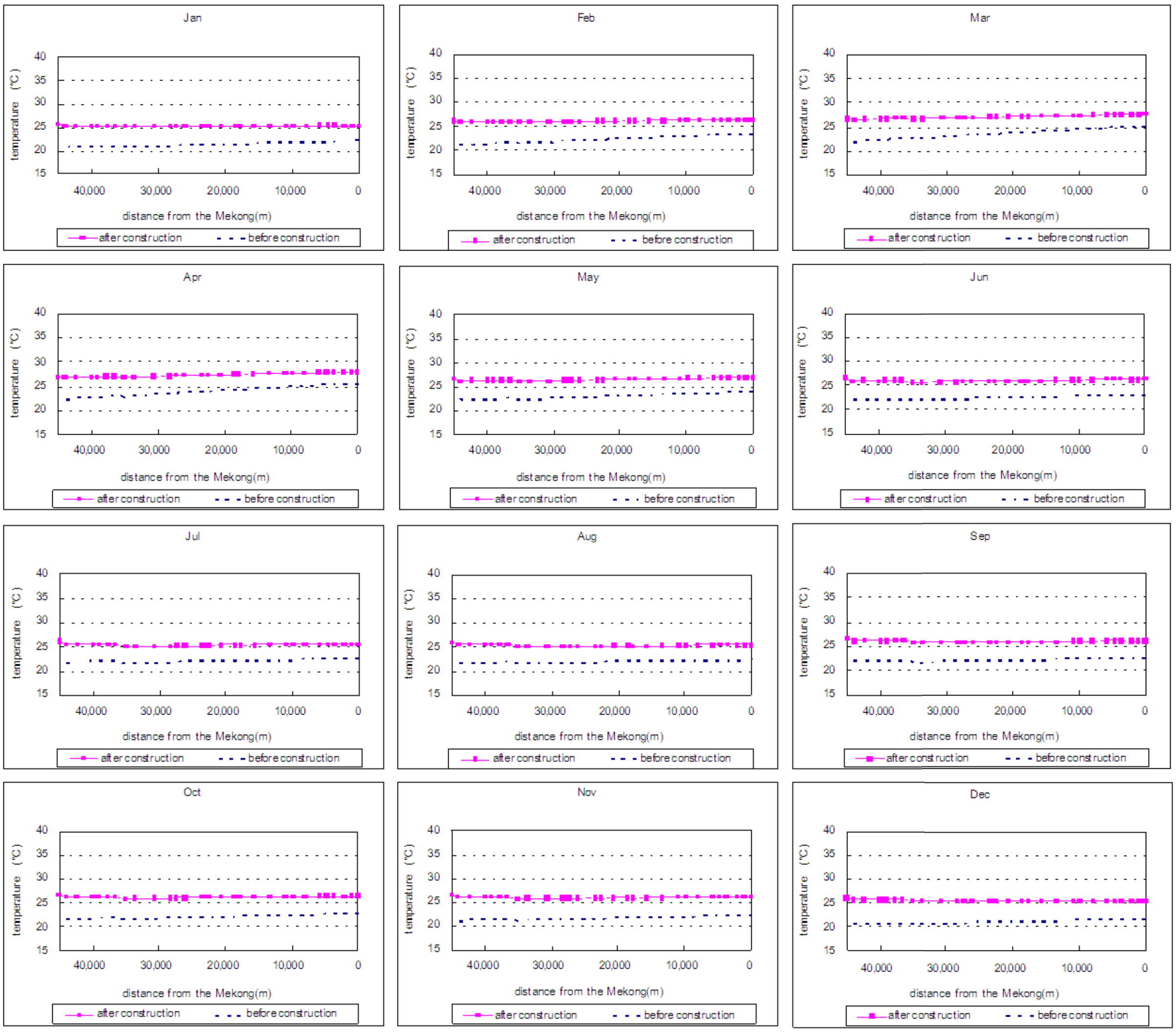



Figure 7-15 Comparison of downstream water temperatures of NNHP-1.

[3] Lessard, J. L. a nd 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

### _Dissolved Oxygen_

The prediction of DO change due to the project was conducted by reviewing the impacts of similar dam projects, taking data of eight (8) years (1991-1998) from those dams, and comparing the results with that of 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 inflow. The predicted range of the DO in the discharge varies from 3.5 mg/L to 7.9 mg/L through the year (Figure 7-16).

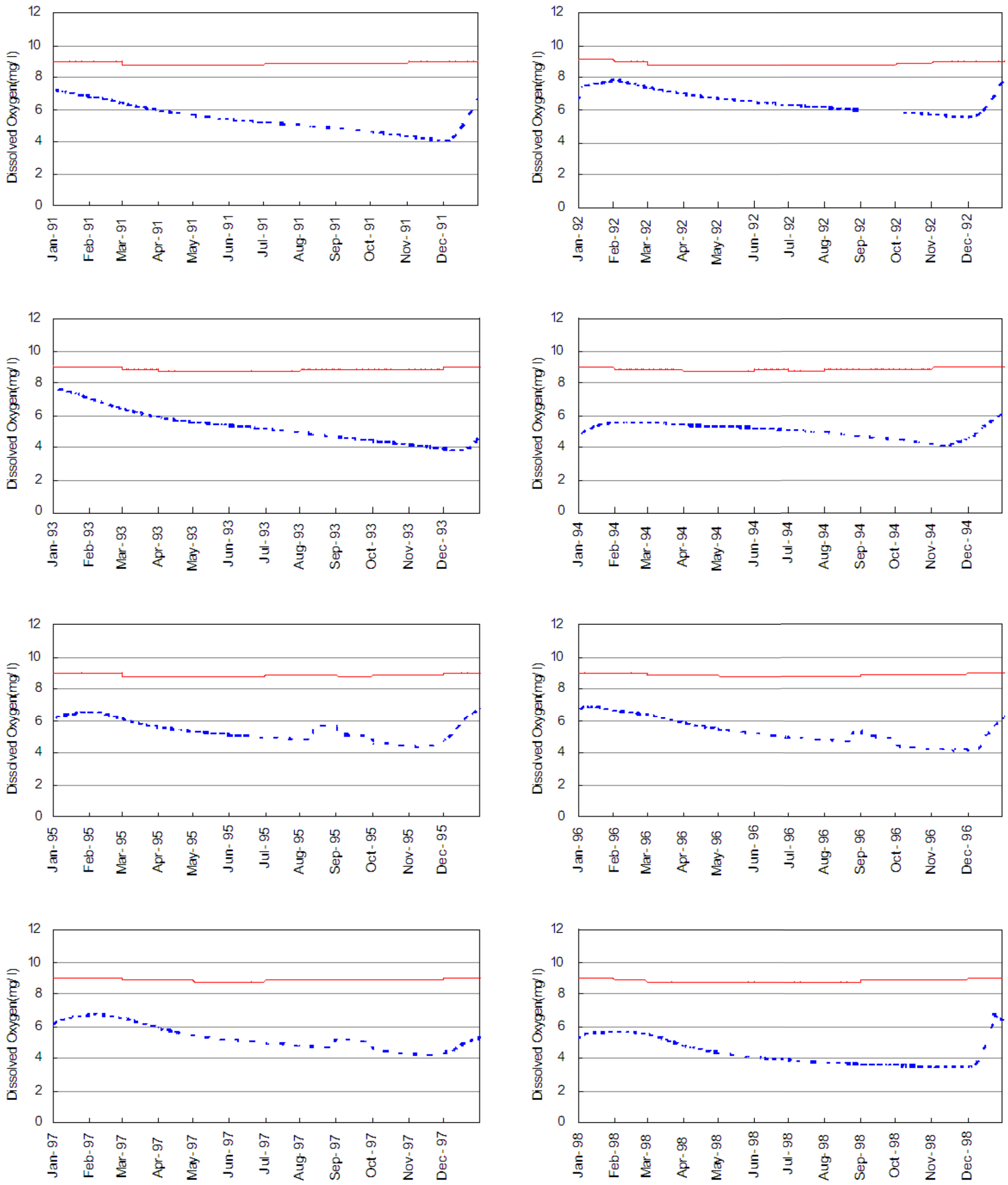



Figure 7-16 Comparison of inflow and discharged DO.

Although the DO concentration deeper than the sill level of power intake is possibly less than 2mg/L, it is not likely that the DO in the discharged water be less than 2 mg/L. (Figure 7-17)

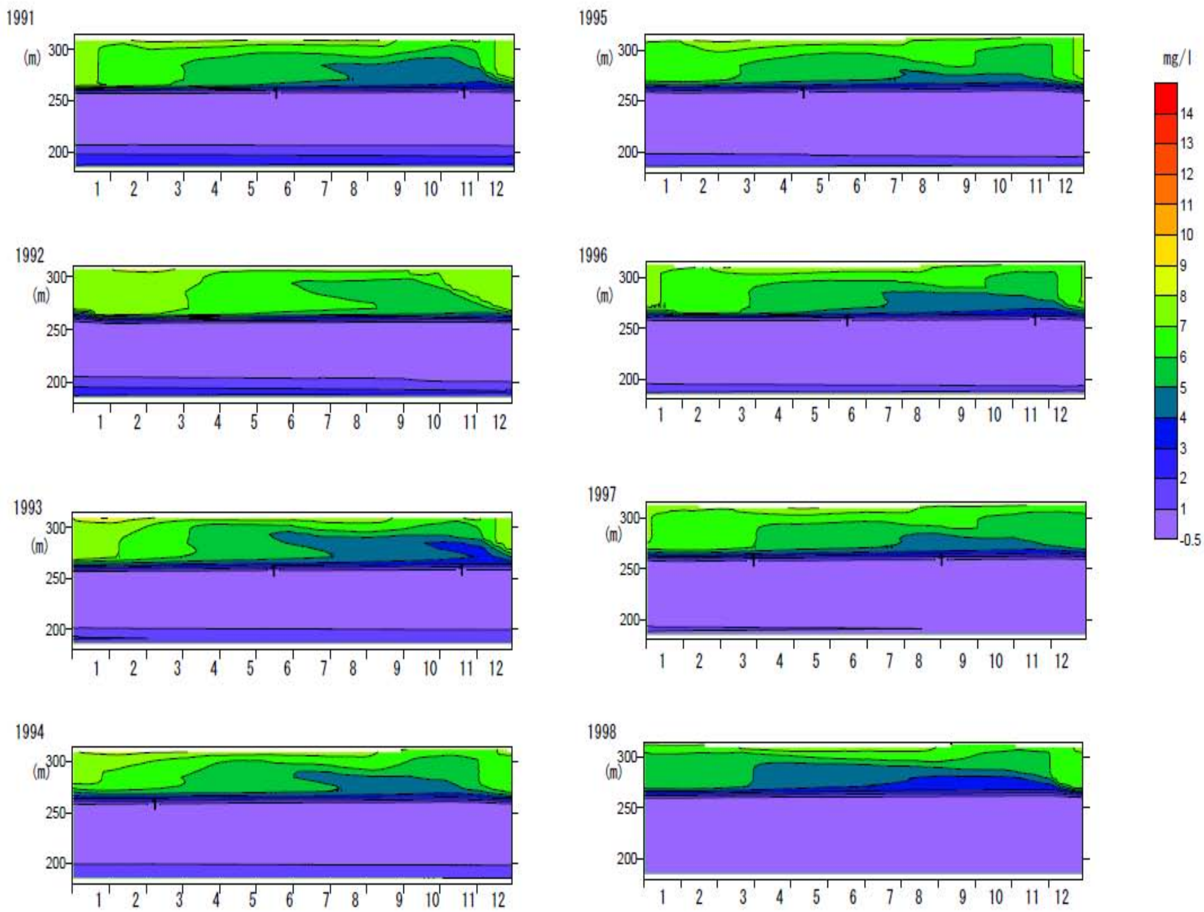



Figure 7-17 DO concentration variations by depth of the dam.

DO concentration of discharged water from the re-regulating dam is over 6 mg/L almost all the year. The DO concentration increases gradually as the water flows further downstream due to oxygenation and dilution. (Figure 7-18)

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, produced 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.

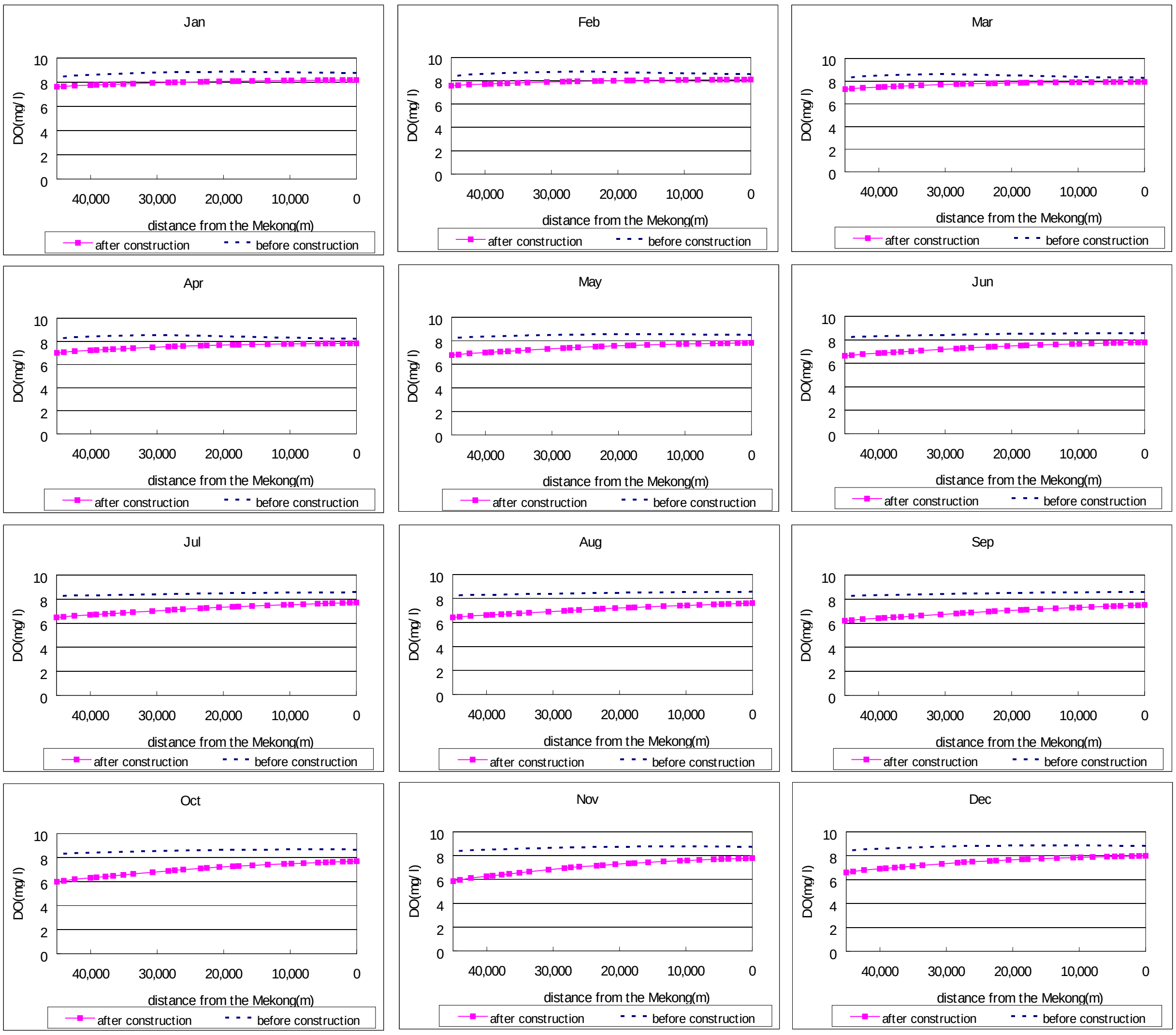



Figure 7-18 Prediction of DO changes per month (longitudinal profile of the river).

In natural conditions, a concentration of 5 mg/L DO was recommended for optimum fish health. Sensitivity to low levels of dissolved oxygen was species specific; however, most species of fish were distressed when DO falls to 2-4 mg/L. Mortality usually occurs at concentrations less than 2 m g/L. The number of fish that could die during an oxygen depletion event was determined by how low the DO gets and how long it remains low.[4]

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 ),

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[4] 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.

increased organic waste entering the reservoir, or death and decay of organic matter at the bottom of the impounded water.

According to the water quality models, the DO of discharge should be optimum for fish during the daytime. Low DO could be determined by noticing the fish behavior. Moribund fish may be seen at the surface trying to get oxygen. If many fish die simultaneously, that could indicate low DO. The weather immediately prior to the harmful to fish may have been hot, still and overcast. 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 nutrient for algae or aquatic plant growth.

***Suspended Solids***

The computation of SS concentration of the reservoir was conducted based on the hydraulic data of eight (8) years (1991-1998) from similar sites, and the results showed that the SS in the discharged water is obviously 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 a few months. In this computation, the fine particle size distribution at the site was assumed as 30% of less than 1μm and 20% of 1-5μm.

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 7-19). This is less than one-tenth of the SS concentration in the water at present, before the project is built. SS settling is a major factor that would reduce nutrients for primary producer and consumers downstream. Jiménez-Montealegre and 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[5]. After the dam is built, the reduction of nutrients downstream because of reduced SS could occur, and aquatic lives could be affected by food depletion.

[5] 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.

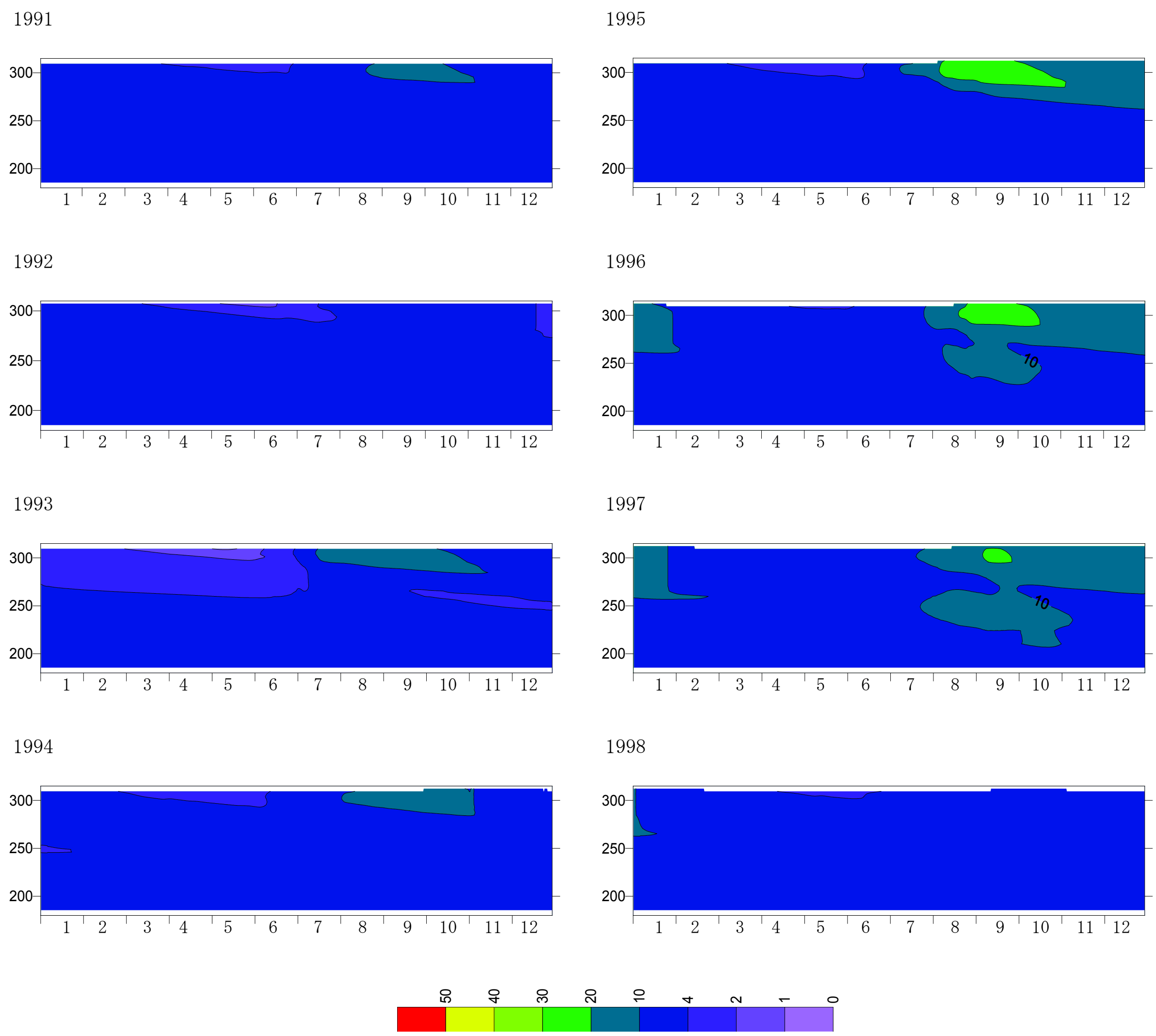



Figure 7-19 SS concentration in depth at the dam.

The sedimentation at the dam would also imply reduced levels of dissolved phosphorus ($P\text{-}PO_4$) concentrations, total phosphorus (TP) concentrations, nitrate ($N\text{-}NO_3$) and ammonium ($N\text{-}NH_4$) downstream during normal operation. However, during the early stage of inundation, the nutrients trapped in the reservoir could be a source for algal bloom.

The most critical period of the project in terms of downstream water quality will be when the impounded water is first discharged. Water pollutants from point sources as well as none-point sources of agricultural drainage and open defecation that have accumulated under anaerobic conditions will certainly affect the water quality downstream. G iven that pathogens such as bacteria that are waterborne diseases and contaminates in the deposit sediment can also be released along with sediments, steps need to be taken to monitor for and educate local people about hygiene to prevent waterborne diseases.

The 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 on water quality for the receiving water downstream. A grievance procedure is required so the developer can receive complaints and take action immediately if the water quality downstream is not suitable for fish and leads to the death of fish. The immediate response to the complaints should be sending staff to observe by sight the dead fish and to measure the DO level. Other responses such as compensation for lost livelihoods from the loss of fish or aeration at the discharge point shall 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 presents 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.

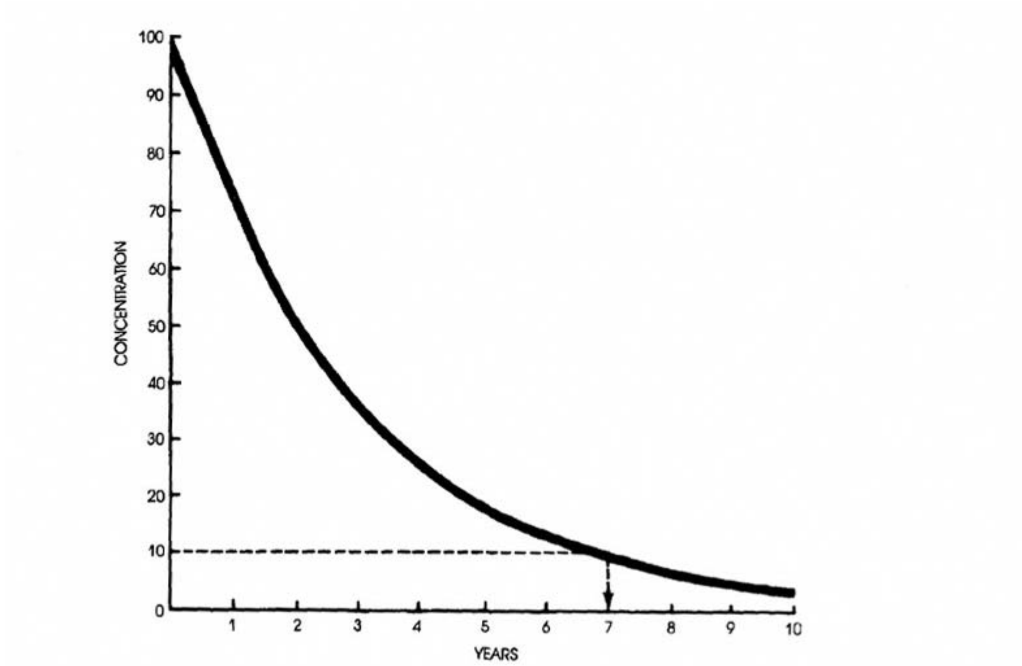



Figure 7-20 Reservoir Recovery Process (Source: World Bank, 1984).

Nevertheless, the EIA Report also presents the result of soil analysis from various villages in the project area. It was shown that the organic matter content at Ban Hat Gniun is in range from 1.21 to 4.24%. To calculate the oxygen demand for organic release rate from ground, the medium value of 2.75% would be adopted.

The following assumption applied in Nan Thuen 2 P roject also would be adopted for calculation:

Soil density = 2.4 ton/m$^3$

Dept 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 in within 1 ha would be calculated as below.

= 500 m$^3$ x 2.4 ton/m$^3$ x 2.75%

= 33 ton

According to the EAMP for Nam Theun 2 Hydroelectric Dam Project, Annex G, Approximately 47% of the carbon should be consumed in methane production (Wetzel, 1983) and another 15~20% of total carbon should be degraded anaerobically to Carbon dioxide (David Hamilton, 1997) Based on this study, approximate 35% of carbon would be left so that the calculation is = 33 ton/ha x 35%

= 11.55 ton/ha or 1,155 g/m$^2$

As a result, the oxygen demand to be required for organic content in ground is,

= 1,155 x 32/12

= 3,080 g/m$^2$

where molecular weight of carbon (C) and carbon dioxide ($CO_2$) is 12 a nd 44, respectively, for mineralization process.

Therefore, during 7 ye ars of recovery period, the daily oxygen demand (for ground) is equal to = 3,080/7/365

= 1.2 g/m$^2$

Due to the 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.

#### **7.3.1.6** Air Quality

The operation phase does not have major activities that can create dust; hence, adverse impacts from dust are not likely after the operation phase begins. During operation, the hydropower project is widely accepted to be air-quality friendly. Air pollution is, then, expected to be very limited, caused more by vehicles traveling to and from the site than from any direct dam-related activities.

#### **7.3.1.7** Potential Contaminated Sites

The possibility of having contaminated sites 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 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 activities are as follows:

1) Use of hazardous chemicals

- The users 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.

2) Spillage prevention

- Vehicles carrying pesticides and fertilizers for landscaping must be covered on the route between the storage warehouse and the landscape site
- The hazardous chemicals must be well sealed before use.

#### **7.3.1.8** Hydrology

Normal High Water Level (NHWL) is a factor controlling the scale and benefits of the project. The recommended level was +320.00 EL m. Because the power generation strategies which have to meet the Power Purchase Agreement (PPA), the consultant has studied only on the operating strategies such as peaking and intermediate peaking hours per day. The criteria for selecting the NHWL are as follows:

#### **(1) Low flow analysis**

The catchment area at the dam site was estimated to be 3,700 $km^2$ with natural average annual discharge of 148.4 $m^3/s$ or 4.68 billion $m^3$. The design specifications of the Nam Ngiep 1 Hydropower Project for operation are shown in Table 7-11.

1) Maximum monthly inflow/outflow

The maximum monthly natural flow was about 483 $m^3/s$. Due to the project operation according to the Kansai study, the flow will be changed to be 405 $m^3/s$. Design flood with a 1000-year probability was 5,210 $m^3/s$. After completion of dam construction, monthly outflow in dry season will decrease and those in rainy season will increase because the main dam reservoir can regulate the discharge between seasons.

2) Riparian Release

Riparian release was included into the calculation. Cases of specific discharge of 0.15 $m^3/s/km^2$ for Nam Ngiep1 (Table 7-11) is adopted, and the minimum discharge after the initial impounding should be 5.5 $m^3/s$.

Table 7-11 Flow of Riparian Release

| Condition | Catchment area ($km^2$) | Minimum discharge ($m^3/s$) | Specific discharge ($m^3/s/100km^2$) |
|---|---|---|---|
| Nam Ngiep1 | 3,700 | 5.5 | 0.15 |

The operation of the main dam would purposely involve the riparian release into the downstream to maintain normal functions of the river.

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.

3) Weekly Operation

The maximum reservoir elevation of the main dam is EL 320.0 m. and the minimum operating level would be at EL 296.0 m. Drawdown of the reservoir normally occurs during the dry season, with filling occurring during the wet season. During periods of high inflow the maximum reservoir elevation could be achieved, resulting in water discharge through the spillway gates. The discharge of normal operation of the main power station was designed at 16-hour peak generation on weekdays and Saturday. There is to be no operation on Sundays except during the rainy season.

The operation of the re-regulation reservoir is based on a maximum reservoir elevation of EL179.0 m. The minimum operating level is at EL 174.0 m. The re-regulation reservoir is for storing the discharged water from the main dam for 16-hour peaking power generation, re-using it for power generation and releasing it downstream evenly on 24-hour basis to regulate the downstream flows. The discharge of the re-regulation power station is for 24 hours everyday.

Operations staff will operate the main power station in accordance with the operations manual. The maximum discharge through the turbines at the main dam is indicated at 230 $m^3/s$. The electricity generated at the main power station will be delivered to EGAT by the

230kV transmission line and common 500kV transmission line through the substation located in Ban Nabong. The re-regulation power station could provide maximum power of 18 MW for domestic supply when the maximum discharge is controlled at 160 $m^3/s$.

**(2) Impacts from dam operations**

- Upstream and Reservoir Areas

Impacts are assessed by considering changes of discharges of riparian rivers, water levels and velocities. One of the most important impacts that the developers have to serious consider and try to avoid is water levels about 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 feelings 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 EAP are 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 Mekong River because the dam and reservoir will control most of the rainy season flow of the Nam Ngiep. 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 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 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. This will occurs 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 clearly that the construction of the NNHP-1 should reduce the possibility of flooding at Pakxan since the release from the proposed dam to Mae Khong 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 Ngam Ngiep River at 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 floods of communities located along the Nam Ngiep River near Mekong River, however, could be misunderstood to be caused by flows from the Nam Ngiep, 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 station at the downstream of the second dam (re-regulation dam) should be closely monitor following the construction, and information regarding water flow and its level should be disclosed to the public.

Recommended mitigation measures to minimize the impacts on hydr ology 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 to 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.
- Project developer must install staff gauge of water level along the river downstream from proposed dam site especially areas of the communities to let local people aware of the water level.
- 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 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.

### 7.3.2 OPERATION IMPACTS ON BIOLOGICAL ENVIRONMENT

#### **7.3.2.1** Terrestrial Ecology/Wildlife

There will be continuous impacts from construction phases that will carry forward to project operation phase. As such, the appropriate mitigation measures recommended are provided as follows:

- Strict rules against logging outside the approved construction areas and 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. The project owner and operator 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 breaks these rules and regulations.
- Wildlife specialists should be engaged to monitor the conditions of the existing wildlife species in the area and to assess if the project owner has taken adequate measures to protect those species.
- The project should develop a wildlife protection plan linked with the forest management plan (including compensatory reforestation program), which aims to manage and protect the forest and wildlife in the watershed area. Participatory Integrated Conservation and Development (PICAD) will be applied for the management of forests and wildlife in the watershed area.

#### 7.3.2.2 Aquatic Biota

Water levels in the Nam Ngiep River depend mainly on season rains. Near the confluence with the Mekong River, water levels also depend on flows of the Mekong. 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. Spawning normally occurs during the wet season. Local residents fish mostly during the beginning and the end of the rainy season, when fish are abundant.

Because of the decay of organic matter in the reservoir, water quality will be adversely affected in the first years of inundation, as described in the section on Water Quality above. 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 are toxic to fish and other aquatic species.

Because the river has been impounded, the dam will block migration routes 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.

During this period, the operations staff will produce wastewater and solid waste, though a much lower total amounts than during construction when about 1,800 people are being engaged. Even so, the wastewater and solid waste produced by the operations staff should be treated and disposed to avoid polluting the river.

***Upstream area and reservoir area***

After dam closure, all migratory fish will face a permanent barrier to their migration paths. 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. Kansai has predicted dissolved oxygen in the reservoir after construction will be 3.5 – 6.0 mg/l in between September to the end of November, compared to 8.8 – 8.9 mg/l in the natural river. This reduced level dissolved oxygen will be caused by an annual reservoir turnover, and it will lead to significantly stunted fish growth, even if occurring for a short period.

Adaptation to new conditions like those that will be found in the reservoir will be the main challenge for some species, especially of small cyprinids, that will need new habitats for their spawning and feeding for the young. This is likely to be the case for *Cirrhinus molitorella, Poropuntius sp., Puntius brevis, Onychostoma sp., Hampala dispar, Labeo erythropterus, Hemibargrus wyckioides, Neolissochilus blanci, Scaphognathops theunensis, Chitala lopis.* A fisheries management program should introduce and maintain indigenous fish populations by finding new breeding and feeding habitats in after the construction phase, both in the reservoir and in other parts of the river.

Effects of impoundment on aquatic biology in the NNHP-1 reservoir will likely be similar to what has occurred elsewhere in Lao PDR and in other tropical conditions. The organic loading in the first years of inundation will be high, which can promote the growth of plankton and benthos, and these in turn can increase production of fish.

All fish found in the Nam Ngiep River are either species common to the Mekong River or common to mountainous waters. They are all potamodromous. When part of the river becomes blocked and turned into a reservoir, habitats for fish will also change, especially spawning grounds. This may lead to decreased fish populations. High priority should be given to fish enhancement programs.

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.

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.

Apart from harmful to fish just after the dam closure due to the habitat change and by low water quality caused of pollution, 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 area***

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. To minimize downstream fisheries losses, a minimum amount of water discharge should be ensured. According to the results of the hydrology models by K ansai, downstream water levels during the project operation will vary ±0.65 meters from the levels in the natural river flow. 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 every year of the construction phase. 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 life to be monitored include plankton organisms, benthic invertebrate animals, aquatic weeds and fish.

In addition, an environmental management plan of aquatic ecology and fishery resources for newly reservoir and downstream area is proposed as follows.

***Fish Enhancement program***

1) Conceptual Approach

The purpose is to increase yield and promote fisheries occupation. The fishery survey found 42 fish species from the sampling stations along the Nam Ngiep River which is the tributary of the Mekong River in the LAO PDR. Several species are significant for their size and known as white migratory fish (undertake long-distance migration, in particular between lower floodplain and the Mekong mainstream). Most fish species depend on different habitats at different stages of their life cycle and at different seasons of the year. During the flood season, most fish species take advantage of the flood plains for feeding, breeding and rearing of young fishes. The construction of barriers acts as a physical to migrations, spawning ground change, lead to decrease fish population and production.

2) Scope

To sustain the fisheries resources in the reservoir and downstream area, fish enhancement program is required with the Fisheries Management Program. To reach the goal, 2 major fields of activities are required, which constitute the core program of fisheries enhancement program

- To carry out additional investigations on t he potential productivities of concerned water bodies, species selection and seed production, and
- To performing of the fish fry and fingering program in accordance with requirements.

The propose area are on both upstream and downstream of project area for additional fish survey and fish stocking program will be only in the future reservoir.

3) Objectives

The objective of fisheries enhancement program is to promote the fishery activities in the future reservoir area and supply the fisheries resources as nutrient source for the people that depend upon it. This program also helps establishing good attitude and positive image against the Project.

4) Content of the program

- Additional fish surveys to be organized the river system of the upstream and downstream area. This should provide a detailed baseline data on fish occurrence, productivity, migration compatibility with potential species to stock.
- Identification of future fry requirement to supply. The introduction of exotic species or strains should be carefully consider of genetic diversity which might be threats to aquatic biodiversity and, in particular, that of wild resources.
- Set up of Fisheries enhancement program. The major responsibilities and duty will be performing of the fish fry and fingerling program to stock in the reservoir. The brood stock fish should be come from the Nam Ngiep River, for fish genetic reasons. The technologies for fry production are available only for some fishes which are Cyprinid species as *Poropuntius* spp., *Barbonymus*

*(Barbodes) altus, B. gonionotus*, *Puntius* spp. and some Bagridae family as *Hemibagrus wyckioides*, most of the fish in this area are not well success on propagation technique in hatchery and these fisheries resources are depend on the wild seed. For enhance of fishery resources, conserve of the breeding area of these fishes and control of illegal fishing and gear used are required.

