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I INTRODUCTION

1.1 General Background

The Government of Lao PDR (GOL) has a clear policy for the development of electricity sector as it has been clearly stated in the National Growth and Poverty Eradication Strategy (NGPES) and it has been reiterated in the 10th ASEAN Summit held in Vientiane in November 2004 that the main strategy of power development is to play a major role in power supply in the region; "making Lao PDR become a battery of ASEAN in the future". At the same time an expansion of domestic electrification in order to attain 90% target throughout the country by the year 2020 is also the main strategy to contribute to national economic development as well as poverty eradication and ridding Lao PDR out off the "Least Developed Country" list by 2020. Electrification of selected villages will contribute to raising rural standards of living and facilitate the establishment of physical and social infrastructure and income generating opportunities to support sustainable economic growth in those areas, and thereby reduce disparities between rural and urban standards of living.

Power demand in Lao PDR is dramatically increased and the need for more reliable power source is also essential. The international road called A3 road was completed and the power requirement for the Northern of Lao PDR is also increasing significantly as many of the business opportunities have been opened and linked between the region (China, Thailand and Myanmar). There are many investments from China to wish to settle in Northern part of Lao PDR as factories, mining, hydropower etc. But one critical is power supply to those industrial activities.

There was also the need for export of power to neighbouring countries as agreement has been already made. Currently Lao PDR has only developed less than 3.5 % of its Hydropower potential which estimated to be 18,000 MW and by the year 2009 with the completion of Nam Theun 2, the percentage would have risen to only approximately 10%; however, such development has already been a major contributing factor to the country's economic output in export earnings for the last couple of decades.

Among the potential of the development of the hydropower projects in the northern part of Lao PDR Nam Khan river is one of the possibility to build a hydropower. The Proposed Nam Khan 2 Hydropower Project (Nam Khan 2 HPP) is situated on the Luangprabang provinces, in the middle of northern part of Lao PDR. At the project site the border is formed by the course of the Nam Khan 2 itself. The right abutments of the proposed dam sites are located in the Xieng Ngeun district of Luangprabang Province.

The proposed Nam Khan 2 HPP with installed capacity about 126.2 MW and 567.8 GWh/annum could be generate for the domestic use. Contract between Electricite Du Laos and has been signed with Sinohydro Corporation Ltd (SHC) in November, 2009 to conduct a feasibility study of the project including this EIA thus than, this report has been preparing by:

+ Name and address of project owner:

Electricite Du Laos,
Nongbone Road, Ban Fay; Saysettha District, P.BOX: 309 Vientiane, Lao PDR.
Tel : (856-21) 451519 - 22, 21 451537; Fax: (856-21) 416381; 21 263794
e-mail: edlgmo@laotel.com; website: www.edl-laos.com

+ Name, address and affiliation of the author of the EIA report:

National Consulting Company (NCC), No. 012 Kaisone Road, Ban Phonexay, Xaysettha District, Vientiane Capital, Lao PDR. Tel: (856-21) 264389, 264390; Fax: (856-21) 261882, 413533.

1.2 Objectives of the study

The main objective of the study is to assess the potential environmental and social impacts associated with the construction and operation of the Nam Khan 2 Hydropower Power Project through the assessment of recent data on the upstream, downstream and the immediate catchment of the proposed dam.

1.3 Areas of Potential Project Impacts

The ESIA will be conducted for two major study areas. The primary zone, where the effects of the development will be most obvious includes:

- the land and communities in the area that could be affected by the construction process or the presence of the dam, powerhouse and related facilities;
- the construction camp;
- the construction waste disposal area;
- aggregate borrow areas;
- lands to be flooded by the reservoir;
- the transmission line corridor from the power house to EDL Substation;
- and the lands and communities where displaced people will be relocated/resettled.

The secondary impact zone includes:

- the area of other protected areas closed to the project area;
- and the communities adjacent to the project area, especially in catchment area or the upstream of the reservoir

1.4 Data Collection and Methods for Inventory

EIA of the Nam Khan hydropower project is carried out by groups of specialists. Besides, local people of villages in the project area – people are directly impacted by the project can provide with many important information relating to exploitation, use of resources as land, water, forests; and quality of living environment and other issues. Therefore, method of individual interview and method of participatory rural-community assessment (PRA) are used in the course of data collection for EIA of Nam Khan 2 hydropower project. Much information on the project area has also been collected through consulting and interviewing specified staff in Xieng Ngeun and Phoukhoun Districts.

A description of the existing physical, biological and socioeconomic environmental conditions will be prepared for the EMMP, based on published information, discussions with knowledgeable individuals and field surveys.

All relevant reports and pertinent information will be collected catalogued and reviewed to evaluate the state of the existing environmental conditions within the project study areas.

Sources of information may include:

- feasibility level and specific studies undertaken for the project

- central and regional government resources agencies and personnel;
- data bases maintained by NCC.
- local and national non-governmental organizations that specialize in studies of the natural environmental and/or impact assessment; and
- previous other hydropower projects.

As required, further documentary research and focused interviews with key informants will be undertaken at the national, regional and district levels. At the completion of the data gathering process, environmental and projects specific information will be compiled and evaluated to assess the extent and quality of that data the extent of data gaps and any other uncertainties that may be identified. The goal of this step will be to determine and document the quality and quantity of existing information. This will form the basis for identifying the requirements for field investigations and studies to obtain the data necessary to complete the various components of the ESIA. The precise scope of the field program will be directly related to the information needed for the initial screening and analysis of project alternatives. A key aspect of the scope of work for the field programs will be to assess the seasonal limitations and timing of specific studies so as to take advantage of either local conditions or specific behavioral responses (wildlife studies during the dry season when animals are more concentrated with the river channel and forested riverbank; fisheries studies during the wet season when fish are moving to spawning areas, etc). This exercise will document the programs required, the aerial extent and time lines associated with each program, and the logistics of implementation, as well as the program costs. Specific data requirements are discussed below.

1.4.1 Physical Environment

The description of the physical environment will include:

- Geology
- Seismicity
- Soils
- Erosion and Sedimentation
- Landscape
- Topography
- Climate
- Hydrology
- Hydrogeology
- Water Quality
- Dust and Noise

Much of the description of the physical environment will be based on survey data. Included among these data are:

- geological mapping and reports prepared by the Geological Survey and those prepared for the earlier feasibility studies for the project;
- climate data from the closest government weather station;
- recent available aerial photography and topographical mapping prepared by Department of National Map (and as modified based on a program of calibration and datum checking of the Forest and Land Use stream flow gauge being carried out by MOAF);
- hydrological records compiled by Louangphrabang Province; and borehole records from nearby communities.

Some field investigations will be required in the following areas.

- characterization of the soils

- assessment of the erosion potential of soils along the future shoreline of the reservoir and along the tributaries entering the reservoir; and
- water quality analysis of the Nam Khan to include nutrients, Dissolved Oxygen, selected metals and suspended solids.

Other studies to be conducted include estimation of flows from tributary streams downstream the dam site based on watershed area and rainfall records.

This information will assist in determination of compensation flow requirements.
The recent mapping carried out by feasibility study team is being analyzed to determine more accurately the area/storage elevation curve for the reservoir as well as the specific areas flooded at different elevations.

I.4.2 Biological Environment

The description of the existing biological environment will focus on the flora and fauna of the areas to be inundated and the along the new transmission line. In particular, field studies will focus on, but not be limited to, the riparian forests.

The design of aquatic field studies in dependent on the adequacy of existing data but will likely involve sampling of fish, invertebrates and aquatic vegetation and classification of critical aquatic habitats (e.g. fish spawning and nursery habitats). The documentation will be reviewed and a field program developed to fill data gaps and expand our knowledge of the biological diversity of the project area. The field program will consist of floral and faunal surveys and quantification of critical habitats.

The description of the biological environment will include an inventory of floral and faunal species, their conservation status and habitat requirements, measures of biodiversity and a quantification of critical habitats with will be lost due to construction and operation facility. In particular, the habitat loss will be assessed in the perspective of residual habitat left in the area (if any), and its ability to support the existing total population.

1.5 Outline of the Report

The approach used in this study and the structure of the report is similar to a normal EIA process and contains the normal EIA elements as it is also prescribed in Lao PDR and ADB guidelines. The report is divided in 2 Sections. The first Section (Chapter 1-8) contains the main impact assessment part. The second Section (Chapter 9-18) contains the different elements which together make up the Environment Management and Monitoring Plan. The chapters are as follow:

- Introduction
- Legal and Policy Framework
- Project Description
- Physical Environment
- Biological Environment
- Project Impacts
- Analysis of Alternatives

II LEGAL AND POLICY FRAMEWORK

2.1 Introduction

In the following a brief summary of the administrative and legal situation in the relevant national sectors, Lao PDR international commitments, and the environmental and social requirements of the International Financing Institutions is provided.

2.2 National Legal and Institutional Situation

Environment Protection

The basic legal framework is laid down in the Environmental Protection Law of 1999, which was approved by the implementation decree of 2002 and 2010. The law includes provisions for EIA for projects and activities that might have impacts on the environment and regulations for all enterprises to control pollution and comply with environmental quality standards. According to the Law the basic principles of environmental protection are:

- Environmental protection shall be the priority consideration and environmental mitigation and restoration are considered to be less preferable but also important activities;
- The social-economic development plans shall include provisions to protect the environment and national resources;
- All persons and organizations residing in the Lao PDR are obligated to protect the environment;
- Whoever causes damage to the environment is responsible for the impact under the law;
- Natural resources, raw materials and energy shall be used in an economical manner, which minimize pollution and waste and allows for sustainable development.

Executing agency

The executing agency of the Environmental Protection Law is the Water Resource and Environment Administration (WREA), which is also responsible for reviewing EIAs. WREA has developed specific guidelines for the content and process of environmental assessment of hydro-power projects, including the preparation of environmental management plans.

Nature Conservation

The conservation of areas for biodiversity purposes has its legal basis in the Prime Minister's (PM) Decree of 1993 aimed at fulfilling the Lao PDR obligations under the Convention of Biological Diversity. Through this decree 21 National Protected Areas (NPAs) have been established. The administrative responsibility for the management of the NPAs has been placed at the Ministry of Agriculture and Forestry.

Forestry

The Forestry Law of 2007 provides general provisions for the management of all forest related resources, including all plants, wildlife, watercourses, etc. The Department of Forestry, Ministry of Agriculture and Forestry, has the overall responsibility and is responsible for allocating the use of forestland and forest resources. Forests are grouped into the following five categories: Protection, Conservation, Production, Regeneration, and Degraded, each with their specific management policy.

Water Management

The Law on Water and Water Resources of 1996 is intended to assure sustainable use of water. Water use is categorized into small, medium and large-scale use. The legislation prescribes the rights and procedures for the different categories of water use. Development of a large-scale user projects will require the preparation of an EIA. The administration of the Water Law is located in the Water Resources Coordination Committee under the Prime Minister Office.

EIA Guidelines

Based on the provision in the Environmental Protection Law that development projects and activities that have the potential to affect the environment shall require an EIA, the GOL has issued EIA regulation for Lao PDR (2010) No.112/PM. This regulation specifies the overall principles for the EIA effort and prescribes the thematic issues to be covered and the outputs expected at the different stages the EIA process.