5) Duration

Additional fishery survey will be 3 years continuously after impoundment and the fish stocking will be throughout the project operation period.

6) Expected results

To ensure that the project will cause minimum impact on fish production, high yield of fish will be promoted in order to increase the productivity and Nam Ngiep reservoir will be one of the major fisheries resources in the area.

## 7.4 (NOTE; PLEASE ADD DISCUSSION REGARDING IMPACTS ON GREENHOUSE GASES (REFER TO NN3 EIA REPORT) AND CUMULATIVE IMPACTS)SUMMARY ON IMPACTS AND MAIN MITIGATIONS IN THE CONSTRUCTION AND OPERATION PHASES

A summary of key environmental impacts for the construction and operation phase, together with recommended mitigation measures, are provided in Table 7-12 and Table 7-13. A detailed description of potential environmental impacts, environmental management plan, and monitoring programme are given in a separate document, namely, the Environmental Assessment and Management Plan (EAMP).

Table 7-12 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 | Changing on Topography | Modification of landscape | • Dam and other civil works area<br>• Access routes and adjacent | | | | • No mitigation measure is needed that relate solely to changes in topography but limitation of works only construction boundary should be conducted. |
| Meteorology | Not expected | Reservoir clearing and burning (if any) | Reservoir | | | | • Limitation and controlling the dispersion of dust created by site preparation activities. |
| Geology, Landforms and Seismology | Landslide and rock movement | Earthquake and Seismic events | Project area | | | | • Take into account with all geological survey data at design stage<br>• Continuous monitoring and investigation after project commencement |
| Erosion and Sedimentation | • Erosion on disturbed area<br>• Increased sediment load in the environment | • Site clearing<br>• Excavation works<br>• Slope stabilization<br>• Underground works | Project area | | | | • Land clearing activities during dry period should be performed as much as possible.<br>• Best practices for excavation and working in riverbed should be conducted.<br>• Limitation of land disturbs activities only in design construction boundary.<br>• Stockpiled should be separated and stabilized.<br>• Appropriate drainage should be implemented.<br>• Erosion and Sediment Control Plan especially during the wet season should be developed and implemented.<br>• Appropriate standards of drainage works, sediment traps, diversion, culverts and other structures designed to treat water before discharge into natural and/or constructed watercourses should be conducted. |
| Reservoir and river water quality | Increasing of pollution into the environment | Discharge of wastewater from worker camps | River | | | | • To provide designate wastewater treatment facilities.<br>• On-site toilets at working areas and toilet facilities at worker camps should be installed with adequate number of workforce<br>• Direct discharge of wastewater into natural receiving water is not allowed. |
| | | Release of contaminants into water during construction | River | | | | • To provide designed contaminants treatment facilities for each significant construction sites. |

| Environmental Aspects | Nature of Impact | Concerned Activities (that would cause impacts) | Impact Area | Magnitude and Level of Impacts | | | Proposed Mitigation Measures |
|---|---|---|---|---|---|---|---|
| | | | | Low | Medium | High | |
| Reservoir and river water quality | | Increasing in sediment load downstream | Downstream | | | | • To conduct best practice in management of earthworks<br>• To provide designed settling ponds for sediment settling before release to environment.<br>• Implementation of mitigation measures for erosion and sedimentation control is strictly required. |
| Noise and Vibration | Noise of construction activities impacts to surrounding area | • Cutting and land excavation<br>• Moving of equipments<br>• Material transportation<br>• Blasting works | Ban Hat Gniun | | | | • Appropriate and sufficient PPE for noise protection shall be provided to all workers.<br>• Sound-control devices on equipments should be maintained in good condition.<br>• Construction activities that may generate harmful noise should be limited only in day time, e.g. 6 am to 7 pm.<br>• People shall be warned in advance with blasting works.<br>• Trespassing to the blasting area shall be strictly control. |
| | | | Communities | | | | |
| | | | Worker Camps | | | | |
| | Vibration of construction activities impacts to surrounding area | Blasting | Communities | | | | • To assure that blast-related vibrations and keeping of air blasts at offsite residential and other occupied structures are as low as possible.<br>• Measured on the ground adjacent to a residential or other occupied structure should be implemented<br>• Monitoring records of air blast and vibration should be documented in detail. |
| Air Quality | Increased dust particles and fugitive dust into atmosphere | • On-site machinery (off-road emissions)<br>• Land clearing and excavation activities<br>• Construction activities (e.g. quarry, crushing plant)<br>• Road traffic on unsealed gravel road surface<br>• Underground activities | • Quarry sites<br>• Crushing and Batching plants<br>• Road construction areas<br>• Embankment and channel construction<br>• Haulage of materials<br>• Construction of worker camps<br>• Communities | | | | • Minimize dust generating activities.<br>• Keep stockpiles for the shortest possible time.<br>• Dust suppression system to minimize dust from construction activities and transportation should be implemented.<br>• Machinery and dust generating activities should be located away from sensitive receptors.<br>• Best practice such as vehicles cleaning and routine maintenance should be implemented for all project equipments and machineries |

| Environmental Aspects | Nature of Impact | Concerned Activities (that would cause impacts) | Impact Area | Magnitude and Level of Impacts | | | Proposed Mitigation Measures |
|---|---|---|---|---|---|---|---|
| | | | | Low | Medium | High | |
| Potential Contaminated Sites | Contaminated of chemical and hazardous into environment | • Chemical storage<br>• Drum reconditioning or recycling<br>• Electric transformers<br>• Explosive product and storage<br>• Landfill operation<br>• Pest control<br>• Petroleum product and oil storage | Project area | | | | • Avoid operation of the proposed quarry site and solid waste landfill near the river.<br>• Register and record all of potentially hazardous chemicals and waste with their movements.<br>• Appropriated training should be conducted for all workers responsible for handling hazardous waste.<br>• Best practice and emergency response procedure will be developed and implemented for all construction site.<br>• Warning/safety signs and rules must be located in the most appropriate places.<br>• Trenches should be provided to divert contaminated runoff to a designed precipitation pond. |
| Hydrology | Change in flow during construction of Dam | • Construction of the Dam and Diversion | Downstream | | | | • River diversion works shall be constructed during low flow season.<br>• 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.<br>• The possibility of flash floods during the rainy season should be included in safety plans during construction period.<br>• Warning system on water level fluctuation must be installed at major locations/communities downstream of the proposed dam site. |
| | Change in flow during Reservoir impoundment | • Reservoir impoundment | Upstream | | | | • To complete the resettlement activities according to Resettlement Action Plan and national standards.<br>• Public consultation with local residents must be conducted frequently. |
| | | | Downstream | | | | • Training should be given to local residents in downstream communities to provide public readiness in case of emergency situations.<br>• Public consultation with local residents must be conducted frequently. |

| Environmental Aspects | Nature of Impact | Concerned Activities (that would cause impacts) | Impact Area | Magnitude and Level of Impacts | | | Proposed Mitigation Measures |
|---|---|---|---|---|---|---|---|
| | | | | Low | Medium | High | |
| **Biological Environment** | | | | | | | |
| Terrestrial Ecology/Wildlife | Disturbance of wildlife | • Temporary and permanence access road through the forest areas<br>• Reservoir clearing<br>• Reservoir impoundment | Upstream area, Reservoir and downstream area | | | | • Conduct updated biodiversity study to identify species the specoes that will be directly impacted by the project and unable to adapt to the new environment created by the impoundment of the reservoir and the modifications upstream and downstream.<br>• Wildlife protection team will be established to protect and rescue wildlife during inundation period.<br>• Wildlife specialists should be engaged to collect more detailed data concerning the existing wildlife species in the project area, and how these species will be affected during construction and operations.<br>• 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<br>• 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.<br>• The remaining forest areas in the catchment, and especially in those areas close to reservoir, a forest and wildlife conservation and management program considered as a biodiversity offset measures need to be implemented. |
| Forest, Vegetation Cover | Loss of some valuable forests and timber species | • Reservoir and sites clearing<br>• Trees cutting and removal<br>• Reservoir impoundment | Reservoir and all construction areas | | | | • To complete the detailed survey of tree species that shall be removed<br>• Regulations and Laws related to forest shall be considered and implemented<br>• Compensation shall be applied according to Resettlement Action Plan<br>• Forest protection and management (including compensatory reforestation program) shall be carried out in the watershed area (or catchment area) as discussed in the Watershed Management Plan |
| Aquatic Biota | Decrease of fish population | • Earth works that may produce sediment | 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. |

| Environmental Aspects | Nature of Impact | Concerned Activities (that would cause impacts) | Impact Area | Magnitude and Level of Impacts | | | Proposed Mitigation Measures |
|---|---|---|---|---|---|---|---|
| | | | | Low | Medium | High | |
| | | adding to water turbidity<br>• Establish of worker camp | | | X | | • 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<br>• Fishing and using of illegal fishing gear anywhere along the river should be prohibited. |

Table 7-13 Summary of Anticipated Impacts from the Project and Propose Mitigation Measures - Project Operation Phase

| Environmental Aspects | Nature of Impact | Concerned Activities (that would cause impacts) | Impact Area | Magnitude and Level of Impacts | | | Proposed Mitigation Measures |
|---|---|---|---|---|---|---|---|
| | | | | Low | Medium | High | |
| **Physical Environment** | | | | | | | |
| Meteorology | • Localized changes to ambient air temperatures and relative humidity, and water temperature at downstream<br>• Changing on the rates and intensity of haze and fog<br>• Increased down slope winds<br>• Changing of cloud base creation or suppression | The creation of a reservoir and inundation of forest area | Localized climatic condition | X | | | • To develop water quality model for prediction and further planning.<br>• Adequate recording of meteorological data shall be conducted continuously during operation. |
| Geology, Landforms and Seismology | Reservoir-induced earthquake / Geohazards | The creation of reservoir that exert pressure to cause an earthquake | Reservoir | X | | | • Routine inspection of dam structure is recommended, particular after initial storage of water in the reservoir |

| Environmental Aspects | Nature of Impact | Concerned Activities (that would cause impacts) | Impact Area | Magnitude and Level of Impacts | | | Proposed Mitigation Measures |
|---|---|---|---|---|---|---|---|
| | | | | Low | Medium | High | |
| Soil | • Low level of soil fertility<br>• Unsuitable of land form and soil depth | Agricultural production | Resettlement sites | | | | • Improvement in soil fertility should be considered.<br>• Crop management should be conducted.<br>• To prevent loss of soil nutrient with appropriate erosion control. |
| Erosion and Sedimentation | Soil erosion in the watershed area | Increasing of agricultural | Watershed area | | | | • Watershed Management Plan should be implemented. |
| | Build up of sediments in reservoir | The creation of reservoir | Reservoir area | | | | • Erosion and sedimentation control plan should be implemented. |
| | Erosion occur along the riverbank | Regulating water release will alter the characteristic of water flow and scorching effect on the river bank | Downstream | | | | • Regularly monitoring of riverbank erosion should be implemented. |
| Reservoir and River Water Quality | Increased organic matter and nutrients in reservoir | Decaying of residual biomass | Reservoir | | | | • To remove as much vegetation from reservoir before impoundment. |
| | Release of water with low dissolved oxygen | Consequence of decaying of biomass in the reservoir | Downstream | | | | • To develop water quality model for prediction and further planning.<br>• Engineering works might be needed if water quality results show significant deterioration of water quality.<br>• Water quality monitoring plan should be conducted during the initial phases of operation.<br>• Water quality, the amount of suspended solid and its chemical parameters e.g. mercury contents should also be monitored annually. |
| Air Quality | Not expected | Air pollution is caused by vehicles traveling to and from the site than from any direct dam-related activities | Road link to project area | | | | • No mitigation necessary |
| Potential Contaminated Sites | Contaminated of chemical and hazardous into environment | Using and storage of hazardous materials such as flammable fuels and pesticides | Project area | | | | • The use of the pesticides and fertilizers must follow proper application methods.<br>• Overuse of hazardous chemicals such as fuels and pesticides and fertilizers must be avoided to prevent soil and water pollution. |
| | | Spillage of chemical or hazardous materials | Project area | | | | • Vehicles carrying pesticides and fertilizers for landscaping must be covered on the route between the storage warehouse and the landscape site. |

| Environmental Aspects | Nature of Impact | Concerned Activities (that would cause impacts) | Impact Area | Magnitude and Level of Impacts | | | Proposed Mitigation Measures |
|---|---|---|---|---|---|---|---|
| | | | | Low | Medium | High | |
| | | | | | | | • Hazardous chemicals must be well sealed and instruction to use shall be clarified. |
| Hydrology | Flood impact on villages and their agricultural lands that are located above EL 320 m. | Water level in reservoir is above EL 320 m during wet season | Upstream and Reservoir area | | | | • Management of the reservoir water levels should be conducted<br>• If flood exceed the design flood, Evacuation Action Plan (EAP) should be proposed.<br>• Provision of adequate information and interactive two ways communications between the project and the local communities should be maintained |
| | Backwater effect at the confluence of Mekong River | Project discharge | The confluence of Mekong River | | | | • To develop water quality model for prediction and further planning. |
| Hydrology | Changing of water level and water flow | Water releasing | Downstream | | | | • Water levels at major locations/communities, especially downstream from the dam site to Pakxan should be monitored continuously.<br>• Additional monitoring points may be considered if needed.<br>• Water levels should be regulated as much as possible similar to normal level prior to project development to avoid negative impacts to the local residents and to the environment.<br>• 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.<br>• Highest water level marker should be install along the river downstream, especially those that close to communities, should be installed.<br>• Provide in place flood forecasting system and early warning protocol for the downstream communities to give an ample time for evacuation if necessary.<br>• A flood warning system should be installed in the river between the dam to the first main tributary.<br>• In case of extreme events, the project must inform people about the expected time and duration of extreme low flows or extreme high flows.<br>• 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. |

| Environmental Aspects | Nature of Impact | Concerned Activities (that would cause impacts) | Impact Area | Magnitude and Level of Impacts | | | Proposed Mitigation Measures |
|---|---|---|---|---|---|---|---|
| | | | | Low | Medium | High | |
| | | | | | | | • 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.<br>• Operational management of the release discharges shall be monitored. |
| **Biological Environment** | | | | | | | |
| Terrestrial Ecology/Wildlife | Disturbance of wildlife | Continuous impact from construction phases | Upstream area ,Reservoir and downstream area | | | | • Strict rules against logging outside the approved construction and inundated areas.<br>• 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. |
| Terrestrial Ecology/Wildlife | | | | | | | • Wildlife specialists should be engaged to monitor the conditions of the wildlife species in the project area.<br>• Wildlife protection plan linked with the forest management plan, which aims to manage and protect the forest and wildlife in the watershed area, should be provided. |
| Aquatic Biota | • Changing of habitats for fish, especially spawning grounds<br>• 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.<br>• Fishing zones, conservation zones and preservation zones (spawning grounds) should be considered in the reservoir according to the data obtained from monitoring<br>• 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<br>• 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.<br>• 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. |

| Environmental Aspects | Nature of Impact | Concerned Activities (that would cause impacts) | Impact Area | Magnitude and Level of Impacts | | | Proposed Mitigation Measures |
|---|---|---|---|---|---|---|---|
| | | | | Low | Medium | High | |
| | | | | | | | • Minimum amount of water discharge should be controlled.<br>• 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. |

# CHAPTER 8

# PUBLIC CONSULTATION

## 8.1 INTRODUCTION

Public consultation and participation has played and will continue to play key roles in planning of the Nam Ngiep 1 Hydropower Project. This study has involved the comprehensive public consultation and disclosure process in accordance with the GOL's and standard EIA guidelines.

Public consultation is considered vital to the project's long term sustainability. Since the project planning started with the EIA study in 2007 to 2008 by E RIC and NCC, there had been more than 29 public consultation and participation briefings and meetings, which had taken place at the villages' level during data collection.

After revising the resettlement plan based on the new resettlement site at Houay Soup, additional village consultation meetings were held for Zones 2UR, 2LR and Zone 3 including Ban Hat Gniun and Ban Thahuea as host villages.

## 8.2 METHODOLOGY

Transparency and openness through the dissemination of information should be a priority for the project in both the development of public consultation plans and in implementation. With the stakeholders being broadly identified, it has subsequently been the objective of the study team to understand the views of these groups. There has been a need to plan and develop appropriate interaction and information sharing techniques for these different stakeholders.

The key priorities for the design of consultation methodologies include:

- Ensuring stakeholders were able to fully understand the project information and the potential project impacts and mitigation plans.
- Ensuring stakeholders understood the composition of the project and the project's objectives.

### 8.2.1 USE OF SUITABLE TECHNIQUES

Techniques developed for public consultation were designed to suit the needs of each target audience. These techniques also required careful consideration in order to meet the requirements of the diverse and numerous participants involved in this study. The techniques adopted included the following methods:

- Use of visual presentations including pictures, diagrams and posters, especially at the local and regional level.
- Practical, visual and face-to-face communication in places where levels of literacy were recognized as being low. This included use of seminars, workshops, general village meetings, semi-structured interviews, small group meetings, models, participatory rural appraisal techniques, and site visits.
- The translation into the Lao language of project documents and summaries. These were used in particular for local leaders, regional officials and national stakeholders.
- The use of local project information centers at Vientiane, Bolikhan and Hom District. These centers enabled 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 a place to conduct periodic meetings with village and district representatives. This system provided access to information for people with questions.
- 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.

Public consultation activities conducted had been recorded and documented with summaries provided in the Laos and English languages.

### 8.2.2 THE APPROACH

Throughout the public consultation process it had been important to take into account the following considerations:

- The uses of communication techniques are culturally sensitive and appropriate;

- The structure of local power and authority structures and the need to ensure that participation in construction activities is not dominated by l ocal authorities;
- The special attention that may be required to ensure the participation of women and vulnerable groups and the consideration of their needs in the design of mitigation measures;
- The effective documentation of the process in terms of two-way communication and accurate recording of participation and documentation of the results of the stakeholder process.

## 8.3 THE STAKEHOLDERS

Through extensive scoping of issues and a review of preliminary study findings, which have been subjected to public and professional review, the key stakeholders identified for consultation for the project are:

- Villagers of the project area who may be affected directly and indirectly by the project;
- Project Developers: KANSAI, EGAT-i and Lao Holding State Enterprises (LSHE);
- The Asian Development Bank (ADB) and other potential funders ; and
- NGOs or other outside parties interested in the project.

Table 9-1 presents each type of stakeholder within these main categories, what is their relative priority of interest, whether the project will affect them adversely or provide benefits, and gives a brief description of their interests in the project.

The purpose of this exercise is two-fold: (1) to assure the concerns of the main stakeholders, in particular the primary stakeholders, are covered in the EIA, SIA, REMP and other key documents, and (2) to assure that all the stakeholders, whether primary or secondary or even external, are included in meetings and other participatory discussions.

Table 8–1 Summary of Stakeholders

| Stakeholder | Potential Project Impact | Relative Priority of Interest | Key Stakeholders' Interests in the Project |
|---|---|---|---|

<table>
<tr><th>Stakeholder</th><th>Potential Project Impact</th><th>Relative Priority of Interest</th><th>Key Stakeholders' Interests in the Project</th></tr>
<tr><td colspan="4">Primary Stakeholders</td></tr>
<tr><td>Directly affected people who will lose their property or lose livelihood opportunities due to inundation of the NNHP1 reservoirs, and/or construction of various Project components</td><td>(-)(+)</td><td>1</td><td>• The comprehensive environmental, economic, social and cultural impacts of the Project.<br>• What properties and how much property will be affected? Privately owned or public property?<br>• What will they get in return?<br>• How will the losses be compensated or the impacts be mitigated?<br>• Where will they be resettled?<br>• How will their livelihoods be affected by the Project?<br>• Who are the main people responsible or the people or organizations to contact in case compensation or mitigations measures are unsatisfactory?<br>• Can they take part in the project as workers or some other capacity?<br>• What will be their sources of income after the project?<br>• Will they still be able to continue their existing ways of life or livelihoods?</td></tr>
<tr><td>Indirectly affected people, who are in the same communities as some of the directly affected people, or who share the Nam Ngiep basin</td><td>(-)(+)</td><td>2</td><td>• What will be the impacts of the project?<br>• Can they be certain there will be no direct impacts to them?<br>• Will they also have the right to participate the development programs or other activities of the Project that can provide benefits?<br>• Is there any chance for them to be hired to work for the project?<br>• What will be their livelihoods with the project?<br>• Will they still be able to continue their existing ways of life or livelihoods?</td></tr>
<tr><td>Laborers and other staff</td><td>(+)</td><td>3</td><td>• Good living conditions in the workers' camp and good facilities<br>• Adequate protection in hazard prone areas or protection from hazardous materials<br>• Sufficient training for the assigned tasks</td></tr>
<tr><td>Village Organizations<br>• Village Headman and Deputy<br>• Village Security (Konglon)<br>• Police<br>• Health Volunteers (Orsomor)<br>• Lao Youth<br>• Lao Women's Union<br>• Front for National Construction</td><td>(-)(+)</td><td>1</td><td>• Continuation of existing organizational arrangements at the new resettlement sites<br>• Boundaries and land use of the new villages<br>• Land reallocation criteria and fair application of the criteria<br>• Management of newly introduced development projects<br>• Priority of participation in the newly introduced development projects or activities</td></tr>
<tr><td colspan="4">Secondary Stakeholders</td></tr>
<tr><td>Developers<br>• EGAT-i</td><td>(+)</td><td></td><td>• The costs<br>• The most economical and practical process</td></tr>
</table>

| Stakeholder | Potential Project Impact | Relative Priority of Interest | Key Stakeholders' Interests in the Project |
|---|---|---|---|
| • KANSAI<br>• LHSE | | | • The fastest way to implement the plan efficiently<br>• Efficient and effective communication with stakeholders<br>• Investment profit and positive image |
| Financiers;<br>• ADB | (+) | | • Investment profit and positive image<br>• The project is implemented according to the plan<br>• Affected people are adequately compensated<br>• Integration of the project into the overall plan and policy of the bank |
| Government of Lao PDR; via various line ministries,<br>• Prime Minister's Office<br>• Ministry of Natural Resources and the Environment (MONRE)<br>• Ministry of Agriculture and Forestry<br>• Ministry of Communication, Transport, Post and Construction<br>• Ministry of Industry and Handicrafts<br>• DOE<br>• Ministry of Labour and Social Welfare<br>• Ministry of Information and Culture<br>• Ministry of Education<br>• Ministry of Health | (-)(+) | | • The return of investment to the country<br>• Integration of the Project to the National Development Plan 2010-2015 and the Millennium Development Goals<br>• Minimizing the environmental and social impacts<br>• Benefits to the local people, distributed thoroughly and evenly<br>• Effectiveness of communication between the Project, GoL authorities, provincial and district counterparts, and the affected people |
| GOL Authorities at Provincial Level:<br>• Vientiane Province,<br>• Bolikhamxay Province,<br>• Xieng Khouang Province | (-)(+) | | • Integration of Project and its elements in provincial development plans<br>• Selection and management of personnel required to help implement and/or monitor the Project |
| GOL Authorities at District Level:<br>• Hom District,<br>• Bolikhan District,<br>• Pakxan District,<br>• Thaphabath District,<br>• Pak Ngum District,<br>• Thathom District | (-)(+) | | • Integration of Project and its elements in district development plans<br>• Selection and management of personnel required to help implement and/or monitor the Project<br>• Benefit to the district and local people<br>• Land use and land reallocation |

| Stakeholder | Potential Project Impact | Relative Priority of Interest | Key Stakeholders' Interests in the Project |
|---|---|---|---|
| *External Stakeholders* | | | |
| NGOs and other external stakeholders | (-)(+) | | • Impacts on environment within Nam Ngiep watershed<br>• Impacts on environment of the Mekong River<br>• Impacts of the Project on local people and the Lao PDR<br>• Issues of culture, gender, ethnicity, etc. |

## 8.4 PUBLIC CONSULTATION PROCESS

Dialogue has been established with stakeholders who are directly or indirectly involved and potentially affected by the NNHP-1 Project and who are in concern. Consultations at the local, regional and national levels were well advanced and continue to progress through steps associated with the public consultation process following:

### 8.4.1 INFORMATION COLLECTION AND DISSEMINATION

This initial phase of consultation is aimed at collecting and disseminating information. Data had been collected on the human and physical characteristics of the current environment in order to predict project impacts. This information is important to adequately evaluate and plan for project implementation. As part of this phase, information was disseminated to stakeholders that detailed the project features and the implications in terms of potential changes to the social and physical environment.

### 8.4.2 STAKEHOLDER CONCERNS

Comments were and will continue to be sought from stakeholders in response to information gathered as part of the phase one studies. This information was disseminated with an ongoing discussion encouraged regarding the alternatives and proposed mitigation measures. Issues for stakeholders that may have been previously overlooked or are outstanding are given a forum for review through public consultation activities. This assessment of stakeholder needs provides a base from which decisions can be made.

### 8.4.3 ACTIVE INVOLVEMENT IN PROJECT DESIGN AND IMPLEMENTATION

Based on the discussion and subsequent commitments to the community as a result of phase two for this project, a set of mitigation measures develop that addresses direct project impacts. In addition, there are concessionary measures provided in terms of education, training, financial and institutional strengthening to communities that are directly and indirectly affected by project activities. The process of stakeholder involvement and identification will continue during project implementation.

## 8.5 CONSULTATION AND PARTICIPATION ACTIVITIES

Consultation events were focused around the dissemination of information and public participation. Some consultations focused around the GOL commissioned study of alternatives, economic analysis, and the environmental management plan. Accessibility of information and participation had been enhanced through the establishing of the information center at each respective district within the affected area of the Project.

The need for participation and involvement at a local level has required attention to ensure the collection and presentation of appropriate information. This desire to obtain such information has involved the utilization of village meetings and focus group discussions with affected people in various project areas. These approaches were adopted to ensure a clear understanding of the existing situation and the cultural and livelihood implications of the project, as well as providing a forum to inform affected persons about the project and involve them in project planning.

### 8.5.1 SUMMARY OF LOCAL EVENTS

Local level consultation had utilized various formats to suit the needs of the situation. In all cases the villagers had been notified prior to the public consultation team’s arrival. Letters were sent by the staff of the district office to inform village authorities of the pending visits and to inform residents within the villages themselves. This notification allowed villagers to adjust their daily activities in order to attend the meetings. All surveys and visits included presentations and interactive discussions, and the display of graphics, including maps.

### 8.5.2 SUMMARY OF REGIONAL EVENTS

Regional level consultation was recognized as an important component of public consultation. Consequently, the establishment of an early working relationship between NNHP-1 Project and the provincial officials and agencies has greatly facilitated information sharing at the local and regional levels. Information centers were established in Bolikhan district, Bolikhamxay province and in Hom district, Vientiane province.

Most staff working on public consultation and participation for the project and the GOL had been recruited from this region. Furthermore, provincial officials and agency representatives had an integral part of all policy planning matters alongside Ministerial representatives. Consultation and participation at the regional level had sought to provide a forum for the exchange of information and idea between project representatives, the GOL and regional stakeholders.

# 8.6 SUMMARY OF PUBLIC CONSULTATION

## 8.6.1 SUMMARY OF PCS ZONE BY ZONE

### 8.6.1.1 Public Consultations of Zone 1 and of Zone 2UR

There have been five official consultation meetings on the SIA study for Zone 1 (Upstream Area) and Zone2UR (Upper Section of the Reservoir Area), both of which are in Xieng Khouang Province. These took place as follows:

| Date | Location | Participants |
|---|---|---|
| Village Level | | |
| during 10-15 Feb 08 and<br>27 June-3 July 08 | | • Villagers<br>• GOL<br>• Project Developer<br>• Consultants |
| 02 Oct.11 | ▪ Ban Pou<br>▪ Thaviang-sub District<br>▪ Xieng Khouang Province | • Villagers (181)<br>• GOL (5)<br>• Project Developer (7)<br>• Consults (8)<br>Total 201 |
| 03 Oct.11 | ▪ Ban Hatsamkhone<br>▪ Thaviang-sub District<br>▪ Xieng Khouang Province | • Villagers (100)<br>• GOL (5)<br>• Project Developer (7)<br>• Consults (8)<br>Total 120 |
| 03 Oct.11 | ▪ Ban Piengta<br>▪ Thaviang-sub District<br>▪ Xieng Khouang Province | • Villagers (72)<br>• GOL (5)<br>• Project Developer (7)<br>• Consults (8)<br>Total 92 |
| District Level | | |
| 21 Feb 08 | Thaviang Sub-District<br>Thathom District<br>Xieng Khouang Province | • Villagers (13)<br>• GOL (56)<br>• Project Developer (8)<br>• Consults (5)<br>Total 82 |
| 2 July 08 | | • Villagers (18)<br>• GOL (4)<br>• Project Developer (1)<br>• Consults (4)<br>Total 27 |
| Provincial Level | | |
| 24 Apr 08 | Thaviang-sub District<br>Xieng Khouang Province | • Villagers (43)<br>• GOL (79)<br>• Project Developer (18)<br>• Consults (21)<br>Total 161 |

The major topics of discussion of the consultation meetings, and the major concerns of the participants from Zone 1, Upstream of the Reservoir Area, and Zone 2UR, Upper Section of the Reservoir Area were:

**Environmental Issues**

1. Fishery, especially, hatchery ecosystem;
2. Forestry survey, mineral development;
3. Impact and the mitigation in long-term on sedimentation and drought;
4. The immerse flood and the water level of the reservoir of NNHP-1;
5. Possible impact to the roads in the Project area;

**Social, Development and Compensation Issues**

1. Compensation scheme;
2. Resettlement site selection (this option was later ruled out, because resettlement was to be carried out within the same district or the same province as much as possible, and all the resettled communities are in Vientiane or Bolikhamxay Provinces). Wangsai (Phonesai) area and Khetyam areas were on the list of recommendation;
3. Occupation training;
4. Possibility of dry-season rice cultivation;
5. Impact caused by widening of the Nam Ngiep, blocking crossing to the other side of the river during rainy season. Ban Piengta asked for a small bridge to be able to let at least hand pushed tractors cross the river;
6. Improving basic infrastructure to the villages;
7. Improving the livelihood of the affected people;
8. Mitigation measures for the loss of productive lands in Zone 2UR;
9. Possibility of building dikes to prevent flooding;
10. Possible hiring of the un-skilled workers for the project from among the Project affected people;
11. Establishing compensation committee from stakeholders of all level: village, district, provincial and national;

**Other issues**

1. Discussion of the project description;
2. Acknowledgement of the impacts of the project;
3. Special concerns of Ban Nakang;
   - Only 2 affected households would face loss of productive land,
   - There was question if the Project could support the relocation process and other facilities to the village. It should be noted that Ban Nakang was already being moved about 10 kilometers away to Phonhom, a larger village in the same valley. This was part of the relocation and village consolidation policy of GOL, to be able to provide better infrastructure and services to rural communities, and it was being done whether or not there was the NNHP-1 project. Though the households moved 10 kilometers distant, they were still using their agricultural lands and other resources.

***Village Level Consultation Meeting on October 2 to 3, 2011 for 3 villages of Ban Pou, Ban Hatsamkhone and Ban Piengta***

Based on the new census carried out from July to August, 2011, consultation meetings for the village level were held to inform the villagers of the updated resettlement action plan and to hear the direct opinions by separate group discussion of women, men and vulnerable people. So that all the villagers could understand the content and participate in the discussions, Hmong language was also used in the meetings.

***Results of Meetings;***

Most of APs agree to the project development with some suggestions and proposals.

***(1) Ban Pou***

The APs commented:

- We propose rearrangement of residential area with infrastructure.
- If we lose land even if a house remains, we cannot survive
- We want to get a chance to work for the project.
- Unregistered land which was developed by French NGO’s fund should be compensated.
- We want to get good health care and education fund up to higher secondary school.

- We want to ask develop paddy field instead of inundated land.
- We want to ask to build 19 new houses for poor families.

***(2) Ban Hatsamkhone***

The APs commented:

- Last CM we proposed followings: school with rooms, suspension bridge, internal road and T/L.
- We want to ask rice supplement program during transition period until we get enough crops.
- We prefer alternative land to cash compensation.
- We've got details of the project. We want to ask developer to come here to explain update frequently.
- We want to ask to build a nursery and to improve a village hall with furniture.

***(3) Ban Piengta***

The APs commented:

- We are happy to hear the presentation of project and dam construction.
- If developer finds a new land, please show it to us first. We want to check before development.
- We want to hear a plan in case developer cannot find any new land.
- We want to ask to build a new school with furniture and materials.
- We want to ask suspension bridge and access road to access to lands on the right bank.
- We want to ask to provide medicine or operation to space birth.

#### 8.6.1.2 Public Consultation of Zone 2LR

The public consultation meetings in Zone 2LR (Lower Section of the Reservoir Area) were conducted as presented in the table below:

| Date | Location | Participants |
|---|---|---|
| Village Level | | |
| 31 Oct 07 | Ban Houaypamom | NR |
| 31 Oct 07 | Ban Sopyouak<br>Hom District<br>Vientiane Province | • Villagers (62)<br>• GOL (9)<br>• Project Developer (5)<br>• Consults (5)<br>Total 81 |
| 4 Oct 07 | Ban Sopyouak | NR |
| 5 Nov 07 | Ban Sopphuane | NR |

<table>
<tr><th>Date</th><th>Location</th><th>Participants</th></tr>
<tr><td>10 Nov 07</td><td>Ban Namyouak</td><td>NR</td></tr>
<tr><td>17 Sep 11</td><td>Ban Sopphuane</td><td>• Villagers (92)<br>• GOL (2)<br>• Project Developer (7)<br>• Consults (9)<br>Total 110</td></tr>
<tr><td>18 Sep 11</td><td>Ban Houaypamom</td><td>• Villagers (34)<br>• GOL (1)<br>• Project Developer (7)<br>• Consults (9)<br>Total 51</td></tr>
<tr><td>19 Sep 11</td><td>Ban Sopyouak</td><td>• Villagers (130)<br>• GOL (3)<br>• Project Developer (7)<br>• Consults (8)<br>Total 148</td></tr>
<tr><td colspan="3">District Level</td></tr>
<tr><td>26 Nov 07</td><td>Office of Energy and Mines Viengkham District Vientiane Province</td><td>NR</td></tr>
<tr><td>18 Jan 08</td><td rowspan="3">Hom District<br>Vientiane Province</td><td>• Villagers (16)<br>• GOL (28)<br>• Project Developer (9)<br>• Consults (12)<br>Total 65</td></tr>
<tr><td>9 June 08</td><td>• Villagers (10)<br>• GOL (9)<br>• Project Developer (1)<br>• Consults (8)<br>Total 28</td></tr>
<tr><td>5 Nov 08</td><td>• Villagers (8)<br>• GOL (16)<br>• Project Developer (1)<br>• Consults (7)<br>Total 32</td></tr>
<tr><td colspan="3">Provincial Level</td></tr>
<tr><td>28 Apr 08</td><td>Viengkham District<br>Vientiane Province</td><td>• Villagers (22)<br>• GOL (42)<br>• Project Developer (17)<br>• Consults (12)<br>Total 93</td></tr>
</table>

NR: No record of the participants in the meeting records

Key issues raised in the meetings were:

**Environmental issues**

1. The meetings suggested the study team work closely with relevant authorities of Vientiane Province. Since there were many hydropower projects in the province, the authorities are well experienced with the process of EIA and SIA studies.

2. The meeting requested the Developer to confirm the demarcation both in the field and with the Geological Department to make sure that its demarcation accurately represents the area where the inundation is to occur.

**Social, Resettlement and Compensation issues**

1. Housing at the new resettlement site should be better than their present structures.
2. The current locations of the 4 affected villages in the province are considered rather high quality sites in terms of access to resources. The new sites should be at least equal in quality if not better.
3. Consideration should be made for the mental effects of resettlement and worry of the affected people.
4. Discussion regarding details of each resettlement sites; choices of agriculture and choices of occupation to the affected people.
5. The Pha-Aen area chosen as a prospected resettlement site of NNHP-1 is also a potential site for another hydropower project. There may be further resettlement in that area in the near future.
6. Discussion regarding the compensation scheme.
7. Availability of resettlement site.
8. Access road to Samtoey, a potential resettlement site, is difficult and probably not possible to be built.
9. There is a conflict of policy on commercial plants; rubber trees, which were recently introduced to the village. Should the villagers go ahead and plant them?
10. Asking for 3 yrs prior compensation for cemetery and graveyard.
11. The amount of available land in the new settlement sites should correspond to the current actual amount of land being used.

**Other issues**

1. Indirect effects, for example: Namyouak, the main rice supply for Phalavaek, will no longer be available; tax to Hom district will be reduced.

2. A request was made that 1% of the profits of the project be set aside for the development of Hom district. However, this cannot be considered by the Project, since any rule about development funds must come from the GOL.
3. A fee to be collected from the Project to create a development fund would be possible under the soon-to-be-released regulation.
4. Dam safety and earthquake issues should be considered.
5. There should concern about local permission for use of local sources of materials to be used in the construction of the Project, and any agreement on this should be included or described in the CA

***Village Level Consultation Meeting on September 16 to 19, 2011 for 4 villages of Ban Namyouak, Ban Sopphuane, Ban Houypamom and Ban Sopyouak***

Based on the new census carried out in July to August, 2011 and the rejection by the APs of the previous resettlement sites, new resettlement site plans were prepared. Consultation meetings at the village level were held to inform the villagers of the updated resettlement action plan and to hear the direct opinions by gr oup discussion of women, men and vulnerable people. Because all the households but one are Hmong in these communities, the Hmong language was used as the main language of the meetings.

***Results of Meetings;***

The main concerns expressed by the villagers about the new resettlement plan are:

- Suspect that the production land provided by the project may not be sufficient for agricultural production.
- Worry about quality of soil in the new resettlement area.
- Afraid of the development plan are not realized and sustainable.
- Until these meetings, the women were not fully involved in the village meetings, which makes difficult to make decision.
- The house model No. 3 is the most attractive.
- The villagers are interested in this resettlement plan. Although not all of the villagers are registered as participating in the meetings, the group discussions have extended knowledge of the project throughout the villages, and people are now beginning to understand the project better.

### 8.6.1.3 Public Consultations of Zone 3 (Construction Area) and Zone 4 (Downstream Area)

A series of meetings at the village, district and provincial levels were held in Zones 3 and 4 of the project area. Both these zones are located in Bolikhamxay Province.

| Date | Location | Participants |
|---|---|---|
| Village Level | | |
| 29 Oct 07 | Ban Hat Gniun<br>Bolikhan District<br>Bolikhamxay Province | • Villagers (30)<br>• GOL (11)<br>• Project Developer (3)<br>• Consults (6)<br>Total 50 |
| 25 Sep 11 | Ban Hatsaykham<br>Bolikhan District<br>Bolikhamxay Province | • Villagers (77)<br>• GOL (1)<br>• Project Developer (6)<br>• Consults (8)<br>Total 92 |
| 26 Sep 11 | Ban Hat Gniun<br>Bolikhan District<br>Bolikhamxay Province | • Villagers (54)<br>• GOL (3)<br>• Project Developer (6)<br>• Consults (8)<br>Total 71 |
| 26 Sep 11 | Ban Thaheua<br>Bolikhan District<br>Bolikhamxay Province | • Villagers (51)<br>• GOL (3)<br>• Project Developer (6)<br>• Consults (8)<br>Total 69 |
| District Level | | |
| 16 Jan 08 | Bolikhan District<br>Bolikhamxay Province | • Villagers (18)<br>• GOL (32)<br>• Project Developer (9)<br>• Consults (10)<br>Total 69 |
| 12 June 08 | Pakxan District<br>Bolikhamxay Province | • Villagers (14)<br>• GOL (8)<br>• Project Developer (1)<br>• Consults (6)<br>Total 29 |
| Provincial Level | | |
| 22 Apr 08 | Pakxan District<br>Bolikhamxay Province | • Villagers (23)<br>• GOL (31)<br>• Project Developer (9)<br>• Consults (30)<br>Total 93 |

Major topics discussed in the Public Consultations of Zone 3 ( Construction Area) and Zone 4 (Downstream Area) were:

**Environmental issues**

1. Mitigation measures on water quality, erosion that could affect water uses;
2. Provision of clean water such as groundwater, bored hole wells;
3. Fishery of affected people in downstream area; protection of aquatic life and possible loss of fishery yield;
4. Mitigation measures for flood protection in downstream areas including tribitraries;

**Social, Resettlement and compensation issues**

1. Regulations or agreement of compensation concerning opportunity losses;
2. Fairness of compensation to affected people, no matter whether they have low income or high;
3. Provision of sufficient land for agricultural activities to those who will lose their lands;
4. Development of the resettlement site before moving affected people out of the existing lands;
5. Size of the houses to be built in the resettlement site should be appropriate for the family sizes;
6. Relocation of sacred sites and tombs in a cemetery and local tradition or culture;
7. Consultation with host community, Ban Hat Gniun;
8. Livelihood restoration plan;
9. Details of agricultural development;
10. Training program in higher occupational skills for Project affected people.

**Other issues**

1. It was suggested that the Project work closely with authorities of Bolikhan district and Ban Hat Gniun for proposed resettlement site.
2. Share project benefit as annual funds contributed to district and provincial development

***Village Level Consultation Meeting on September 25 and 26, 2011 for 3 villages of Ban Hatsaykham, Ban Hat Gniun and and Thahuea***

Based on the new census carried out in July to August, 2011 and the new resettlement site plan on Houay Soup as another bank of Ban Hat Gniun, consultation meetings for the village level were held to inform the villagers of the updated resettlement action plan and to hear the direct opinions by gr oup discussion of women, men and vulnerable people. Also, in the meetings, Hmong language was used for the meetings at Ban Hatsaykham, so the villagers could understand the contents fully.

***Results of Meetings;***

Most of APs agree to the project development, but some considerations were raised through direct consultation meeting, which will be reflected to further development program.

***(1) Ban HatsayKham***

Some of the key comments from villagers were:

- Planned resettlement site on the left bank (close to Hat Gniun) is easily eroded due to slope and not suitable for paddy filed due to hilly topography.
- We hear that for villages at 2LR will not approve to resettle if Hat Gniun joins in the right bank. We want to move to the right bank with four villages, because we are also Hmong.
- We have developed the right bank from dense forest and have already farmed part of it, and we are waiting for irrigation.
- My two children cannot read even though they graduated from elementary school.
- We want to request a residential area close to access road and to build the school near residential area.

***(2) Ban Hat Gniun***

Comments by villagers here were:

- As host village, we will welcome APS.
- We settled here 130 years ago and also use the right bank. According to District instructions, we have developed the right bank. If our agricultural land is taken away how are we to survive?
- We want to propose to use right bank as agricultural land with all villagers concerned and allocate facilities at one place on the left bank to increase cultivated land and to reduce cost for facilities.

***(3) Ban Thahua***

Comments by the villagers here were:

- We want to request to build a lower secondary school and electricity distribution line.
- We are happy for the opportunity to join the project.

### 8.6.1.4 Public Consultation of Zone 5 (Resettlement Area)

Meetings were held in Zone 5, the original proposed resettlement areas, as indicated in the table below. Note that the meetings in the resettlement area of Hat Gniun were included in the public consultations for Zone 3.

Although these are no longer being considered as resettlement areas, the consultation process is indicated for public record.

| Date | Location | Participants |
|---|---|---|
| Village Level | | |
| 15 Nov 08 | Ban Pha-Ane<br>Hom District<br>Vientiane Province | • Villagers (70)<br>• GOL (1)<br>• Project Developer (-)<br>• Consults (5)<br>Total 76 |
| | Ban Phukatha<br>Hom District<br>Vientiane Province | • Villagers (52)<br>• GOL (-)<br>• Project Developer (2)<br>• Consults (8)<br>Total 62 |
| District Level | | |
| 5 Nov 08 | Hom District<br>Vientiane Province | • Villagers (8)<br>• GOL (16)<br>• Project Developer (1)<br>• Consults (7)<br>Total 32 |

Major topics of discussion in the Public Consultations of Zone 5 (Resettlement Area) were:

**Environmental issues**

1. The villagers were worried about the availability of agriculture land after distribution to the newcomers, followed by concern about the availability of forest resources and wildlife, and also the behavior of the new comers in terms of use and conservation of the natural resources.

**Social and Development issues**

1. Share land for housing to the new comers up to capacity of the available space.
2. The host village would like to have the right to use or share infrastructure with the resettled communities, including road, electricity, water supply, school, health center, village office, village hall, market, bus station, and other facilities.
3. The hosts should have the opportunity to participate in any vocational training being provided.
4. The development of the resettled communities should follow the policy of Lao PDR that encourages the integration of small villages into larger ones.

#### 8.6.1.5 Other Meetings

Aside from the formal public consultation meetings, a number of other meetings were held with key stakeholders and with officials from the GOL for information and consultation. The dates, locations, and participation in these meetings are provided where possible.

| Date | Location | Participants | Remark |
|---|---|---|---|
| 5 June 08 | Hom District,<br>Vientiane Province | • GOL (10)<br>• Project Developer (1)<br>• Consults (6)<br>Total 17 | |
| 10 June 08 | Pakxan District,<br>Bolikhamxay Province | • GOL (8)<br>• Project Developer (1)<br>• Consults (9)<br>Total 18 | |
| 11 June 08 | | • GOL (8)<br>• Project Developer (1)<br>• Consults (7)<br>Total 16 | |
| 3-4 July 08 | Meetings with officials of Thaviang Sub-District on possible resettlement sites | | |
| 7 July 08 | Establish information center in project area | | |
| 8 July 08 | Establish information center in project area | | |
| 9-10 Oct 08 | The 2nd Closed Consultation Meeting Plaza III, Lao Plaza Hotel | • GOL (6)<br>• Project Developer (22)<br>• Consults (27)<br>Total 55 | |

# CHAPTER 9

# PROJECT GRIEVANCE REDRESS MECHANISM AND ADB ACCOUNTABILITY MECHANISM

## 9.1 RATIONALE

No matter how effective and participatory the consultations, planning, and implementation of the resettlement, livelihood restoration, and other social and economic components of the project. With thousands of people affected by the project, there are likely to be at least some complaints or grievances from PAPs as individuals or as communities, whether on the social or economic impacts, the environmental impacts, the compensation packages, or the provision of livelihood restorations and social development programs. Even when there has been full effort at consultations and transparency, differences can still remain in perception and expectations, and these may lead to conflicts between the PAPs on the one hand, and the government, the developer, and those hired to implement the project on the other. A process is needed to hear the PAPs' grievances and to resolve them to the satisfaction of the PAPs.

The GOL's Technical Guidelines on Compensation and Resettlement of People Affected by Development Projects (March 2010), a series of procedures and mechanisms is required to redress any grievances. T he GOL recognizes that the best way to avoid conflicts or grievances is through the process of consultations, disclosures, and participatory planning and decision-making. Thus, the first stage is Conflict Avoidance. This should be done through consultations and disclosures, as well as participation in planning and decision making. I f disagreements do arise, but have not yet become firm conflicts, then the issue may still be solved through informal negotiations and other informal means. It is only when problems have become more intractable that they need to be taken to the more formal grievance process. The steps given below are indicative of the intensity of disagreement and the level of the grievance process required to resolve it.

① Conflict Avoidance ◇ Consultations, Disclosures, Participatory Planning and Decision Making

② Simple Disagreements ◇ Informal Negotiations, Discussions, Mediation

③ Early Conflict Development ◇ Refer to the Village Grievance Committee

④ Emerging Conflicting Positions ◇ Refer to the District Level Grievance Committee

⑤ Hardened Conflicting Positions ◇ Refer to Provincial Level Grievance Committee / Authorities

⑥ Intractable Conflict ◇ Refer to the Courts

The purpose of the grievance procedure is to ensure that PAPs have the means to assure they are satisfied they have been adequately protected from adverse impacts of the project, or if impacts cannot be avoided that they are satisfied they have obtained adequate compensation and that their entitlements are delivered sufficiently and on schedule. If an affected person or group or community feels they have not been adequately protected or compensated, have not received the entitlements due them, or otherwise believe there have been unfairly affected by the project, that person or group or community has the right to make a claim. The Grievance Procedure established by the Company will cover both social issues and environmental issues, since most of the environmental impacts are those that affect people.

In addition, the Asian Development Bank (ADB), one of the project funders, has established an Accountability Mechanism if there are violations of ADB's operational policies and procedures that result in direct harm to claimants. The ADB Accountability Mechanism is appropriate for those instances when the harm is due to actions taken by the ADB or by the omission of actions that should have been taken by the ADB, particularly those concerning the ADB's social and environmental safeguards.

## 9.2 PROJECT GRIEVANCE PROCEDURE

### 9.2.1 Establishment of Grievance Committees

Following approval of the Project by the GOL and before the start of implementation of resettlement activities, the Project authorities will make a formal request to the GOL for the PRLRC in each province to establish the Provincial and District Grievance Committees. These committees will address complaints and grievances made by Affected People concerning land acquisition, compensation, and resettlement related to Project activities. The

District Grievance Committees will be given the authority to establish Village Grievance Committees in those villages that are affected by the project within the district.

The Provincial Grievance Committee will consist of at least these members:

- Representative of the Provincial authority, as chairperson,
- Representatives of Provincial or District Authorities,
- Representatives of PAPs,
- Representatives from mass organizations, including the LWU,
- Representatives from Local Non-for-Profit Organizations, and
- Representatives from the Company

Other members can be appointed to the Provincial Grievance Committee as deemed appropriate by the PRLRC.

The District Grievance Committee will consist of:

- Representative of the District authority, as chairperson,
- Village head(s),
- Representatives of PAPs other than Village Head(s),
- Village Elders and/or Other Representatives from mass organizations, including the LWU,
- Representatives from Local Non-for-Profit Organizations, and
- Representatives from the Company

Other members can be appointed to the Provincial Grievance Committee as deemed appropriate by the PRLRC.

The Village Grievance Committee will consist of:

- The village head as chairperson,
- Representatives of village authorities,
- Village elders, and
- Representatives from mass organizations, including the LWU.

### 9.2.2 The Grievance Process

The Grievance Redress Process will consist of the steps described below, and indicated in the following Figure 9-1.

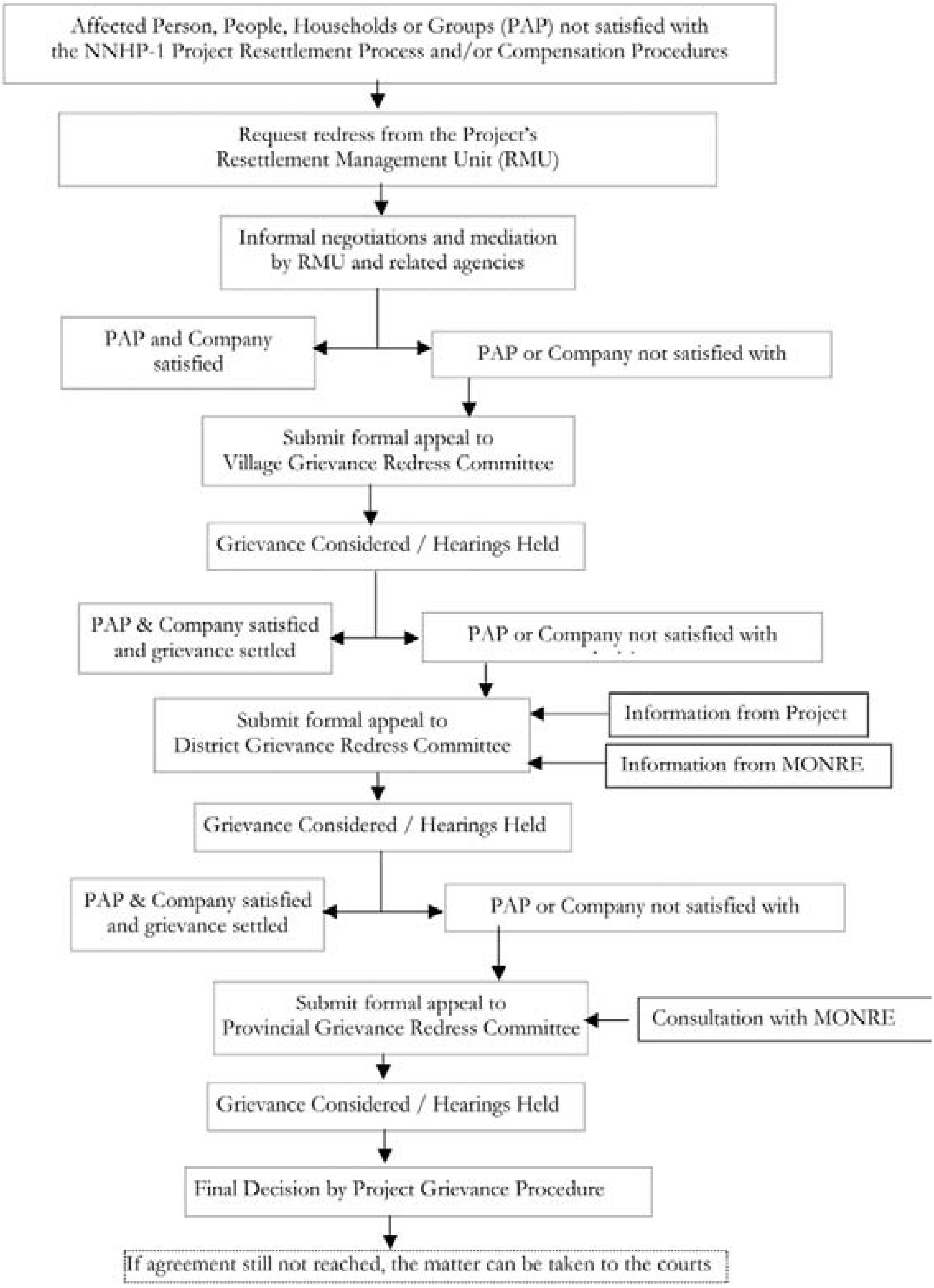



Figure 9-1 Schematic of the Grievance Procedure for the NNHP-1 Project.

The EMO and SMO of the Environmental and Social Division of the Company and the RMU should be in regular consultation with affected people and communities, and so be able to learn at an early stage of any complaints or grievances that may arise. Those Affected Person or People, Households or Groups (PAPs) with a claim or grievance can also take their claim or grievance to the RMU. Staff of the EMO and SMO together with their counterparts in the RMU and the relevant agencies should make every effort to settle the complaints or grievances, through informal negotiations, discussions, and mediation between the aggrieved parties and the Project, before those disagreements, to reach consensus at the project level. These discussions and negotiations must be held in a transparent manner, with proper documentation, and with any agreements signed voluntarily by all parties concerned.

If the PAP is not satisfied with the decision at the project level, or wishes to initiate the process at the level of the Village Grievance Committee, the PAP can submit a complaint. The meeting of the Village Grievance Committee will be held in a public place, no more than 15 days from the date of formal receipt of the grievance. However, sufficient advance notice should be given to allow for attendance by representatives of the PAP, Company representatives, and any other interested members of the public. 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 meetings and hearings of the Village Grievance Committee must be held in a transparent manner, with proper documentation. The report of the decision of the Village Grievance Committee must be in writing and must be signed by the 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.

If either the PAP or the Company is not satisfied with the decision by the Village Grievance Committee, or if the Project does not abide by the decision of the Village Grievance Committee, an appeal can be made to the District Grievance Committee. The 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 the 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 claim and grievances it receives, including a summary of the decisions made, and must also make public all reports on 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. However, sufficient advance notice should be given to allow for attendance by representatives of the PAP, Project representatives, and any other interested members of the public. 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 meetings and hearings of the District Grievance Committee must be held in a transparent manner, with proper documentation. The report of the decision of the District Grievance Committee must be in writing and must be signed by the 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.

If either the PAP or the Project is still not satisfied with the decision made by 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 (PGRC). The 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 the Lao Women's Union, or representatives of the PAP, can ensure that the appeals are forwarded to the PESMC of the province where the PAPs reside. The PGRC will examine and consider the complaint or grievance in consultation with representatives of MONRE and the Company.

If the matter is still not resolved to the satisfaction of the PAPs and the Project within 20 days after filing the complaint with the PGRC, the matter can be forwarded to the Court of Law at the request of the PAPs and/or representatives of local non-profit organizations or mass 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 relevant authorities to make the final and binding decision.

In cases that the Project is found responsible for negligence of compensation, the Project will cover in full all administrative and legal fees incurred by the PAPs in the grievance redress process at the District level, the Provincial and MONRE level, and in the Court of Law. Claims for such payment should be made by the PAPs to the Project staff of the ESD, and a copy of such claims also submitted to MONRE for record and information.

The Project will recruit an independent monitoring team to assure that the grievance procedure is being established and implemented in a timely and appropriate manner. The hiring of this independent monitoring team will be done with the agreement and approval of MONRE.

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 of the project. Complaints and grievances concerning impacts from operation of the project will be considered from the official date of the start of operations.

It is in the best interest of all parties that appropriate resettlement activities and mitigation measures are implemented in time and to the satisfaction of the PAPs, and that an appropriate, transparent and effective grievance redress mechanism be established, so that construction works can be carried out without conflict and delay.

## 9.3 ASIAN DEVELOPMENT BANK ACCOUNTABILITY MECHANISM

Partial funding for the NNHP-1 Project will be provided by the Asian Development Bank (ADB). Environmental and social safeguards of the ADB will also apply to the Project. Among them is the ADB Accountability Mechanism (AM), which provides access to affected persons to the ADB's grievance procedure.

The AM has been set up to allow affected persons the ability "to voice and seek solutions to their problems and also report alleged violations of ADB's operational policies and procedures." This is done in two stages. If a complaint is considered eligible for review there is first consultation with the stakeholders, to try to solve the problems that they have raised. If the results of the consultation process are satisfactory to the complainants, it is not necessary to continue with a compliance review. If the results of consultation process are not satisfactory to the APs, the ADB's Compliance Review Panel can recommend to the ADB Board of Directors the eligibility of the complaint for review. If approved, an independent investigation is made to ensure project compliance and to recommend any changes in the project that are needed to ensure that compliance.

Residents and other stakeholders in the area of the NNHP-1 Project will be informed of the AM process and provided with a Lao language brochure describing the process and their rights. A copy of this brochure in Lao and English is provided as Annex B to this report.

# CHAPTER 10

# ENVIRONMENTAL MANAGEMENT PLANS

For each of the potential environmental impacts described in the previous chapter, measures are suggested either to prevent those impacts or to mitigate their effects. T his chapter presents the various preventative 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 and construction phases and (2) the operations phase.

The Environmental Management Plan (EMP) will be updated and/or revised, both for construction and operation phases, to adapt the measures to the prevailing conditions and monitored impacts during the construction period.

## 10.1 ENVIRONMENTAL MITIGATION MEASURES DURING PRE-CONSTRUCTION AND CONSTRUCTION PHASES

### 10.1.1 ENVIRONMENTAL MITIGATION MEASURES FOR PHYSICAL IMPACTS

#### 10.1.1.1 Landslides and Seismicity

**(1) Objective**

- To prevent landslides
- To avoid reservoir induced seismic activity

**(2) Actions to Be Taken**

The slope and geology around the reservoir are not conducive to landslides. Given the size of the reservoir and the height of the water at the dam, reservoir induced seismic activity is not expected.

During the initial storage of the reservoir, routine visual inspections should be made to evaluate the safety of the dam. Routine visual inspections should also be made of the slopes around the construction area and the reservoir for signs of any landslides.

**(3) Responsible Unit / Agency**

Developer / Environmental Management Office (EMO)

**(4) Cost Estimate (USD)**

No additional costs expected

**(5) Work Plan:**

Continuous during construction

| Work Plan | | Frequency | Pre construction | Construction Phase (year) | | | | | | Operation Phase (year) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | 1 | 2 | 3 | 4 | 5 | 6 | 1 | 2 | 3-8 | >8 |
| 1 | Monitoring for landslide and other signs of seismic activity | yearly | | | | | | | | | | | |

10.1.1.2 Erosion and Sedimentation

**(1) Objective**

- To prevent or limit erosion during construction due to the clearing of lands and exposure of soil.
- To prevent sedimentation in the river from erosion caused by c onstruction activities or from topsoil stockpiles, or surplus waste piles.
- To monitor and report on the planned control measures related to soil erosion, landslide and rock movements
- To estimate the predicted level of sediment-related situations which will occur at the project site (i.e., soil erosion, landslide and rock movements)

**(2) Actions to Be Taken**

Erosion and sediment controls and mitigation measures will be undertaken by the Developer / Contractor / Sub-contractor according to the recommendations in the EMP Sub-Plan SP01 on Erosion and Sediment Control in Appendix 1 of this report. These include but are not limited to the following actions.

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.

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
- In order to minimize impacts in sensitive erosion areas, the following measures shall be adhered to:
- 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
- Suitable measures to control the 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.
- Land clearing and slope stabilization activities should be conducted in their proper sequence and disturbed areas are to be suitably protected and maintained until permanent protection is established.
- Areas should not be prematurely exposed prior to the ability to temporarily or permanently protect such areas against erosion. More specifically, only areas intended for immediate construction activity will be cleared of vegetation and topsoil, in cognizance of the overall construction schedule.

- Any and all disturbed areas that are not subject to construction traffic will receive temporary protection and stabilization via means such as erosion blankets/mats or temporary seeding that is capable of protecting the areas until permanent stabilization measures are put in place. Therefore, after initial disturbance or rough grading, all areas subject to erosion should receive suitable control measures such as a temporary seeding in combination with straw or a suitable material.
- Soil and spoil removed during the construction process will be stockpiled separately and stabilization measures implemented. The stockpiles will be constructed with smooth slopes and free draining patterns. Topsoil stockpiles will be deep ripped to provide for moisture retention and re-growth. Drainage and erosion from the stockpiles will be controlled by locating them in areas away from drainage lines. The erosion of the base of the dump will be prevented by providing a diversion bank uphill to prevent any runoff from reaching the pile, and at the same time constructing a silt fence, if necessary, to contain any runoff resulting from the pile.
- Ridges maybe created on topsoil stockpiles to provide for moisture retention to assist re-growth and slow runoff.
- Soil and spoil piles will be placed in such a manner that will avoid areas of drainage lines in order to control drainage and reduce erosion discharge from the stockpiles. Such piles shall be placed in a manner that does not interfere with temporary surface flows or established watercourses.
- Potential problems with erosion along the base of waste or soil surplus piles must be considered in planning the location of such sites.
- Waste or surplus materials shall not be placed in areas subject to potential flooding and inundation or in manmade or natural watercourses.

In terms of erosion control as part of the project, the major effort at construction sites will focus on the management of erosion of excavated surfaces, especially during the wet season when the volume of runoff is expected to be high. A Site Management Plan which includes a sub-plan for Erosion and Sediment Control will be prepared by the lead contractor for use at all the construction sites. It will include environmental management and pollution control techniques for all areas of activity including drainage measures for underground works. It will also include a Water Quality Monitoring Plan. The Plan will meet the appropriate standards and include the development of drainage works, sediment traps, diversions, culverts and other structures designed to treat water to reach an acceptable quality before discharge into natural and/or constructed watercourses.

There will be regular monitoring of the control measures, to assure they are up to standard and follow best practices. As conditions change during construction, revisions will be made to predicted levels of sediment-related situations that may occur at the project site (such as soil erosion, landslide and rock movements).

**(3) Responsible Unit/Agency**

- For all prevention and mitigation measures: Developer / Contractor / Sub-Contractor
- For monitoring: Environmental Management Unit (EMU) and EMO

**(4) Cost Estimate (USD)**

- For prevention and mitigation measures: included in construction costs
- For monitoring: USD $5,000 per year

**(5) Work Plan:**

- For prevention and mitigation measures: by task
- For monitoring:

| Work Plan | | Frequency | Pre construction | Construction Phase (year) | | | | | | Operation Phase (year) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | 1 | 2 | 3 | 4 | 5 | 6 | 1 | 2 | 3-8 | >8 |
| 1 | Monitor soil erosion, landslide and rock movements | occasional | | | | | | | | | | | |

10.1.1.3 Reservoir and River Water Quality

1) River water quality

Most of the potential sources of water pollution should 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
- Removal of surplus vegetation in the reservoir area prior to impoundment

Worker camps will need to be provided with potable water and adequate sanitation facilities including having waste water treatment facilities installed. In order to avoid water pollution caused by rubbish and waste, regular waste collection will be part of the camp requirements. Solid waste should be taken to a managed waste disposal facility. The location of the temporary and permanent camps and water and waste treatment facilities will be determined during the detailed design phase after discussions with the contractor and other stakeholders.

Water quality issues related to construction activities will be managed by the Contractors, under the monitoring and supervision of the Company, which will 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 due to biological oxygen demand, oxygen depletion, and release of hydrogen sulfide and methane. It is recommended that the bulk of the vegetation in the reservoir area is cut, cleared and burned. However, the Company should ensure that the burnt material should 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 the section on vegetative removal);
- 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 will be carried out to assure water quality is maintained. Samples will be taken at sites upstream (at least 2 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. Throughout and up to the end of construction, monthly samples will be taken to test the chemical and physical quality of the water. Some of the chemicals will be tested monthly, while others will be tested once every four months.(Note: Please provide a map showing the location of the water sampling stations)

Details of a recommended Water Quality Monitoring program for the Contractor is presented in Annex 1, Section SP04.

**(1) Objective**

To control the quality of discharge through water courses

**(2) Actions to Be Taken**

Water quality at selected stations will be monitored (these should be selected from among the sampling stations used to test water quality in the EIA report, so there is some continuity of findings and the EIA results can be used as a baseline):

- 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 t he EMU and/or EMO staff.
- The monthly report should present aggregate data in table and format, accompanied by narrative explanation and interpretation. A separate section should summarize the water quality situation and changes related to the project and project activities.

**(3) Responsible Unit/Agency**

- For all prevention and mitigation measures: Developer / Contractor / Sub-Contractor – except removal of commercial timber, which is responsibility of Provincial Agriculture and Forest Office
- For monitoring: EMU and EMO

**(4) Cost Estimate (USD)**

- Monthly monitoring plan: USD $10,000/year
- Seasonal monitoring plan: USD $5,300/year

Total yearly budget for Specific Water Quality Monitoring Program: USD $15,300/year or USD $76,500 for the five years of construction phase

**(5) Work Plan:**

| Work Plan | | Frequency | Pre construction | Construction Phase (year) | | | | | | Operation Phase (year) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | 1 | 2 | 3 | 4 | 5 | 6 | 1 | 2 | 3-8 | >8 |
| 1 | Monthly monitoring plan: | Monthly | | | | | | | | | | | |

| Work Plan | | Frequency | Pre construction | Construction Phase (year) | | | | | | Operation Phase (year) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | 1 | 2 | 3 | 4 | 5 | 6 | 1 | 2 | 3-8 | >8 |
| | Temperature, pH, conductivity, turbidity, suspended solid, total dissolved solid, DO, COD, $BOD_5$, total coliform and fecal coliform | (except months for seasonal sampling) | | | | | | | | | | | |
| 2 | Seasonal monitoring plan: Including the above parameters and Mn | 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 during the first years of operation. With less vegetative matter remaining in the water, there is less organic matter to decay and the water quality will be better.

**(1) Objective**

To mitigate the impact of water quality deterioration due to decaying organic matter (i.e., plants and forest matter)

**(2) Actions To Be Taken**

The provincial government will be requested to adjust its regional logging plan to give precedence to commercial logging of the reservoir area and to do so 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 NTFPs by affected villagers from the reservoir area prior to clearing and burning. Specific expenses incurred by t he government as a result of conducting these operations will be reimbursed by the developer.

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 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. Along the major tributaries, this buffer zone could be reduced to 20m along each bank to control sediment movement.

A monitoring program will be implemented that involves the District Agriculture and Forestry Office (DAFO), the village development coordination committee (VDCC), the EMU and the EMO.

Guidance on clearance operations might include:

- Removal of the maximum quantity of commercially viable timber (except in some designated buffer zones). As evacuation of logs from the reservoir area may be difficult, costly and cause negative impact 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 should 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. The developer shall be directly responsible for dissemination of all regulations and information concerned to its staff and employees as well as for any misconduct made by its staff and workers.

Details of the Vegetative Clearing activities to be carried out by the Contractor are presented in Section SP11 of Annex 1

**(3) Responsible Unit/Agency**

Project Developer will have the overall responsibility for the implementation of the Biomass Clearance Plan through the following: (i) provision of management, planning and control through EMO; (ii) engaging a Contractor with appropriate technical and management expertise to clear the proposed reservoir area; and (iii) provide training for clearance team staff in operations methods, health and safety, UXO surveys and management, physical cultural resources (PCR) Chance Find Procedures, environmental awareness, etc.

**(4) Cost Estimate (USD)**

USD $527,125 per clearing area; the budget must be prepared during preconstruction phase

**(5) Work Plan:**

| Work Plan | | Frequency | Pre construction | Construction Phase (year) | | | | | | Operation Phase (year) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | 1 | 2 | 3 | 4 | 5 | 6 | 1 | 2 | 3-8 | >8 |
| 1 | Vegetation Clearing Plans<br>- Identification of vegetation to be cleared<br>- Demarcation of reservoir perimeter and the Full | | | | | | | | | | | | |

| Work Plan | | Frequency | Pre construction | Construction Phase (year) | | | | | | Operation Phase (year) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | 1 | 2 | 3 | 4 | 5 | 6 | 1 | 2 | 3-8 | >8 |
| | Supply Level (FSL)<br>- Clearing and removal methods for soft biomass (to avoid haze), timber<br>- Procedures to avoid re-growth of vegetation<br>- Use of herbicides<br>- Retention of large trees<br>- Erosion and sediment controls<br>- Tree cutting<br>- Storage and disposal of timber products<br>- Removal of partially burnt biomass and ashes<br>- Impacts on agricultural land use<br>- Responsibility and need of UXO clearance at certain areas within the reservoir<br>- 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, and distant from forests possibly still inhabited by wildlife.

**(1) Objective**

- To monitor noise and vibrations during construction and from transportation
- To report measurements to the relevant organization(s)

### (2) Actions to Be Taken

<u>Measures for noise control plan:</u>

1) Minimize noise generation at source
    - All noise-generating construction equipment shall be operated with sound control mechanisms by using proper sound dampening devices and good maintenance
    - Provide workers with ear protection
2) Reduce transmission of noise to receivers
    - Noise sources will be sited as far as possible from villages, construction camps and settlement areas
    - Persons who are subjected to noise levels greater than 80dB(A) may request noise protection gear to limit damage to their hearing
3) Construction and Blasting hours
    - Prepare blasting procedures and blasting schedule, and inform and post in all nearby communities.
    - Activities generating harmful noise and located within 1 km of a settlement should be restricted to reasonable hours (from 6:00 to 20:00), or starting at an earlier time or ending at a later time if agreed upon with the affected residents in the nearby communities.
    - If blasting is found to exceed specified levels of noise and vibration in nearby communities, controlled blasting or alternative blasting or excavation measures shall be used in the specified areas, so noise or vibration levels are not exceeded.

<u>Measures for vibration control plan:</u>

- Assure that in no instance shall blast vibration, as measured on the ground adjacent to a residential or other occupied structure, be allowed to exceed the frequency-dependent limits specified in the Alternative Blasting Level Criteria contained in USBM Report of Investigations 8507

- Keep air blasts at offsite residential and other occupied structures as low as possible; in no instance shall air blasts, as measured at a residence or other occupied structure, be allowed to exceed the 0.013-psi (133 dB) limit recommended in USBM Report of Investigations 8485
- Monitor and record air blast(s) and vibration(s) for blasts within 1,000 feet (330 m) of worker camps and other occupied structures to verify that measured levels are within the recommended limits at those locations
- Air blast and vibration monitoring shall be made at the nearest offsite residential or other occupied structure
- Specific locations and distances where air blast(s) and vibration(s) are measured shall be documented in detail along with measured air blast and vibration amplitudes.
- Detailed noise and vibration control measures are presented in Section SP08 of Annex 1.

**(3) Responsible Unit/Agency**

- For all prevention and mitigation measures: Developer / Contractor / Sub-Contractor
- For monitoring: EMU and EMO

**(4) Cost Estimate (USD)**

The expense of implementation should be included in good management practices of construction sites.