WREA has also instructed the Ministries to develop sectored guidelines for the project categories within their respective area of responsibilities. The Ministry of Mines and Energy responded promptly to this request and have issued the following guidelines for power and transmission line projects:

- Decree on Environment Assessment No.112/PM, (2010)
- Regulation on Implementing Environmental Assessment for Electricity Projects in Lao PDR, No. 447, 20.11.2001
- Power Sector Environmental Policy, No. 581, 4.10.2001
- Environmental Management Documents for the Department of Electricity, No. 582, 4.10.2001
- Department of Electricity Environmental Records Management, No. 583, 4.10.2001
- Environmental Management Plans for Electricity Projects, No. 584, 4.10.2001
- Environmental Management Standard for Electricity Projects, No.0366/ MIH.DOE,2003
- Environment Assessment Regulation, No. 112/PM, 2010
- National Standard of WREA 2009

2.3 International Commitments

Mekong River Commission

Lao PDR is one of the four signatory parties to the 1995 Agreement on the Co-operation for Sustainable Development of the Mekong River Basin and one of the members of the Mekong River Commission (MRC). The Commission succeeded the Mekong Committee, which, among other things, was instrumental in the planning of Nam Ngum, the first larger hydropower project in Lao PDR. Whereas the Committee was primarily focused on hydrology, navigation and hydropower, the mandate of the Commission is more oriented towards co-operation for the promotion of sustainable development, utilization, management and conservation of the water and related resources of the Mekong River Basin.

The primary purpose of the Agreement is to promote economic and social well-being of the people in all the riparian countries through the protection of the environment, improvement of navigation and the cooperation in the maintenance of flows and intra-and inter-basins diversions. MRC has initiated several basin-wide planning and research programmes, including the Water Utilization Plan (WUP), the Environmental Programme (EP), the Basin Development Plan (BDP) and the Fisheries Programme. Lao PDR has its own National Mekong Secretariat in Vientiane.

ASEAN Membership

Lao PDR became a member of the Association of Southeast Asian Nations (ASEAN) in 1997. ASEAN countries have adopted an agreement on the Conservation of Nature and Natural Resources. However, this agreement has been ratified by only three countries since it was adopted in 1985, and is therefore not in force. ASEAN also has provisions to assist member countries to establish trans-boundary nature reserves.

Greater Mekong Sub-region (GMS) Initiative

In 1992, with the assistance of ADB, Cambodia, Lao People's Democratic Republic, Myanmar, Thailand, Viet Nam, and Yunnan Province in the People's Republic of China entered into a program of sub-regional economic cooperation, designed to enhance economic relations among the countries. The program has contributed to infrastructure development and better use of the resource base in the sub-region.

International Conventions and Treaties

- **Convention on Biological Diversity (CBD)**

Lao PDR became a signatory to the CBD in 1992, following up the ASEAN Agreement of the Conservation of Nature and Natural Resources, which was signed in 1985. The obligations of CBD have been fulfilled in terms of new policy and legislation and by establishing NPAs.

- **Convention on the Protection of World Cultural and Natural Heritage**

This UNESCO convention was ratified by GOL in 1987. The convention addresses the protection of both cultural and natural objects and sites of high national and international value.

- **Convention on International Trade in Endangered species (CITES)**

Lao PDR ratified this convention in early 2004. Prior to the ratification, the Ministry of Agriculture and Forestry (MAF) issued a regulation that banned all hunting for trade. Hunting for consumption was still allowed. This is a signal that GOL is now committed to increasing efforts to halt the extensive trade in wildlife from Lao PDR to its neighboring countries.

2.4 Development Bank Guidelines

EIA process

The process of Environmental Impact Assessment is a method used by many International Financing Institutions (IFIs) including the Asian Development Bank (ADB) to ascertain the environmental risks and benefits associated with their lending operations and other financial support to development projects. The Environmental Policy of the ADB dates from November 2002 and forms the basis for environmental requirements and interventions for project implementation. The Environmental Assessment Guidelines (2003) describe procedures and methodology to be used to investigate environmental and social impacts of projects to be considered for funding. The WB's environmental assessment procedures are described in OP/BP 4.01 (Operational Policy, Bank Procedures). This policy is considered to be the umbrella policy for the Bank's "safeguard policies", which includes specific requirements and policies. In both ADB and WB projects Environmental Assessment (EA) plays a key role in improving decision-making and in ensuring that project options under consideration are sound and sustainable. The other three policies have more relevance to the preparation and content of the EIA.

- **Safety of Dams (OP/BP 4.37)**

For large dams (15 meters or more) it is a requirement that the borrowers adopt and implement certain dam safety measures for the design, bid tendering, construction, operation and maintenance of the dam and associated works.

- **International Waterways (OP/BP 7.50)**

The policy does not allow financing of a project on an international waterway until all the riparian countries are notified of the project. If there is an objection from one of the riparian the Bank will assess and confirm that the project will not cause appreciable harm to the interests of the other riparian.

- **Natural Habitats (OP/BP 4.04)**

The World Bank does not support projects that, in the World Bank's opinion, involve the significant conversion or degradation of critical natural habitats.

IFIs Project Preparation and Consultation Process

The ADB is committed to ensure that key stakeholders are systematically identified and involved in project planning and implementation. Early consultations have to be held with affected groups to guide project decision making, and their views and preferences has to be reflected in the plans developed as an integral part of the project.

III PROJECT DESCRIPTION

3.1 General Project Components

The Nam Khan 2 project is located in the northern of Lao PDR at Phoukhoun and Xieng Ngeun districts of Luangprabang province. The prospective dam site is more than 60 km upstream of the confluence of the Nam Khan river with the Mekong. The Mekong is navigable at this location. Material and equipment could be brought to the site by river from China or Thailand.

The Nam Khan is located in northern Laos and joins the Nam Mekong near the city of Luangprabang, contributing approximately 0.9% of the total river discharge. Various studies have been undertaken to evaluate the hydropower potential of the Nam Khan during the past years. In 1970, within the scope of an inventory study on promising tributary projects in the lower Mekong basin, the Mekong secretariat identified three possible sites along the Nam Khan:

- Nam Khan 1, located about 1O km from the mouth of the river, with a reservoir full supply level (FSL) at EL.340 m.
- Nam Khan 2, located 68 km upstream from the mouth of the river, with a reservoir FSL at EL.475m.
- Nam Khan 3, located about 60 km upstream from Nam Khan 2, with a reservoir FSl at El.600m.

In 1994, a consortium formed by RSW International, Hydro-Quebec International and Acres International Limited and is hereafter designated as Consortium RHA completed the prefeasibility study of the project.

After signing MOU between GOL and SINOHYDRO, the feasibility study report has been finalized based on the prefeasibility study, using existing mapping and data after SINOHYDRO making the site visit.

The Nam Khan 2 project dam site is located approximately 68 km upstream from and 30 km Southeast of Luangprabang, near the village of Kengkoung, at the location identified by the Mekong Secretariat in 1970. The basin is a mountainous region with elevations extending above El. 2,200 m. The majority of the area is forested with agricultural development along the river banks and a tropical climate.

The watershed drainage basin area tributary to the dam site is 5,221 km2 and the mean annual flow is 64.4 m3 is. Floods are severe: the average flood is estimated at 583 m3is and the 10,000 - year return flood could be as high as12,400 m3/s.

The reservoir covers an area of 37.9 km2 at FSL, less than 1 km wide, it has a length of about 60 km along the river. The creation of the reservoir will affect 11 villages and total project affected people is approximately 3,000 persons.

The river cross section at dam site is narrow with rather steep slopes. The bedrock geology consists mainly of limestone intermixed with some sandstone. The site conditions are appropriate incorporate for the construction of a roller compacted concrete (RCC) dam, which can incorporate the spillway and intake structures. The entire head available for power generator is developed by the dam, which will create a reservoir with a full supply level at 475 m. The low supply level will be at El. 455m. The 25m drawdown will provide a live storage of 635 km3, which will be used for seasonal flow regulation. During the passage of extreme floods, the reservoir level will surcharge to an extreme level of 487m.

The dam will be a gravity RCC structure with conventional concrete veneer on the upstream and downstream slopes. With a crest level at El. 488 m, the dam will have a maximum height of 160 m and a crest length of 405 m. Due to the potential for caustic bedrock at the site, special attention was devoted to the design of the grout curtain, which extends into both abutments using excavated galleries along the dam axis.

Separate service and emergency spillways will be incorporated in the dam. The service spillway will be located in the centre section of the dam and will have an ogee-shaped crest structure, a ski-jump terminal structure and a pre-excavated plunge pool in the river bed. The spillway will have two bays equipped with 14m wide radial gates with a sill level at El. 460 m. The emergency spillway will consist of a free overflow over the dam crest near the left abutment of the dam. The emergency spillway section will include a stepped chute on the downstream face of the dam to dissipate a significant portion of the energy. The spillway will have an overflow width of 49 m and a crest level at El. 481 m. Overtopping of the dam is anticipated during the passage of the PMF, but the dam will be designed to withstand this condition without failure.

The powerhouse and related structures will be located on the right bank at the foot of the dam. The project will produce a peak output of 126.2 MW from a rated plant discharge of 104 m^3/s under a net head of 137.5 m. The two units will be fed individually by an intake and a penstock. The intake structure will be incorporated into the dam and the 4.1 m diameter penstocks will be placed on the downstream face of the dam. The powerhouse will house two generating units driven by vertical Francis turbines. The structure will be conventional, with concrete sub-structure and mixed concrete and steel super-structure.

A Sort tailrace channel will discharge directly to the Nam Khan. The estimated annual average energy generation is 567.8GWh (at generator output).

During construction, diversion will go through a tunnel excavated in the left abutment of the dam. The tunnel will have a nominal cross sectional area of 177.5 m2 and will be unlined. Tunnel closure will be achieved by two gates located at the concrete plug. Other temporary diversion works include upstream and downstream cofferdams to allow dewatering of the dam site.

Access road from Luangprabang is via National Highway 13 to a permanent road which will be constructed along the left bank of the Nam Khan to the dam site. The project energy production will be transmitted to the Luangprabang substation via a 115kV double circuit line.