Monitoring: USD $5,000, for instruments, materials and analysis

**(5) Work Plan:**

| Work Plan | | Frequency | Pre construction | Construction Phase (year) | | | | | | Operation Phase (year) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | 1 | 2 | 3 | 4 | 5 | 6 | 1 | 2 | 3-8 | >8 |
| 1 | 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 | | | | | | | | | | | |

| Work Plan | | Frequency | Pre construction | Construction Phase (year) | | | | | | Operation Phase (year) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | 1 | 2 | 3 | 4 | 5 | 6 | 1 | 2 | 3-8 | >8 |
| 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.

**(1) Objective**

- To monitor air quality during construction
- To report measurements to the relevant organization(s)

**(2) Actions to Be Taken**

<u>Measures for emission and dust control plan:</u>

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 if they expect to be close to sensitive receptors
- 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

Emission and Dust Control measures are presented in Section SP07 of Annex 1.

**(3) Responsible Unit/Agency**

- For all prevention and mitigation measures: Developer / Contractor / Sub-Contractor
- For monitoring: EMU and EMO

**(4) Cost Estimate (USD)**

The expense of implementation should be included in good m anagement practices of construction sites.

Monitoring: USD $10,000, for instruments, materials and analysis

**(5) Work Plan:**

| Work Plan | | Frequency | Pre construction | Construction Phase (year) | | | | | | Operation Phase (year) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | 1 | 2 | 3 | 4 | 5 | 6 | 1 | 2 | 3-8 | >8 |
| 1 | Prepare emission and dust control plan | | | | | | | | | | | | |
| 2 | Monitor emissions and dust levels | monthly | | | | | | | | | | | |

10.1.1.7 Potential for site contamination

**(1) Objective**

- To prevent site contamination
- To monitor and report measurements to the relevant organization(s)

### (2) Actions to Be Taken

The Developer, Contractor and Subcontractors will be responsible to follow best practices to avoid contamination of the sites and waters with hazardous waste, explosives, and chemicals.

1) Explosives

Explosives should 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 should 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, should be stored in these facilities, to limit the possibility of any leakage or other accidents.

Explosive boxes should be labelled with an "explosives" sign, and "explosives" posters should be clearly shown at each site storage facility. Fire fighting equipment should be kept available next to each storage facility.

The developer, 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 should 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 should be entered in log books at the storage facility and at other critical sites, to the place it is being used.

Acids, coagulants and flocculants should be stored within a separate containment area to avoid comprising the water treatment facility. A bund should 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 should be stored sufficiently separate to avoid accidental mixture.

Fuel should be stored safely, in bunded storage yards. There should 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 should 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 should be treated before being released or, if that is not possible, collected and discarded according to the hazardous waste management procedures.

The developer, 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.

The developer, 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 should 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 should 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 should 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 should 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.

The developer, 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.

Several sections of Annex 1 deal with possible site contamination. These are: SP02 on Spoil Disposal, SP03 on Quarry and Construction Layout Management, SP05 on Chemical Products and Spillage Management, SP06 on an Emergency Plan for Hazardous Materials, Section SP12 on Waste Management and Disposal, and SP16 on Construction of Work Camps.

**(3) Responsible Unit/Agency**

- For all prevention and mitigation measures: Developer / Contractor / Sub-Contractor
- For monitoring: EMU and EMO

**(4) Cost Estimate (USD)**

The expense of implementation should be included in good management practices of construction sites.

Monitoring: USD $ 10,000, for instruments, materials and analysis

**(5) Work Plan:**

| Work Plan | | Frequency | Pre construction | Construction Phase (year) | | | | | | Operation Phase (year) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | 1 | 2 | 3 | 4 | 5 | 6 | 1 | 2 | 3-8 | >8 |
| 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

***Water Levels***

**(1) Objective**

- To monitor water levels
- To inform the local people about water levels and related issues

**(2) Actions to Be Taken**

Water levels at major locations/communities, especially downstream from proposed dam site to Pakxan, should 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.

**(3) Responsible Unit/Agency**

EMU and EMO

**(4) Cost Estimate (USD)**

- Set up three (3) gauging stations: USD $30,000 per station, totaling USD $90,000
- Monitor water levels and reporting: USD $1,000 per year

**(5) Work Plan:**

| Work Plan | | Frequency | Pre construction | Construction Phase (year) | | | | | | Operation Phase (year) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | 1 | 2 | 3 | 4 | 5 | 6 | 1 | 2 | 3-8 | >8 |
| 1 | Set up three (3) gauging stations in downstream area | | | | | | | | | | | | |
| 2 | Monitor water levels | weekly (daily in emergencies) | | | | | | | | | | | |

***Flood Warning***

**(1) Objective**

- To establish early warning systems in the event of flooding
- To train local people for emergency flood situations

**(2) Actions to Be Taken**

- 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 well secured and stored during the potential flooding season. To avoid any loose construction materials getting caught in the floodwaters, several mitigation measures must taken. These should 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, the developer should accept responsibility for losses and prepare adequate compensation of such losses to the local people who are affected by the project.

**(3) Responsible Unit/Agency**

Development of Plan and Warning System: Developer, Construction Contractor, and EMO

**(4) Cost Estimate (USD)**

- Installation of flood warning system: USD $5,000 per system, totaling USD $15,000 for three stations
- Training: USD $2,000 per year

### (5) Work Plan:

| Work Plan | | Frequency | Pre construction | Construction Phase (year) | | | | | | Operation Phase (year) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | 1 | 2 | 3 | 4 | 5 | 6 | 1 | 2 | 3-8 | >8 |
| 1 | Installation of flood warning system in downstream area (three stations) | | | | | | | | | | | | |
| 2 | Reporting to communities | As needed | | | | | | | | | | | |

## 10.1.2 ENVIRONMENTAL MITIGATION MEASURES FOR BIOLOGICAL IMPACTS

### 10.1.2.1 Terrestrial Ecology and Wildlife

Aside from relocating remaining wildlife from the reservoir area, the project should also implement programs to help protect the remaining terrestrial ecology and wildlife. Measures specifically dealing with forests are dealt with in the following section. Those concerned with wildlife are presented here. Two programs should be implemented. The first is program to rescue, protect and translocate the remaining wildlife left within the reservoir area or outside the watershed area. The second is a protection program which includes raising the awareness of people in the project area about the importance and the means to conserve and protect the wildlife and their habitats.

***Wildlife Rescue Program***

#### (1) Objective

To rescue wildlife which might be affected by inundation and relocate such wildlife to a new location outside the inundation zone as an offset measures to conserve and protect the project affected biodiversity.

#### (2) Actions to Be Taken

- Rescue and relocate the wildlife
    - The Company will undertake a biodiversity study that would include:
        - Update of the vegetation and forest cover of the areas impacted by the project on the basis of the interpretation of satellite imagery and ground surveys;
        - Collection, compilation and analysis of baseline data on aquatic and terrestrial flora, and fauna and their habitats;

  - Classification of the habitats impacted by the project according to definitions of critical, natural or modified habitats;
  - Identification, assessment and recommendation of various measures to offset, enhance, protect and conserve the project affected biodiversity

- The Company will need to collect baseline data mentioned above through field surveys and satellite image study in various project impact areas such as: (i) inundation area, (ii) downstream of the reservoir up to the re-regulating dam, (iii) downstream of the re-regulating dam and (iv) construction and quarry areas. If wildlife is identified to be in the reservoir area a detailed wildlife rescue plan should be prepared for the protection of wildlife and its habitats.

- Biodiversity offsets and compensatory reforestation for the project will be identified as (i) not to conflict with existing communities' uses or access, in a manner which cannot be resolved by compendation by NNp1 and (ii) once identified will be declared by GoL as conservation areas.

- NNp1 will prepare and implement a wildlife rescue plan acceptable to GoL, if recommended in the updated biodiversity study that will include the following activities:

  Ensure that personnel are prepared and necessary equipment is available for rescuing and relocating wildlife when needed

  During vegetative clearing and impoundment of the reservoir, wildlife in the project area will be captured, removed and kept in captivity as appropriate until relocation and release can occur.

  Injured animals that have been identified in the project area will be rescued and treated.

  Strict rules against wildlife hunting and poaching will be imposed on project staff, workers, and all contractors engaged to the project, with penalties levied for anyone caught carrying or using firearms, or using animal snares or traps.

The sale of wildlife and NTFP products by local people to construction workers and staff will be banned.

**(3) Responsible Unit/Agency**

- The Company will provide the necessary financial support to GOL to implement appropriate measures, consistent with the recommendations made in the biodiversity study, with respect to biodiversity offset (translocation) and conservative initiatives.
- In particular relevant GoL authorities will identify viable and comparable host ecosystem; located wither within the Nam Ngiep watershed or outside.
- The GoL shall also take necessary actions to ensure that the recommended measures, including formalizing necessary biodiversity offset for both terrestrial and aquatic habitats, be effectively implemented in accordance with the timelines specified in the work plan. The biodiversity offsets will be put in place before the commencement of impoundment of the NN3 reservoir.
- To Implement Program: Provincial Agriculture and Forest Office (PAFO), District Agricultural and Forest Office (DAFO), Developer, and Contractor
- To Monitor the Implementation: EMU and EMO

**(4) Cost Estimate (USD)**

USD $30,000 for survey, USD $80,000 for the rescue and protection of wildlife animals, USD $10,000 for monitoring (NOTE: FOR NN3PC THE ALLOCATED BUDGET FOR THE COMPENSATORY REFORESTATION AND B IODIVERSITY CONSERVATION, OFFSETS AND PROTECTION IS US$3.6 MILLION FOR 9 YEARS – (5 YRS PRE-COD PLUS 4 YRS POST COD). FOR NNP1 THE TOTAL BUDGET ALLOCATED INCLUDING THESE SURVEY AND M ONITORING WORKS, TRAINING AND THE WATERSHED MANAGEMENT PLAN IS US$1.567 MILLION. PLEASE RE-COMPUTE TO CONSIDER ABOVE MENTIONED OFFSETTING AND CONSERVATION MEASURES).

**(5) Work Plan:**

| Work Plan | Frequency | Pre construction | Construction Phase (year) | | | | | | Operation Phase (year) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 1 | 2 | 3 | 4 | 5 | 6 | 1 | 2 | 3-8 | >8 |

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Survey all wildlife in the affected portions of the project area (construction site, reservoir area, downstream of the reservoir up to re-regulating dam, and downstream of the re-regulating dam) and in other wildlife habitats in the project area | Twice before construction | | | | | | | | | | | |
| 2 | Capture and remove the wildlife from the affected area and hold in captivity as appropriate prior to relocation/release | Upon finding the animals | | | | | | | | | | | |
| 3 | Release wildlife in a new habitat | At appropriate time | | | | | | | | | | | |

***Wildlife protection and conservation awareness***

**(1) Objective**

- To educate all construction staff and villagers on wildlife conservation, anti-poaching regulations and relevant penalties for violation of regulations
- To engage villagers in the conservation of wildlife and their habitats
- To monitor the animal diversity, density and their habitats
- To protect against logging and poaching through a village-based monitoring program

**(2) Actions to Be Taken**

- Hold meetings with all construction staff and villagers to relay pertinent information
- Use various media channels - print, radio, and television - to convey the new regulations to all persons within the project area
- Engage the village communities in monitoring and protecting wildlife and their habitats.

**(3) Responsible Unit/Agency**

- Implementation: PAFO, DAFO, EMO, Social Management Office (in work with villagers)
- Monitoring: EMU, EMO

**(4) Cost Estimate (USD)**

US$ 27,000 per year

**(5) Work Plan:**

| | Work Plan | Frequency | Pre construction | Construction Phase (year) | | | | | | Operation Phase (year) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | 1 | 2 | 3 | 4 | 5 | 6 | 1 | 2 | 3-8 | >8 |
| 1 | Training construction staff, workers and villagers | yearly | | ― | ― | ― | ― | ― | ― | ― | ― | ― | |
| 2 | Media distribution | As appropriate | | - - | - - | - - | - - | - - | - - | - - | - - | - - | |
| 3 | Monitor logging and poaching | Monthly | | ― | ― | ― | ― | ― | ― | ― | ― | ― | ― |
| 4 | Monitor animal habitat | Yearly | ― | ― | ― | ― | ― | ― | ― | ― | ― | ― | ― |
| 5 | Monitor animal diversity and density | Yearly | ― | ― | ― | ― | ― | ― | ― | ― | ― | ― | ― |

10.1.2.2 Forest and vegetative cover

Conserving forest and vegetative cover, replacing forest area lost to the inundation of the reservoir, and rehabilitation of deteriorated forest areas are all part of the watershed management plan. These activities will be carried out with the active support of the villages in the watershed area.

**(1) Objective**

- Reduce forest encroachment;
    - Headwater forest area is preserved; limit de forestation, maintain forest density and biodiversity
    - Proper zoning of land use, forest use, resources use
- Maintain water supply for community use – household consumption & agriculture
- Minimize soil erosion

**(2) Actions to Be Taken**

- Reduce forest encroachment
    - o Preserve headwater forest area; limit deforestation, maintain forest density and biodiversity

    - Encourage and support GOL authorities to define zoning in the Nam Ngiep watershed - development zone, buffer zone, conservation zone & other zones.
    - Set up targets for resources management in the head water forest area i.e. area of the forest to be preserved, forest density, and biodiversity. These targeted resources management areas for conservation and offset measures should be identified, confirmed and implemented together with GOL relevant agencies, with NNp1's financial support.
    - Encourage and support GOL to establish rules for forest use of the head water area
    - Promote education and information campaign on awareness of headwater forest preservation including the flora and fauna habitats
    - Support participation of villagers and local authorities on forest preservation and management of headwater area.
    - Assess forest density and biodiversity, and put up plan to preserve and manage the watershed through proper financial support.
  - Setup proper zoning of land use, forest use, resource use
    - In close coordination with the concerned GOL offices clear definition of forest types, forest boundary, forest uses – forest reserved for village use, pasture (livestock) zone, including rules and regulations upon using of those resources – forest services, water, fisheries will be covered. The information should be available and easy to understand by local villagers
    - Promote education and awareness of forest zoning, forest use and resource use
    - In close coordination with the concerned GOL offices set up strategy to reduce slash & burn agriculture, reduce forest encroachment – promote law enforcement, decreasing demand on farmland, and reducing household poverty

    - Decreasing demand on farmland – family planning targets decreasing population; encourage GOL on land allocation and land titling; and reducing household poverty
    - Household poverty reduction – increase income from farm and non-farm activities by increasing agricultural productivity and increase access to formal market
  - Incorporate village administration structure to the forest and land use plan.
  - Plant replacement forests of equivalent area to that lost by the construction of the dams and the filling of the reservoirs.
- Maintain water supply for community use – for household consumption & agriculture purposes;
  - Headwater forest preservation and management
  - Encourage communities to set up water management plan of each village
  - Match up agricultural practices with water supply patterns
- Reduce soil erosion, protect topsoil cover, and maintain good soil structure
  - Build awareness of good agricultural practice and promote technical transfer – using crop & residue cover, crop rotations, tillage practice, contour plowing and strip cropping
  - Enhance agricultural production via soil improvement using organic treatment
  - Maintain riparian buffering function

**(3) Responsible Unit/Agency**

- Implementation: PAFO, DAFO, EMO, SMO
- Monitoring: EMU, EMO

**(4) Cost Estimate (USD)**

USD $1,420,000 for total watershed

**(5) Work Plan:**

| | Work Plan | Frequency | Pre construction | Construction Phase (year) | | | | | | Operation Phase (year) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | 1 | 2 | 3 | 4 | 5 | 6 | 1 | 2 | 3-8 | >8 |
| 1 | Detailed study and finalizing the WMP | | | | | | | | | | | | |
| 2 | Forest encroachment reduction program<br>• Village Consultations<br>• Headwater forest area; limit deforestation, maintain forest density and biodiversity preservation: village forest management program<br>• Zoning of land use, forest use, resource use: village land use planning and allocation program<br>• Incorporation of village administration structure to the forest and land use plan | | | | | | | | | | | | |
| 3 | Maintain water supply for community use – household consumption & agriculture program | | | | | | | | | | | | |
| 4 | Reduce soil erosion, protect topsoil cover, and maintain good soil structure program | | | | | | | | | | | | |
| 5 | Small-scale fisheries for food security | | | | | | | | | | | | |

### 10.1.2.3 Aquatic biota

Changes in water flow and temperature, and the blocking of the river by the Nam Ngiep 1 Hydropower Project may affect aquatic biota. Given that fish is the main source of protein and a part of nearly every meal for the people in the villages along the river, it is essential that the supply of fish be maintained in the river and its tributaries and supplemented by fishponds.

Two activities will be undertaken to help maintain adequate supplies of fish stock: regular monitoring of the aquatic biota, and a program create fishponds and to improve fish stock in the river and its tributaries.

***Aquatic Biota Monitoring Program***

**(1) Objective**

To monitor aquatic biota

### (2) Actions to Be Taken

Aquatic biota, plankton, benthic invertebrates, aquatic weeds and all applicable fish species should be monitored yearly starting from the first year and continuing until the end of the construction phase. Beginning from the start of the operation phase and continuing through the eighth year of operation, monitoring should be continue to be conducted yearly, or more often if the aquatic population appears under threat. After that, the monitoring should be conducted once every three years.

### (3) Responsible Unit/Agency

EMU and EMO

### (4) Cost Estimate (USD)

USD $3,000 per test site, total 5 test sites (one upstream from reservoir, one in reservoir, one immediately downstream from re-regulation dam, one about 10 km downstream from the re-regulation dam, one about 20 km downstream from the regulation dam): USD $15,000 per test, for 16 tests: USD $ 240,000 total

### (5) Work Plan:

| Work Plan | | Frequency | Pre construction | Construction Phase (year) | | | | | | Operation Phase (year) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | 1 | 2 | 3 | 4 | 5 | 6 | 1 | 2 | 3-8 | >8 |
| 1 | Monitor aquatic biota – construction period | Yearly | | | | | | | | | | | |
| 2 | Monitor aquatic biota – first 8 years of operation period | Yearly | | | | | | | | | | | |
| 3 | Monitor aquatic biota – after the $8^{th}$ year of operations | Every 3 years | | | | | | | | | | | |

***Fish stock improvement and fishpond development program***

**(1) Objectives**

- To enhance the supply of fish for household consumption and assure food security.
- To develop fishponds to supplement riverine catch and to assure continuous supply of fish in case of depletion of river aquatic biota.
- To develop small-scale fisheries for local sale to contribute to poverty alleviation and food security.

**(2) Actions to Be Taken**

- Maintain percentage of fish stocks within their level of maximum biological productivity
- Set up monitoring system to
  - Classify the state of the fish stock of various species over time.
  - Assess the time and labor used by villagers in fishing activities
- Develop fishponds for communities throughout the project area, to assure regular supply of fish

**(3) Responsible Unit/Agency**

- Implementation: DAFE and EMO
- Monitoring: EMU and EMO

**(4) Cost Estimate (USD)**

USD $210,000 total

**(5) Work Plan:**

| Work Plan | | Frequency | Pre construction | Construction Phase (year) | | | | | | Operation Phase (year) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | 1 | 2 | 3 | 4 | 5 | 6 | 1 | 2 | 3 | >3 |
| 1 | Provide new fish stock | As needed | | | | | | | | | | | |
| 2 | Prepare and stock fishponds | As needed | | | | | | | | | | | |

### 10.1.3 UNEXPLODED ORDINANCES

**(1) Objective**

To facilitate service for and management of UXO survey and clearance

**(2) Actions To Be Taken & Methodology**

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 should be conducted to ensure the safety of all concerned parties. Such measures may include:

- 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 accompany the field clearing teams to sweep, identify, and dispose of UXO. Workers will receive health and safety training, including a training component on UXO recognition and management.

**(3) Responsible Unit/Agency**

Developer and EMO

**(4) Cost Estimate (USD)**

USD $600,000 per clearing area; the budget must be prepared before preconstruction phase

### (5) Work Plan:

| Work Plan | | Frequency | Pre construction | Construction Phase (year) | | | | | | Operation Phase (year) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | 1 | 2 | 3 | 4 | 5 | 6 | 1 | 2 | 3-8 | >8 |
| 1 | Survey and clear UXO in construction site | | — | | | | | | | | | | |
| 2 | Survey and clear UXO in resettlement site | | — | — | | | | | | | | | |
| 3 | Survey and clear UXO in reservoir area | | | — | — | | | | | | | | |

10.1.3.1 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 should 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 the Developer 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 the Developer that work can commence within that area. Should the experts determine that further protection of the site is required, the ESD will inform the Developer and the site be protected as needed. Details of measures to be taken to protect cultural properties are presented in SP09 of Annex 1.

#### 10.1.3.2 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 should 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 should have negligible adverse impact on humans, they should be effective against target species, they should have minimal effect on non-target species and the natural environment, and they should be safe for the personnel who apply them.

Measures recommended for the construction of work camps are presented in SP16 of Annex 1. Detailed recommendations for worker health and occupational safety are presented in SP17 of Annex 1.

## 10.2 ENVIRONMENTAL MITIGATION MEASURES DURING OPERATIONS PHASE

### 10.2.1 ENVIRONMENTAL MITIGATION MEASURES FOR PHYSICAL IMPACTS

#### 10.2.1.1 Seismicity

**(1) Objective**

- To prevent landslides
- To avoid reservoir induced seismic activity

**(2) Actions to Be Taken**

- The slope and geology around the reservoir are not conducive to landslides. Given the size of the reservoir and the height of the water at the dam, reservoir induced seismic activity is not expected.
- During the first years of storage of the reservoir and operation, routine visual inspections should be made to evaluate the safety of the dam. Routine visual inspections should also be made of the slopes around the construction area and the reservoir for signs of any landslides.

**(3) Responsible Unit/Agency**

Developer and EMO

**(4) Cost Estimate (USD)**

No additional costs expected

**(5) Work Plan:**

Occasional during first 8 years of operation

| | Work Plan | Frequency | Pre construction | Construction Phase (year) | | | | | | Operation Phase (year) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | 1 | 2 | 3 | 4 | 5 | 6 | 1 | 2 | 3-8 | >8 |
| 1 | Monitoring for landslide and other signs of seismic activity | occasional | | | | | | | | | | | |

10.2.1.2 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 even of any unexpected impacts.

**(1) Objective**

- 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 c hanges in water quality and hydrology

**(2) Actions To Be Taken & Methodology**

- Conduct soil survey and collect soil samples on a gricultural lands in the downstream areas
- Implement a soil improvement program in the resettlement area.
- Conduct soil survey and collect soil samples on a gricultural lands in resettlement sites once the size of resettlement area has been established

**(3) Responsible Unit/Agency**

- For improving the soils in the resettlement areas: Resettlement Management Unit and Social Management Office

- For monitoring soil fertility: EMU and SMO

**(4) Cost Estimate (USD)**

- For the soil improvement program: this is part of the Resettlement and Ethnic Minority Plan
- For the monitoring: USD $10,000 every 2 years, until operation phase year 8

**(5) Work Plan:**

| Work Plan | | Frequency | Pre construction | Construction Phase (year) | | | | | | Operation Phase (year) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | 1 | 2 | 3 | 4 | 5 | 6 | 1 | 2 | 3-8 | >8 |
| 1 | Soil improvement in resettlement sites | | | | | | | | | | | | |
| 2 | Conduct soil surveys at resettlement sites | Every 2 years | | | | | | | | | | | |
| 3 | Conduct soil surveys downstream | Every 2 years | | | | | | | | | | | |

10.2.1.3 Erosion and Sedimentation

**(1) Objective**

- To prevent sedimentation in the river upstream from the dam by erosion caused by the clearing of large areas of forest by logging and for agriculture and the expansion of farmland into steeper slopes.
- To prevent sedimentation in the reservoir from cleared lands on slopes around the reservoir.

**(2) Actions to Be Taken**

These will be part of the watershed management program:

- 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.

A vegetative buffer will be maintained around the reservoir by the project, to prevent erosion and sedimentation from the surrounding slopes into the reservoir.

The EMU and EMO will conduct occasional monitoring of the land use in the watershed, to determine areas of greater risk of erosion and sedimentation. These organizations will also conduct occasional monitoring of the slopes and vegetative buffer around the reservoir, to assure they are not eroding.

**(3) Responsible Unit/Agency**

- For the watershed management program: PAFO and DAFO, and the Environmental and Social Division
- For monitoring: Environmental Management Unit (EMU) and EMO

**(4) Cost Estimate (USD)**

- Implementation: to be included as part of the Watershed Management Plan
- Monitoring: $5,000 per year

**(5) Work Plan:**

For monitoring:

| Work Plan | | Frequency | Pre construction | Construction Phase (year) | | | | | | Operation Phase (year) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | 1 | 2 | 3 | 4 | 5 | 6 | 1 | 2 | 3-8 | >8 |
| 1 | Monitor soil erosion, landslide and rock movements | occasional | | | | | | | | | | | |

10.2.1.4 Reservoir and River Water Quality

**(1) Objective**

- To conduct intensive monitoring of water quality at selected sites upstream from the reservoir, in the reservoir, and downstream from the dams, until the water quality stabilizes
- To conduct regular monitoring of water quality at selected sites upstream from the reservoir, in the reservoir, and downstream from the dams

**(2) Actions to Be Taken**

(2.1) Intensive Water Quality Monitoring Program (short- to medium-term)

The Intensive Water Quality Monitoring Program will last for at least eight years, or until the water quality has become balanced and stabilized (based upon monitoring of water quality by the EMU and EMO). There will be frequent tests of several key parameters, and occasional tests of a broader range of parameters:

- Biweekly tests – to observe temperature, pH, conductivity, turbidity, SS, DO, COD, $BOD_5$, total coliform and fecal coliform
- Three times a year – to observe physical 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
- 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.

(2.2) Routine Water Quality Monitoring Program (long-term)

- Seasonal Monitoring Plan: After the eighth year of operation, or if the EMU and EMO have determined before then that the water quality has become stabilized and balanced under the new hydrological conditions, the routine water quality monitoring program will be implemented in place of the more intensive program. The monitoring parameters include physical and chemical water quality (temperature, pH, conductivity, turbidity, suspended solid, total dissolved solid), biological water quality (DO, COD, $BOD_5$, P, $PO_4^{3-}$, N, $NO_3^-$, $NH_3$), bacteriological water quality (total coliform and fecal coliform), and Mn; and will be conducted every four months (three times a year.

**(3) Responsible Unit/Agency**

EMU and EMO

**(4) Cost Estimate (USD)**

(4.1) Intensive Water Quality Monitoring Program (short- to medium-term, potentially for the first 8 years of operation)

- Biweekly Monitoring Plan: USD $19,700 /year

- Seasonal Monitoring Plan: USD $5,300 /year

Total annual budget for the comprehensive Intensive Water Quality Monitoring Program: USD $25,000 /year (or USD $200,000 for the first eight years of operation phase)

(4.2) Routine Water Quality Monitoring Program (after the 8th year of operation, or whenever water quality has become stabilized and balanced under the new hydrological conditions)

- Seasonal Monitoring Plan: USD $5,300 /year

**(5) Work Plan:**

| Work Plan | | Frequency | Pre construction | Construction Phase (year) | | | | | | Operation Phase (year) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | 1 | 2 | 3 | 4 | 5 | 6 | 1 | 2 | 3-8 | >8 |
| *Intensive Water Quality Monitoring Program (short- to medium-term)* | | | | | | | | | | | | | |
| 1 | Biweekly Monitoring Plan:<br>Temperature, pH, conductivity, turbidity, SS, DO, COD, $BOD_5$, total coliform and fecal coliform | Biweekly (Every two weeks except the week with seasonal sampling) | | | | | | | | — | — | — | |
| 2 | Seasonal Monitoring Plan:<br>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 (three times a year) | | | | | | | | — | — | — | |
| *Routine Water Quality Monitoring Program (long-term)* | | | | | | | | | | | | | |
| 1 | Seasonal Monitoring Plan:<br>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 (three times a year) | | | | | | | | | | | — |

***Groundwater Quality Monitoring***

Although there is not expected to be any major impact on the quality of groundwater downstream from the dam, occasional monitoring of the quality of groundwater will be conducted, to determine if there is any change in groundwater tables and quality due to seepage.

**(1) Objective**

To monitor the quality and other characteristics of the groundwater in areas downstream from the dam

**(2) Actions To Be Taken & Methodology**

- Conduct occasional tests of groundwater quality and levels.
- Respond to any reports by villagers of changes in groundwater quality and levels

**(3) Responsible Unit/Agency**

EMU and EMO

**(4) Cost Estimate (USD)**

USD $5,000 per test, once every 3 years (year 1, 4 and 7)

**(5) Work Plan:**

| Work Plan | | Frequency | Pre construction | Construction Phase (year) | | | | | | Operation Phase (year) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | 1 | 2 | 3 | 4 | 5 | 6 | 1 | 2 | 3-8 | >8 |
| 1 | Impact assessment of ground water hydrology and quality | Once every 3 years until stabilization | | | | | | | | | | | |

10.2.1.5 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.

Monitoring of the use of these materials will be part of the operations procedure for the project.

10.2.1.6 Hydrology

***Water Level Monitoring***

**(1) Objective**

- To monitor water levels
- To inform the local people about water levels and related issues

**(2) Actions To Be Taken & Methodology**

- 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 to as near the natural level as possible to avoid negative impacts to the local residents and to the environment.

**(3) Responsible Unit/Agency**

EMU and EMO

**(4) Cost Estimate (USD)**

Costs indicated in Construction Phase

**(5) Work Plan:**

| Work Plan | | Frequency | Pre construction | Construction Phase (year) | | | | | | Operation Phase (year) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | 1 | 2 | 3 | 4 | 5 | 6 | 1 | 2 | 3-8 | >8 |
| 1 | Set up three (3) gauging stations in downstream area | | | | | | | | | | | | |
| 2 | Monitor water levels | weekly (in extreme case, daily) | | | | | | | | | | | |
| 3 | Prepare report to publication | Yearly | | | | | | | | | | | |

***Flood warning plan***

**(1) Objective**

- To establish early warning systems in the event of flooding
- To train local people for emergency flood situations

**(2) Actions To Be Taken & Methodology**

- 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.
- 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, the developer has to compensate the local people for the losses.

**(3) Responsible Unit/Agency**

Developer, Operator, EMU and EMO

**(4) Cost Estimate (USD)**

Costs indicated in Construction Phase

**(5) Work Plan:**

| Work Plan | | Frequency | Pre construction | Construction Phase (year) | | | | | | Operation Phase (year) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | 1 | 2 | 3 | 4 | 5 | 6 | 1 | 2 | 3-8 | >8 |
| 1 | Installation of flood warning system in downstream area (three stations) | | | | | | | | | | | | |
| 2 | Training and follow up | yearly | | | | | | | | | | | |

10.2.2 ENVIRONMENTAL MITIGATION MEASURES FOR BIOLOGICAL IMPACTS

10.2.2.1 Terrestrial Ecology and Wildlife

The Wildlife Protection and Conservation Awareness program will be continued through the first years of operations.

10.2.2.2 Forest and Vegetative Cover

The clearing and inundation of the reservoir will entail the loss of 125 ha of dry evergreen forest and 3,089 ha of mixed deciduous forest.

Article 70 of the Amended Forestry Law (No. 06/NA-2007) requires compensatory regeneration and planting of forests lost to development projects. The PAFO and DAFO will have the responsibility to implement the program as part of the watershed management program and the resettlement scheme.

The areas for compensatory regeneration will partly constitute the planting of woodlots for the resettlement villages and replacement of areas of degraded forest (unstocked forest). In some areas modifications to the swidden techniques of the villagers may be introduced, to have mixed forest and cultivation in a managed regeneration of the cultivated areas.

#### 10.2.2.3 Aquatic Biota

The Aquatic Biota Monitoring Program and the Fish Stock Improvement and Fishpond Development Program will continue from the construction phase.

## 10.3 CUMULATIVE AND TRANS-BOUNDARY IMPACTS

Given that there will also be the Nam Ngiep 2 Hydropower Project and likely other projects within the Nam Ngiep River watershed that can have impacts on the environment of the watershed, the NNHP-1 Project should 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.

# CHAPTER 11

# ENVIRONMENTAL MONITORING PROGRAM

## 11.1 TYPES OF MONITORING

Environmental monitoring will be carried out at three levels.

1) Daily or regular monitoring of activities and conditions in construction and operation by the Contractor and/or Subcontractors.
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 Developer's Environmental and Social Department.
3) Occasional monitoring of impacts and of compliance by a third party external monitor.

### 11.1.1 DAILY AND OTHER REGULAR MONITORING BY CONTRACTOR AND SUBCONTRACTORS

For all preconstruction activities and during construction and operations, the Developer, Contractor, and Subcontractors will monitor their activities on a regular basis. For all their work, the Developer, Contractor, and Subcontractors are to monitor for potential adverse impacts, including but not limited to those that have been identified by the EIA of this project, and they are to comply fully with all standards and safeguards.

An Environmental Management and Monitoring Plan will be prepared for the Construction Phase (EMMP-C) prior to the commencement of construction activities. There will also be Site Specific Environmental Management and Monitoring Plans (SSEMMP) for each of the main construction sites and for other distinct activities that may have an environmental impact. These plans will be part of the contractual obligations for the Contractor and all Subcontractors.

Another Environmental Management and Monitoring Plan will be prepared for the Operations Phase (EMMP-O) prior to commissioning of the hydropower project.

Both the EMMPs and the SSEMMPs will provide details the various actions and measures intended to prevent adverse environmental impacts or, if they cannot be prevented, to mitigate the adverse impacts. The EMMPs and SSEMMPs 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. I ndicative examples of environmental monitoring activities are presented in Section 5.2 be low, based upon t he example of environmental management sub-plans in Annex A.

### 11.1.2 PERIODIC AND REGULAR MONITORING BY GOL AND DEVELOPER

To assure the Developer, Contractor, and Sub-Contractors 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). The Developer 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 Chapter 7 of this report.

The EMU will serve several functions on be half 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 t he Developer, Contractor, and Subcontractors; advising MONRE on e nvironmental matters of the project; and serving as liaison between the GOL and the Lao people 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 will serve as the main arm of the Developer in assuring the project follows the measures to prevent or mitigate adverse environmental impacts. It is responsible for ensuring compliance with all the environmental standards and safeguards. This will involve preparing the environmental monitoring plans for the contractor 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 Information System 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, sub-plans and site plans
- All site plans as approved by the developer
- 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
- Disciplinary procedures

### 11.1.3 EXTERNAL MONITOR

An external monitor will be engaged by the GOL, funded by the Developer, to conduct annual reviews of the effectiveness of the environmental measures carried out by the project. The external monitor should have international experience in environmental auditing and monitoring.

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 and water quality have stabilized.

## 11.2 SPECIFIC MONITORING ACTIVITIES AND CRITERIA

The monitoring activities described below are indicative. The final set of monitoring criteria and responsibilities will be prepared after consultations with GOL and preparations of the EMMP-C and EMMP-O and of the SSEMMPs.

| Category & Topic | Monitoring Action | Frequency of Monitoring | Monitoring Criteria |
|---|---|---|---|
| **WATER QUALITY MANAGEMENT & POLLUTION CONTROL** | | | |
| Drinking water | 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, full analysis once a month | Color, odor, free chlorine |
| | 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, FC |
| Effluents | Routine sampling of treated effluents by operating Company | Weekly monitoring of treated effluents | Temperature, pH, Suspended Solids (SS), DO, Fecal Coliforms |
| | Visual Inspection | Weekly inspection | 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 | Monthly | Discharge, temperature, pH, Suspended Solids (SS), Fecal Coliforms , DO |
| | Registration of sludge movements | When required | Date & volumes of movements from station to disposal area and from septic tanks to station |
| | Review of sludge movements registration | Once a month | Date & volumes of movements;<br>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 | Twice a month | General cleanliness of camp; Collection and drainage of all water from sanitary facilities and canteens; Stormwater drainage |
| | Review of septic tank emptying operation register | Once a month | Date of maintenance and facility concerned |

| Category & Topic | 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;<br>Indication of defecation around the camp |
| | Review of maintenance register | Once a month | 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 | Monthly | pH, SS, Temperature |
| Maintenance areas (workshops , garages) | Visual inspection implementation of pollution control measures | Daily/weekly | Refueling area and practice;<br>**Bunded** storage for HM as waste engine oil, grease, hydraulic oil;<br>Stormwater design (hydro-carbon separation pit) |
| | Ensure presence and maintenance of spill response equipment kit according to products stored | Weekly | Presence of equipment according to standard; Procedures posted in the premises; Emergency response team identified and trained |
| | Registration of used waste generated | Daily registration by garages and workshops as concerned | Date and volumes |
| **HYDROLOGY** | | | |
| Spoil Disposal and Drainage | Ensure spoil disposal areas located and designed in accordance with hydrological requirements | As required when delineating disposal site | 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;<br>Design documentation |
| | Ensure implementation of sediment transport reduction measures | Weekly | Visual observation |
| | Monitor stormwater drainage from concerned areas | Twice a month | Suspended solids (SS) |

| Category & Topic | Monitoring Action | Frequency of Monitoring | Monitoring Criteria |
|---|---|---|---|
| Top soil protection | Ensure top soil properly managed and preserved for eventual use in restoration | Weekly during large excavation works; as requested thereafter | Visual observation;<br>Design documentation |
| | Monitor application of design standards for erosion control and topsoil protection | Twice a month | Visual observation |
| **BIODIVERSITY CONSERVATION** | | | |
| Clearing | Ensure demarcation and tree marking for clearing and respect of clearing limits | Daily observation during clearing by Forestry Department | No. of trees |
| | Ensure log evacuation completed before work starts | Weekly | Visual observation |
| | Monitor clearing operations by Company to ensure no trees felled | As required | According to project design and clearances given |
| Revegeta-tion/Compensatory Reforestation Program | Ensure revegetation done with native species<br>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<br>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 | 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 |
| **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 | Seasoning | Absence of pollution indicators |

| Category & Topic | Monitoring Action | Frequency of Monitoring | Monitoring Criteria |
|---|---|---|---|
| | water and stormwater | | |
| | 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 | Containers, labels, collection register, drainage water control, etc. |
| | Ensure appropriate HW registration and disposal of waste in accordance with obligations | Weekly | Registration, design of storage area (bunded and fenced area), container quality, labeling, spill response kits, safety procedures posted, workers in charge trained and PPE available |
| | Inspection of temporary and main HW disposal sites | Twice a month to monthly | Same criteria as directly above |
| Hazardous Chemicals | Ensure appropriate hazardous material registration, storage and handling in accordance with safety regulation | Weekly | Registration, design of storage area (bunded and fenced area), containers quality, labeling, spill response kits, safety procedures posted, workers in charge trained and PPE available |
| | Inspection of hazardous material management | Monthly | Same criteria as directly above |
| | Eventual safe disposal of hazardous wastes and chemicals | As required | According to national specifications and safeguards. |
| **CULTURAL PROPERTIES** | | | |
| | Ensure no cultural site, when notified prior to works, is disturbed without community agreement | As needed | Documentation review and site visit |
| | Ensure procedure implemented if heritage artifacts discovered | As justified | Notification to Owner;<br>Effective application of decisions on site;<br>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;<br>Subsequent conservation measures implemented |
| **ACCESS TO SITE AND ROAD SAFETY** | | | |
| Road safety | Ensure implementation of road signs and speed reduction bumps | Daily observations | 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' | Non-conformity observed on the road;<br>Register of truck/car maintenance for sub-contractors |

| Category & Topic | Monitoring Action | Frequency of Monitoring | Monitoring Criteria |
|---|---|---|---|
| | | service maintenance | |
| | Ensure truck load not overweight, stabilized and covered if bulk | Daily observation | Non-conformity observed on the road, registered with plate number an d driver's name |
| | Monitoring of traffic safety | Daily observation, random control point once a month | Direct observation, systematic control regarding truck condition and load, and identified use of alcohol or drugs by drivers |
| | Ensure watering of roads is provided in residential areas and in dangerous/dusty road sections to limit dust emission | Daily observation in dry season | Visual observation;<br>Number of watering /day;<br>Number of watering trucks |
| 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 | 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;<br>Posters printed and posted;<br>Leaflet printed and distributed;<br>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 | 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 staffed | Monthly | Staff and equipment available per facility;<br>Number of consultations registered |
| | Monitor efficiency and cleanliness of medical facilities | Monthly | Visual observation;<br>Inspection of medical supplies and sterile procedures |
| Vector control | Ensure measures implemented in worker camps and in construction sites | Weekly | Camps' inspection for hygiene; Awareness posters posted in camps and on working places; Medicine for treatment available to staff; Prevalence statistics |
| | Monitor enforcement of control and effects | Monthly | Visual observation from camps inspection;<br>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 | Number of cases and events; Implementation of sanitation and waste management practices; Observation of good personal hygiene practices |
| | Monitor enforcement of | Quarterly | Visual observation from camps and canteens |

| Category & Topic | Monitoring Action | Frequency of Monitoring | Monitoring Criteria |
|---|---|---|---|
| | control and effects | | inspection;<br>Review of medical register |

| Category & Topic | Monitoring Action | Frequency of Monitoring | Monitoring Criteria |
|---|---|---|---|
| **OCCUPATIONAL HEALTH AND SAFETY** | | | |
| First Aid Training and Field Implement-ation | Ensure Foremen and key personnel of "at risk" activities received first aid training | Monthly | Registration of personnel attending training and subsequent job affectation;<br>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. |
| | 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 |
| Compensa-tion | 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 |

| Category & Topic | Monitoring Action | Frequency of Monitoring | Monitoring Criteria |
|---|---|---|---|
| | | | 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 |

| Category & Topic | 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;<br>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;<br>Ensure no washing and bathing directly in water courses or discharge of wastewater directly to streams, etc.;<br>Visual inspection |
| Personal Safety Equipment | Ensure all workers adequately equipped with PPE | Daily | Visual inspection to determine use of proper footwear, hard hats, goggles/masks, gloves etc., where required.<br>Refer to Annex A, Section SP17. |

# CHAPTER 12

# NAM NGIEP WATERSHED MANAGEMENT PLAN

## 12.1 INTRODUCTION

Planning efforts for Nam Ngiep River watershed management should be initiated by the GOL, with appropriate technical and financial support from the Environmental and Social Division (ESD) of the NNHP-1 Project, and from other hydropower projects (such as the Nam Ngiep 2 Hydropower Project) that use any of the waterways within the watershed, as well as from other development projects within the watershed that depend on sustainable use of natural resources. Local residents together with Provincial and District GOL authorities should implement the plan.

Mitigation measures for environmental impacts within the project area (in the vicinity of communities that are directly or indirectly affected by the project) are addressed in the environmental management plan (EMP). However, some potential environmental issues need to be addressed at a much broader scale, at the level of the watershed, and these will be covered in the watershed management plan (WMP). The goal of the WMP is to ensure sustainable use of natural resources in the Nam Ngiep River Basin by means of co-ordination and information exchange of natural resources management activities among relevant stakeholders. Major approaches of the WSM will be on preservation of headwater forests and sustainable management and uses of ecological resources.

In Lao PDR, the Ministry of Agriculture and Forestry is applying integrated watershed management as a key strategy. This approach was endorsed by the 2002 National Agriculture and Forestry Conference. Based on this objective, there should be a watershed management framework (WMF) established by the government. Additionally, the Ministry of Agriculture and Forestry is to collaborate with provinces and districts to develop integrated watershed management plans[1]. However, as of the time of this report, a watershed management framework for the Nam Ngiep watershed has not yet been prepared.

The strategy for the watershed management of the Nam Ngiep should be in line with the government's objective for the year 2020, which aims to shift the country from a subsistence economy to a market economy through the sustainable use of natural resources.

# 12.2 EXISTING ENVIRONMENT AND SOCIAL CONDITIONS

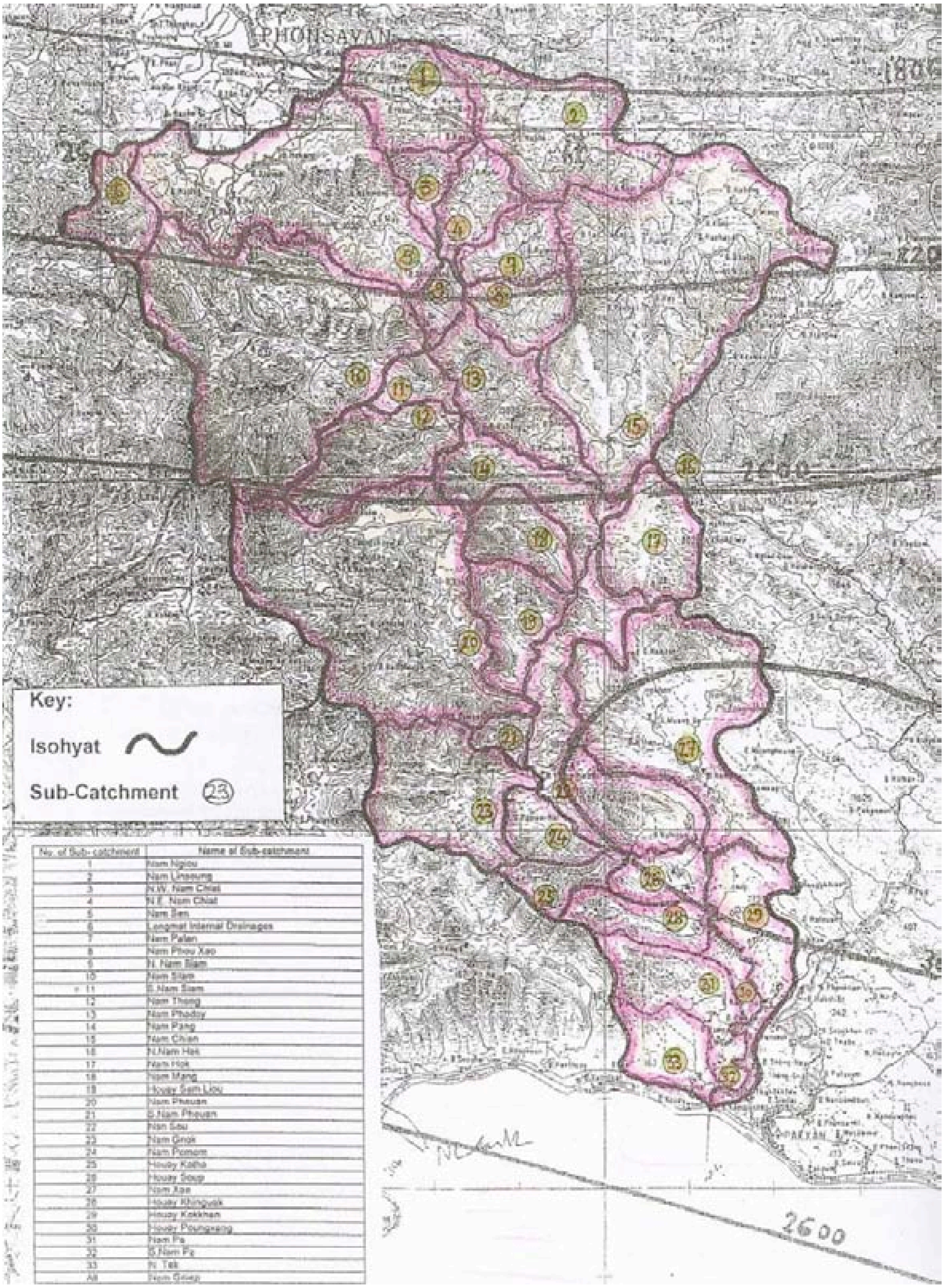
## 12.2.1 ENVIRONMENT CONDITIONS

The Nam Ngiep Watershed Area consists of 33 tributaries and sub-basins, as shown in Figure 12-1, with the area of the sub-basins and flow contributions presented in Table 12-1. Although the Department of Water Resources has recently reduced the number of the sub-basins in the Nam Ngiep watershed to 15, but details of this new demarcation of sub-basins have not yet been released so the original 33 are presented.

The total area of the basin is approximately 4,533 $km^2$ of which 3,725 $km^2$ is in the catchment area.[2] Most of the sub-basins are rather small. The three largest tributaries – Nam Siem (10), Nam Chian (15), and Nam Phouan (20) – account for a third of the total flow, with the next 6 in size accounting for another 30 percent of total flow.

[1]Pravongviengkham, P.; Khamhung, A.; Sysanhouth, K.; Qwist-Hoffmann, P.; Achouri, M. *(ed.)*; Tennyson, L. *(ed.)*; Upadhyay, K. *(ed.)*; White, R. *(ed.) (2003)* "Integrated watershed management for sustainable upland development and poverty alleviation in Lao People's Democratic Republic" *in* Preparing for the next generation of watershed management programmes and projects. Asia. Proceedings of the Asian Regional Workshop, Kathmandu, Nepal 11-13 September 2003.

[2]There are slight variations in the area calculated for the watershed, because of different measurements obtained from satellite images and the difficulty of accurately determining surface area with the steep slopes of most of the watershed. Calculation of land use types presented below, for example, totals about 4,495 $km^2$, a 1% difference.




| No. of Sub-catchment | Name of Sub-catchment |
|---|---|
| 1 | Nam Ngiou |
| 2 | Nam Linaoung |
| 3 | N.W. Nam Chiat |
| 4 | N.E. Nam Chiat |
| 5 | Nam Sen |
| 6 | Longmat Internal Drainages |
| 7 | Nam Palan |
| 8 | Nam Phou Xao |
| 9 | N. Nam Siam |
| 10 | Nam Siam |
| 11 | S.Nam Siam |
| 12 | Nam Thong |
| 13 | Nam Phoday |
| 14 | Nam Pang |
| 15 | Nam Chian |
| 16 | N.Nam Hek |
| 17 | Nam Hok |
| 18 | Nam Mang |
| 19 | Houay Sam Liou |
| 20 | Nam Phouan |
| 21 | S.Nam Phouan |
| 22 | Nan Sau |
| 23 | Nam Gnok |
| 24 | Nam Pomom |
| 25 | Houay Katha |
| 26 | Houay Soup |
| 27 | Nam Xae |
| 28 | Houay Khinguak |
| 29 | Houay Kokkhan |
| 30 | Houay Poungxang |
| 31 | Nam Pa |
| 32 | S.Nam Pa |
| 33 | N. Tek |
| All | Nam Gniep |

Figure 12-1 The 33 sub-basins of the Nam Ngiep watershed.

Table 12-1 Sub-basins of Nam Ngiep River: Area and Contributions to Flow

| No | Name of sub-basin | Area | | Flow Contribution ($m^3$/s) | Annual Volume (mcm) |
|---|---|---|---|---|---|
| | | $Km^2$ | % | | |
| 1 | Nam Ngiou | 134 | 2.9 | 5.4 | 168.9 |
| 2 | Nam Linsoung | 196 | 4.3 | 7.9 | 247.6 |
| 3 | N.W. Nam Chiat | 29 | 0.6 | 1.2 | 36.8 |
| 4 | N.E. Nam Chiat | 92 | 2.0 | 3.7 | 116.8 |
| 5 | Nam Sen | 256 | 5.6 | 10.3 | 323.8 |
| 6 | Longmat Internal Drainages | 63 | 1.4 | 2.5 | 80.0 |
| 7 | Nam Palan | 66 | 1.5 | 2.7 | 83.8 |
| 8 | Nam PhouXao | 66 | 1.5 | 2.7 | 83.8 |
| 9 | N. Nam Siem | 34 | 0.8 | 1.4 | 43.2 |
| 10 | Nam Siem | 528 | 11.6 | 21.2 | 667.9 |
| 11 | S. Nam Siem | 34 | 0.8 | 1.4 | 43.2 |
| 12 | Nam Thong | 165 | 3.6 | 6.6 | 208.2 |
| 13 | Nam Phadoy | 129 | 2.9 | 5.2 | 163.8 |
| 14 | Nam Pang | 124 | 2.7 | 5.0 | 157.4 |
| 15 | Nam Chian | 519 | 11.4 | 20.8 | 656.4 |
| 16 | N. Nam Hok | 24 | 0.5 | 1.0 | 30.5 |
| 17 | Nam Hok | 127 | 2.8 | 5.1 | 161.3 |
| 18 | Nam Mang | 72 | 1.6 | 2.9 | 91.4 |
| 19 | Houay Sam Liou | 121 | 2.7 | 4.9 | 153.6 |
| 20 | Nam Phouan | 459 | 10.1 | 18.4 | 580.3 |
| 21 | S. Nam Phouan | 28 | 0.6 | 1.1 | 35.6 |
| 22 | Nam Sou | 214 | 4.7 | 8.6 | 270.4 |
| 23 | Nam Ngok | 202 | 4.5 | 8.1 | 255.2 |
| 24 | Nam Pamom | 45 | 1.0 | 1.8 | 57.1 |
| 25 | Houay Katha | 47 | 1.0 | 1.9 | 59.7 |
| 26 | Houay Soup | 57 | 1.3 | 2.3 | 72.4 |
| 27 | Nam Xao | 313 | 6.9 | 12.6 | 396.1 |
| 28 | Houay Khinguak | 67 | 1.5 | 2.7 | 85.1 |
| 29 | Houay Kokkhen | 126 | 2.8 | 5.1 | 160.0 |
| 30 | Houay Poungxang | 24 | 0.5 | 1.0 | 30.5 |
| 31 | Nam Pa | 78 | 1.7 | 3.1 | 99.0 |
| 32 | S. Nam Pa | 26 | 0.6 | 1.0 | 33.0 |
| 33 | Nam Tek | 64 | 1.4 | 2.6 | 81.3 |
| Total | Nam Ngiep | 4,533 | 100 | 181.8 | 5,734.0 |

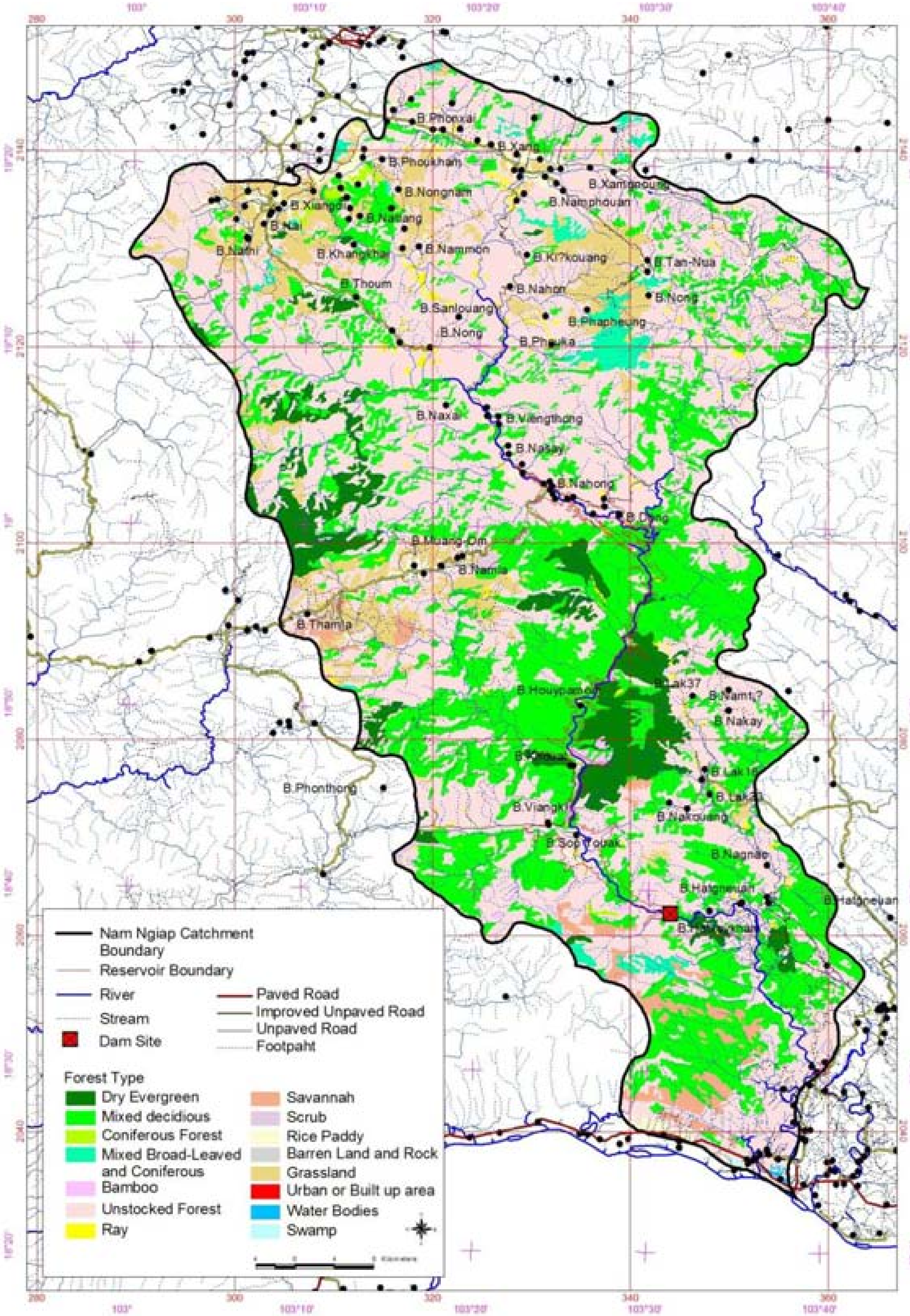



Figure 12-2 Coverage of Nam Ngiep Watershed and land use types.

Land uses in the watershed are presented in Figure 12-2 and Table 12-2. The forest types in the table are classified according to the Forest Inventory and Planning Division classification of the Department of Forestry.

A land use and vegetation map was been produced based on analysis of satellite imagery and aerial photographs, combined with field surveys, and ground truthing. According to the result of the survey the forest/vegetation cover and land use map conducted by Forest Inventory and Planning Division, Department of Forestry (2002), the main types of land uses are Unstocked Forest, accounting for slightly over half the area, and Mixed Deciduous Forest, accounting for another 27 percent. Another 7 percent is grassland, and 5.5 percent is Dry Evergreen Forest. Less than 3 percent of the area is paddy.

Table 12-2 Land Use and Vegetation Types of the Nam Ngiep Watershed

| Land Use and Vegetation Type | Code | Area | |
|---|---|---|---|
| | | % | ha |
| Dry Evergreen Forest | DE | 5.50 | 24,736 |
| Mixed Deciduous Forest | MD | 27.40 | 123,135 |
| Coniferous (Pine Forest) | S | 0.19 | 869 |
| Mixed Coniferous and Broadleaved | MS | 1.54 | 6,916 |
| Bamboo | B | 0.19 | 869 |
| Unstock Forest | T | 52.45 | 235,752 |
| Ray | RA | 0.79 | 3,538 |
| Savannah | SH | 1.69 | 7,591 |
| Scrub Forest | SR | 0.19 | 869 |
| Rice Paddy | RP | 2.88 | 12,931 |
| Barren Land and Rock | R | 0.01 | 32 |
| Grassland | G | 7.11 | 31,942 |
| Swamp | SW | 0.02 | 97 |
| Water Bodies | W | 0.04 | 193 |
| Total | | 100 | 449,470 |

Source: Forest Inventory and Planning Division, DOF, 2002

There are six slope classes in the Nam Ngiep watershed, their classification presented in Table 12-3. Figure 12-3 shows the watershed according to the different slope classes. Most of the gentler slopes are to the south and southeast, near the Mekong River, and in the large valleys in the northeast. The Steep to Extremely Steep slopes, covering much of the watershed, require the greatest protection, since they have the greatest risk of erosion.

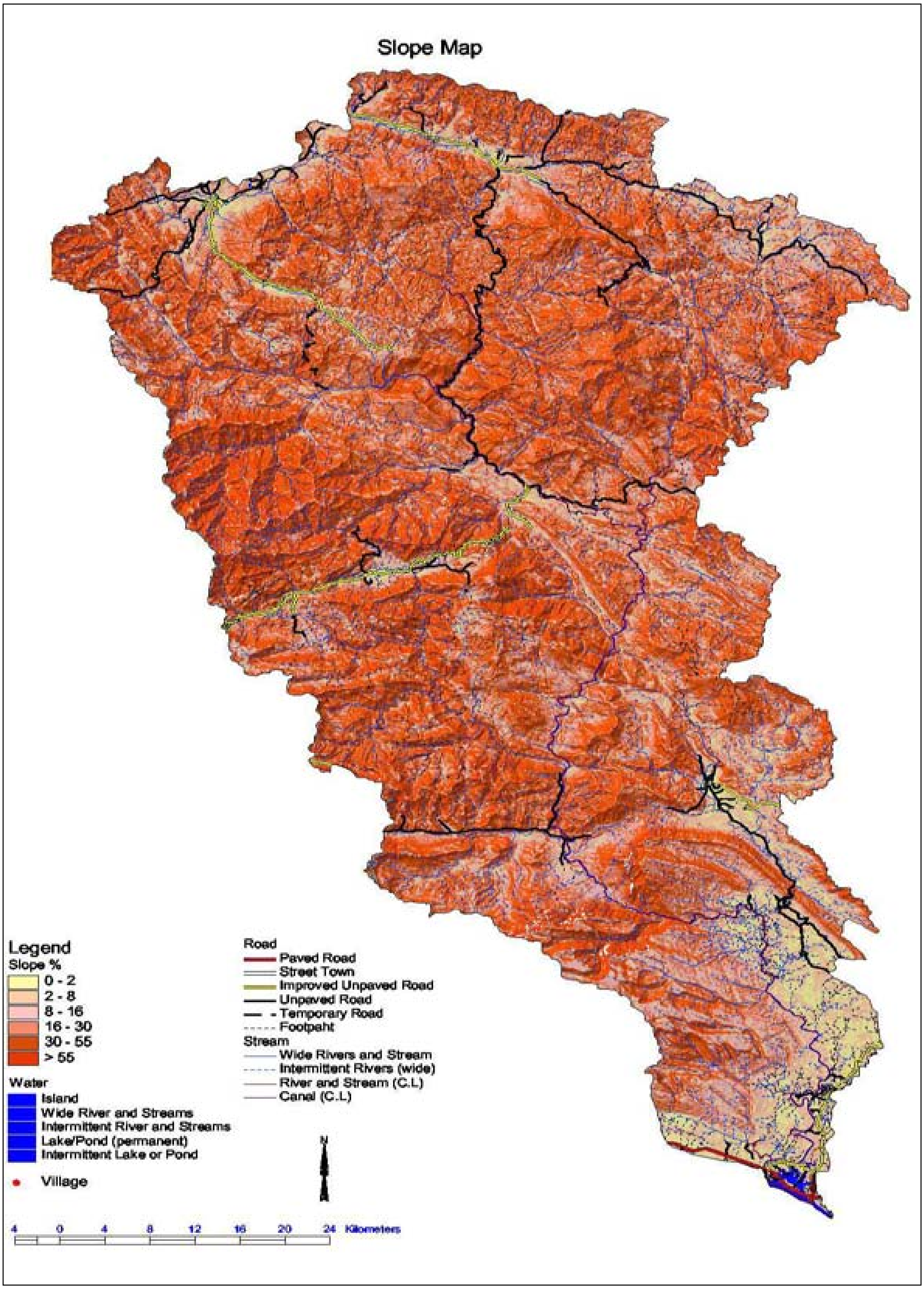



Figure 12-3 Slope classification map of the Nam Ngiep watershed.

Table 12-3 Slope Classification of the Nam Ngiep Watershed

| Slope classes | Slope in (%) | Landform description |
|---|---|---|
| I | 0-2 | Flat and rolling |
| II | 2-8 | Undulating |
| III | 8-16 | Hilly |
| IV | 16-30 | Steep |
| V | 30-55 | Very steep |
| VI | >55 | Extremely steep |

### 12.2.2 SOCIAL CONDITIONS

#### (1) Pressure from population

Though population density is not high, the area suitable for settlement is limited – around 3 percent of the watershed is rice paddy. Agricultural land is always in high demand. There are some newcomers moving into the area from the northern parts of Lao PDR, seeking better land and resources than in their original homes.

The 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. It is therefore practicable to use zoning as a means to preserve the headwaters or other forest areas in the watershed.

The Nam Ngiep watershed covers parts of seven districts in three provinces: two districts in Bolikhamxay (Bolikhan and Pakxan Districts), two in Vientiane Province (Hom and Xaisomboun Districts), and three in Xieng Khoung Province (Thathom, Phaxai and Khoun Districts). Table 12-4 presents the area of the provinces, and the number of villages, households, and population (male and female) in the entire province and in each of the districts that are part of the Nam Ngiep watershed.

Table 12-4 Districts, Villages, and Population in the Provinces in the Nam Ngiep Watershed Area (2008)

| | Area ($km^2$) | Village | HH | Population | | |
|---|---|---|---|---|---|---|
| | | | | Total | Female | Male |
| 1.Vientiane (12 districts) | 22,554 | 528 | 77,069 | 433,567 | 216,595 | 216,972 |
| - Hom | | 41 | 4,044 | 28,153 | 13,540 | 14,613 |
| - Xaisomboun | | 56 | 4,513 | 28,236 | 14,030 | 14,206 |
| 2. Bolikhamxay (6 districts) | 14,863 | 326 | 39,827 | 231,544 | 114,509 | 117,035 |

| | Area ($km^2$) | Village | HH | Population | | |
|---|---|---|---|---|---|---|
| | | | | Total | Female | Male |
| - Bolikhan | | 45 | 5,592 | 35,964 | 17,549 | 18,415 |
| - Pakxan | | 59 | 8,088 | 42,261 | 21,445 | 20,816 |
| 3. Xieng Khouang (8 districts) | 17,506 | 502 | 39,029 | 249,817 | 123,865 | 125,952 |
| - Thathom | | 23 | 2,163 | 13,106 | 6,355 | 6,751 |
| - Phaxai | | 32 | 2,018 | 12,031 | 5,975 | 6,056 |
| - Khoun | | 52 | 4,777 | 33,490 | 16,748 | 16,742 |

As can be seen from Table 12-5, which presents demographic characteristics of the provinces that share parts of the Nam Ngiep watershed, some public health conditions have changed dramatically for the better. It should be noted that at the time this information was collected, the portion of the project area now in Vientiane Province was then in the Xaysomboon Special Region. In all, the crude birth rate has declined, as has the infant mortality rate. There has also been a drastic reduction in the crude death rates as basic health care, cleaner water, and other improvements have reached more communities. Yet the natural rate of population growth is still higher than the natural average in all but Vientiane Province. In all the poor and high priority poor areas of the watershed, it is likely that growing population is causing more pressure on the natural resources, with over-fishing, over-hunting, unsustainable use of lands, and over-extraction of non-timber forest products. As the resources are over-exploited and degrade, it is then the poorest who suffer the most.[3]

Table 12-5 Birth and Death Rates, Fertility and Infant Mortality in the Provinces of the Nam Ngiep Watershed: 1995 and 2000

Unit: percent

| Name of provinces | Crude Birth Rate | | Crude Death Rate | | Natural Increase Rate | | Total fertility Rate | | Infant Mortality Rate | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1995 | 2000 | 1995 | 2000 | 1995 | 2000 | 1995 | 2000 | 1995 | 2000 |
| Xieng Khouang | 41.9 | 38.3 | 15 | 7.5 | 2.6 | 3.08 | 6.3 | 5.8 | 121 | 69.6 |
| Vientiane | 36.3 | 32.6 | 13.9 | 5.6 | 2.4 | 2.7 | 5.9 | 3.9 | 102 | 34.9 |
| Bolikhamxay | 39.3 | 36.9 | 16.5 | 3.6 | 2.5 | 3.33 | 5.8 | 5.2 | 136 | 26 |
| Xaysomboon SR | 40.4 | 44.6 | 16.9 | 6.7 | 3.0 | 3.79 | 7.2 | 6.8 | 138 | 58.7 |
| Whole Country | 41.3 | 34 | 15.1 | 6.3 | 2.5 | 2.77 | 5.4 | 4.9 | 104 | 82.2 |

Source: Calculated from population census 1995 and Lao Reproductive Health Survey, 2000

[3]Natural Resources Information Clearinghouse, Issues in Poverty Reduction and Natural Resource Management. Washington, D.C.: USAID, 2006.

Table 12-6 presents the dependency ratio for the provinces with territory in the Nam Ngiep watershed. The dependency ratio in 2005 was 0.97 in Xieng Khouang, 0.92 in Xaysomboon SR (now part of Vientiane Province), 0.84 in Bolikhamxay and 0.72 in what was then the much smaller Vientiane Province.

Table 12-6 Dependency Ratio in the Provinces with territory in the Nam Ngiep Watershed, from the 2005 Population Census

| Province | Number of people Under 15 years and 65 and older | Population 15-64 Years | Dependency ratio |
|---|---|---|---|
| Xieng Khouang | 113,093 | 116,428 | 97 |
| Vientiane | 162,436 | 226,397 | 72 |
| Bolikhamxay | 102,934 | 122,338 | 84 |
| Xaysomboon SR | 18,837 | 20,579 | 92 |
| Whole Country | 2,435,016 | 3,186,306 | 76 |

Source: Results from the Population and Housing Census 2005, NSC,CPI

Nearly all of those in the dependent population are under 15. In 2005, there were only about 231,000 people ages 65 and over, while there were about 2,512,000 aged 0 to 14.[4] The national dependency ratio in 2005 was about 0.8, while in much of the project area the dependency ratio is higher, indicating even greater population pressures in coming years.[5]The people in the Nam Ngiep watershed now rely almost solely on land-based and other natural resource based livelihoods. The future health of the watershed will depend upon the increase in non-land based livelihoods.

### (2) Ethnic difference in use and management of natural resources

In Lao PDR the main difference in use of natural resources among ethnic groups is generally due to the relative altitude of their settlements and the availability of resources at the different altitudes. A common way of dividing the groups is to classify them as either Lao Loum (lowland Lao), Lao Theung (midland Lao), and Lao Sung (upland Lao). The Lao Loum are the ethnic Lao-Tai groups, who live in the lowlands and valleys, and make up about two-thirds of the total population. Ethnic Lao were the largest of all groups, comprising 55 percent of the country's population in the 2005 population census. The Lao Theung are

[4] http://www.nsc.gov.la/Statistics/Selected%20Statistics/Population.htm

[5] http://www.nsc.gov.la/Products/Populationcensus2005/PopulationCensus2005_chapter1.htm

mainly the Mon-Khmer groups, the largest of which are the Khmu, who comprised about 11 percent of the country's population in 2005. They live in the middle hills, and were likely the original lowland inhabitants before the Lao-Tai migrated to the region. The Lao Sung are mainly Hmong-Mien or Tibeto-Burman groups who live in the highlands. The largest of these groups in Lao PDR are the Hmong, accounting for about 8 per cent of the total population of the country.

Resource use traditionally depended on the lands available for agriculture. The Lao Loum traditionally live in permanent settlements, with a combination of sedentary rice cultivation in paddies and supplementary swidden cultivation on hillsides. The Lao Theung also tend to live in permanent settlements, and depend upon a rotational swidden agriculture of upland rice, maize, and other crops on the hillsides near their settlements. The Lao Sung traditionally practice pioneer swidden agriculture on the higher slopes, using the lands until they become degraded, then moving their settlement to clear new, as yet still fertile, lands.[6] With increasing population and fewer new lands available to move into, the Lao Sung are not able to move as frequently as before, and their swidden agriculture has become less sustainable. The swidden cultivation of both the Lao Theung and Lao Loum is also under pressure from increasing populations, forcing people to reduce the number of years they leave fields fallow.[7]

In the Project area, all the ethnic groups now tend to practice a similar type of agriculture. The Hmong and Khmu, traditionally in the highlands and midland respectively, now live in valleys, practice sedentary rice cultivation in paddy, grow fruit trees and tend vegetable gardens around their houses, as well as vegetable gardens in small plots near the watercourses (sometimes a corner of the paddy field, after the rice crop has been harvested), with a supplementary swidden cultivation of some upland rice, maize, and other field crops in the surrounding slopes, generally on rolling hills. Most of this is upland area in the watershed is officially forest land, but now barren of larger trees, and designated as Unstocked Forest.

[6] Asian Development Bank, National Statistics Center & State Planning Committee. Participatory Poverty Assessment: Lao PDR, Vientiane, 2001.