Figure 1: Location of Proposed Nam Khan 2 Hydropower Project

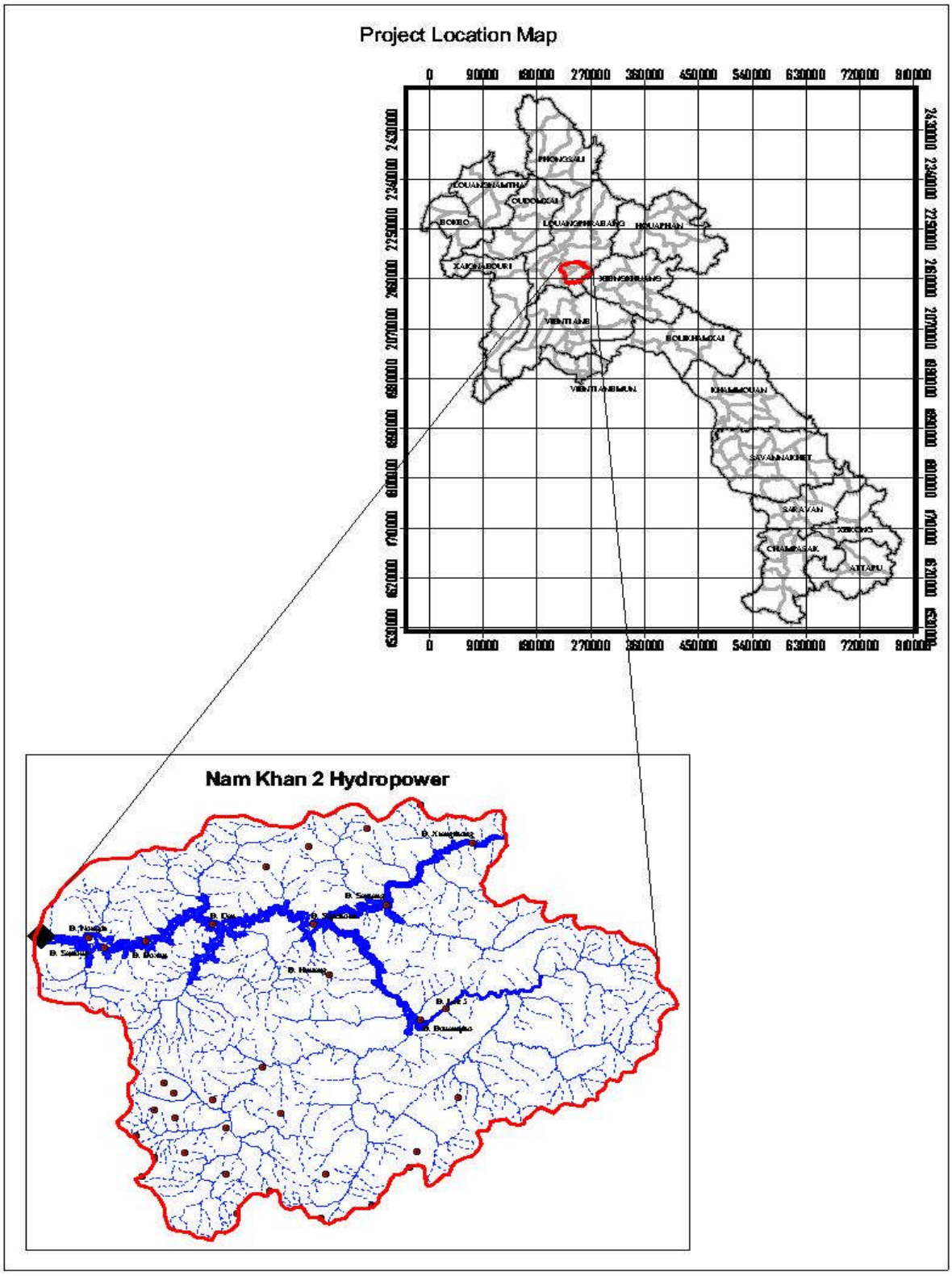

Table 1: The Main Technical Parameters of the Nam Khan 2 HPP

Descriptions	Unit	Nam Khan 2
Hydrology		
Catchment Area	km^2	5,221
Annual average discharge	m3/s	64.4
Reservoir		
Full Supply Level (FSL)	m	475
Area at FSL	km^2	37.9
Total storage (below critical operation level)	$M.m^3$	1,366
Total storage (below full supply level)	$M.m^3$	1,078
Active storage	M.m3	635
Flood control storage	M.m3	288
Backwater length	km	60
Dam		
Type		Gravity RCC (Roller Compacted Concrete)
Crest Elevation	masl	488
Height	m	160
Crest length	m	405
Crest wide	M	15
Spillway		
Service Spillway		
Type		Ski-jump with a plunge pool
Discharge capacity at El. 475 and 487	m3/s	5,460 and 8,900
Number of bay		2
Bay width		14 m
Emergency spillway		Dam craver flow section with tapped chute
Discharger capacity at El. 487	m3/s	1,400
Number of bay		2

Descriptions	Unit	Nam Khan 2
Bay width		14 m
Turbines		
Type		Francis
Number	ea	2
Rated net head	m	137.5
Total Design discharge	m3/s	104
Design capacity (one Unit)	MW	64.4
Power Facility		
Installed capacity (all units)	MW	126.2
Annual Energy	GWhr	567.8

Source: Feasibility Study Report, July 2009.

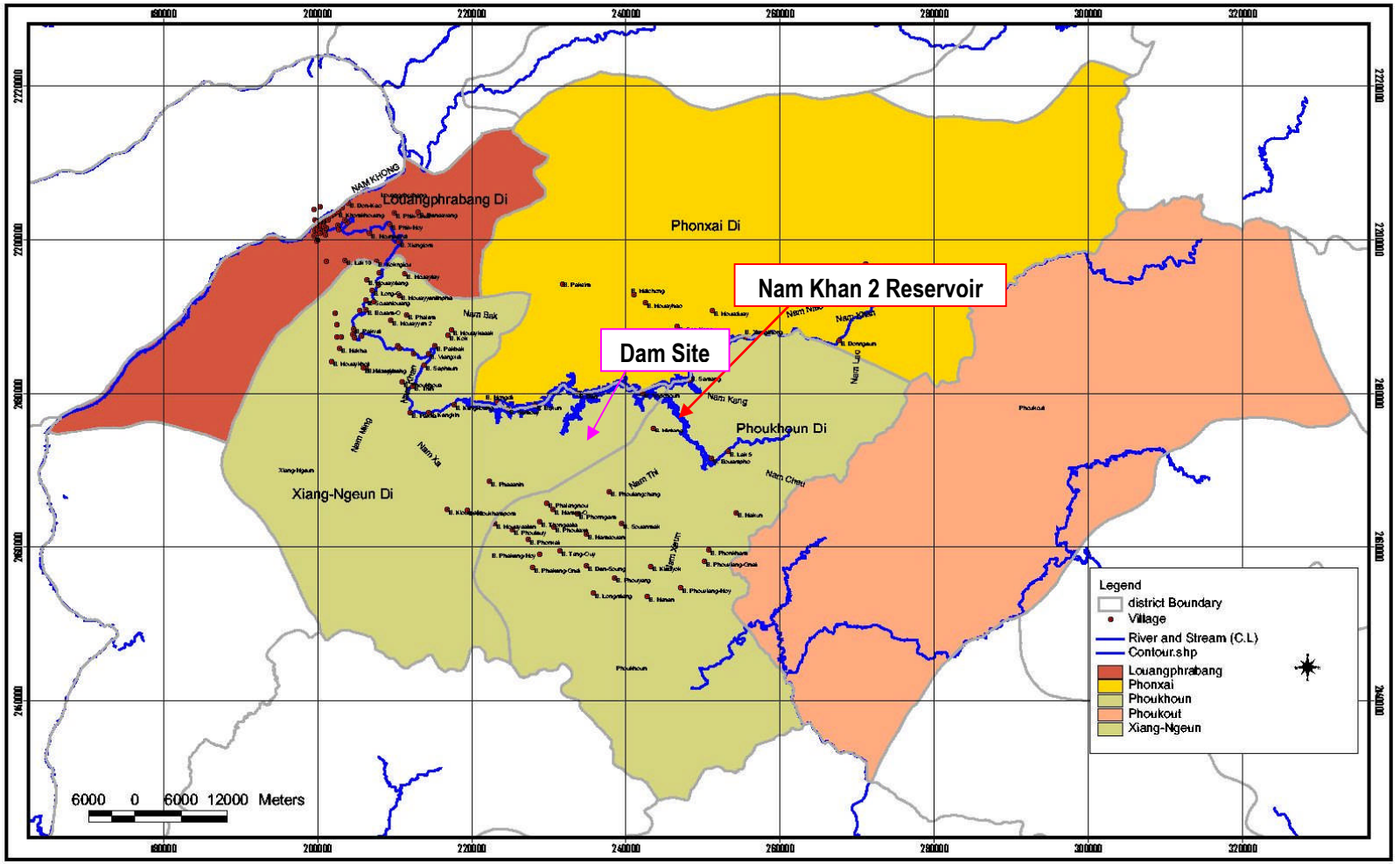

Figure 2: Map of the potential affected villages

3.2 Project Location

3.2.1 River Basins

The planned reservoir is located on the Nam Khan, which is one of the major tributaries on the Mekong river system. As for the proposed Nam Khan 2 Power Plant the dam will create a reservoir for producing of electricity and divert water to Nam Khan itself just below the power house. The location of the main project features in relation to landscape and infrastructure elements are shown in Figure 2.

3.2.2 Project Zones and Potential Project Affected Area

For the purpose of the impact assessment and presentation the area potentially impacted by the project can be divided in different zones. The need for specification of the zones differs from topic to topic, with the most detailed specification used for the purpose of social impact assessment and resettlement planning. The zones used in both the Environmental Impact Assessment and the Social Impact Assessment are described in the sections below.

The potential affected area from the proposed Nam Khan 2 HPP are located in Luangprabang Provinc with could be divided as following impacted are:

- Upstream area combined of:

  B.Viengsamay, B. Nakeun villages of Phoukhoun District, Luangprabang Province

- Reservoir area:

  B. Samang, Bouampho villages of Phoukhoun District, Louangphrabang Province.
  B. Sopchoun, Dankhoua, Boxeun, Samui, Nongdy of Xieng Ngeun district, Luangphrabang Province.

- Construction area:

  B. Nongdy village of Xieng Ngeun District, Louangphrabang Province.

- Downstream area:

  B. Kengkoung village of Xieng Ngeun District, Louangphrabang Province.

3.3 Project Construction and Operation Schedule

The project construction period will take 3 years. The filling up of the reservoir will start at the beginning the rainy season of the year 3, when the dam is constructed high enough.

IV PHYSICAL ENVIRONMENT

4.1 Climate

Nam Khan Stream is situated in the mountainous region of Phoukhoun and Xieng Ngeun Districts area with a watershed of 5,221 km^2. The project is located in a mountain valley area with

an altitude between 300-1500 m above sea level. Geological survey found that most of mountains slopes along the stream are from rock with small bushes and grass land. No evidence of fissures, or unstable slopes was found. There is no crack which could deduce influent seepage on the two sides of the mountain. There is no record of the earthquake intensity in this area. On average, the humidity is 78% and the annual evaporation is 1,100 millimeters.

The climate of northern provinces of Lao PDR is subtropical and strongly influenced by the annual southwest monsoon rains that affect the region from April/May to September/October (mean annual rainfall for the year 2007 at Luangprabang is about 1,225mm). The period of the dry season in Luangprabang from October to April, no rain may fall in December in Luangprabang. The hottest month is March (about 35.1^{o}C), and the coolest month is February (about 13.4 ^{o}C).

Table 2: Climate Data for Luangprabang Provinces

Month (2007)	**Luangprabang**		
	Avr.Max Tem.(^{o}C)	**Avr.Min Tem.(^{o}C)**	**Rain (mm)**
January	29.1	13.7	1.0
February	32.4	13.4	12.2
March	35.1	18.0	30.4
April	33.4	21.6	118.7
May	33.7	22.6	125.0
June	35.0	24.1	138.2
July	33.9	24.5	146.9
August	33.2	24.1	242.7
September	32.6	23.0	256.0
October	31.3	21.0	117.2
November	28.4	16.3	37.0
December	29.7	16.2	0.0
***Annual** (Mean)*	***32.3***	***19.9***	***1,225.3***

Source: Agricultural Statistics; Year Book 2007 (Department of Planning, Ministry of Agriculture and Forestry, May 2008) and Department of Meteorology and Hydrology (2007).