[7] D. Schmidt-Vogt, "Secondary Forests in Swidden Agriculture in the Highlands of Thailand" in Journal of Tropical Forest Science, Vol. 13, No. 4, 2001, pp. 748-767.

Any effort at reforestation of the current Unstocked Forest lands or at maintaining existing forest cover will have to take into account the widespread swidden practices, especially on steeper slopes. Differentiation would need to be made clearly between the more sustainable rotational swidden practices of the Lao Theung ethnic groups and the traditional migratory practices of the Lao Sung.

However, these traditional swidden practices, even when under population pressure, are not as great a threat to watershed resources as are illegal or even poorly-managed logging.[8] It has also been found in Thailand that the extension of roads into the highlands and better access to markets has led many of the primary swidden cultivators to change to sedentary agriculture of vegetables and other commodities.

It can be expected, though, that these traditional practices will decline over time, as has been the case in other parts of Lao PDR and other parts of mainland Southeast Asia where there has been considerable infrastructure development and increased involvement in the market economy. People will tend to practice more sedentary and at least partly commercial agriculture, as well as move into new non-land based and non-natural resource based livelihoods (trades and services).

**(3) Pressure from poverty**

Poverty is perhaps the greatest threat to the sustainable use of natural resources in the area. The majority of the people in the watershed area live in poverty and practice subsistence agriculture. While their way of life may be considered to be sustainable, any event such as drought, flooding, or an infestation of pests or crop disease can threaten people's livelihoods, with few in such circumstances able to grow sufficient life for the entire year.

The Prime Minister's Instruction No 010/PM resulted in the definition of a poverty line together with different poverty criteria, allowing local authorities to identify and monitor poverty at the district and also at the household level. 'Poor' districts were those districts where over 51% of the villages were poor. There were additional criteria, which included districts where over 40% of the villages were without a school in or nearby the village, or

[8] Michael Dove, "Theories of swidden agriculture, and the political economy of ignorance," in Highland Systems, Vol.1, no. 2, 1995, pp. 85-99.

without a dispensary or pharmacy in or nearby the village, or if over 60% of the villages had no access road or were without access to clean water.

Figure 8-4 shows the districts in the Nam Ngiep watershed area in terms of their level of poverty. Districts that determined to be not poor districts are white, while poor districts are yellow and high priority poor districts are red. The Nam Ngiep Watershed Area includes 4 high priority poor districts – Xaisomboun (now part of Hom District) in Vientiane Province, Bolikhan in Bolikhamxay Province, and Thathom and Khoun in Xieng Khoung Province. The portion of Hom District in Vientiane Province that did not yet include Xaisomboun is classified as poor, but not high priority

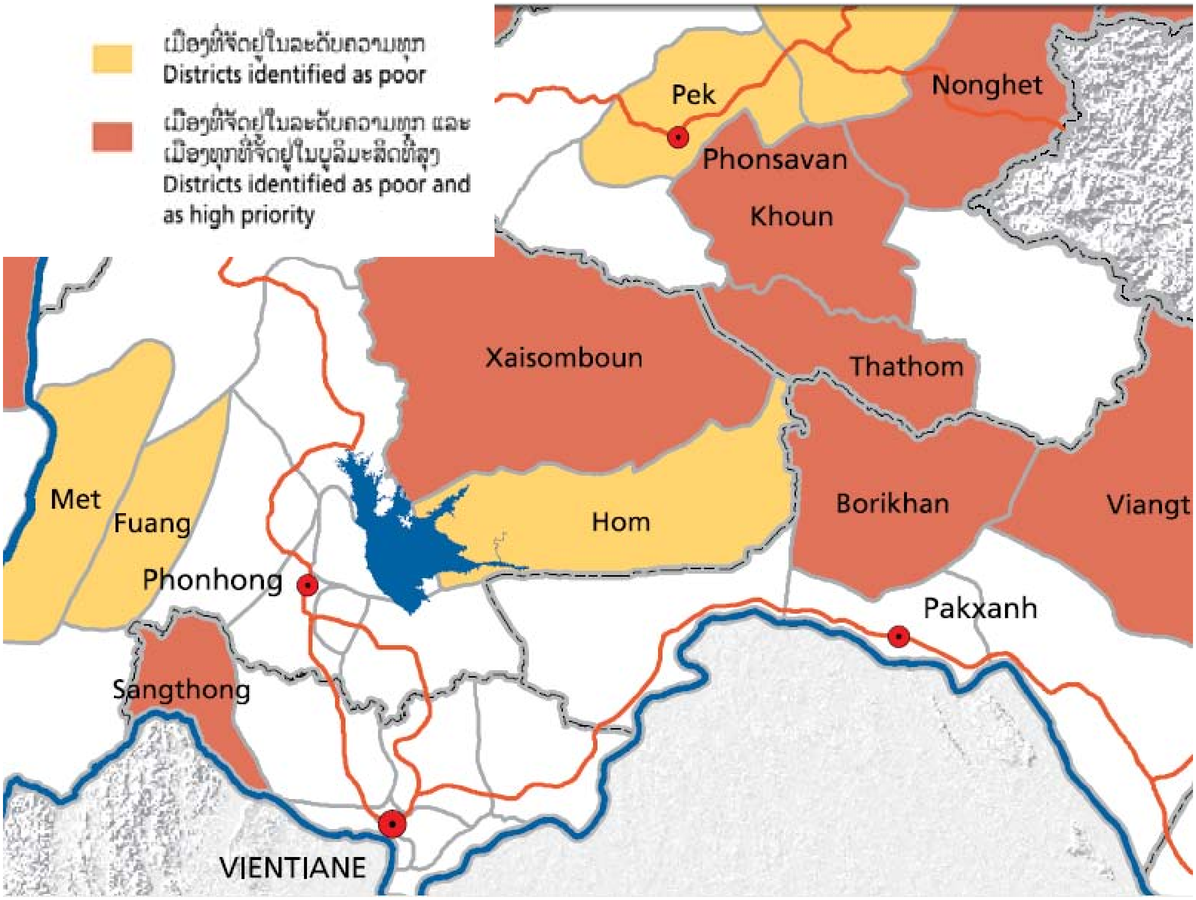
The relationship between poverty and natural resources is multifaceted. The rural poor generally are more dependent on the resource base for their livelihood, on non-timber forest products, fishery resources, and their crops. Yet when under pressure to provide for their families, the rural poor will need to extract whatever resources they can in order to survive, even if at an unsustainable rate. Increasing population is thought by some to be one factor that increases that pressure on the resources, particularly increasing populations in poor areas.

During fieldwork, most local residents identified themselves as poor but claimed they could sustain their livelihood with little use of money. Natural resources were still sufficient to make a modest living. What they felt they lacked were basic infrastructure and services such as all weather access road, reliable health service and better schooling.

The people grow rice, vegetables, fruit and other crops for family consumption. Any surplus they have would not be able to earn them much income, because of the high transportation cost to the market. Most production provides fairly low yields. There is considerable scope for improving yields through changes in farm techniques and the introduction of fertilizers.

Most farm cash income comes from sales of poultry and livestock. These meats are eaten mainly on special occasions, and they command relatively high prices for each of the animals. The main source of protein during the year is fish, mostly from the Nam Ngiep or its tributaries.

As noted earlier, increasing population pressure on resource contributes to poverty. Some of the poorest districts also have some of the largest average family sizes, with Khoun District in Xieng Khouang having about 7 people in each household, compared to an average family size of 5.2 in Pakxan District in Bolikhamxay.




Source: Socio-Economic ATLAS of the LAO PDR, 2005

Figure 12-4 Districts identified as poor and high priority poor in the project area.

## 12.3 UTILIZATION OF NATURAL RESOURCES IN THE WATERSHED

### (1) Forest and land use

As described in Table 12-2 and shown in Figure 12-2, about half of the watershed area is classified as unstocked forest, another 35 percent is either dry evergreen forest or mixed deciduous forest. There is no national biodiversity conservation area (NBCA) in the watershed, though the Phou Khao Khoay NBCA is immediately to the southwest.

Only about 4 percent of the area is *ray* (upland fields) or rice paddy. Given the large area of unstocked forest together with this small area of production land, it is likely that much of the unstocked forest is in fact previously forest land that has been cleared for upland agriculture. A survey of the actual use of these lands will be necessary for there to be an effective watershed management plan. This will require effective communication and local participation, so that the people using the land can join in converting it into land uses that remain productive while helping sustain the environment. There should be no penalties for having used the land, even if it has not been done so legally, so long as the people are willing to join in the watershed management program.

Traditionally, people in the watershed would rely on the forests for building materials (timber, bamboo), fuelwood, fodder, mushrooms and vegetables, and birds or small animals for food. The collection of NTFPs is done mostly in community reserved forests located near the villages. They mostly collect the NTFPs for domestic use, with only a little being traded or sold. Outside traders in NTFPs have not been attracted to the Nam Ngiep watershed, in part because of the low amounts of NTFPs extracted by villagers but also because of the difficulty traveling to most communities in the watershed. Once the roads are improved and access to the communities (and the nearby forests) is easier, there will need to be stricter control over extraction of NTFPs and timber, assuring that it is still available for domestic use, but limiting the exploitation of any of the products for commercial sale or trade.

Despite the difficulties of transport, almost daily transport of logs was seen during field visits, and has been confirmed by villagers as occurring for much of the past decade. This logging has certainly contributed to the decline of the forests in the area. During the wet season, the heavy loads of the logging trucks have been one of the main causes of road damage in the area. Local residents have had little involvement in the logging business. Even the workers are mostly from outside.

**(2) Land and Soil**

Land based activities in the area are fit into two main categories: agriculture and animal husbandry.

The low flatland, where water can be retained, is reserved for rice paddy. Upland rice,other crops and fruit trees were grown in highland areas– on the gently sloping hills or even on some of the moderately steep areas. All households raise poultry, pigs or goats, and let the animals roam freely. Most also raise livestock: cows or buffalo. Only a few household raise enough livestock to require fencing and their own grazing areas. Most households let their cattle roam and graze in common grazing areas. Given the relatively low number of livestock and of other domestic animals, there is rather low impact from the animals on the watershed, whether in terms of land or water required. However, even a relatively low number of livestock need to have their grazing areas somewhat restricted, to assure they do not pollute streams and other waters intended for domestic use or consumption.

There are two major concerns with land use and soil. These are the soil fertility and the risk of erosion. With lower population levels, there was sufficient land available for the soil to replenish during the fallow periods under the traditional swidden techniques. Now that populations have increased, land is more limited, the swidden cycle is reduced and the time land is left in fallow is no longer adequate to replenish the soil fertility. People have tended to try to clear new – and steeper – lands, with the risk of increased erosion. The watershed management program could provide the opportunity to introduce organic soil improvements and other techniques to help increase yields in the existing lands. In local markets, chemical pesticides and fertilizers are beginning to be available, and farmers in the Nam Ngiep watershed are starting to use them. It is obvious that as villagers are changing their farming practices, opportunities are available to assure those changes are sustainable environmentally and economically.

The expansion of farmland into steeper slopes and the clearing of large areas of forest increase the risks of soil erosion. A number of improvements can be made on existing lands, to help prevent soil erosion while increasing productivity. These include soil covering, contour plowing, soil protection with Vetiver grass, and terracing. When the detailed WMP is prepared, the sub-basins should be assessed as to their risk in causing erosion and sedimentation, with higher priority given to managing the land use of the sub-basins with the greatest risk.

As the villages in the watershed have become more involved in the market economy, many have started to grow commercial trees such as rubber, eaglewood, and teak. Some forms of economic forestry, using commercial trees as part of a forest rehabilitation program, could provide both economic and environmental benefits, if sufficiently managed.

**(3) Water**

Water is considered an abundant resource in the watershed. Rice and other crop cultivation rely on rain and water runoff, with a few small village-level irrigation systems using springs or streams from higher ground. The Nam Ngiep River has not been used for an irrigation system, with river water mainly used only for small riverside vegetable gardens, and for washing and providing drinkingwater for livestock. In most communities located near the river, the river water is also be used for cleaning, bathing or washing. Drinking water is often from streams from higher grounds, dammed and piped in for household consumption. In some cases, the flow is low during the dry season, but is soon replenished after the rains.

During public consultations, several communities upstream from the dam raised the possibility of having small irrigation schemes built by using low cost supplies and local design and techniques. All would get their water from small streams or tributaries of the Nam Ngiep River.

In general, there is potential to increase productivity and maintain water security for communities in the watershed by proper integrated water resource management. This also should be explored in the detailed study and design of the watershed management plan.

**(4) Ecological services and biodiversity**

The Nam Ngiep Watershed is not known for an abundance of fauna or flora, perhaps because of its rather steep terrain. However, there is still need for adequate protection and conservation. Further investigation should be conducted for proper biodiversity zoning and management, in order to maintain ecological services and biodiversity of the fauna and flora in the area of headwaters and more pristine areas remote from settlements.

In areas around villages, community based forest management supported by the GOL is already practiced. All villages in the watershed have their own conservation reserve forests for village uses. The program allows villagers to collect NTFPs from the forest and at the same time, participate in helping manage and maintain the forests. The Project could encourage more such projects and work within the current GOL framework.

The NNHP-1will construct two dams which will create two significant reservoirs, one 67 $km^2$ in area and the other1.3 $km^2$ in area. In creating such reservoirs and changing the flow of the river, environmental changes are unavoidable.

Fish and other aquatic species that prefer large, deep and still bodies of water may increase, while those that prefer shallower waters with a constant flow may decrease. As already promoted in the Environmental Management Plan (EMP), the project will promote a program that enhances fish stock. With its large reservoir, it is possible to increase the quantity of fish and other aquatic culture.

## 12.4 INFRASTRUCTURE AND SERVICES IN THE AREA

The main road through the watershed is National Road 1D, until recently a dirt road with some sections covered in gravel that connects Phonesavanh, the capital of Xieng Khouang Province, with Pakxan, the capital of Bolikhamxay Province. The road was impassible for motorcycles, cars or small trucks during the rainy season, muddy with deep holes, and small streams turned into raging torrents. Only larger trucks could travel over it, though with considerable difficulty. Since 2009, the road is being upgraded to an all-season paved road, planned for completion by the end of 2011.

The other important change in infrastructure has been the extension of the national electric grid into some villages.

The improved roads and the provision of electricity have led to significant changes in people's lives. More cash crops are grown, including those that were earlier difficult to transport. A larger variety of occupations are emerging: small grocery shops, petrol stations, auto repair shops, small electric appliance repairs, beauty salons, small restaurants and food stalls, small guesthouses, and other non-land based services, have recently emerged. These serve both local residents and the increasing number of outsiders coming to the area.

The infrastructure developments also have implications for resource use and management. The improved roads not only improve access to and from the communities, but also provide access to the natural resources, threatening forests with uncontrolled extraction of timber and NTFPs.

Electricity can help people change from fuelwood for cooking and kerosene for lighting. Yet people will also begin to use more electrical appliances, and so require added income to pay for those appliances and for the electricity they use.

## 12.5 MAJOR DEVELOPMENT PROJECTS IN THE NAM NGIEP RIVER WATERSHED

Aside from the NNHP-1 scheme, there are also plans for the Nam Ngiep 2 Hydropower (NNHP-2) project. The NNHP-2 project is situated on the Nam Sen River, with a tributary dam on the N.W. Nam Chiat. These are in the north-north-west portion of the Nam Ngiep watershed, with the 2 tributaries accounting for 6.2 percent or 385 km$^2$ of the total 4,544 km$^2$

area of the watershed and 6.3 percent (11.5 $m^3$/sec of 181.8 $m^3$/sec) of the total flow and (360.6 mcm of 5,734 mcm) of the total volume of the Nam Ngiep River.

With the NNHP-2 project located along two of the northernmost tributaries of the Nam Ngiep River, coordination would be useful in watershed management, to assure the continued flow of water for both projects and to control erosion and sedimentation in the rivers.

Several of the communities in the upstream zone (Zone 1) of the NNHP-1 Project are considered downstream communities for the NNHP-2 Project. Care should be taken with the water quality of the Nam Ngiep River after commissioning, given that anaerobic conditions are expected with the deterioration of the vegetation in the NNHP-2 reservoirs. The NNHP-2 is planned for completion in 2015, before inundation of the NNHP-1 reservoir.

If possible, a single Nam Ngiep Watershed Management Committee should be considered, to coordinate the efforts of all the projects in the watershed.

As for the impact of the NNHP-1 Project on the Mekong River, given that the flow of Nam Ngiep river will not be changed significantly by the NNHP-1 Project, and that the contribution of the Nam Ngiep river to the total flow of the Mekong River is rather minor, no impacts from this project are expected downstream from the confluence with the Mekong.

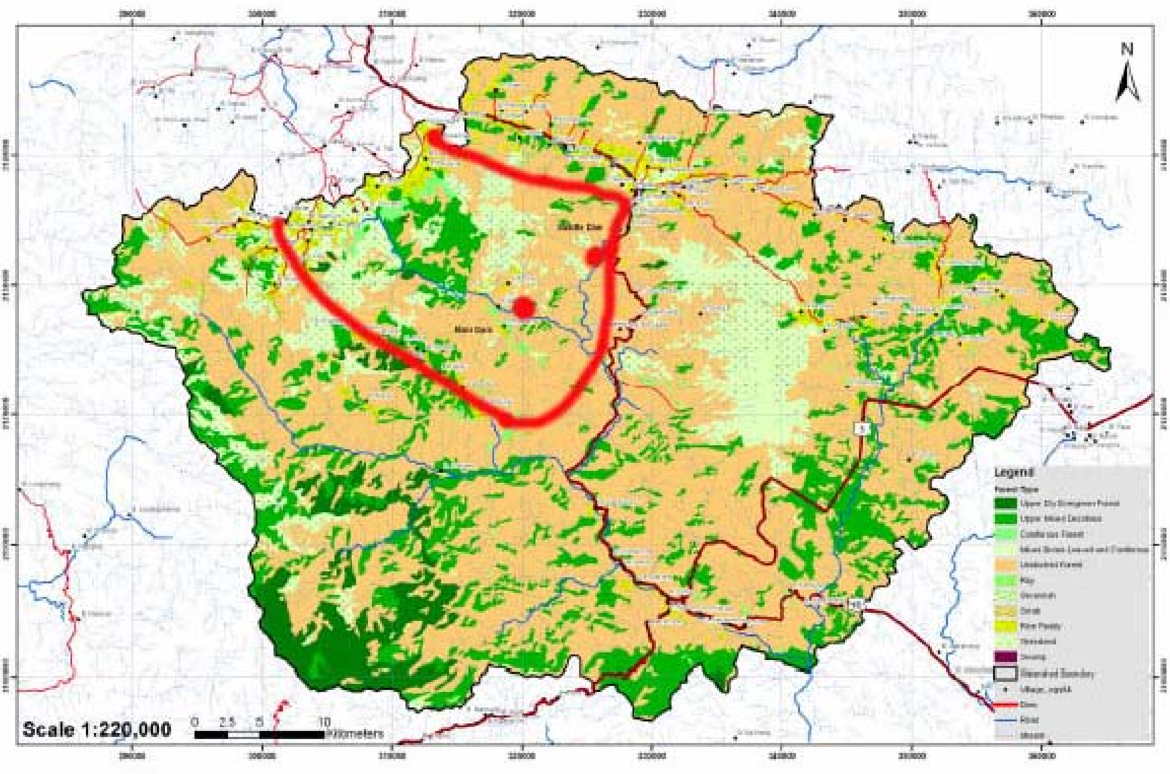



Figure 12-5 Map of land use and forest types in the Nam Ngiep II watershed.

The area inside the red line is the watershed of the NNHP-2 (modified from EIA report of the Nam Ngiep II hydropower Project)

## 12.6 PROBLEM AND ROOT CAUSE ANALYSIS

It can be foreseen that watershed degradation will involve decreasing forest cover, decreasing biodiversity, increased frequency of floods and droughts, increasing soil erosion and decreasing water quality.

The main problems that cause degradation or unsustainable use of the natural resources in the Nam Ngiep watershed are forest encroachment, unsustainable commercial logging and unsustainable use of agricultural lands.

Forest encroachment is caused by the lack of enforcement and increasing demand for agricultural land, with increasing population, household poverty, and lack of land for farming.

Household poverty results from low farm income and lack of opportunities for non-farm income. Farm income is limited because of a combination of low agricultural productivity and limited access to the market. All of these components are linked as indicated below:

In summary, degradation of the Nam Ngiep watershed is a consequence of the absence of sustainable natural resources management in the area, a lack of clear regulations and lax enforcement on forestry and other natural resource laws, over-allocation of the annual cut and inefficient and wasteful timber harvesting, a lack of proper land use zoning and allocation, and the lack of an overall planning and management system.

Reforestation efforts have been slow for a variety of reasons, including insufficient funds for planting, lack of personnel and funds to maintain the new growth, and low quality planting stock.

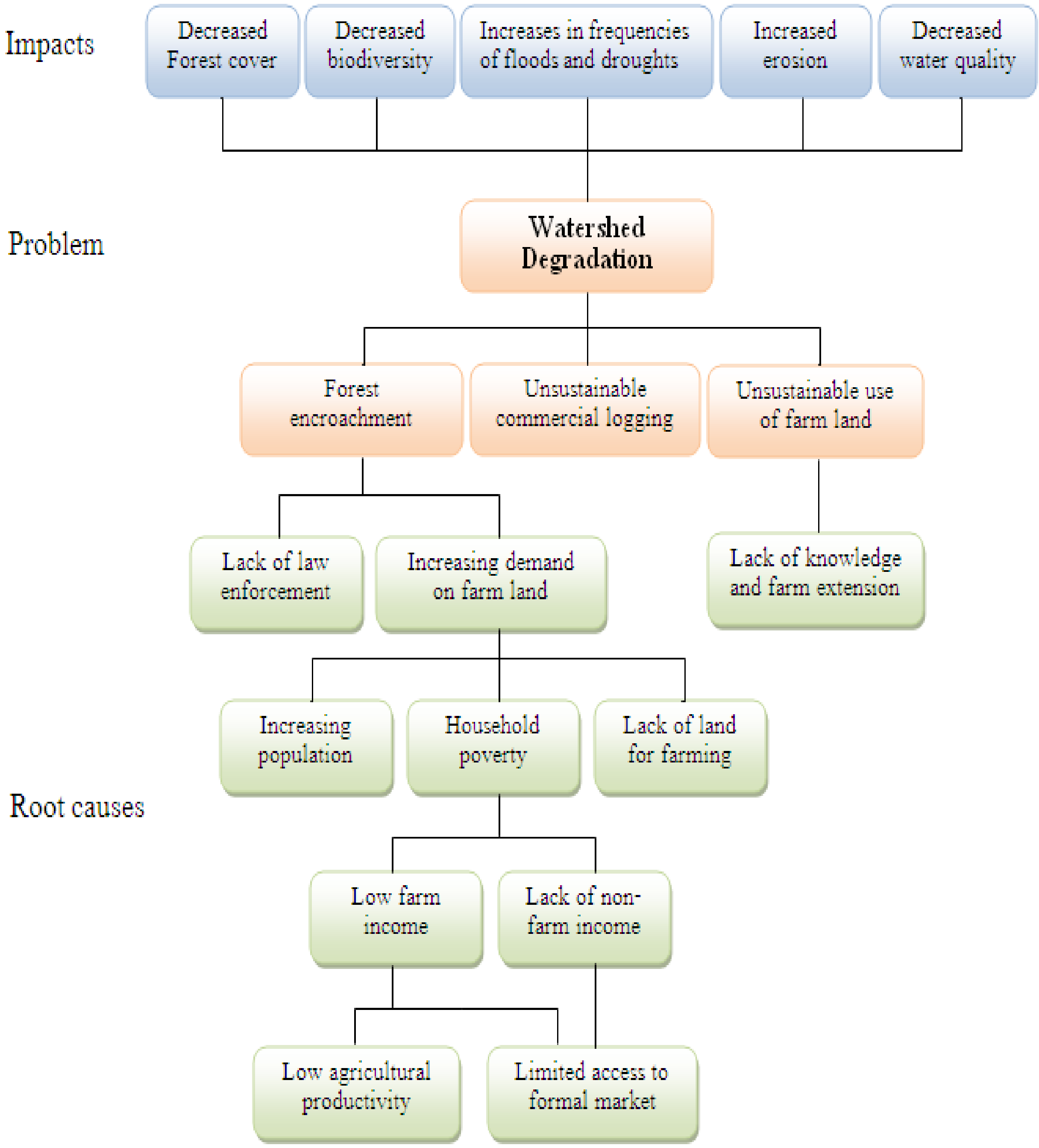



Figure 12-6 Problem and root causes diagram.

# 12.7 MANAGEMENT APPROACH, STRATEGIES, PLANNED ACTIVITIES AND PRIORITIES

Table 12-7 Design Summary of the Nam Ngiep River Basin Watershed Management Plan

<table>
<tr><td colspan="2">Impact:<br>Sustainable use of the natural resources in Nam Ngiep River Basin</td></tr>
<tr><td colspan="2">Outcome:<br>With supports from the Project, villagers and GOL authorities take roles in management on natural resources use and maintaining its services in Nam Ngiep River Basin</td></tr>
<tr><td colspan="2">Outputs:<br>1. Reduce forest encroachment;<br>1.1. Headwater forest area is preserved; limit deforestation, maintain forest density and biodiversity<br>1.2. Proper zoning of land use, forest use, resources use<br>2. Maintain water supply for community use – household consumption & agriculture<br>3. Minimum soil erosion<br>4. Maintain or enhance fishery in the area</td></tr>
<tr><td>Activities:<br>1. Reduce forest encroachment<br>1.1. Preserve headwater forest area; limit deforestation, maintain forest density and biodiversity<br>1.1.1. Encourage and support GOL authorities to define zoning in the Nam Ngiep watershed - development zone, buffer zone, conservation zone & other zones.<br>1.1.2. Set up t argets for resources management in the head water forest area i.e. area of the forest to be preserved, forest density, and biodiversity.<br>1.1.3. Encourage and support GOL to establish rules for forest use of the head water area<br>1.1.4. Promote education on awareness of headwater forest preservation<br>1.1.5. Support participation of villagers and local authorities on forest management of headwater area.<br>1.1.6. Assess forest density and biodiversity, and put up plan to preserve.<br>1.2. Setup proper zoning of land use, forest use, resource use<br>1.2.1. Clearly define forest types, forest boundary, forest uses – forest reserved for village use, pasture (livestock) zone, including rules and regulations upon using of those resources – forest services, water, fisheries. Theinformation should be available and easy to understand by local villagers<br>1.2.2. Promote education and awareness of forest zoning, forest use and resource use<br>1.2.3. Set up strategy to reduce slash & burn agriculture, reduce forest encroachment – promote la w enforcement, decreasing demand on f armland, and reducing household poverty<br>1.2.3.1. Decreasing demand on f armland – family planning targets decreasing population; encourage GOL on land allocation and land</td><td></td></tr>
</table>

| | |
|---|---|
| titling; and reducing household poverty<br>1.2.3.2. Household poverty reduction – increase income from farm and non-farm activities by increasing agricultural productivity and increase access to formal market<br>1.3. Incorporate village administration structure to the forest and land use plan | |
| 2. Maintain water supply for community use – household consumption & agriculture<br>2.1. Headwater forest preservation<br>2.2. Encourage communities to set up water management plan of each village<br>2.3. Match up agricultural practices with water supply patterns | |
| 3. Reduce soil erosion, protect topsoil cover, and maintain good soil structure<br>3.1. Build awareness of good agricultural practice and promote technical transfer – using crop & residue cover, crop rotations, tillage practice, contour plowing and strip cropping<br>3.2. Enhance agricultural production via soil improvement using organic treatment<br>3.3. Maintain riparian buffering function | |
| 4. Enhance roles of small-scale fisheries in contributing to poverty alleviation and food security<br>4.1. Keep Percentage of fish stocks exploited within their level of maximum biological productivity<br>4.2. Set up indicators<br>4.2.1. Classify the state of the stocks.<br>4.2.2. Time series of catch and effort data for each exploited stock.<br>4.3. Ensure that the biomass of target fish stocks are maintained at or above a certain level approximating an optimum level of biomass | |

Detailed planning studies should be completed within one year and should be carried out during project construction. Subsequently, individual action plans formulated by the detailed planning exercise will be implemented during the remaining period of project implementation and some projects would continue on into the project operation phase.

NNHP-1 encourages and supports the provincial institutions to take action upon their responsibility toward the watershed management based on GOL's vision.

The provincial level is responsible for making strategies on natural resources based on the area's potential and priorities, including considerations of where to build infrastructure, site biodiversity conservation areas and linking areas with market opportunities. The districts are responsible for budgeting and planning and are therefore the key administrative level for developing integrated watershed management plans.

The management activities have to focus on finding out appropriate forest management that allows for sustainable harvest of timber, along with appropriate techniques to rehabilitate the degraded forests. These need to involve the local residents, as protectors and as the main beneficiaries of the sustainable management and use of the forests. DAFO and PAFO should work with the villagers to establish a database for the management and protection of the forests and other natural resources in the area.

To assure that basic human needs are met through sustainable use of the natural resources, land use zoning, integrated land use planning, and the development and conservation of lands and soils appropriate for agriculture need to be promoted. T his planning needs to be done at several levels: the local village and mini-watershed level, linked with each other and with the broader catchment area.

## 12.8 BUDGET, SCHEDULE AND MONITORING

The budget and schedule provided in Table 12-8 is indicative. M ore detailed and accurate budget will be determined after the detailed study and finalization of the WMP.

Table 12-8 Estimated Budget for NNHP-1 Watershed Management

| Activities | Budget | Schedule |
|---|---|---|
| 1. Detailed study and finalizing the WMP | 100,000 | Cons - Year 1 |
| 2. Forest encroachment reduction program<br>2.1. Headwater forest area; limit deforestation, maintain forest density and biodiversity preservation: village forest management program<br>2.2. Zoning of land use, forest use, resource use: village land use planning and allocation program<br>2.3. Incorporation of village administration structure to the forest and land use plan | 700,000 | Cons: Years 2 - 5 / Oper: Years 1 - 3 |
| 3. Maintain water supply for community use – household consumption & agricultureprogram | 200,000 | Cons: Years 2 - 5 |
| 4. Reduce soil erosion, protect topsoil cover, and maintain good soil structure program | 210,000 | Cons: Years 2 - 5 / Oper: Years 1 - 3 |
| 5. Enhance roles of small-scale fisheries in contributing to poverty alleviation and food security program | 210,000 | Cons: Years 2 - 5 / Oper: Years 1 - 3 |

Table 12-9 Monitoring and Evaluation

| Activities | Indicators | Responsible Party |
|---|---|---|
| 1. Detailed study and finalizing the WMP | Completed plan | EMU/EMO |
| 2. Forest encroachment reduction program<br>2.1. Headwater forest area; limit deforestation, maintain forest density and biodiversity preservation: village forest management program<br>2.2. Zoning of land use, forest use, resource use: village land use planning and allocation program<br>2.3. Incorporation of village administration structure to the forest and land use plan | • Increased village involvement in reforestation, watershed management<br>• Clear zoning and management of land and forest resources<br>• Increased forest area (protected, economic, community, etc. | EMU/EMO DAFO, PAFO |
| 3. Maintain water supply for community use – household consumption & agricultureprogram | • Improved water supply systems in villages<br>• Effective community irrigation systems | EMU/EMO DAFO, PAFO |
| 4. Reduce soil erosion, protect topsoil cover, and maintain good soil structure program | • Improved soil fertility/increased yields<br>• Reduced erosion (area and amount) | EMU/EMO DAFO, PAFO |
| 5. Enhance roles of sm all-scale fisheries in contributing to poverty alleviation and food security program | • Number of fish ponds, improved fish stock<br>• Amount of catch per household<br>• Amount of fish in diet | EMU/EMO DAFO, PAFO |

## 12.9 ANNEXES TO THE WMP

### 12.9.1 PROPOSED OVERALL WATERSHED LAND USE ZONES

Based on the physical relationship between elevation, slope and geology, as well as existing land use, overall land use zones for the Nam Ngiep watershed have been proposed. The proposed watershed zoning offered here is based on a template of MRC watershed classification model (Watershed classification map, Figure 12-7). The more definite boundaries can only be finalized when village land use planning has been completed. The proposed land use is split into conservation and development zones with the overlap providing a buffer zone. This is directly related and comparable to the Land and Forest Allocation agriculture, production and protection zones.

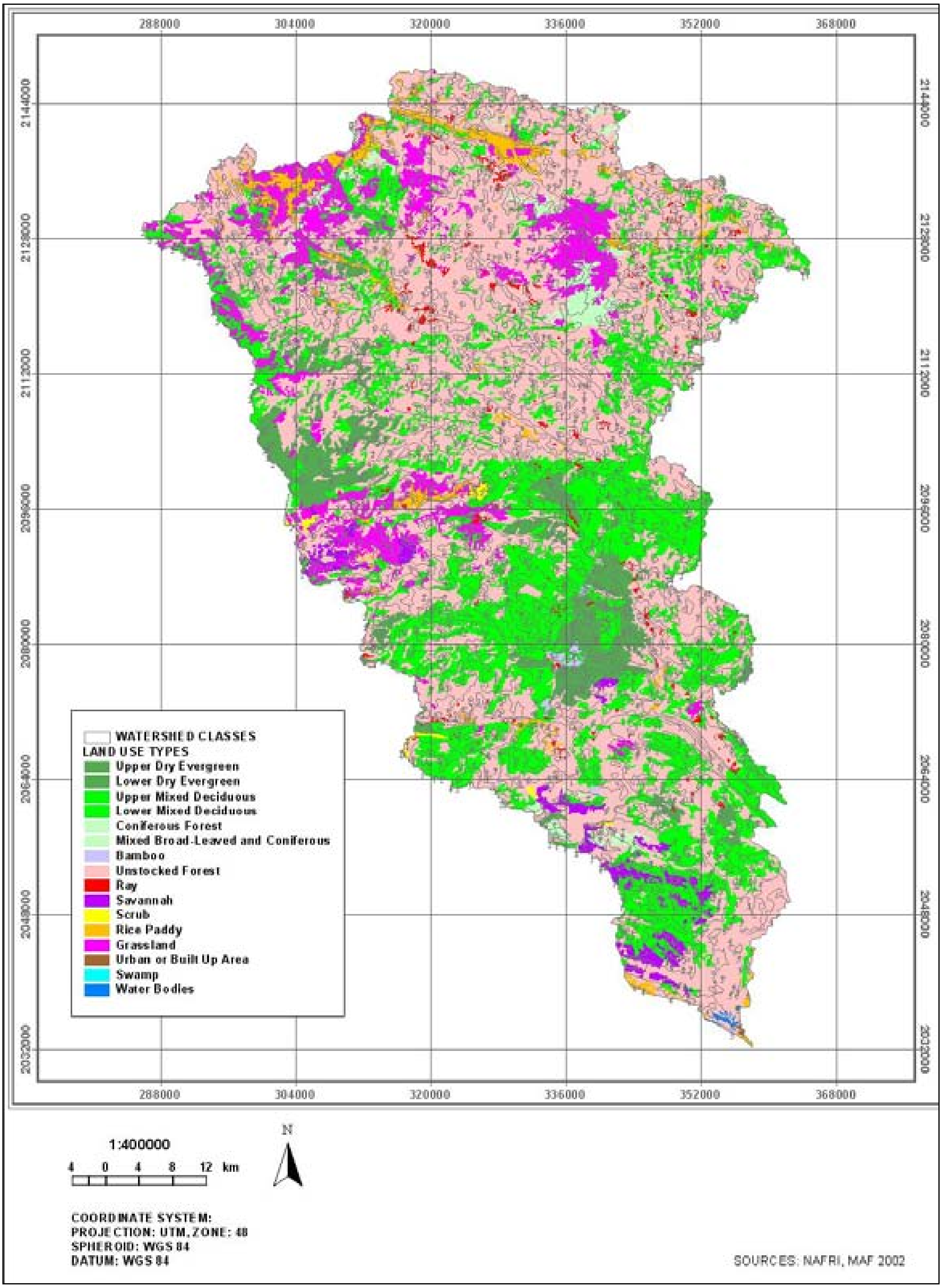



Figure 12-7 Land use types on watershed classification map.