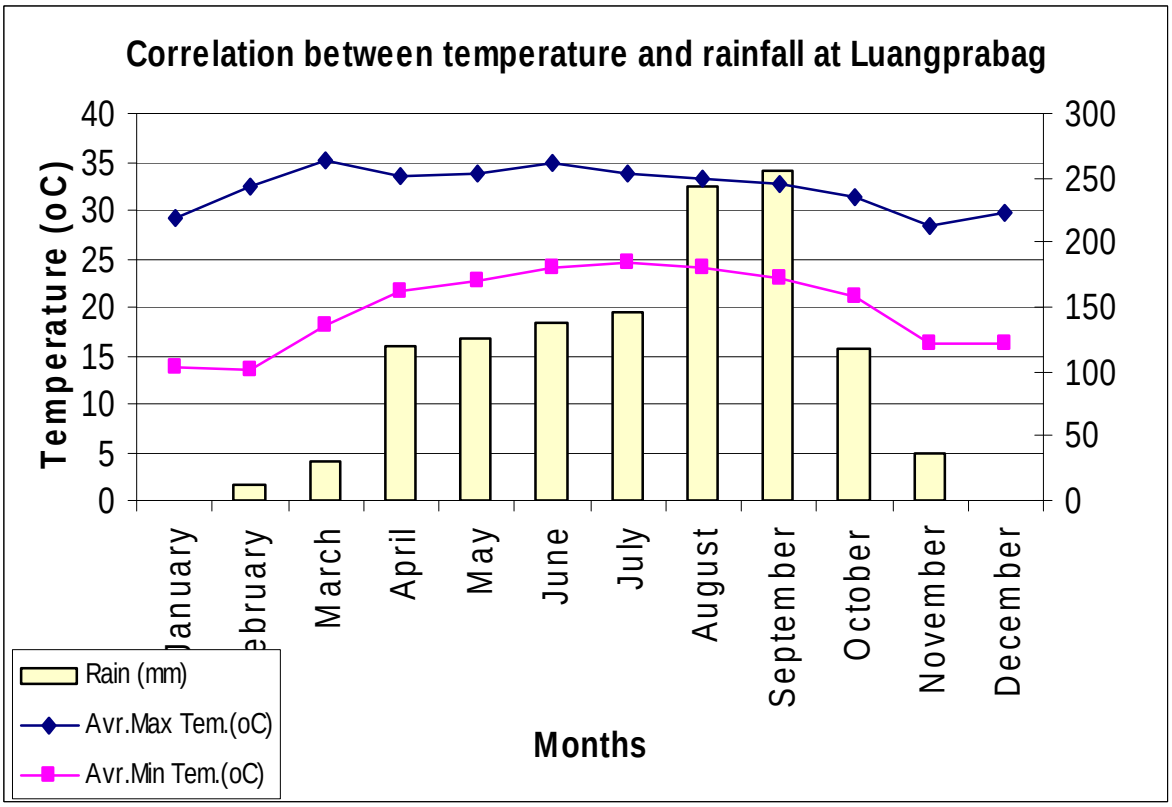

Figure 3: The charge show the correlation between the temperature and rainfall at two provinces

4.2 Evaporation

Evaporation estimates are required to estimate the various components of the water budget of a landscape that includes a reservoir area. Evaporation rates from dams have been notoriously difficult to estimate in Lao PDR, partly because of a scarcity of pertinent data and partly because of a lack of applied climatologically research to obtain pertinent correlations between data that is available and the parameters of interest. This may be rectified using the results of climatologically research being undertaken in Thailand.

Pan evaporation is a basic parameter that is easily obtained in some locations, but difficult in tropical environments because of the need to correct for heavy rainfalls that fall into the pan. This difficulty makes reading and adjusting pan evaporation observations a tedious and intensive operation to be conducted by a skilled trained observer. Hence in the Lao PDR pan evaporation is measured at only a few stations around the country. Moreover experience is that at a given altitude with similar rainfall patterns pan evaporation varies on slightly over 10 degrees of latitude or so. This is because pan evaporation is largely driven by the net radiation falling on the grounds surface. It is also influenced by air temperature. The hotter the air temperature the greater the proportion of the net radiation is partitioned into evaporation and the less is portioned into heat loss from the pan. Secondly, in general, the hotter the air the greater the humidity deficit and the greater the drying power of the air as it blows over the pan.

When attempting to use pan evaporation to determine the likely evaporation of water from a wide body of water it is also necessary to consider the different factors at work influencing the evaporation from a pan and say from a large reservoir. In the case of a deep reservoir with clear water, most of the radiation is trapped within the reservoir and the average surface temperature, (the temperature at the surface drives evaporation from a water surface) is less than for a pan. It may release more evaporation when it gets cooler in the dry season, but overall, less of the energy it absorbs is converted to evaporation.

Secondly, when air flows over significant distances over smooth water, the drying power of the air flow is reduced because the surface is less exposed to ambient conditions (the air flow is smoother) and secondly the air approaches saturation and loses its drying power. One observes this as one walks into an area of irrigated rice paddy in the dry season - the air becomes much more humid and has lost part of its capacity to advert water vapour away from the irrigated surface.

Evaporation estimates are required to accurately estimate the various components of the water budget for the hydro power project. Evaporation is largely driven by the net radiation falling on a surface, thus the evaporation levels in a reservoir increase as a function of the increased surface area. Evaporation rates are also determined by: the shape and orientation of the reservoir; its exposure to winds; the temperature and relative humidity of these winds; and water clarity. The importance of the evaporation figure is that this represents water that otherwise would have been available to turn turbines, generating electricity and revenue, and must be subtracted from water budgets calculated using normal river flows. In project reservoir the increased evaporation will impact the surrounding climate.

According to the report of Luangprabang Hydropower Project, September is month in that evaporability is maximum with mean monthly value of evaporability trough many years is 66.1 mm. Evaporability in February is the lowest, 27.1 mm. Total mean evaporability for many years is 517.5mm.

4.3 Hydrology

4.3.1 Surface water

4.3.1.1 Flow regime

Nam Khan 2 Hydropower Project is located on the Nam Khan river, a tributary of the Mekong River, Luangprabang Province, Lao PDR. Nam Khan river originates in Xiengkhouang Province before joining the Mekong River.

The flow of the river is determined by the seasons and is characterized by a peak flow rate in September. This peak lags the August peak in the rainfall by between 1 and 2 months. Rainfall then declines steeply and so to does the flow rate. From the beginning of the dry season in November, the flow rate declines more slowly reducing by half every 50 days until the rains come again in May next season. The decline in flow stops once the wet season arrives.

In July, two months after the wet season has arrived, the river flow increases rapidly. Some of the rainfall will flow into storage within the watershed before this flow commences. However some of the rainfall would be used to replenish the soil moisture deficit generated by vegetation during the dry season. The remaining is stored in wetlands and/or underlying groundwater aquifers.

This is undertaken on a spreadsheet or using an accounting software package until the budget balances for every month of the year. A typical value assumed for the maximum amount of water lost from the soil during the dry season is 100 mm though for an evergreen forest with deep soils it may be greater. The amount of evapotranspiration during the wet season is assumed

to be related by a pan factor to pan evaporation. Other assumptions used initially in these calculations for the Nam Khan 2 project site were:

There are hard rock areas and water courses where all rainfall runs off directly into the river. These are assumed to cover a given percentage of the water shed and induce flows immediately in the river system. The rest of precipitation is lost to the watershed by evapotranspiration or, after the soil moisture store has been recharged, passes downward to aquifers to emerge later as groundwater discharge.

The budget equation above allows the groundwater recharge to be calculated every month. To account for flow through aquifers to the river system, each monthly episode of recharge is delayed and dispersed over time by fixed proportions such that the sum of monthly flows over the dry season decays at the same rate as the observed stream flow. With these assumptions the time profiles of the water budget components evapotranspiration, moisture stored in the soil, groundwater recharge and discharge, and the river flow are computed from the end of the dry when the soil moisture is set at its minimum value. A comparison of these calculated monthly values with observed rainfall and stream flow obtained indicate the following:

The observed stream flow is very high relative to the observed rainfall. The required pan factors needed to obtain a balancing of the water budget were 0.5 for the dry season and 0.3 for the wet season seem too low. In addition the annual evapotranspiration of 475 mm is also too low for the region. Accordingly we suspect the rainfall in remote upland areas of the watershed are higher relative to those measured more often in the lowland areas and used to derive the rainfall for Nam Khan watershed. However to obtain a good match between observed and stream flow requires further adjustments.

It is noticeable in the observed stream flows that there is a very steep increase in stream flow in July and August when rainfall is at it highest and it is during this time we have greatest disparity in flows derived from the budget and observed flows. If we assume that there is a restriction in drainage from the soil profile into deeper aquifers limiting the flow to 90 mm/month, when the soils are wet then we get a good match between the observed and budgeted monthly stream flows. This is equivalent to assuming that over much of the watershed the soils are poorly draining and that there is a clay layer at relatively shallow depths that is inducing surface runoff when the soil profile completely saturated. This would be consistent with the significant areas of poorly draining and moisture absorbing soils covered by dry dipterocarpus and mixed deciduous forest. It is also consistent with the soil maps for the watershed.

Our conclusions, after making various assumptions and looking at the relative magnitude of the budgeted and observed stream flows for the Nam Khan watershed is as follows:

The Nam Khan 2 watershed may have slightly higher rainfalls that we currently suppose. Overall, within the limits of accuracy of the stream flow and rainfall data, the watershed appears to be poorly draining, but this is not precluding significant recharge still to underlying aquifers.

Saturated overland flow would appear to be occurring in the months of August September and October over wide areas of the watershed. Regular strongly peaking and dangerous flood flows can be expected at this time.

Over the wet season groundwater discharge builds up to a peak discharge a few months before the end of the dry season (the late peak in the bottom diagram is an artifact of the assumption of a uniform watershed) and provides a significant contribution to the total river flow.

Flash runoff and areas of bare rock and water surfaces connected to the main stream that induce surface runoff or immediate flow responses appear to cover less than 10% of the watershed, otherwise stream flows earlier in the wet season would be much higher. However the detailed hydrograph is likely to show such characteristics exist over a much wider area during the three wettest months because of the wide areas of saturated soils and temporary wetlands.

4.4 Sediment transport

Sediment transport in a river is generally separated into two classes. These are bed load, wherein grains move along or near the bed by sliding, rolling, or hopping, and suspended load, wherein grains are swept off the river bed into suspension by turbulent eddies in the flow. In most streams grains smaller than about 1/8 mm tend to always travel in suspension; grains coarser than about 8 mm tend to always travel as bed load. In between these sizes, the grains may travel as suspended load or bed load, depending on river conditions including the slope of the bed and the size of materials available for transport as bed load. Bed load is extremely difficult to measure but when measured it generally amounts to a proportion smaller than 50% of the total load transported by a river.

The Nam Khan river bed is composed of a broad mix of sand, gravel and boulders up to 20cm across. Most of this material will pass down the river as bed load, the size fraction depending on the velocity of the water flow. In flood flow when the velocity is highest, part of the roar that can be heard is the smashing of the larger rocks together especially, near the edges of the river bed. The size of the bed load material at the project site indicates that the capacity of the river to transport sediment is very high as might be expected from relatively large slope of the river bed through the project area. Accordingly there is the potential for significant sedimentation to occur. Given the nature of the sediment transport process and the fact that the turbulent energy varies as the square of the velocity, the sediment transported tends to increase exponentially with the flow rate. Thus most sediment is transported in the wet season especially during when peak flood flows.

No measurements of suspended load for the Nam Khan river are available but there is a considerable amount of data for the world's mountainous rivers in the literature. The literature shows that the amount of sediment transported in a river declines with the size of the basin and the distance downstream due to deposition of various fractions within the stream and on the flood plains. This is illustrated in the Figure where the sediment load at upstream and downstream locations have been plotted for a suite of large rivers, mainly in Europe [Nile (Sudan-Egypt), Wisla (Poland), Lech (Fed.Rep.Ger.), Po (Italy), Me Nan Tha Pla (Thailand), Atrak (Iran) ,Nazus (Mexico)]. Also shown is a compilation of sediment loadings expressed in terms of thickness of the watershed surface actually passing the measuring point. A soil density assumed in converting the sediment load measurements to this parameter is 1.5 tonne m^{-3}. The sediment load measured in the lower reaches of rivers especially in the flood plain areas will generally be over an order of magnitude less than in the streams in the upland areas that collect eroded material from the landscape. Accordingly a maximum estimate of the river sediment load is an order of magnitude less than the erosion rate from small areas of land undergoing upland cultivation after slashing and burning.

According to the relationships obtained in field observations by Anneke de Rouw (2006) we might expect the average erosion rate from cultivated upland areas to be less than 0.25 mm. In the Philippines which have very much higher population pressures than the Lao PDR the

accepted nominal erosion rates for lowland, upland and gin (slash and burn) land uses are 0.04 mm/y and 0.35mm/y respectively (Domingo 2000).

We have also plotted the data of Rest repo (2003) showing the sediment loads for a suite mountains rivers from SE Asia, and tropical South America. Using the envelope line marking the probable maximum sediment flux that can be expected (95% of values plot below it) we can be confident that the sediment transport for the Nam Khan river at the project site (watershed area = 5,755 km^2 for NS1 and 5,195 km^2 for NS2) is less than 10 mm per year. Considering also that there is no significant area of degraded land in the Nam Khan watershed it probably plots at the lower limit of this suit of data at less than 1 mm/yr.

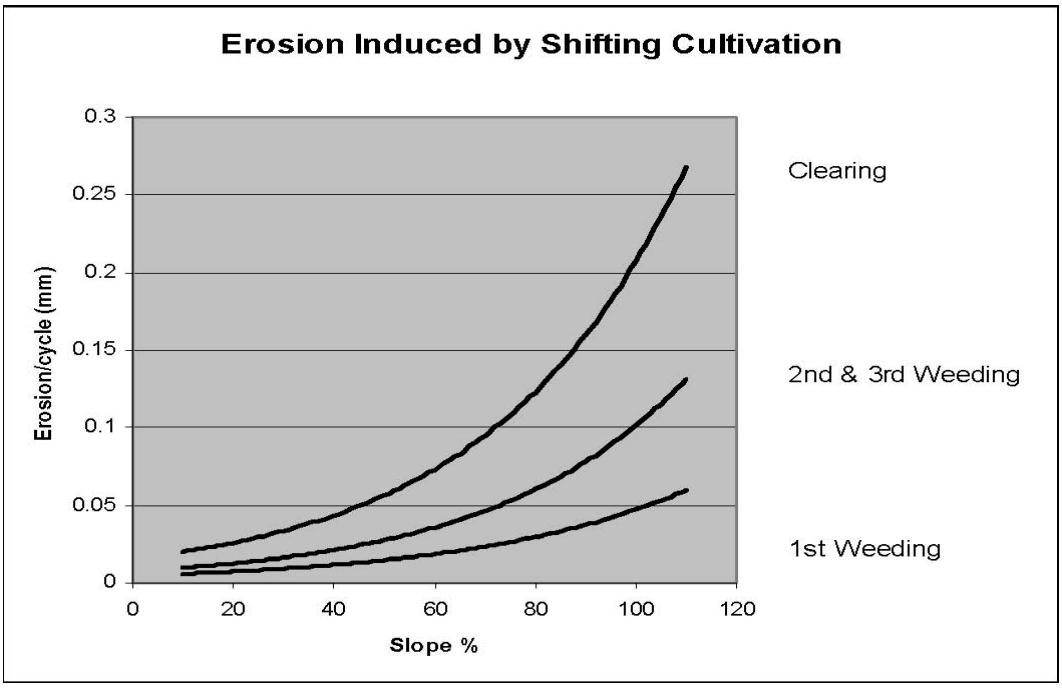

Figure 4: Erosion as influenced by slope, caused by shifting cultivation sites in Luangprabang at various times of the cultivation cycle (Anneke de Rouw et al. 2006).

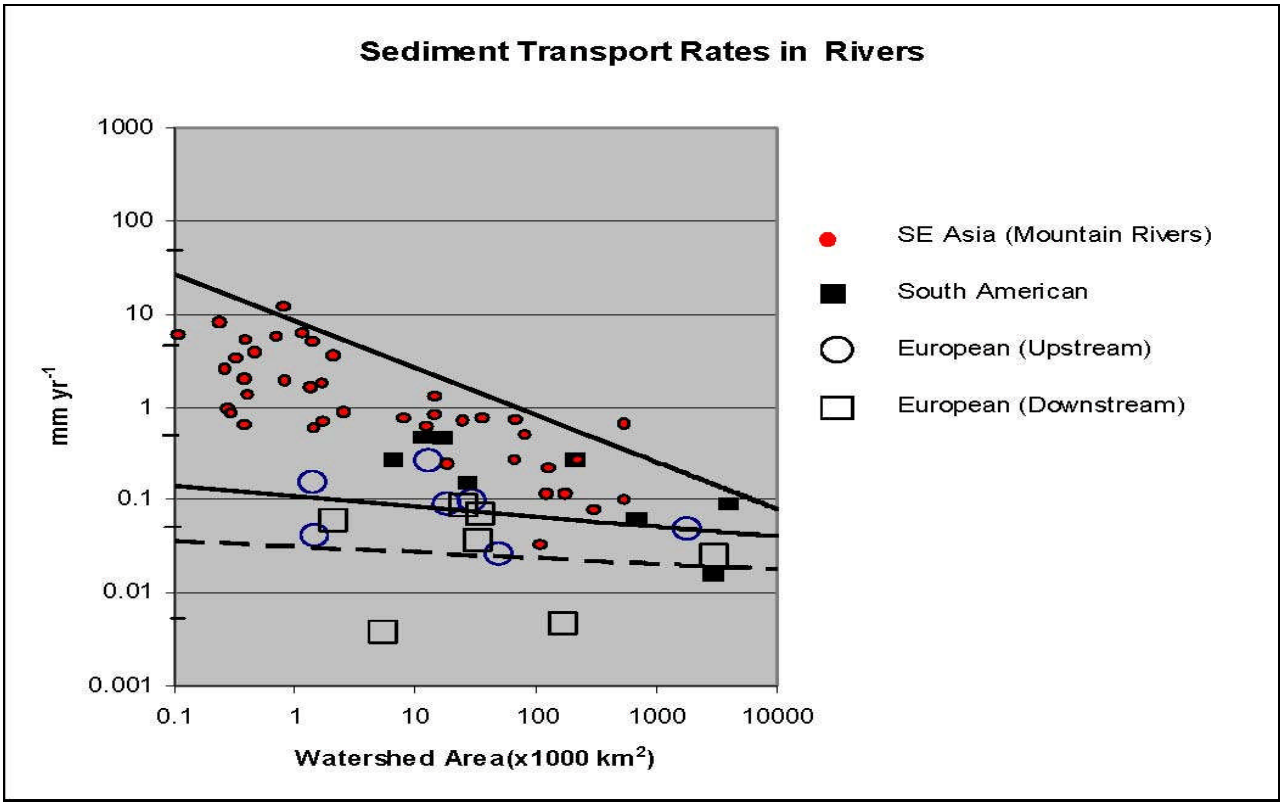

Figure 5: Sediment loads for a suite mountains rivers from SE Asia, Tropical South America and Europe.

4.5 Topography

Nam Khan 2 hydropower project is located in mountainous area of Northern Laos where topography varies considerably, from about 300 m to over 1,500m (msl). There are many peaks higher than 1,000 m of which the highest is 1,899 m. The lowest area is waterfront of the Mekong. Elevation at dam site is about 300 m. Topography of the project area is strongly divided by the Mekong river and its tributaries.

This type of topography with peaks over 1,000m is distributed in both north and south of the project area. Integrated denudation process has common rule that the stepping-backwards and regression of a slope will create at slope foot an inclined surface with sloppiness corresponding to each erosion basis. Products of this process are slope surfaces with different elevations. The deeply weathered process of soils and rocks in the area facilitated the denudation activities taken place in the beginning of erosion cycle and created a series of slopes in diversified types such as integrated denudation slope or eroded slope.

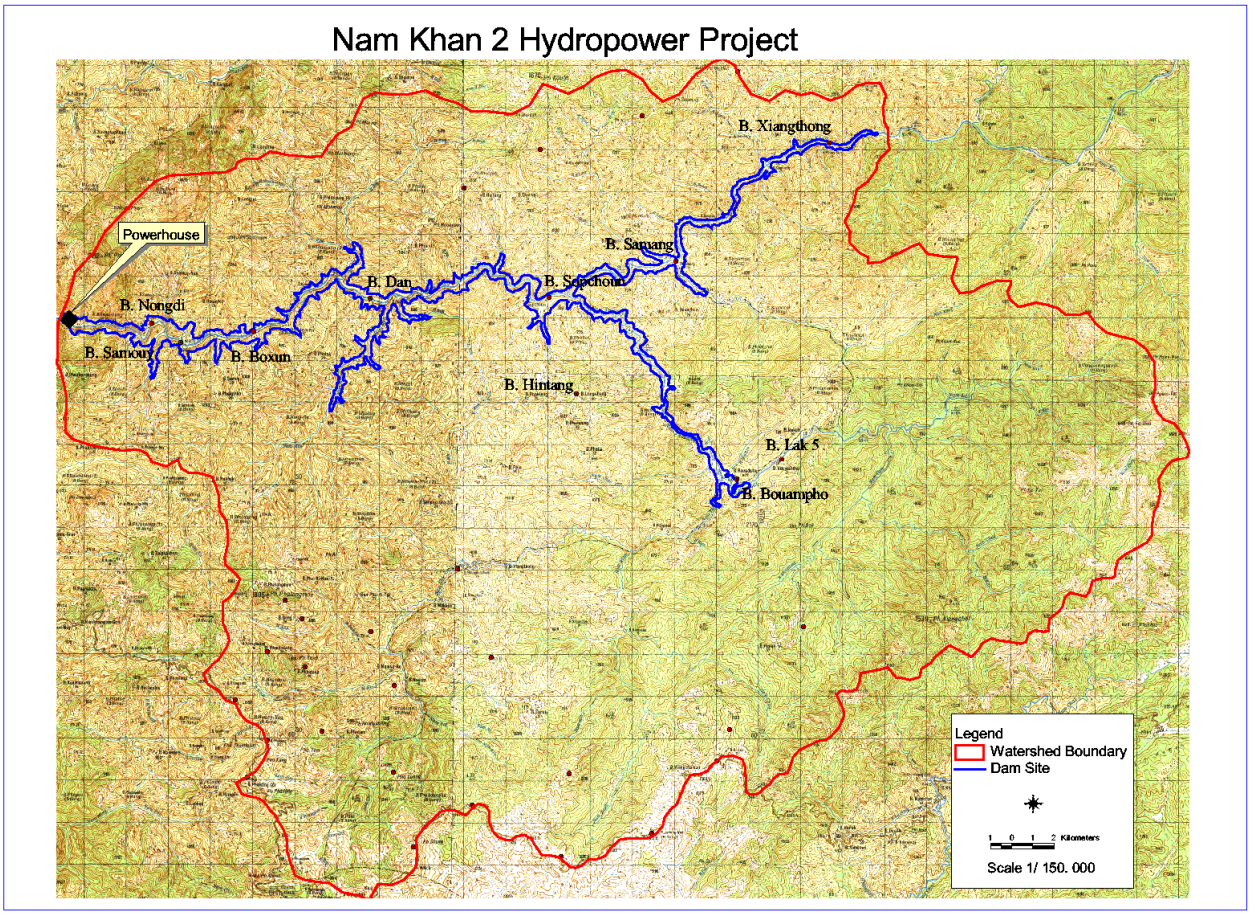

Figure 6: Topography map of the project area

4.6 Geology, Physiography and Soils

4.6.1 General Physiography

The Northern-Central Laos provinces of Luangprabang is characterized by their young landscapes where ongoing processes continue to shape the land. The topography is predominantly steeply dissected hill country, ranging in elevation from 320 masl in valley bottom areas like Luangprabang and Xiengkhouang to over 2,000 masl on mountain ridges. The highest mountain is Phoubia Mountain, 2,820 masl at Xiengkhouang Province. Almost 90% of Luangprabang Province is mountainous. The slopes of the lower hill zone tend to be steep where tributaries have downcut in V-shaped valley bottoms. Upper hill slopes tend to be less steep and more rounded. Large flat areas are rare, occurring occasionally in Louang prabang Province and along the major rivers where valleys open up to allow river flood plains to develop.