#### 12.9.1.1 Conservation zone

Within the Nam Ngiep watershed, the conservation zone covers approximately 26 percent of the total area. It includes the majority of the steepest slopes, most important biodiversity areas, and forest and river headwaters. This zone is where occasional shifting cultivation occurs. Forestry, agro-forestry, farming and soil management should in general improve water infiltration and soil water holding capacity, thus decreasing runoff and erosion. Land use zoning and management should lead to reduced risk from hazardous use of sloping lands. There are parts of this protection zone being used without adequate restrictions and in parallel there are areas suitable for conservation oriented agro-forestry, that are not being used at all.

#### 12.9.1.2 Development zone

Majority of the designated development zone is taken up by t he flat lands along the Nam Ngiep River Basin and its tributaries, but also includes rolling lands and some of higher slope and elevation where sustainable land use can be practiced. Valley floors and terraced fields where rice can be grown under flooded condition provide a favourable environment for rice production, especially where there are possibilities for local-scale irrigation. Indeed, many villages in Nam Ngiep watershed have small areas of paddy rice and in many cases there is the potential to expand this area. As food needs become satisfied from these paddies, farmers are likely to adopt diversified land use systems on the sloping uplands for income generation and for producing goods that satisfy other livelihood needs. Despite the potential role of high land paddies in improving farmer livelihoods, the economic feasibility of increasing productivity and developing paddy terraces have not been adequately investigated.

#### 12.9.1.3 Buffer zone (Production forest)

Buffer zone is designed to link, protect and promote the dual interests of conservation and development. Forest cover in Nam Ngiep watershed has continue decreased due to shifting cultivation, which takes part in food production in rural areas. However measures to discourage shifting cultivation must provide rural populations with alternate opportunities for income generation, village forestry development and promote intensive upland farming to improve the farming system.

For production forestry, Province Agriculture and Forestry Office (PAFO) and District Agriculture and Forestry Offices (DAFOs) together with local authorities, are to carry out field surveys needed for plan formulation and to guide, monitor and control implementation, encouraged as part of the agricultural planning processes to collaborate with districts and central government resources in delineating major farming system zones within their jurisdictions, and use them as a basis for their planning and implementation (Table 12-11 and Figure 12-8).

Table 12-10 Watershed Classification Statistics

| Code | WSC Class | Land Use Type | Area | |
|---|---|---|---|---|
| | | | ha | % |
| 1 | Watershed Class 1 | Protection Forest | 118,984 | 26.00 |
| 2 | Watershed Class 2 | Commercial Forest | 215,169 | 47.02 |
| 3 | Watershed Class 3 | Agro-Forestry | 79,784 | 17.44 |
| 4 | Watershed Class 4 | Upland Farming | 37,066 | 8.10 |
| 5 | Watershed Class 5 | Lowland Farming | 6,600 | 1.44 |
| | | Total | 457,603 | 100.00 |

Table 12-11 Total Area of Land Use Distribution on Watershed Class

| LAND USE TYPE | WSC 5 | WSC 4 | WSC 3 | WSC 2 | WSC 1 | TOTAL | |
|---|---|---|---|---|---|---|---|
| | Area (ha) | Area (ha) | Area (ha) | Area (ha) | Area (ha) | ha | % |
| Upper Dry Evergreen | 0 | 516.4436 | 2,650.3253 | 10,294.9598 | 13,790.5921 | 27,252 | 5.955 |
| Lower Dry Evergreen | 239.2592 | 479.2401 | 0 | 0 | 0 | 718 | 0.157 |
| Upper Mixed Deciduous | 304.6398 | 4,754.5843 | 25,153.2036 | 58,177.3128 | 31,785.9344 | 120,176 | 26.262 |
| Lower Mixed Deciduous | 1,179.8344 | 3,832.1727 | 180.1308 | 124.3373 | 0 | 5,316 | 1.162 |
| Coniferous Forest | 0 | 0 | 37.1438 | 586.0999 | 199.4262 | 823 | 0.180 |
| Mixed Broad-Leaved and Coniferous | 0 | 24.8020 | 800.7056 | 3,453.5991 | 2,501.5947 | 6,781 | 1.482 |
| Bamboo | 0 | 0 | 39.4579 | 498.0172 | 298.3567 | 836 | 0.183 |
| Unstocked Forest | 4,052.3546 | 18,975.2242 | 36,414.7627 | 120,075.7541 | 56,729.7417 | 236,248 | 51.627 |
| Ray | 22.6011 | 550.0701 | 1,332.3125 | 1,659.8063 | 417.3803 | 3,982 | 0.870 |
| Savannah | 125.8287 | 802.9069 | 3,091.6893 | 2,297.0582 | 1,177.9226 | 7,495 | 1.638 |
| Scrub | 0 | 11.6991 | 265.2512 | 149.5551 | 518.1507 | 945 | 0.206 |
| Rice Paddy | 543.5501 | 5,099.8871 | 4,637.1398 | 1,921.7061 | 106.1145 | 12,308 | 2.690 |
| Grassland | 10.4465 | 1,757.3386 | 5,098.8266 | 16,109.6742 | 11,401.0108 | 34,377 | 7.512 |
| Urban or Built Up Area | 12.5103 | 51.3238 | 0 | 0 | 0 | 64 | 0.014 |
| Swamp | 0 | 12.2663 | 0 | 0 | 0 | 12 | 0.003 |
| Water Bodies | 95.6418 | 160.8698 | 12.8824 | 0 | 0 | 269 | 0.059 |
| Total | 6,586.6665 | 37,028.8286 | 79,713.8315 | 215,347.8801 | 118,926.2247 | 457,603 | 100.000 |

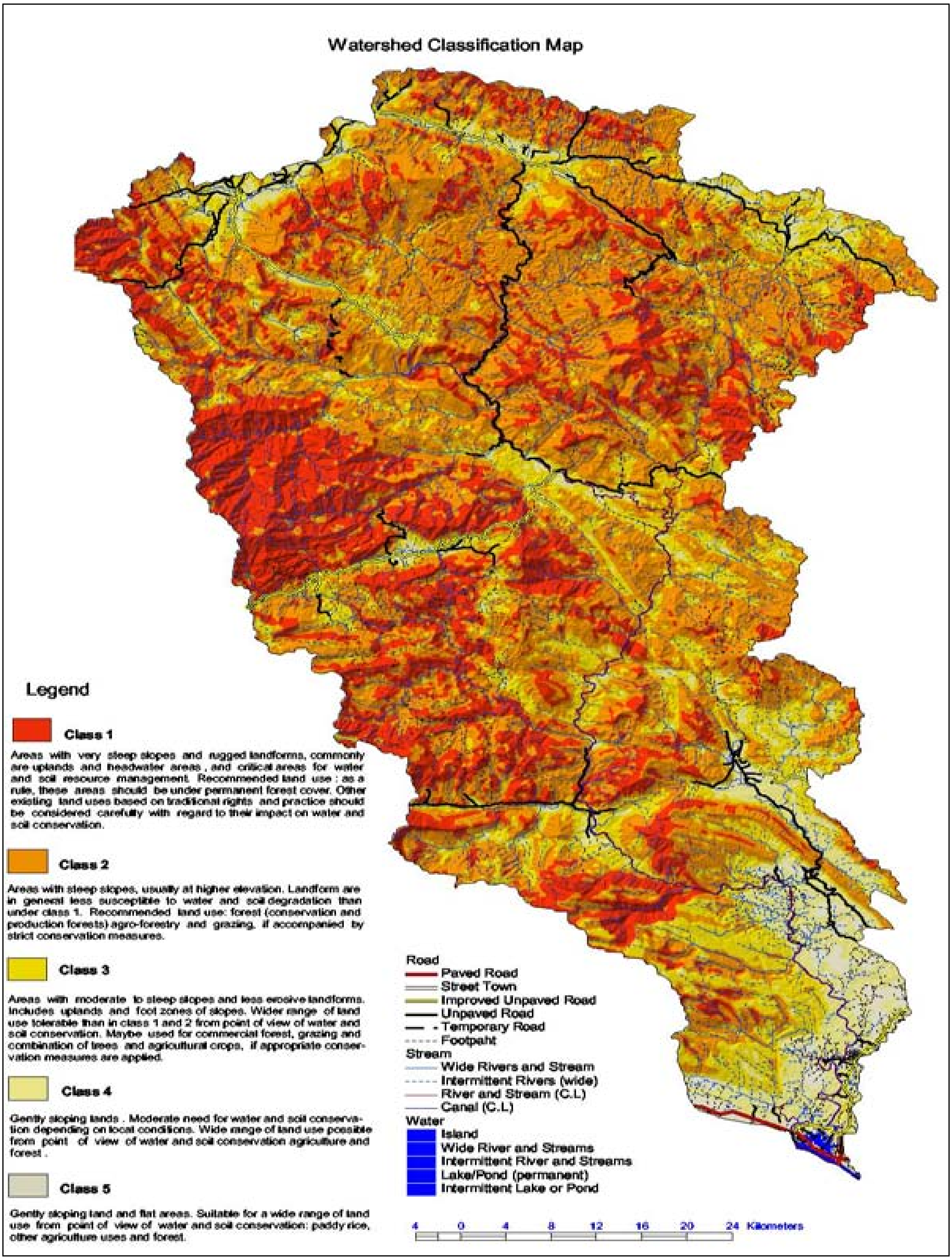



Figure 12-8 Watershed classification map.

### 12.9.2 VILLAGE FOREST AND L AND USE PLANNING AND AL LOCATION (VFLUPA)

The future sustainable management and use of land and forests by villagers is a critical component of planned and sustainable management and development of the watershed-as the two main fixed, physical components of a watershed are (a) soil/land and (b) the vegetation cover to this soil/land, while the main anthropogenic component of the watershed is villagers who use and modify the soil and its vegetation cover. Problems and issues in relation to forest and land resource management and utilization which have led the GOL, and this project, to implement the VFLUPA include:

- Unclear tenure or management responsibility over land and forest resources often leads to mismanagement and over exploitation;
- Lack of tenure rights is also a constraint to investment in productivity;
- Lack of clarity of village boundaries also leads to mismanagement and lack of investments or productivity; and
- The lack of a framework within which to promote the gradual stabilization of shifting cultivation.

Positive impacts of well conducted VFLUPA should include:

- Development of the understanding and the skills of GOL staff in their task of encouraging villagers to protect and manage the watershed into the future;
- Provision to villagers of a practical framework (and an understanding) within which they can care for and manage the watershed’s natural resources;
- Provision to villagers with a practical and legal framework for productive land tenure, thus encouraging them to make more investments in sustainable and productive land uses;
- Ensuring that the Nam Ngiep watersheds maintain or increase their forest cover, into the future; and,
- Ensuring the optimization of a seasonally balanced flow of water from the watershed.

Table 12-12 Responsible Parties for Watershed Zoning Management

| Party | Responsibility |
|---|---|
| PRMLCRC | Review of report on VFLUPA, review of proposed improvements in methodology, review of each village VFLUPA report, other direction as required. |
| PAFO | General direction, provision of technical advice, equipment and other facilitation |
| ESD | Technical assistance, mapping and database assistance, etc. |
| DAFO, other District agencies | Undertaken full range of village level participatory work: baseline surveys, surveys of fields and forest, participatory mapping and land use planning, PRA, etc. |
| District Land Office | Technical support, and land law, and provision of temporary land use certificates |
| District women's Union | Focus on socio-economic, food security and income generation data and planning, and ensuring gender balance and inclusion of the poor. |
| Village authorities | Provide information, labor as required, etc. |

# CHAPTER 13

# ENVIRONMENTAL MANAGEMENT AND MONITORING BUDGET

## 13.1 INTRODUCTION

An indicative budget is presented for the environmental management and monitoring of the Nam Ngiep 1 Hydropower Project (NNHP-1). There are four components to this budget. The first presents an estimate of the personnel and operating costs for the Environmental and Social Division of the NNHP-1 Project (Table 13-1). The second presents the estimated costs for the Environmental Management Unit under MONRE (Table 13-2). The third presents the estimated program budget for the various activities to be conducted under the Environmental Management and Monitoring Plan (Table 13-3) that are not already included in other budgets (such as construction costs). The final table presents the estimated budget for the Watershed Management Plan (Table 13-4).

# 13.2 INDICATIVE BUDGET FOR ENVIRONMENTAL MANAGEMENT AND MONITORING OF THE NAM NGIEP 1 HYDROPOWER PROJECT

### 13.2.1.1 PERSONNEL AND OPERATING COSTS

Table 13-1 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 amd 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** | 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** |

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Manager** | | | | | | | | | | | | | | |
| **Construction Monitoring Team** | | | | | | | | | | | | | | |
| Assistant EMO Manager | 1,500 | 1 | 1,500 | | 18,000 | 18,000 | 18,000 | 18,000 | 18,000 | 18,000 | | | | **108,000** |
| 2 field staff | 500 | 2 | 500 | | 6,000 | 6,000 | 6,000 | 6,000 | 6,000 | 6,000 | | | | **36,000** |
| **Environmental Monitoring Team** | | | | | | | | | | | | | | |
| Assistant EMO Manager | 1,500 | 1 | 1,500 | | 18,000 | 18,000 | 18,000 | 18,000 | 18,000 | 18,000 | 18,000 | 18,000 | 18,000 | **162,000** |
| 2 field staff | 500 | 2 | 1,000 | | 12,000 | 12,000 | 12,000 | 12,000 | 12,000 | 12,000 | 12,000 | 12,000 | 12,000 | **108,000** |
| Consultant | | | | | | | | | | | | | | **0** |
| **Health and Occupational Safety Team** | | | | | | | | | | | | | | |
| 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** |
| **Watershed Management Team** | | | | | | | | | | | | | | |
| Watershed Management Expert | 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 | | | | **72,000** |
| | | | | | | | | | | | | | | |
| **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** | | **652,800** | **652,800** | **652,800** | **652,800** | **652,800** | **652,800** | **261,600** | **261,600** | **261,600** | **4,701,600** |

| 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 | | | | | | | | | |
| Motrocycles | 3,000 | 10 | 30,000 | | 30,000 | | | | | | | | | |
| Total Vehicles | | | | | **210,000** | | | | | | | | | |
| | | | | | | | | | | | | | | |
| | | | | | **C 1** | **C 2** | **C 3** | **C 4** | **C 5** | **C 6** | **O 1** | **O 2** | **O 3** | |
| Total | | | | | 530,000 | 49,000 | 49,000 | 49,000 | 45,000 | 37,000 | 37,000 | 37,000 | 37,000 | |
| **Grand Total** | **7,755,600** | | | | | | | | | | | | | |

13.2.1.2 ENVIRONMENTAL MANAGEMENT UNIT

Table 13-2 Support to EMU

Monitoring will be conducted twice per year

| 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** |

### 13.2.1.3 ENVIRONMENTAL MANAGEMENT AND MONITORING ACTIVITIES

Table 13-3 Environmental Management and Monitoring Program Budget

| **Item** | **Unit** | **Quantity** | **Unit Price** | **Amount** | **Pre** | **C1** | **C2** | **C3** | **C4** | **C5** | **C6** | **O1** | **O2** | **O3** | **O4-8** | **>O8** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. Specific water quality monitoring program | yearly | 5 | 16,000 | 96,000 | | 16,000 | 16,000 | 16,000 | 16,000 | 16,000 | 16,000 | | | | | |
| 2. Air quality, Noise and Vibration monitoring program | | | - | 5,000.00 | | | | | | | | | | | | |
| 3. Timber logging | area | | 64,865 | 64,865 | 10,811 | 10,811 | 10,811 | 10,811 | 10,811 | 10,811 | | | | | | |
| 4. Vegetation clearing | area | | 527,124 | 527,124 | 87,854 | 87,854 | 87,854 | 87,854 | 87,854 | 87,854 | | | | | | |
| 5. UXO survey | area | | 600,000 | 600,000 | 600,000 | | | | | | | | | | | |
| 6.1 Water quality monitoring program | Yearly | 3 | 25,000 | 96,000 | | | | | | | | 24,000 | 24,000 | 24,000 | 24,000 | 24,000 |
| 6.2 Routine water quality monitoring program | Yearly | | 5,300 | 5,300 | | | | | | | | | | | | |
| 7. Groundwater hydrology and quality assessment program | Program | | 5,000 | 5,000 | 5,000 | | | | | | | | | | | |

| | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 8. Soil fertility monitoring | Yearly | | 10,000 | 160,000 | 10,000 | 10,000 | 10,000 | 10,000 | 10,000 | 10,000 | 10,000 | 10,000 | 10,000 | 10,000 | 50,000 | 10,000 |
| 9. Sedimentation monitoring | Yearly | | 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 |
| 10. Soil erosion and sedimentation control | Yearly | | 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 |
| **11. Water level monitoring** | | | | 0 | | | | | | | | | | | | |
| 11.1 setting up Station | Station | 3 | 10,000 | 30,000 | | 30,000 | | | | | | | | | | |
| 11.2 monitor water level and reporting | Yearly | | 1,000 | 15,000 | | 1,000 | 1,000 | 1,000 | 1,000 | 1,000 | 1,000 | 1,000 | 1,000 | 1,000 | 5,000 | 1,000 |
| **12. Flood warning plan** | | | | 0 | | | | | | | | | | | | |
| 12.1 Warning system | stations (down-stream) | 3 | | | | 15,000 | | | | | | | | | | |
| 12.2 Training | yearly | | 0 | 30,000 | | 2,000 | 2,000 | 2,000 | 2,000 | 2,000 | 2,000 | 2,000 | 2,000 | 2,000 | 10,000 | 2,000 |
| **13. Wildlife Protection program** | | | | 0 | | | | | | | | | | | | |
| 13.1 Collect baseline data | total area | | 50,000 | 50,000 | 50,000 | | | | | | | | | | | |

| | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 13.2 Logging and poaching | yearly | | 30,000 | 450,000 | | 30,000 | 30,000 | 30,000 | 30,000 | 30,000 | 30,000 | 30,000 | 30,000 | 30,000 | 150,000 | 30,000 |
| 13.3 Monitor animal Habitat | yearly | | 18,000 | 288,000 | 18,000 | 18,000 | 18,000 | 18,000 | 18,000 | 18,000 | 18,000 | 18,000 | 18,000 | 18,000 | 90,000 | 18,000 |
| 13.4 Monitor animal diversity and density | yearly | | | | | | | | | | | | | | | |
| 13.5 Forest regeneration | yearly | | 0 | 0 | | | | | | | | | | | | |
| 13.6 Monitor the vegatation and wildlife | yearly | | 0 | 0 | | | | | | | | | | | | |
| **14. 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 | |
| **15. Wildlife translocation** | yearly | | 30,000 | 90,000 | | 30,000 | 30,000 | 30,000 | | | | | | | | |
| **16. Forest regeneration** | total area | | 150,00 0 | 1,650,000 | | | | | 150,000 | 150,000 | 150,000 | 150,000 | 150,000 | 150,000 | 750,000 | |
| **17. Survey and monitoring of aquatic biota** | yearly | | 56,000 | 840,000 | | 56,000 | 56,000 | 56,000 | 56,000 | 56,000 | 56,000 | 56,000 | 56,000 | 56,000 | 280,000 | 56,000 |
| **18. TLs (Water quality analysis)** | event | 1 | 200 | 1,200 | | | | | | 1,200 | | | | | | |
| **Total, EMMP** | - | - | - | **5,331,489** | **791,665** | **328,665** | **283,665** | **283,665** | **403,665** | **404,865** | **305,000** | **313,000** | **313,000** | **313,000** | **1,469,000** | **151,000** |

13.2.1.4 WATERSHED MANAGEMENT PLAN

Table 13-4 Watershed Management Plan

| Watershed Management Fund | Yearly Budget | Cons Year 1 | Cons Yrs 2 - 5 | Oper Yrs 1 - 3 | Total USD |
|---|---|---|---|---|---|
| 1. Detailed study and finalizing WMP | 100,000.00 | 100,000 | | | 100,000 |
| 2. Forest encroachment reduction program | | | | | |
| 2.1 Headwater forest area | 33,333.33 | | 133,333 | 100,000 | 233,333 |
| 2.2 Zoning of landuse, forest use, resource use | 33,333.33 | | 133,333 | 100,000 | 233,333 |
| 2.3 Village forest management program | 33,333.33 | | 133,333 | 100,000 | 233,333 |
| 3. Water suppy for community use / agriculture | 50,000.00 | | 200,000 | | 200,000 |
| 4. Reduce soil erosion / maintain good soil | 30,000.00 | | 120,000 | 90,000 | 210,000 |
| 5.Small-scale fisheries for food security | 30,000.00 | | 120,000 | 90,000 | 210,000 |
| Total | | **100,000** | **840,000** | **480,000** | **1,420,000** |

# CHAPTER 14

# INSTITUTIONAL 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 Nam Ngiep 1 Hydropower Project (NNHP-1) build upon existing institutional structures that have been established for hydropower projects or that otherwise concern environment or social or economic issues relating to this project. The institutional arrangements are intended to provide the 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. The arrangements are also set up in such a way as to facilitate the concerns and needs of the main stakeholders – the project affected people, the project owners and developers, and the government – and to provide a framework for the participation of the project affected people, for the resolution of any grievances that may arise, and for the involvement of any other project stakeholders in the process.

## 14.1 INSTITUTIONAL ARRANGEMENTS DURING PRE-CONSTRUCTION AND CONSTRUCTION PHASE

The roles of the GOL at the national level will be provided through the Joint Steering Committee (JSC) and the Ministry of Natural Resources and Environment (MONRE) as the primary supervisory and monitoring body. A Secretariat of the JSC will include key government agencies and organizations involved in the environmental and social components of the Project, specifically the Department of Environmental and Social Impact Assessment (DESIA) of MONRE, the Department of Energy Promotion and Development (DEPD) of the Ministry of Energy and Mines, and the Resettlement Management Unit (RMU) established for this project.

An Environmental Management Unit (EMU) will be established in MONRE to oversee monitoring of the project. E nvironmental 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.

A Provincial Resettlement Management and Living Conditions Restoration Committee (PRMLCRC) 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 c ompensation, and for the expression and resolution of grievances.

A Resettlement Management Unit (RMU) will be established by the PRMLCRC to coordinate the work of the government in resettling the most severely affected people in the project area, together with the technical assistance, financial support, and related work of the project developers through the Project's Environment and Social Division.

At the project level, the project owners will establish an Environment and Social Division (ESD), responsible for assisting the relevant government agencies and programs in the implementation of the mitigation measures. An Environmental Management Office (EMO) in the ESD will be responsible for environmental mitigation measures and monitoring, while a Social Management Office (SMO) will be responsible for social and economic mitigation measures and monitoring, including assistance with resettlement efforts of the RMU.

The overall institutional framework is shown in the Figure 14-1. T his framework is indicative and might be modified during the implementation phase as agreed between the parties.

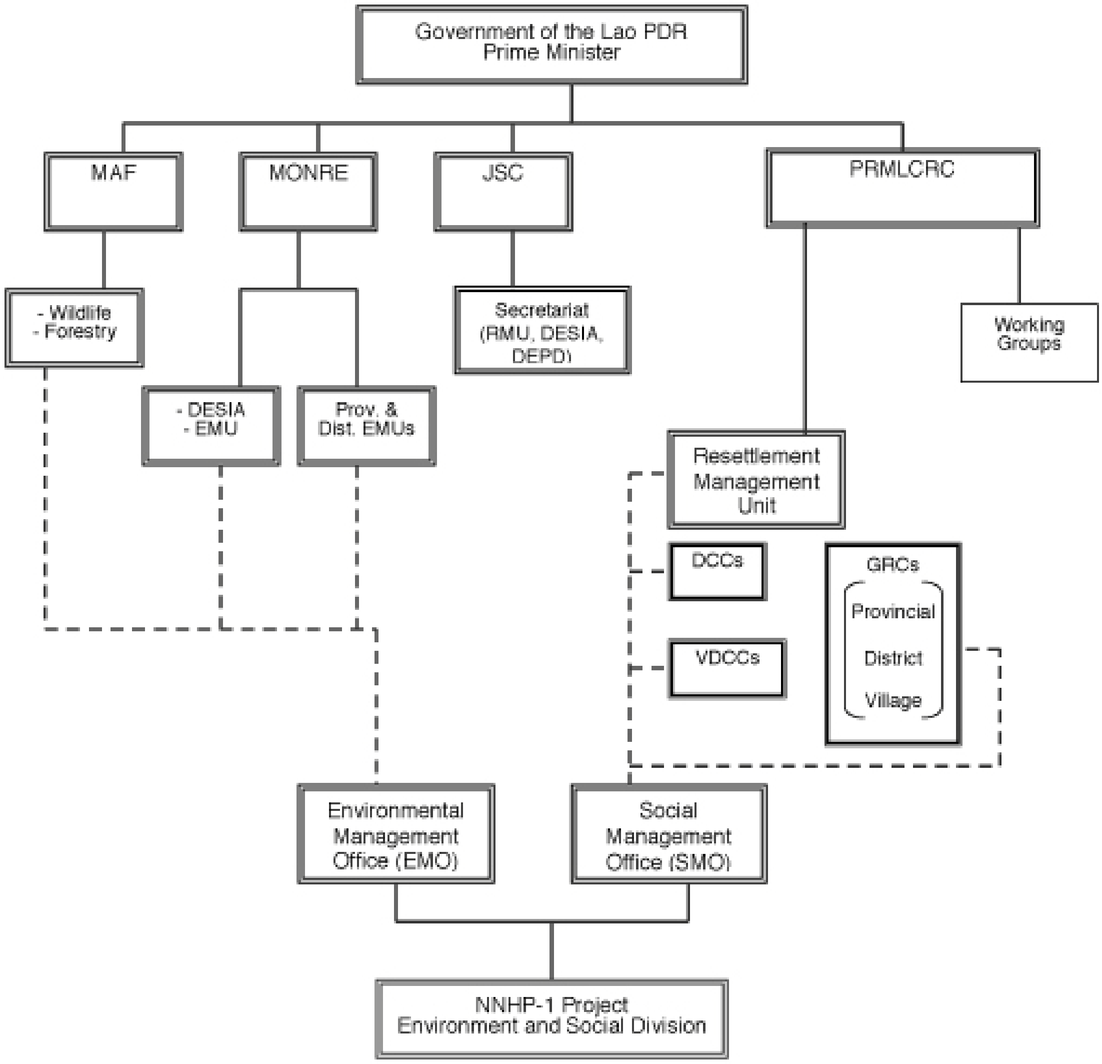



Figure 14 - 1 Institutional Arrangements for the NNHP-1 Project.

## 14.1.1 GOVERNMENT INSTITUTIONAL ARRANGEMENTS FOR THE PROJECT FOR PRE-CONSTRUCTION AND CONSTRUCTION PHASE

The GOL will establish the national level organizations responsible for setting policy and directions, for supervising and monitoring of NNHP-1. The project will provide additional resources so that these organizations can provide efficient and effective support to the implementation and monitoring of the mitigation measures and development programs under the project.

### 14.1.1.1 Joint Steering Committee

The Nam Ngiep 1 Project Joint Steering Committee (JSC) will be established by GOL to serve as a task force for the implementation of the NNHP-1 Project. It will be attached to the Department of Energy Promotion and Development under the Ministry of Energy and Mines.

Other members will include representatives from Electricitè du Lao, MONRE and the Resettlement Management Unit of the Project.

The JSC will lead GOL's public relations work and disclosure for the Project; provide GOL engineering staff and facilitate their work; coordinate with GOL project units and various government entities at national, provincial, and district levels; and monitor progress of the project.

#### 14.1.1.1.1 Environmental Management Unit

The main GOL agency dealing with environmental issues of the Project is the Environmental Management Unit (EMU), which will be established by MONRE to monitor the environmental components and mitigation measures of the Project. MONRE will coordinate as appropriate with other departments of GOL with respect to matters such as biodiversity, forests, wildlife, aquatic life and other matters. In addition to its monitoring activities, the EMU is also responsible for responding to any public comments, complaints and inquiries in relation to environmental aspects of the project.

EMU staff will be engaged full time on this project. They can be seconded from other offices or engaged as under contracts.

Provincial EMUs will be established in each of the provinces affected by the project, and District EMUs will be established in each of the districts affected by the project, to assist the EMU in monitoring the environmental impacts and the mitigations measures of the Project. Their work will be conducted with the support of and in coordination with the Environmental Management Office of the Environmental and Social Division of the Project.

**1) Staff of the Environmental Management Unit**

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 Department of Environmental and Social Impact Assessment (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 Provincial EMU will consist of:

- Head of the Provincial Natural Resources and Environment Division as Director, and
- Other staff from the provincial environmental office as required.

The District EMU will consist of:

- Head of the District Natural Resources and Environment Office as Direcgtor, and
- Other staff from the district environmental office as required.

**2) Responsibilities of the Environmental Management Unit**

The primary tasks of the EMU are to

- Review and make recommendations on the EMMP,
- Monitor the implementation of the EMMP (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 and coordinate with the Developer concerning all environmental grievances of APs,
- Provide the lead in public consultations on environmental matters concerning the Project,
- Inspect and identify measures to solve environmental issues created by the Project,
- Coordinate with central and local government agencies in the implementation of the EMMP,
- Review environmental reports of the Developer,
- Recommend the selection of an independent monitoring agency (IMA) for environmental matters, and coordinate work of the IMA on e nvironmental 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.

#### 14.1.1.1.2 Provincial Resettlement Management and Living Condition Restoration Committee

The GOL will establish a Provincial Resettlement Management and Living Condition Restoration Committee (PRMLCRC) to overseeing and monitoring the planning and implementation of the resettlement, compensation, livelihood restoration, and other social development activities of the project. The PRMLCRC will establish the Resettlement Management Unit (RMU), the District Coordination Committees (DCC), and the Provincial and District Grievance Redress Committees (PRGC and DGRC); and will supervise and instruct the RMU, the DCCs, and the Village Development Coordination Committees (VDCCs) concerning the implementation of the resettlement, compensation, livelihood restoration, and other social measures. T he PRMLCRC will be responsible for these activities in all areas affected by the Project, and will work closely with the Environment and Social Division of the Project.

Because the majority of resettlement activities will be in Bolikhamxay Province, including all the new resettlement sites, the chairperson of the PRMLCRC will be the Governor of Bolikhamxay Province. The Vice Governors of Vientiane and Xieng Khouang Provinces will serve as vice-chair persons. Other members will be District Heads of all the Districts affected by the Project, Directors of the relevant Provincial government offices, and a representative from the Lao Front for National Reconstruction. The Head of the RMU will serve as Secretary to the Committee.

#### 1) Structure of the PRMLCRC

The PRMLCRC shall comprise of the following members:

1. Governor of Bolikhamxay Province, Chairperson;
2. Vice Governor of Vientiane Province, Vice Chairperson;
3. Vice Governor of Xieng Khouang Province, Vice Chairperson;
4. Representative from Lao Front for National Construction, member;
5. Head of Pakxan District, Bolikhamxay Province, member;

6. Head of Bolikhan District, Bolikhamxay Province, member;
7. Head of Hom District, Vientiane Province, member;
8. Head of Thathom District, Xieng Khouang Province, member;
9. Director of the Provincial Department of Energy and Mines of Bolikhamxay Province, member;
10. Director of the Provincial Department of Energy and Mines of Vientiane Province, member;
11. Director of the Provincial Department of Energy and Mines of Xieng Khouang Province, member;
12. Director of the Provincial Department of Agriculture and Foresty of Bolikhamxay Province, member;
13. Director of the Provincial Department of Agriculture and Foresty of Vientiane Province, member;
14. Director of the Provincial Department of Agriculture and Foresty of Xieng Khouang Province, member;
15. Director of the Provincial Land Office of Bolikhamxay Province, member;
16. Director of the Provincial Land Office of Xieng Khouang Province, member;
17. Director of the Provincial Water Resources and Environment Office, Bolikhamxay Province, member;
18. Director of the Provincial Water Resources and Environment Office, Vientiane Province, member;
19. Director of the Provincial Water Resources and Environment Office, Xieng Khouang Province, member;
20. Head of the Resettlement Management Unit, Secretary.

**2) Environmental Responsibilities of the PRMLCRC**

Although the main work of the PRMLCRC 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:

- Determining compensation payments in kind or in cash for losses of the APs and their communities,
- 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,
- 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.

#### 14.1.1.1.3 Resettlement Management Unit

A Resettlement Management Unit (RMU) will be established by and serve under the direction of the PRMLCRC, consisting of officials seconded from relevant GOL agencies or personnel hired directly by the RMU. The RMU will administer the resettlement, compensation, livelihood restoration, and other social development activities of the project and ensure participation of all relevant GOL agencies in these activities. The RMU will work in coordination with the Social Management Office (SMO) of the Project.

The RMU and SMO will first work out of the main offices at the construction site, to help with the resettlement of Ban Hatsaykham to Ban Hat Gniun during the first year of the project. A field office will then be established in the resettlement area in Bolikhamxay Province, where most of the resettlement will take place. This office is also to be shared by the RMU and the SMO.

The RMU will be headed by a Director, who should have proven resettlement implementation experience. 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 Director 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 PRMLCRC, 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.

#### 14.1.1.1.4 District Coordination Committees

The PRMLCRC will establish District Coordination Committees (DCC) on recommendation of the RMU in districts affected by the project. The DCCs will work under the supervision of the PRMLCRC and the RMU, and in cooperation with the SMO. The DCCs will help implement the various resettlement, compensation, livelihood restoration, and other social development works of the Project. This will also include the construction or provision of roads, buildings, rural electrification, bridges, water supply and other infrastructure projects related to resettlement and livelihood restoration works; provision of health services, education, occupational training, and other social development programs; agricultural development programs; and cultural and ethnic minority programs.

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 staff as required.

#### 14.1.1.1.5 Village Development Coordination Committees

The DCCs will establish Village Development Coordination Committees (VDCC) as necessary in those villages affected by the project. With the support of the SMO and DCCs, the VDCCs shall be the implementing body for the management and implementation of the resettlement, livelihood restoration, and other social development works and activities. The VDCCs are expected to represent the villagers in the affected areas, and to voice their concerns and assure their needs are met.

The VDCCs will consist of the Head of the Village as Leader of the committee, and village authorities (Mass organisations, public security, defense, etc.), village elder representatives (naeow hom), Lao Women's Union representatives, other skilled members of the community, representatives of all ethnic groups, and representatives of all vulnerable groups, as members.

### 14.1.2 PROJECT INSTITUTIONAL ARRANGEMENTS FOR PRE-CONSTRUCTION AND CONSTRUCTION PHASE

The Project Developers 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, including resettlement, compensation, livelihood restoration, and other social development works. These are all to be carried out in close cooperation and in coordination with the relevant government organizations set up to implement environmental and social aspects of the project, such as the EMU, the PRMLCRC, the RMU, the DCCs and the VDCCs, and government agencies responsible for various works.

Among the ESD's responsibilities will be:

- 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, and
- 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.

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 NNHP-1 Project. The ESD will be the main contact between the project developer and the projected affected people concerning environmental matters.

#### 14.1.2.1 ESD Manager

The Developer will appoint an Environmental and Social Manager (ESM) to head the ESD on a full time basis. 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 EMP, SDP, and REMP 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 project manager.

The ESM will act on behalf of the Project Developer in dealing with GOL or other parties concerned with environmental, social, and economic impacts and components of the project. The ESM will be responsible for maintaining good relations and communications with the local communities. Other activities will include but not necessarily be limited to:

- Coordination, supervision, monitoring and reporting on activities undertaken in the EMP, SDP and REMP
- Liaising between the Project and the Consultants, GOL Agencies, and the contractors and concerned or contracted NGOs.
- Supervising and monitoring of field activities of sub-contractors in relation to implementing the EMP, SDP and REMP.
- Supervising specific routine technical tasks of the ESD such as water quality monitoring

To implement these tasks, the ESM will be aided by full time staff as required and part time international/or national consultants.