4.6.2 Regional Geology and Stratum Lithology

In the long geological development and evolvement history, in the project area, Devonian System (D) and Permian System (P) of upper Paraeozoic era exist, which are mainly distributed in the large western part and small northern part of this area, accounting for about 50% of the total project area. And Triassic Period (T), Jurassic System (J) and Cretaceous system (K) of Mesozoic era exist, which are mainly distributed in the large eastern part of the project area, accounting for about 50% of the whole project area. The above strata of Upper Paraeozoic era and Mesozoic era are of conformable contact, invasion unconformable contact or fault contact. Sedimentary deposit of Carboniferous System and Devonian System is absent in this area. Moreover, slope wash and colluvium of Quaternary System is widely distributed on the slope surface.

4.6.3 Soils

According to OSTE (1993), soils in northern Laos tend to be heavily leached and acidic, with low water retention capacity, and generally low fertility. Combined with the rugged terrain, this limits the opportunities for intensive agriculture.

As a result from the study conducted by FAO-ADB noted that based on observations made of road cuts on steep slopes, it appears that the bedrock has been thoroughly weathered in places to a depth of two or meters such that the original rock structure is not distinguishable. The study further reported that the A and B soil horizons on sloped ground are thick and relatively undifferentiated from one another, suggesting that erosion and soil genesis are in balance. The soils were found to be acidic (pH 4.6-5.6) and of low to medium fertility, with limited available phosphate (FAO-ADB 1998, in WCTPC-IUCN (2000a).

Margules and Pöyry, et al (2000) report that the National Agriculture and Forestry Research Institute (NAFRI) are undertaking a national soil classification for Laos, which was completed at the end of 2000. They provide the most definitive information on soils in Luang Prabang Province, indicating the following (Margules and Pöyry, et al, 2000).

The soils are mostly derived from siltstones, and sandstones on an ancient uplifted peneplain, which has been heavily dissected by rivers over time. These soils generally highly weathered, moderately deep (0.4 to 1.2 m or more) and well drained. However, the soils are typically acid (sometimes with pH less than 5), with relatively low organic matter, limited available phosphate, and only medium to low fertility. There are also small areas of limestone outcrops, but these areas are generally very steep with shallow soils not widely used for agriculture. The major groups of soils in Luangprabang consist of Acrisols, Alisols, Luvisols and Cambisols, with areas of gleyed soils also found in lowland areas. The soils are generally suitable for shifting cultivation or swidden provided that a fallow period of 7 years or more is maintained, except on steep slopes where sever erosion problems can occur following heavy rains. For more permanent agricultural systems involving annual cropping on less steep slopes (less than 36%), a combination of practices such as soil and water conservation measures, use of nitrogen-fixing legumes, and application of manure, compost or other soil amendments would be required.

4.7 Water Quality

4.7.1 Reservoir Water Quality

Water quality in a reservoir can be affected by stratification. Stratification in reservoirs is caused by density variations in the water body induced by differences in temperature and other water quality parameters. Accordingly when the surface waters or epilimnion of a reservoir are warmed by the sun a negative temperature gradient or thermo cline is established between the warmer epilimnion layer and cooler waters at depth referred to as the hypolimnion. Because the density of water decreases with increasing temperature this stratification of layers is stable and the reservoir is said to be stratified. The stratification can be removed by energy inputs that cancel the tendency for stratification. Energy inputs that force circulation are largely derived form the wind inducing strong wave action and lateral movement of the warmer surface waters to one side of the reservoir. Reservoirs undergo stratification if:

- The reservoir depth is more than 15 m
- The ratio of inflow to volume is small
- The reservoir depth is greater than the light penetration

In several sections of the Nam Khan 2 all these criteria are satisfied and accordingly stratification at least for some times of the year is expected depending on the direction, and thence the fetch and exposure to prevailing winds.

Stratification affects the quality of reservoir water because it prevents deeper water mixing with oxygen rich surface water. Deeper stable waters then remain in contact with decomposing vegetation rotting under anaerobic conditions. These cool anoxic waters are unsuitable for most life forms but certain species can tolerate such condition in the short term (hour or days). The most likely time it will become stratified is during the dry season when the dominant winds are from the NE and the fetch is limited.

The most significant impact of thermal stratification is on dissolved oxygen levels, which in turn affects:

- Reservoir water quality
- Functional uses of reservoir
- Downstream use of flow releases

4.7.2 Reservoir Water Quality

Adverse changes is water quality within the dam is not expected to have any adviser impact other than prevent deep bottom feeding fish and invertebrates and underwater flora from inhabiting parts of the reservoir. The main impacts of such poor water quality are potential downstream impacts on the fishery.

4.7.3 Functional Uses of Reservoir

The reservoir is not expected to have any other functional use than water supply for the power station and as a smooth transport route for tourists and local inhabitants.

4.7.4 Downstream Use of Flow Releases

Hypolimnial release results in the discharge of cold water that may be low in dissolved oxygen and high in iron, manganese, nutrients and hydrogen sulphide. High hydrogen sulphide concentrations can create odor problems, cause fish-kills, and result in corrosion of operational equipment. In addition, high iron and manganese content may create treatment problems if the water is to be used for domestic water supply especially for those villagers who live in the downstream areas.

When oxygen levels are returned to natural levels downstream there may still be some changes in fauna because of changed water temperatures. Even if water is drawn from the epilimnion there may still be significant temperature changes. Water from the hypolimnion released through deep penstocks tends to be warmer in the winter and colder in the summer. Discharges warmer than the receiving river will raise water temperature and accelerate biological productivity. This may be beneficial or may occur to such an extent that dissolved oxygen is depleted and adverse impacts result. Complex systems of stratified currents can occur downstream when cold water flows in warm river water, with little mixing taking place for some considerable distance.

4.7.5 Mitigation of Thermal Stratification

Many of the adverse impacts associated with reservoirs relate to thermal stratification. A variety of operational techniques and structures of different design have been used to control the quality of reservoir releases and to minimize the adverse effects of reservoir stratification. These can be summarized include; changes in inlet structure configuration; multilevel outlet works for mitigation of downstream effects; forced mixing and aeration by fountain jets or compressed air.

The provision of multiple level outlets to facilitate selective withdrawal provides the simplest method of controlling water quality but possibly the most expensive. Selected releases of water from the epilimnion, through appropriately positioned outlets, will provide high quality discharge during times of stratification. Releases from a number of outlets can be used to dilute hypolimnial water over a longer period, and can be used to improve discharge water quality. Maintaining high discharge flows may prevent thermal stratification and the associated development of hypolimnial waters by stimulating mixing in the water column, so that the water quality of the releases can approach that of pre-impoundment conditions.

4.7.6 River water Quality

The structure is expected to improve some aspects of water quality for some distances downstream especially in the wet season. The higher dry season flows have the potential to suspend a greater sediment load and thus there is the potential for a slightly higher load of suspended sediment. During the dry season there could also be a significant decline in dissolved oxygen (DO) levels below the level needed to sustain life forms for a short distance downstream if water is withdrawn from the hypolimnion.

The distance downstream for natural purification processes to work is depends on the degree of natural turbulence its surface area to depth ratio and initial DO levels. Experience elsewhere indicates that DO levels might remain below the critical threshold for most fish of 4 mg/L for up to 10 km downstream. Mitigation measures aimed at maintaining levels above this standard have included large impellors installed in the reservoir to force fresh oxygenated surface water down to the intakes, installation of air intakes into the turbines, forced aeration of bottom waters and tail waters and construction of downstream aeration weirs. It may prove necessary for the government to set a water quality standard at certain point downstream of the dam in response to which the project will establish and then adjust its mitigation strategies.

4.8 Unexposed Ordinate (UXO)

Lao PDR has the unwanted distinction of being per capita the most heavily bombed nation in the world. During the second Indochina conflict, the country was the scene of extensive ground battles and intense aerial bombardment. More than half a million US bombing missions were carried out between the years 1964 to 1973, delivering more than two million tons of explosive ordnance on the country. This includes more than 266 million anti-personnel sub-munitions (known as “bombies” in Lao) released from cluster bombs. According to figure 23, there quite some number of UXO contamination in Luangprabang Province. There some small part of Luangprabang and Pakxeng district are contaminated by UXO as well.

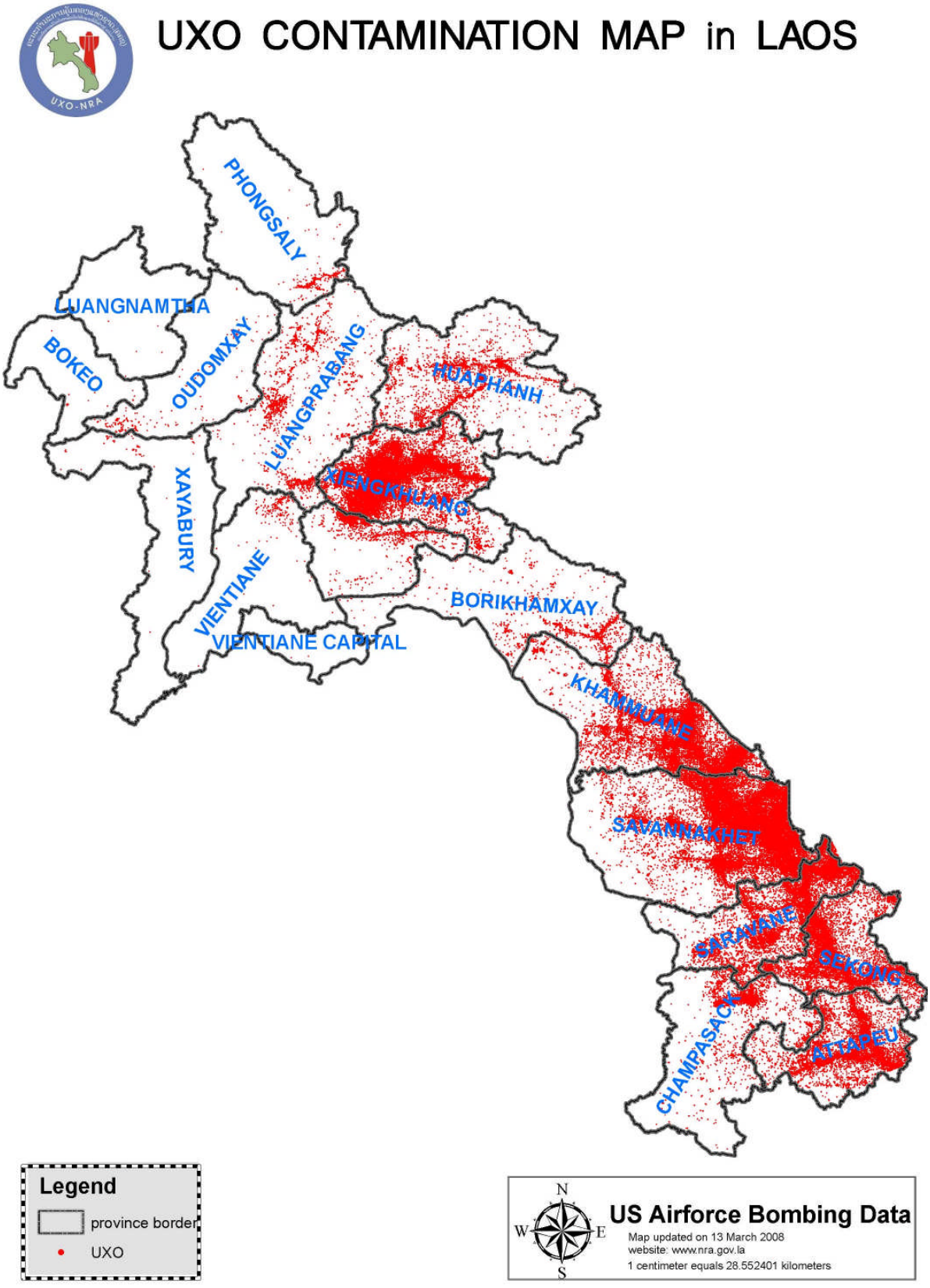

Figure 7: Map Showed the UXO Impacted in Lao PDR.

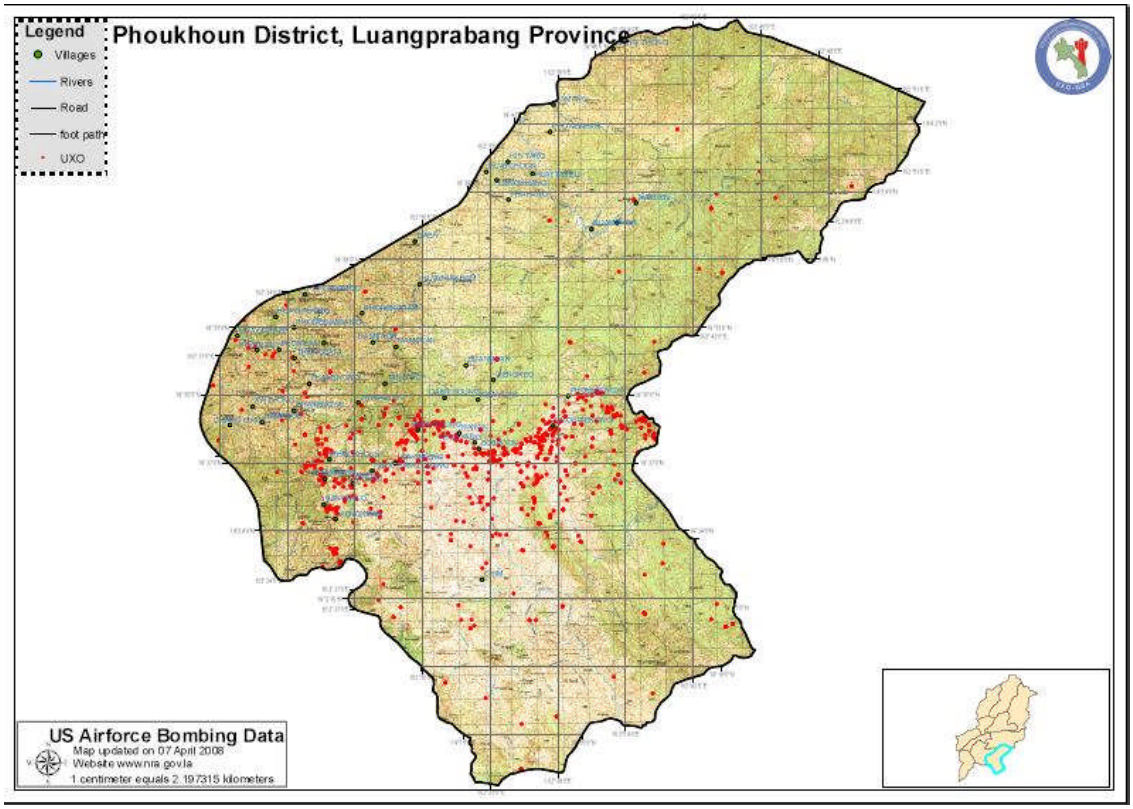

Figure 8: UXO of Phoukhoun, Luangprabang Province.

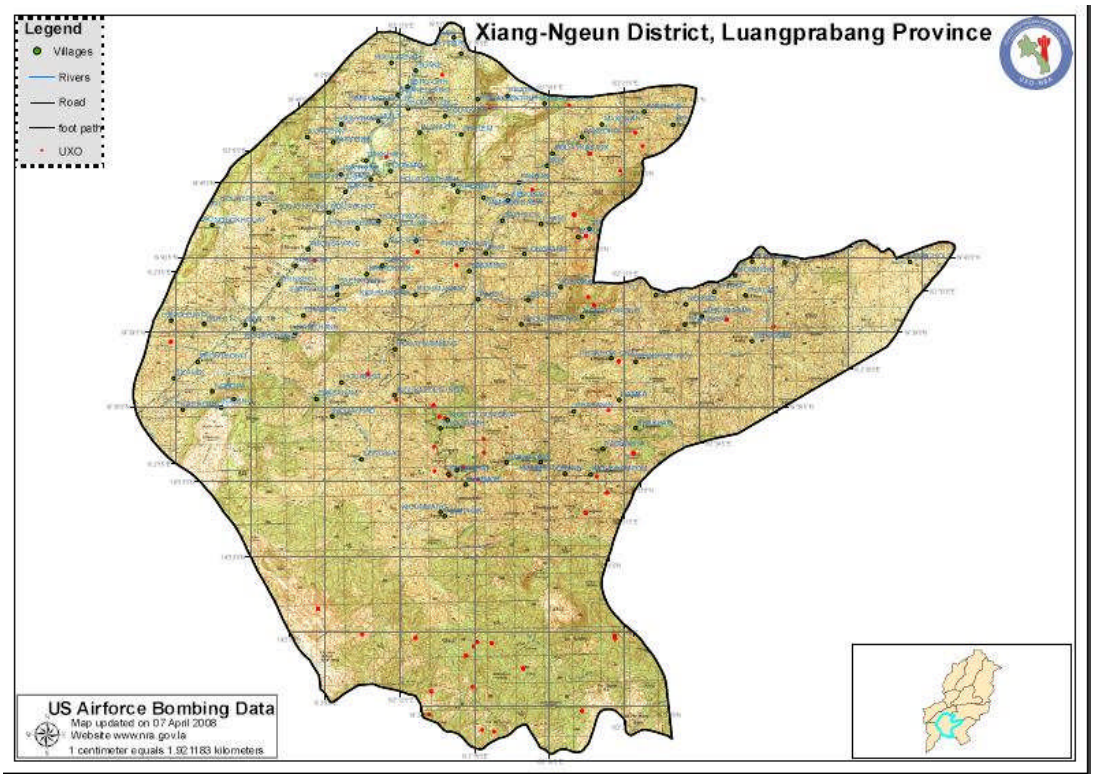

Figure 9: UXO of Xieng Ngeun, Luangprabang Province.

4.9 Air

There is no any environmental monitoring station in the Project area neither air quality and noise. By observation the air quality in the Project area was good during the period of evaluation. There are no industrial pollution sources in the vicinity of the Project, and there is no noise

disturbance from human activities. There is only sometime noise from small motor boats used by local people for fishing or travelling to other villages.

V BIOLOGICAL ENVIRONMENT

The 'survey area' in this report is broadly defined as the area north of the dam site extending to the northern margin of reservoir. The surveys were conducted to provide baseline information on the distribution of wildlife and wildlife habitat areas forests and flora to determine likely impacts of the project on the fauna and flora and assess how any such impacts might be mitigated through appropriate interventions.

The method involved in assessing the biological environment was to compile all maps and available literature on the land and water resources of the region and in particular the survey area defined above. The affected villages are located along the Nam Khan river and access to the site area is difficult especially the forested areas where primary data need to be collected; some of these villages are accessible only by boat (water way). As a result the amount of site-specific information available is very limited.

In addition an extensive indigenous information surveys was conducted during May-June 2008 in all villages within the proposed project area that are assessed as needing location. Survey villages were selected on the basis of likeliness to be influenced by either direct or indirect impacts from the currently proposed hydropower project. There are some other villages that may need to be resettled, but which were not surveyed. In each survey village the village authority selected ten to fifteen persons for interviews. Selection was based on the person having experience in forest products wildlife and experience with the vegetation and non-timber forest products. The selected villagers were divided into two study groups, a group of wildlife-experienced participants and a group of forest product participants, with selection based on their stated experience. Information on medicinal plants and non-timber products was collected at the same time as data on wildlife. The interviews for obtaining information on forest product and wildlife were conducted at the same time

Some interviewees were sensitive to questions regarding hunting which can skew the distribution of results obtained from formal interviews. In 1998 and 1999 the government as part of an attempt to protect biodiversity collected rifles and guns. When the villagers were asked what kinds of animals were hunted in their village boundary, they often answered that no animals had been hunted since the time guns were collected. Yet animal parts could be seen around the villages.

5.1 Wildlife Conservation in Lao PDR

Wildlife is the undomesticated animals and plants, which are living in nature. They are included many types and species of a very small size up to a very big size of vertebrates or invertebrates or any type of habitats, such as: mammals, birds, reptile, amphibian, fishes, insects and all type of plant's communities.

Lao PDR, overall is still harboring rich fauna, with many species' populations and their habitats less depleted than many countries of the region. At least 166 species of reptile and amphibian, 700 bird species, and 100 mammal species occur in Lao PDR. However, most of them are found only in the existing NBCAs.

Currently, the richness of Lao PDR's wildlife has less to do with conservation efforts than with the country's low population density and consequently extensive forest cover. Although hunting pressure in the country is still far and wide, the relative abundance of habitat and, in some areas, its long distance from human settlements and the inaccessibility has provided partial protection

for the country's wildlife. However, human population and development pressures are on the increase, especially since 1990 and consequently the wildlife population dramatically declines throughout the country.

5.1.1 Threats to wildlife

Lao PDR is located in Southeast Asia and has the highest percentage of forest cover in the region (69.9%, FAO Report 2005, while the rich forest covers 41.5%, FS2020; MAF, 2002). The non-market based political system of the previous two decades and its low population density has helped to preserve the forest cover, thus preserving the habitat of many species that are threatened or extinct in other areas. Despite significant hunting pressure, there are still healthy wildlife populations due to this relative abundance of habitat in some areas. However, remoteness from human pressure can no longer ensure all species' conservation in Lao PDR and recently initiated management interventions need to continue for the long term and need to be expanded. Unfortunately, institutions and activities dedicated to wildlife conservation are under-resourced. Threats to wildlife in Lao PDR include the direct human uses detailed above, of which the most important are:

- Local hunting for consumption, recreation, internal trade, as well as, livestock and crop protection.
- Hunting and capture of wildlife for local, national and international trade. Principally for traditional oriental medicines and foods.
- Commercial logging (legal and illegal).
- Proposed hydropower development as well as cutting and clearing of forest and other habitats for agriculture cultivation.

5.1.2 Legal Protection of Wildlife and Wildlife Habitats

All wildlife in Lao PDR is the property of the state. At present, laws provide protection of wildlife use and are regulated by. Government and provincial programmed to collect guns from villagers and to conduct significant long-term activity for wildlife conservation in Lao PDR.

The Government of Lao PDR has developed a national protected area system for several years. The program to establish a national biodiversity conservation system[1] has been active since 1989. PM's Decree Nº 164/1993 firstly established 18 NBCAs covering approximately 10% of the land area of the country, a further two (Dong Phou Vieng and Xe Sap) were added in 1995-1996 plus two corridor areas. The current area totals 3.4 million hectares or 14.3% of the country's area. In addition, provinces and districts have designated their own conservation areas[2] and protection forests[3] bringing the overall national total to 5,3 million hectares or 22.6% of the total land area.