The ESD is composed of a Social Management Office (SMO), and an Environmental Management Office (EMO), as indicated in Figure 14-2

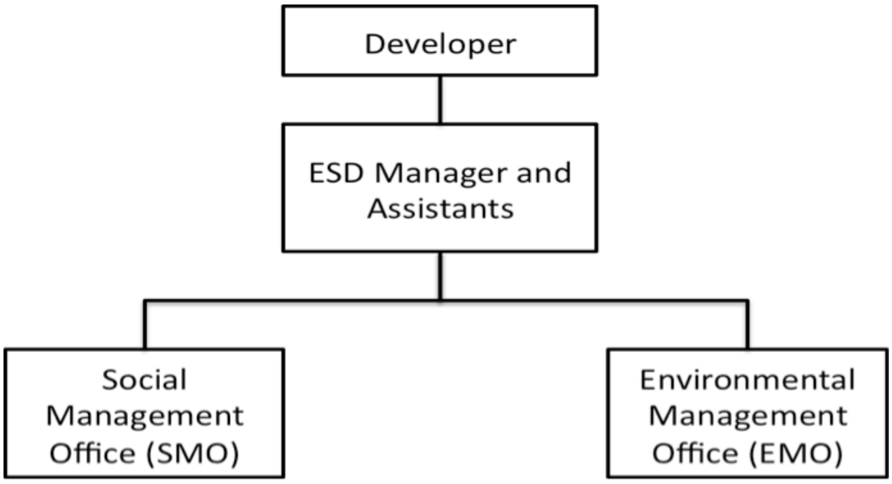



Figure 14 - 2 Components of the ESD.

**14.1.2.1.1 Social Management Office**

The Social Management Office (SMO) will work directly with the Provincial Resettlement Management and Living Conditions Restorations Committee (PRMLCRC) and the Resettlement Management Unit (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 P roject Construction Lands.

The SMO will be headed by a Manager with proven resettlement implementation experience, who will report directly to the ESD Manager, and work closely with the RMU and other GOL support staff (see below). The Unit will consist of three teams.

The tasks of the three teams in the SMO will be as follows:

<u>Infrastructure Team</u>

Coordinate with the RMU to:

- Ensure access to new sites/adjacent villages through the construction of new bridges and roads; and rehabilitation or upgrading of existing transportation facilities.
- 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.

Livelihood Team

Coordinate with the RMU to:

- Develop suitable agricultural cropping systems, and carry out extension and technical support work to ensure food security and income targets for resettled people and villagers in adjacent villages.
- Ensure sustainable livestock and aquaculture development for all households (resettled people and adjacent population) in the adjacent villages.
- 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.
- Monitor livelihood development until income targets are reached and sustained.

Project Lands and Compensation Team

- 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 PAP benefit from livelihood activities, where required.

- Coordinate with the RMU to valuate the assets lost due to construction activities in Project Construction Lands.
- Coordinate with the RMU to undertake cash compensation to entitled APs together with Compensation Disbursement Agent.

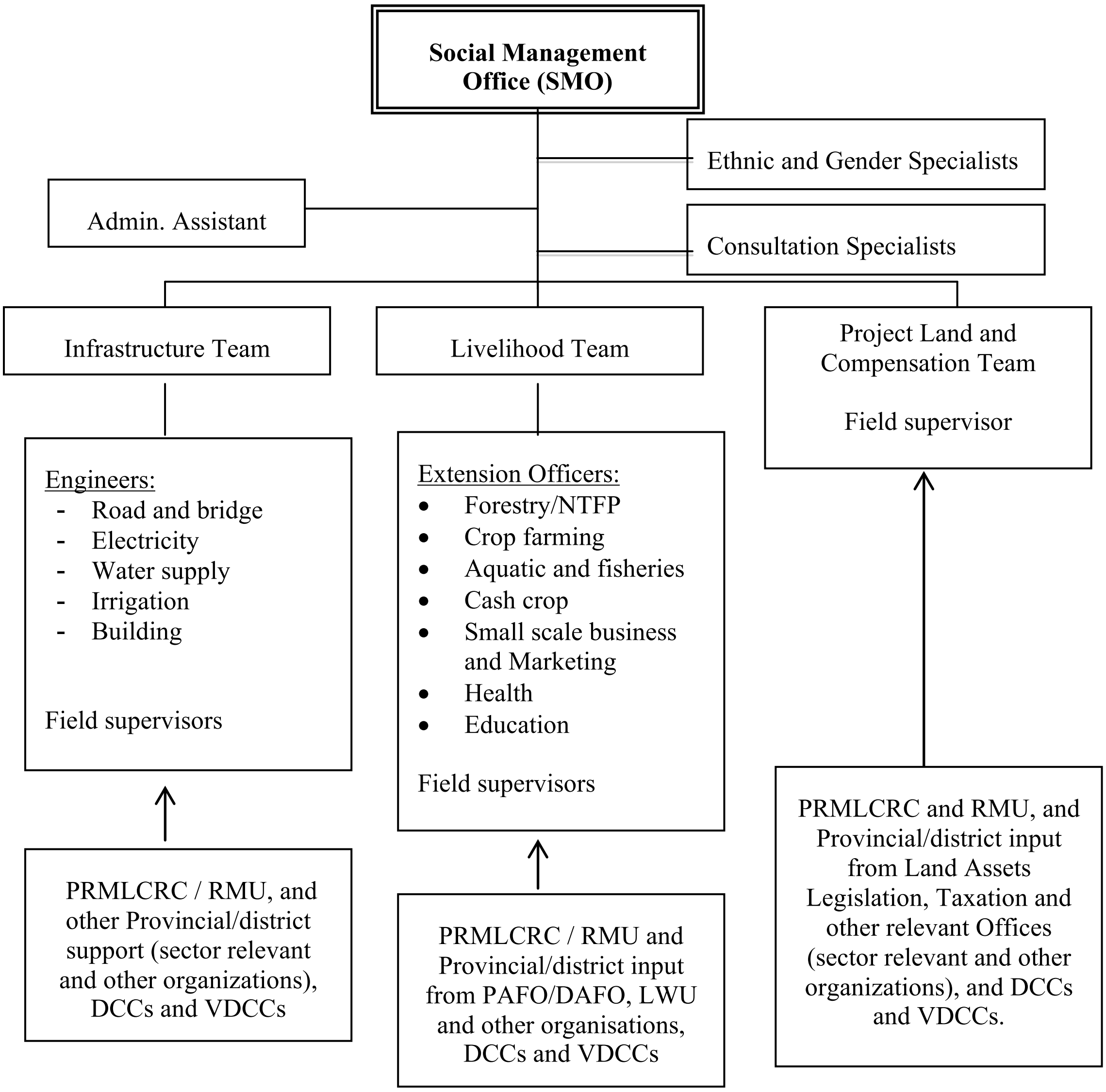



Figure 14 - 3 Organisation of the Social Management Unit.

Consultation Specialists and Ethnic and Gender Specialists

- Participatory planning support for resettled people and villagers in adjacent villages, ensuring that local concerns and beliefs are incorporated.
- Participatory planning for downstream, the watershed and project construction land areas.

- Establish consultation feedback loops between affected households and project implementing organizations.
- Ensure that gender and ethnic issues are incorporated into planning procedures and implementation.
- Ensure that all affected households are familiar with content and mechanisms of the Grievance Procedure.
- Pay special attention to vulnerable groups in the resettlement and livelihood development processes.
- Link up with NGOs for community development initiatives.

**14.1.2.1.2 Environmental Management Office**

The major tasks of the Environmental Management Office (EMO) are to

- Collect all the baseline data and information and conduct subsequent monitoring of all aspects of the environment that could be affected by the project, such as fish and other marine resources, hydrology, water quality, river bank erosion, forest cover, etc., and
- Coordinate with the EMU and other GOL agencies to implement the mitigation measures in the EMMP.
- Coordinate with GOL in watershed management issues
- Coordinate with GOL in health and educational matters for communities that are not included in the resettlement program.
- Assist the EMU in public consultations on environmental matters with the APs and other stakeholders.

The EMO should have 5 teams:

<u>Environmental Compliance and Monitoring Team</u>

- Establish baseline data on the status of the project area environment in the watershed, upstream, dam site, downstream and resettlement areas.
- Carry out as planned the daily, weekly or monthly monitoring of various environmental conditions.

- Prepare reports for the ESD Manager to present to the appropriate government agencies for the timely management of the environment in the Project area.
- Coordinate with the EMU and other GOL agencies in the implementation of mitigation and prevention measures.

Construction Monitoring Team

- Prepare detailed plans with the contractors on the management and mitigation of environmental aspects of different construction sites, including access roads and transmission lines.
- Ensure the contractors provide adequate environmental facilities and management for the work sites.
- Monitor safety of the workers in the work sites.
- Prepare 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.

Health Team

- 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 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 da m-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.
- 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.

Education Team

- Facilitate development of a comprehensive education and training strategy and plan for project-affected groups outside the resettled communities.
- Oversee the reestablishment and upgrading of school facilities
- Assist District and Provincial education authorities in recruiting teachers and link up with GOL education initiatives.
- Monitor education programs and school attendance.

Watershed Management Team

- Facilitate development of a watershed management strategy and plan for the project.
- Coordinate with relevant GOL agencies in the implementation of the watershed management plan
- Monitor watershed conditions that might affect the project (such as erosion and sedimentation) in areas of the watershed outside the immediate project area, and recommend remedial measures to the appropriate GOL agencies.
- Work with the appropriate GOL agencies in the planning and implementation of the recommended remedial measures


Figure 14 - 4 Structure of the Environmental Management Office

# 14.2 INSTITUTIONAL ARRANGEMENTS FOR OPERATION PHASE

## 14.2.1 GOVERNMENT INSTITUTIONAL ARRANGEMENTS FOR OPERATION PHASE

For the first years of operation, the GOL institutional arrangements will remain the same as for the construction phase.

### 14.2.1.1 Resettlement Arrangements

The Provincial Resettlement Management and Living Condition Restoration Committee (PRMLCRC), as well as the Resettlement Management Unit, the District Coordination Committees, and the Village Development Coordination Committees all established under the direction of the PRMLCRC, will continue to function for the first three years of operations, when resettlement works are to be completed.

### 14.2.1.2 Environmental Management Unit

The Environmental Management Unit (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.

## 14.2.2 PROJECT INSTITUTIONAL ARRANGEMENTS FOR OPERATION PHASE

For the first three years of operation, the project institutional arrangements will remain the same as for the construction phase. There will continue to be an Environmental and Social Division, which will consist of a Social Management Office and an Environmental Management Office.

#### 14.2.2.1 Social Management Office

The Social Management Office 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.

The Project Land and Compensation Team will end its work as soon as all the compensation matters have been completed.

The Infrastructure Development Team will also greatly reduce its staff and responsibilities as the infrastructure works are completed and operating. Only some minimal staff will remain in this team for the first three years of the operation phase, to monitor the results of the infrastructure works and to make any necessary repairs.

The key team that will remain during the first years of the operation phase will be the Livelihood Team, which will continue to function until the resettlement activities are deemed completed.

#### 14.2.2.2 Environmental Management Office

The Environmental Management Office 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 Construction Monitoring Team will end its functions as soon as construction works are completed. Any remaining monitoring activities of this team that need to be carried into the operation phase will be taken over by the Environmental Compliance and Monitoring Team.

The Health and Occupational Safety Team and the Education Team will gradually reduce their staff and work as their health and education works become part of the normal GOL programs, with a tentative end to their work in the third year of the operation phase. The occupational safety aspects of the Health and Occupational Safety Team will be incorporated into the normal operating procedures of the Project.

As watershed management activities become mainstreamed into a broader GOL watershed program, the work of the Watershed Management Team will also be reduced, and remaining monitoring and compliance functions be transferred to the Environmental Compliance and Monitoring Team.

The Environmental Monitoring and Compliance Team will continue its monitoring work throughout the operation phase, with a remaining staff at a level appropriate for the greatly reduced requirements.

## 14.3 GRIEVANCE REDRESS COMMITTEES

The PRMLCRC in consultation with appropriate authorities will establish the Grievance Redress Committees (GRC) at the village, district and provincial levels, to address any complaints and grievances pertaining to land acquisition, compensation and resettlement that are brought forward by APs.

Details about the Grievance Redress Process and the various committees are presented in Chapter 11 of this report.

# CHAPTER 15

# 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.

## 15.1 ADAPTIVE MANAGEMENT

### 15.1.1 ADAPTIVE MANAGEMENT APPROACH

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. In this way of system monitoring, decision making simultaneously maximizes one or more resources objectives and, either passively or actively, accrues information needed to improve future management. Adaptive management is a tool which should be used not only to change a system, but also to learn about the system. Because adaptive management is based on a learning process, it improves long-run management outcomes. The challenge in using adaptive management approach lies in finding the correct balance between gaining knowledge to improve management in the future and achieving the best short-term outcome based on current knowledge.

Project such as NNp1, pursuing sustainability strategies employ an adaptive management framework to ensure that the organization is prepared to deal for the unexpected and unanticipated and geared for change. During the development phase, consultants have set up the general environmental and social management framework plan for the developer and later the Company 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 may need to be reflected in the presently allocated budgets and financing for these measures.

## 15.2 REPORTING BY THE DEVELOPER

### 15.2.1 REGULAR REPORTING

#### 15.2.1.1.1 Monthly Reports

The Developer will prepare monthly reports of environmental matters. This will begin immediately after the start of construction works and continue until the end of the Concession Period. These monthly reports will be prepared in a unified format to be approved in advance by MONRE. They will be submitted in both hard copy and digital version. Information in these reports will include:

- Progress made to date on implementation of environmental measures, as measured against the submitted implementation program;
- Difficulties encountered in implementing the environmental measures and recommendations for remedying those difficulties and steps proposed to prevent or avoid similar future difficulties;
- Number and type of non-conformances with the environmental measures and proposed remedial measures and timelines for completion of remediation;
- Relevant information from reports received by the Developer from Construction Contractors, Subcontractors, and the Project Operator;
- Accidents or incidents relating to the health, safety, and welfare of stakeholders and the environment; and
- Monitoring data of environmental parameters and conditions as committed in the EIA, EMMP-C, and EMMP-O.

#### 15.2.1.1.2 Annual Reports

The Developer will prepare and submit to MONRE annual reports, at a time and in a format agreed upon with MONRE. These reports will be submitted in hard copy and digital versions. Information in these reports will include:

- A summary of the items covered by the Monthly Reports;
- Gantt diagram showing the activities (construction works, environmental measures, monitoring) carried out during the period, as 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 EMMP-C, EMMP-O and EMP.

#### 15.2.1.2 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, the Developer will report in writing as soon as possible, but no more than seven (7) days of 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.

The Developer 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 APs.

## 15.3 REPORTING BY INDEPENDENT MONITORING AGENCY

An Independent Monitoring Agency (IMA) is to be engaged by GOL and funded by the Developer 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, IFIs, lenders, and the general public.

Independent monitors will not start their 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.

## 15.4 SUMMARY OF REPORTING AND DISCLOSURE ARRANGEMENTS

The proposed reporting arrangements related to environmental and social issues are presented in Table 15-1 below.

| Report & documents | Source | Frequency (times/year) | Disclosure [a] |
|---|---|---|---|
| Monthly Report | Developer | • 12 during construction, | Yes |
| Annual Report | Developer | • 2 during operations | Yes |
| Independent Monitoring Agency (IMA) Report | IMA | • 2[b] | Yes |

[a] Public disclosure either on the project's website, or that MONRE, and on applicable IFIs website.

[b] IMA will review the quarterly reports and other pertinent information, and submit semi-annual reports.

## 15.5 REVIEW BY GOL

The main agency responsible for review of environmental reports prepared by the Developer and by the IMA will be the Environmental Management Unit.

The EMU will be responsible for any subsequent reporting of information from the reports of the Developer and of the IMA to other offices in MONRE and to other GOL agencies.

## 15.6 MONITORING BY THE DEVELOPER AND OTHER PARTIES

### 15.6.1.1 MONITORING ARRANGEMENT

Monitoring arrangements proposed for the NNp1 Project 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 was 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.

#### 15.6.1.1.1 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 of specific local environmental and social activities and help to coordinate interviews with contractors’ representatives, village authorities, and project affected households, if required.

#### 15.6.1.1.2 Monitoring and inspections by MONRE

MONRE will have the possibility 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.

# CHAPTER 16

# CONCLUSION AND RECOMMENDATION

## 16.1 CONCLUSION

### 16.1.1 PROJECT INFORMATION

| | |
|---|---|
| Project Name: | Nam Ngiep 1 Hydropower Project |
| Project Owner: | Nam Ngiep1 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 50 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 for the safety to the downstream area of the re-regulation dam. The re-regulation power station is planned to generate the power of 17.8 MW (Plant output at the switchyard). |

### 16.1.2 EXISTING ENVIRONMENTAL QUALITY

#### 16.1.2.1 Surface Water Quality

Generally, surface water quality in the project area is ranging from moderate to good, depending on the level of human activities near the project area where the water was tested. However, the quality of water could be poor when there is more human activities. There is evidence that water quality is being deteriorated, especially in the lowland plains of Pakxan district near the Mekong River. In upstream reaches of the Nam Ngiep River which remains relatively undisturbed until few villagers shift their cultivation and grew industrial trees. Even with such a low population, the agricultural practices and the residential activities could directly pollute the Nam Ngiep River. Therefore, the water samples were collected along the river to cover all types of existing land usage including natural areas, agriculture lands, residential areas, and other types of discharges that change or lead to deterioration in water quality.

The studies revealed that natural water temperatures ranged between 24°C to 31°C in April and 24°C to 30ºC in October. Other physical properties such as conductivity, salinity and hardness were natural as expressed through the good freshwater and less disturbed forest in the upper catchment. 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. Its average value was about 83 ppm in April and 17 ppm in October.

DO concentrations were high within a range of 7 and 10. However, correspondence water quality to the nutrient concentrations showed that the nitrate concentration in April was higher than October. The increasing of nitrates during the rainy season might be from the runoff discharged of nitrate-pollutant that generated 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 October was classified as Class 2 according to the Thai Surface Water Standards. This means that very clean fresh surface water resources can be used for consumption with the simple water treatment. It was also appropriate for aquatic organism for conservation, fisheries and recreation. However, the quality of water in April fell to Class 3 according to the Thai standard, which is medium clean fresh surface water resource. It can be used for agriculture but that required water treatment prior to use for consumption. The incremental of $BOD_5$ was caused by the nutrients flushed from the agricultural lands and residential areas into the river during the start of the rainy season.

### 16.1.2.2 Groundwater Quality

Water quality of the sample collected from the well at Ban Somseun was good according to the Groundwater Quality Standard for Drinking Purpose as notified in the Lao National Environmental Standard. However, the water was slightly acidic due to the presence of waterborne disease contaminated in the well water, as found in the WHO/UNICEF Joint Monitoring Programme. It is to be noted that residents of Ban Somseun do use water from the well and also from the Nam Ngiep River for their domestic use.

As for potential water contamination from existing mineral resources and mines, the chance of contamination from mines is extremely small since the closest mines are located quite far from the project reservoir.

### 16.1.2.3 Noise and Vibration

Only one community, Ban Hat Gnuin, about 3 km from the construction site to the west, which is close to the dam site enough to be affected by noi ses and vibrations during construction or operation phase. There are 395 residents in Hat Gniun and 86 s tudents attending to 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. Noise and vibration annoyance in this community must be considered and controlled to an acceptable levels by not to disturb the life of residents and students.

Due to the actual background noise and vibrations were unable to measure, reference to other projects and activities similar to the NNHP-1 Project. In particular, the background sound level of the Hutgyi Hydropower Project in Kayin state and the south of Myanmar, were compared and applied to 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 is 60 dB(A) in the small towns with vehicular noise and sometimes as major 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 were mostly the two-wheel tractor and the natural acoustic environment, so sound levels should be 40 to 60 dB.

#### 16.1.2.4 Air Quality

The baseline ambient air quality of the project site could not be obtained because there is no permanent air quality monitoring station in the Project area. Conducting a site specific monitoring is also not possible because the permission was not granted during the period of field assessment. However, the project area is situated in a low density of industrial pollution and transportation activities and no sources of major pollutants in the project area, hence air quality is expected to be good. . In addition, the study results in “The Lao PDR Environment Monitor 2005” of the World Bank showed that overall air quality is currently at acceptable levels in both urban and rural areas in Lao PDR. Therefore, it is reasonable to expect that the ambient air quality in the project area is considered to be in good quality.

#### 16.1.2.5 Potential Contaminated Sites

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. As no pot ential mineral resources located in the region, there was no contaminated site from minerals or mineral extraction that could cause hazardous contamination in the project area. There is also no industrial activity within or immediately adjacent the Nam Ngiep River basin.

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 area. These wastes were mostly organic and plastic waste. Plastic bags remained scattered throughout the villages while organic waste will be degraded. Furthermore, waste from animals such as water buffaloes, cows, and fowl can mix with runoff and flow through the riverbank down to the river body.

#### 16.1.2.6 Terrestrial Ecology and Wildlife

At present, the only remaining viable wildlife habitats are on t he steep and relatively inaccessible slopes of undisturbed forests outside the project area. Within and around the Project Area, wildlife conditions were surveyed and assessed by visual inspection and interviews with villagers. Additionally data and information were gathered from previous assessments and from local authorities who responsible for wildlife, forestry, and related activities.

The definition of wildlife used for the purpose of this study consists of 4 gr oups of animals: mammals, birds, reptiles, and amphibians.

Mammals: There was considerable mammals in the project area, both in number of species with higher populations. At the present, mammal widely were extensively hunted or captured, most of these species are no longer seen or only rarely seen in the areas where the dam and reservoir are located. Some of agile animals migrated down the steep slopes to the river, and this will still be possible for them after the dam is built.

Birds: Data on bird species was recorded during interviews and field surveys and compared with the list of species found in Lao PDR. Some species in this list were derived from authoritative sources in Lao PDR, however, not all listed species have adequate supporting evidence. Some of them had been mentioned in interviews, but no evidence of their actual existent during the field surveys such as two globally threatened vulnerable species were identified which were the green peafowl and the Rufous-neck hornbill (*Aceros nipalensis*). There are also other species in the IUCN Red List (2009) found in or near the project area or identified through interviews.

Reptiles and Amphibians: Reptile and amphibian species were recorded. These included turtles, tortoises, monitors, varanus spp., python spp., and king cobra. Provisionally at-risk species that were recorded as present from the surveys include the Reticulated Python and the Water Monitor. None of the reptiles are on the IUCN Red List (2009). Only 5 of the amphibians are listed.

Official forest classification for most of the project area is largely (1) unstocked forest that is a part of the cycle of slash and burn agriculture and (2) mixed forest where is located either on areas of steep land where the forest is inaccessible or on poor soils, unsuitable for upland rice and other crop production. The original forests of the Northern-Central Highlands, where the project is located, were predominantly dried evergreen and mixed deciduous forests. However, shifting cultivation has removed much of the original forest and large areas of grassland, bamboo which are now replaced by vegetation. Non-timber forest products (NTFPs) such as leaves, shoots, flowers, fruits and bark are used extensively by the Lao people. They are very important as food source, medicinally and also cultural usage.

According to the field reconnaissance survey and interviews, a larger portion of the project area was already disturbed many years ago. Forests have not only been converted to various usage, mostly agriculture and also burning for hunting and illegal logging within and near by the proposed reservoir and dam site. The land is a medley of vegetation communities, with local agricultural practices heavily impacting on species composition and maturity.

Three main forest types are found in the area of the Nam Ngiep 1 Hydropower Project; Dry Evergreen Forest, Mixed Deciduous Forest, and Unstocked Forest.

The main NTFPs found in the project area are bamboos and bamboo shoots, rattans, mushrooms, and agarwood. Most villagers around the project area collect NTFP mostly for daily life usage as food and household consumption. They are not for commercial purpose because the area is far from the town and market.

There are two National Biodiversity Conservation Areas (NBCAs); Phou Khao Khoauy and Nam Ka Ding area, Vientiane and Bolikhamxay provinces, respectively. However, both NBCAs are located far from the project area. The project does not pose any direct threat to an NBCA or major protected forest. However, it is situated some important forests reserve area including village conservation forests and special spirit pool forests at Namyouak, Sopyouak and Sopphuane Villages, Hom District and at Hatsaykham Village, Bolikhan District. These are on steep terrains, relatively inaccessible lands to humans, allowing the vegetation to remain relatively intact and keeping the areas as viable sites for a number of species. Especially, these forest reserves are at elevations above the reservoir flood level.

#### 16.1.2.7 Aquatic Biota

Because the Nam Ngiep River passes through different habitats with elevations ranging from 1,300 m at the source to 200 m above the mean sea level (MSL) at its convergence with the Mekong, it supports a large variety of aquatic biota. The survey in this study found 42 fish species along the Nam Ngiep River. They are common species that can be found in other water bodies in Lao PDR and are not categorized as Red List species by the IUCN (2009). Many species are caught almost daily and sold at local fresh markets. Most fish sold at the markets were juveniles. Cyprinidae were dominated and accounted for 24 species. The other species were in the Bagridae family (3). The other families, such as Notopteridae family and Siluridae were represented by only 1 or species each.

The 42 fish species caught in the project area can also be classified into three groups according to their feeding habits; surface feeders, bottom feeders, and mid-water (column) feeders. The column feeders (mid-water) comprised of the largest proportion, accounting for 38.10% of the total, followed by both surface feeders and bottom feeders, each accounting for 30.95% of the total. Most of the surface and mid water fish were cyprinids, accounting for over half to the total fish population in the river (54.8 %).

The Nam Ngiep River has a great diversity of plankton species. About 104 species were found in the project sites, of which 64 were phytoplanktons and the other 40 species were zooplanktons. During the dry season, most of the river becomes shallow, so that light can penetrate into the water for longer periods and with higher light intensity. This can accelerate photosynthesis for the planktons and algae to grow.

In addition, twelve species of benthic fauna were found in Nam Ngiep project area. The most abundant species were earthworms. Other species found mostly in the mid-part of the river that will be most affected by the project are the Mayfly Nymph and the Stonefly Nymph. The remaining 8 invertebrate species were found at much lower density. The higher density of earthworms indicates the soils around these areas are in a virgin or near virgin stage. Earthworms and other insects are excellent food for many kinds of local fish. Some species of benthic invertebrates are very sensitive to environment, such as water temperature, turbidity, and flow pattern.

### 16.1.3 RESULTS OF ENVIRONMENTAL IMPACT ASSESSMENT

16.1.3.1 During Construction Period

**(1) Water Quality**

Suspended Solid is expected to have a major impact on water quality downstream during construction 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. 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 by runoff. The soil erosion during the rainy season that causes sedimentation downstream 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 major 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 a settling pond. When there is the peak of 1,800 workers, with estimated wastewater of 50 L/day/person, the project could produce a total of 90,000 L/day or 1.0 x $10^{-3}$ $m^3/s^2$ 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 the rate of 1.0 x $10^{-3}$ $m^3/s$ will not have a significant impact on water quality.

### (2) Noise and Vibration

During the construction phase, activities that can cause noise impacts to the surrounding area include cutting and land excavation, and moving equipment and materials for construction. Typically, construction-site noise levels are about 80 - 90 dBA, measured 50 feet (15.24 m) from the activity. Ban Hat Gniun lies about 3 km, or nearly 9,900 feet, from the construction site, so the noise level would be less than 50 dBA.

Noise impacts can occur throughout the construction phase. The Project will involve the use of many different types of equipment and activities. Raw materials for construction will be transported from the Thai border by trucks along the newly constructed access road. The noise impacts from this transportation will be low, because there are few residential areas along the new road. However, where the road does pass near a community or a house, the contractor should take measures to mitigate the impacts of noise on those residences during transportation.

### (3) Air Quality

At the construction site, dust particles and fugitive dust from the construction activities, the emissions from on-road vehicles associated with the construction site and on-site machinery (off-road emissions) need to be controlled. In addition, the land clearing and surface excavation activities, construction of water conveyance systems, tunnels, and distribution systems also represent potential sources of air emissions from point sources. Increased traffic on unsealed gravel road surfaces will contribute to air pollution by the generation and release of fugitive dust. All of these activities can lead to considerable negative impacts on the ambient air quality at the project site. However, the impacts can be limited through good construction management practices. The contractor should implement an emission and dust control plan within their environmental protection and mitigation framework. The emission and dust control plan should include methods for dust suppression resulting from quarry sites, crushing and batching plans, including road construction, embankment and channel construction, haulage of materials and construction of work camps.

### (4) Potential Contaminated Sites

For hazardous sources, the possible sites of contamination were determined by reviewing plans of transport, storage, and use of hazardous substances during project construction. The chemicals that must be used for the project during construction were reviewed to predict the potential site contamination. The project materials that would be stored in the construction site and could cause hazardous contamination to the environment were determined to be explosive materials, fuel (diesel, LPG), lubricant oils, pesticides and paints. The activities that involve hazardous materials are; used chemical and storage, drum reconditioning or recycling, electric transformers, used explosive and storage, landfills, pest control, used petroleum product and oil storage, and scrap yards. Hazardous materials used for the Roller-Compacted Concrete, RCC, were also considered. Since the functional units during construction are projected to be close to the river, the risk enhanced by high slope surfaces would be increased. The cut-and-fill technique that is planned for application for the high slope can only retain the contamination. Stringent management of hazardous materials to prevent spills must be applied to the construction sites.

For non-hazardous contamination, sources of waste, and potential contamination sites were determined based on plans for construction. Human waste and wastewater of the workers could also be a source of land and water contamination. It is estimated that 1,000 to 1,800 persons will work for the project on a daily basis for six years; thus solid waste is expected to generate by 2,000 to 3,600 kg/day. 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 and plant year, the potential quarry site near the river, and other sites where project activities will be carried out that could run the risk of contamination.

**(5) Terrestrial Ecology and Wildlife**

The project will cover parts of three provinces, and 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. None of the reservoir area or other project area is situated on conservation forest or protected area.

The construction of the Nam Ngiep Hydropower Project will not have a significant impact on wildlife in the area. That wildlife will not be affected by the reservoir, resettlement, or other project-related activities. The areas of the reservoir, dam, and re-regulation dam are not significant for wildlife migration, breeding, or feeding. Whatever remaining wildlife found in the project area lives mostly in the higher elevations, and these have been and are still being indiscriminately and extensively hunted and captured. Another threat to local wildlife would be hunting of the animals by construction workers and other project staff. Prohibitions to hunting must be strictly enforced.

As a main objective project component that reservoir would be provided, the impact from the lost of forest area is realized. The comparative lost of forest between NNHP-1 and Nam Theun 2 showed that NNHP-1 ratio in term of lost forest per MW (24.2 ha/MW) less than Nam Theun 2 (41.7 ha/MW).

**(6) Aquatic Biota**

The Nam Ngiep River does not host as many fish species as most other Mekong tributaries. Furthermore, the fish are all common species that can be found in other water bodies Small cyprinidae, the dominant species in the river, can adapt to the different environments in the various sections of the river.

Dust and sediment would be produced from construction activities and cause turbidity. This turbid water can prohibit penetration of sunlight to deeper layers in the river, and reduce the population of plankton, consequently leading to a decrement of fish biomass. To prevent sediment discharging to water, sediment controls e.g. sedimentation pond, silt fence, check dam, and any other best practices should be adopted during construction.

To avoid pollution that can affect aquatic species, toilet, cooking, and other facilities must be maintained and must avoid releasing waste or sediment into the river. Construction materials must be adequately stored to avoid leaching of pollutants from those materials.

16.1.3.2 During Operation Period

**(1) Water Quality**

After reservoir impounded, 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 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 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 that 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 ability 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 included the load of sediment in the reservoir and the change in downstream water quality caused by altered flow pattern. The sedimentation would also imply reduced levels of dissolved phosphorus ($P\text{-}PO_4$) concentrations, total phosphorus (TP) concentrations, nitrate ($N\text{-}NO_3$) and ammonium ($N\text{-}NH_4$) downstream during normal operation. However, during the early stage of inundation, the nutrients trapped in the reservoir could be a source for algal bloom, 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 made 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 was considered as 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 major activities that can create noise and vibration impact.

**(3) Ambient Air Quality**

The operation phase does not have major activities that can 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 having contaminated sites 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 and improperly stored. Meanwhile, this contamination would be limited only to the areas where applied.

For non-hazardous contamination, sources of waste, and potential contamination sites were determined as very low during operation period.

**(5) Terrestrial Ecology and Wildlife**

The operation or other project-related activities of the Nam Ngiep Hydropower Project will not have a significant impact on wildlife in the area. The remaining wildlife found in the project area lives mostly in the higher elevations, and these have been and are still being indiscriminately and extensively hunted and captured.

Based on the 320 MSL full supply level (Full Reservoir Load), it was shown that inundated lands will consist of about 1.62% Dry Evergreen Forest and approximately 40% Mixed Deciduous, while the largest portion of the reservoir area (almost 46%) is covered by unstocked forest and scrub and about 2% Bamboo forest. Apart from these, some agricultural land will be affected: 3.3% of the area is shifting cultivation and 7% is rice paddy fields. Although there remains some relatively undisturbed forest in the upper part of the proposed reservoir and near the dam site, these represent only a fraction of the surrounding forest so that inundation of the reservoir will cause minimal disturbance to the wildlife in the area.

**(6) Aquatic Biota**

The fish in Nam Ngiep River are all common species that can be found in other water bodies and can adapt to the different environments in the various sections of the river. If there is a large amount of anaerobic sediment, this will certainly degrade the downstream water quality. Aquatic life and human use of water would be adversely affected by temperature differences and sudden oxygen depletion.

After dam closure, all migratory fish will face a permanent barrier to their migration paths. 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 initial 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. To prevent this impact, it is strongly recommended to clear the existing trees as much as possible in reservoir prior to inundation to minimize the amount of biomass.

Moreover, 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. In addition, fisheries enhancement and management program should be introduce and maintain indigenous fish populations by facilitating new breeding ground and feeding habitats following the construction phase, both in the reservoir and in alongs the river.

## 16.2 RECOMMENDATIONS

Recommendations toward the Project are as follows:

### 16.2.1 BASELINE DATA

The impact assessment requires essential baseline data to provide better assessment and prediction on the future trend on environmental quality. Due to 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 pre-construction period and construction period to provide essential baseline data. In addition, it will be 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.

### 16.2.2 DOWNSTREAM FLOOD ANALYSIS

To precisely and be able to predict downstream flood event, in particular, at Pakxan District where is influenced from Mekong River in flooding season, hydrological data in the project area and vicinity should be gathered along with the development of flood model. 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.

### 16.2.3 WASTE DISPOSAL FACILITY

According to the latest edition of the Decree on Environmental Impact Assessment dated 18 February 2010, i t is required all waste disposal facility development to perform environmental impact assessment for a new waste disposal facility. It is expecting that it will require considerable time for EIA preparation and approval process and may affect the schedule and performance of waste management in the future. To avoid potential delay, conceptual design and initial project information on waste disposal facility should be provided and proposed as soon as possible where the impact assessment to be carried out accordingly.

### 16.2.4 RESERVOIR CLEARING

There are four options for reservoir clearing: (1) do not hing, (2) cutting trees without removal, (3) cutting trees with removal, and (4) cutting trees with burn. Cutting trees with removal and cutting trees with burn 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.

### 16.2.5 SEISMOLOGICAL INFORMATION

Due to the existing seismological data is only available at a regional scale and detailed assessment at this stage is limited. Furthermore, a preliminary assessment of the geological structures in the region has shown that there are possibly joints and fractures in the rock formations. However, judging from the available seismic records, the current design has been made to be seismic resistant design with sufficient safety margin. Additional assessment of conditions will be done during detailed design.

### 16.2.6 ENVIRONMENTAL FRIENDLY DESIGN AND EQUIPMENT

In case there is indication of poor water quality at downstream caused by water releasing from dam, the project owner shall carry out all applicable design and equipment in accordance with environmental protection concerns. Effective turbine design can be used to increase the amount of oxygen in discharging water downstream.

### 16.2.7 CONTRACTORS' ENVIRONMENTAL OBLIGATIONS

It is recommended to include all proposed mitigation measures, monitoring programs, as well as obligations and commitments in relation to environmental preservation and protection in all construction contract. The involvement of Contractors, especially during the construction period, will helps to achieve and maintain environmental preservation and protection. Based on environmental obligations as addressed in the contract, the benefit is that contractors shall put the environmental management into practice through the effective implementation, and manage risk to the environment arising from all construction activities during the construction phase.