Under the Lao government system, Ministry of Agriculture and Forestry (MAF) has overall responsibility for management of all categories of forest including those NBCAs and Protection

[1] The Lao term 'Pa Sa-Nguan Heng-Sat' means **"**National Conservation Forest". To distinguish them from other types of conservation forest, the term 'National Biodiversity Conservation Areas (NBCA)', which more accurately reflects Government intent according to the wording of the Decree, has been adopted for English use (Berkmüller et al. 1995).

[2] 57 provincial biodiversity conservation areas (PBCAs) total 932,000 ha and 144 district biodiversity conservation areas (DBCAs) totaling 504,000 ha.

[3] 23 provincial protection forests totaling 461,000 ha, and 52 district protection forests totaling 56,000 ha.

Forests nation wide. Responsibility is delegated to the Department of Forestry (DoF), with the Forest Resource Conservation Division (FRCD) and Protection Forest Management and Forest Rehabilitation Division (PFMFRD) in the role of technical units. From DoF decentralized responsibilities are with the Provincial Agriculture and Forestry Office (PAFO) and the District Agriculture and Forestry Offices (DAFO) who manage the conservation forests, aquatic animals and wildlife within their jurisdiction. The DAFOs themselves must in turn cooperate with people living inside and on the periphery of the relevant forests.

In addition to the NBCAs and National Protections Forests, the provinces and districts have also established a number of Provincial and District Protected Areas (PPAs and DPAs) including protection forests[4]. The location of these PPAs and DPAs is quite difficult to confirm especially in the field areas, as the Provincial Agriculture and Forestry Division (PAFOs) have no accurate maps of these areas except for the lists and numbers of PPA and DPA.

5.1.3 Net Effects of Hunting

Extreme hunting pressure has reduced the population and species richness of wildlife near towns, noticeably including birds that are elsewhere abundant in urban environment (e.g. crows, Coppersmith- Barbet). The wildlife numbers are also reduced levels in likely populates in rural area. Hunting is the major factor pushing wildlife species in Lao to extinction (see pictures). Among species, very few of mammals, reptiles, amphibians and birds are not traded internationally. Among the wildlife valued mainly the survival economy, the species most affected by over-harvesting seem to be those of edge habitats and extensive dense forest. The wholesale removal of wildlife from Lao forests along international border is a major local concern (J. Baker and W.G. Robichaud personal communication 1999).

5.1.4 Forests and Flora Conservation in the Lao PDR

The project area lies within the Southern Mid-Highlands of Lao PDR, one of the three main physiographic units in the country, characterized by rugged hill topography mostly between 200 and 1,200 m in altitude. Regional drainage is south to the Mekong Plain. The Lao landscape has historically been dominated by dense forest and, despite more recent clearance, still retains significantly more forest coverage than neighbouring countries such as Thailand, Vietnam and China (Yunnam Province) (Duckworth et al, 1999). The original forests of the Northern Highlands were predominantly dry evergreen and mixed deciduous forests. However, shifting cultivation has removed much of the original forest and large areas of grassland, bamboo and other secondary vegetation are now present especially in the northern part and mountainous areas of the Lao PDR. Non-timber forest products (NTFPs) such as leaves, shoots, flowers, roots, fruits, flowers and bark are used extensively by the Lao people and are of great importance both as a food source and also medicinally and culturally.

The project area does not adjoin any NBCAs. However, it contains some important habitat areas, including downstream waterfalls and wetlands as well as a special spirit pool that is a unique geological site. Due to the steepness of these areas and the pattern of settlement concentrating on more accessible land, in some areas where inaccessible, the vegetation has remained relatively intact, providing important habitat for a range of species. However, the more accessible areas

[4] The Forestry Law also defines 'protection forests' as a distinct forest category (Art. 17) not intended for protection of biodiversity, environment or culture but for watershed protection, erosion control, national security and/or prevention of natural disasters.

have been destroyed and converted for years. New concessions have been issued recently and logging is continuing in both evergreen and mixed deciduous forests.

The area is under pressure from hunting activities, continuing patterns of shifting cultivation and from settlement. In the more remote and steep areas there are patches of evergreen forest. These are in areas difficult to access by boat or by foot (more than a day's walk). Hunting is reduced in areas that are difficult to access on foot.

5.2 Wildlife Surveys

The specific objectives of the survey were:

- To observe and document the main wild species (mammals, reptiles, fish, amphibians, and birds) that live in the Nam Khan Hydroelectric Project area.
- To check if there area any endangered species, rare species and red list species in the area.
- To record the forest types and land-use within the project area.
- To observe the importance of various species of wildlife in terms of livelihood support to the villages in the reservoir area.
- To consider avenues of escape as the reservoir fills and alternative areas of habitat for the endangered species of fauna in the reservoir area.
- To determine eco-tourism potential.

As a starting point, lists of wild animals know to exist in the area were obtained in the PAFOD and DAFO. Data collection was then carried out with the assistance of district officials who helped interview villagers with checklists that included pictures which were used to assist villagers to identify species that were considered important. Information collected on key species was checked against information recorded by nearby projects. Villagers were asked about their use of wildlife and also how wild life impacted negatively on their livelihood.

The survey information was divided as coming from the following areas;

- Upstream area
- Reservoir area
- Downstream area, and
- Around affected villages

5.2.1 Wildlife Habitats

Forest is the dominant habitat of wildlife and areas affected by shifting cultivation is the dominant land cover. The forest types consist largely of unstocked forest representing areas that are being incorporated into the cycle of slash and burn and significant areas of mixed deciduous forest that is either located either on areas of steep land where the forest is inaccessible or on poor soils unsuitable for upland rice and vegetable production. It should be noted that it is sometimes difficult to distinguish the virgin uncut, but sparse, forest from the unstocked forest, especially from aerial surveys. Shifting cultivation and clearing land for tree (Teak) plantation are practiced near and around the Nam Khan Hydroelectric Power Project site.

5.2.2 Wildlife Species

Since 1991, many wildlife surveys have been conducted in Lao PDR in collaboration between the Department of Forestry and other international organizations including NGOs such as the World Conservation Union (IUCN), the World Wildlife Fund (WWF), and the Wildlife Conservation Society (WCS). The field surveys have mostly focused on assessment of habitat

cover and condition, and on establishing inventories of species including mammals, reptiles, amphibians and birds (including bats).

In the last decade, exploration of wildlife has uncovered increasing densities of mammals, reptiles, birds and some amphibians' species such as: elephants, tigers, monkeys, deer, turtles (Manouria impressa), soft-shell turtle species, water monitor, flying lizard, python, king cobra, Siamese fire back, peafowl species etc. However, it is expected that with more development, more intensive land use and higher population densities that the overall population of wildlife and endangered species including some Red List (IUCN) and very rare species is declining.

The government has collected hand-made guns and rifles since 1998, and also contributed laws to help and protect those animals. There are international organizations made efforts to conserving wildlife such as the World Conservation Union (IUCN), World Wildlife Found (WWF), and Wildlife Conservation Society (WCS). Those organizations are trying to implement more laws and regulations to protect wild animals. Even with these efforts, and although the pressure on wildlife trade is decreased, but some endangered species are still found for sale in markets as dried, fermented or fresh meat. Some are sold live as pets or for future slaughter. Hunting is still a significant pressure on wildlife populations.

5.2.3 Key Species of Mammals of Special Conservation Significance

Globally threatened species are listed as vulnerable, endangered or critical. Global status information is based on the 1996 IUCN Red List of threatened wildlife species (IUCN, 1996). Endangered mammals that appear on the mammals survey list include: the Asian elephant, the Banteng (wild cow), and the Duoc Languer. Mammals that are listed as globally threatened and vulnerable include the Asiatic Black Bear, the Eastern Porcupine and the Pygmy. However, according to the Lao Forestry Law, Wildlife Law and regulations concerned, some endangered and threatened species of wildlife have also been listed as indicated in the MAF' Regulation No. 0360/MAF.2003, dated 8 December 2003.

5.2.3.1 Mammals within and around the Project Area

Within and around the Project Area, wildlife conditions were surveyed and assessed by visual inspection and villagers' interview as well as secondary data and information gathered from available sources in the authorities concerned. Most local villagers within and around the project area including affected and unaffected villages were interviewed regarding their account of wildlife conditions within and around their village areas. According to the available sources of data as well as field survey and villagers' interview, only significant remaining habitats are on the steep inaccessible slopes of dense and undisturbed forests outside the project area. All wildlife has been and is still indiscriminately and extensively hunted. The majority of significant wildlife species have either been eliminated from the project area either due to the habitat losses through agricultural clearing mainly slash and burn cultivation or indiscriminately hunting practices which has been for generations a significant part of livelihood of local people.

According to the villagers' interview, it was indicated that more than ten years ago, there was abundant wildlife including higher populations of key species around the project area. However, at present, these mammals are declining and some of them are likely to have become endangered species. Due to habitat loss, hunting, as well as collection for pets and medicinal uses, some species around the project area are categorized as Red List species by the IUCN.

Most endangered species were not found in and around the project area due to habitat loss. However, some of them were found in pockets of virgin forest that exist scattered over the region. There may be pockets of such forest and habitat areas in the valley floor of the Nam Khan and Nam Seng, that are unique. It is clear that wild animals and people are living in the same areas with rich forest, high density of commercial trees and wildlife.

5.2.4 Reptiles and Amphibians within and around the Project Area

Reptiles and Amphibians (herpetofauna) in Lao PDR have always existed and the reports on herpetofauna (Gressitt 1970, Salter 1993s) of the Lao PDR have been reviewed and edited again recently (Wildlife in Lao PDR 1999). The latest data, listing species such as turtles, tortoises, tree frogs, monitors, pythons, king cobra and caecilians indicates that at least 166 species of reptiles and amphibians have been recorded. Most have been mostly verified with pictures.

5.2.4.1 Key Reptile and Amphibian Species of Special Conservation Significance

In the interviews, the following species were recorded; turtles, tortoises, monitors, varanus sp, python sp, king cobra and also salamander sp. Provisionally at-risk species that were recorded as present by the surveys include the Reticulated Python and the Water Monitor.

5.2.5 Birds within and around Project Area

The bird species data was gathered using field surveys and interviews during May-June 2008 and compared with the list of species recorded 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.

5.2.5.1 Key Species of Birds

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 classify Birds in Lao PDR, November 2003.

Table 3: Wildlife Conditions within and around the Project Area

English (Lao) Name (Common Name)	Scientific Name	Within Project Area	Outside Project Area	Classification and Status
<u>Some Mammal and Reptile Species</u>:				
Monkey (Ling)	Macaca Spp.	A	A	Managed List 2
Wild boar (Mou Paa)	Sus scrofa Linnaeus	A	A	-
Non flying squirrel (Ka Hork)	Sciuridae	A	A	-
Porcupine (Men)	Hystrix brachyuran	A	A	Managed List 2
Pangolin (Liin)	Manis javanicus	A	A	Managed List 2
Common palm civet (Ngen Om)	Paradoxurus hermaphroditus	A	A	-

English (Lao) Name (Common Name)	Scientific Name	Within Project Area	Outside Project Area	Classification and Status
	Pallas			
Jellow Tree Monitor (Len)	Varanus bengalensis	A	A	-
Some Species of Birds:				
Red jungle fowl (Kay Paa)	Gallus gallus	A	A	-
Owls (Nok Khaow)	Glaucidium spp.	A	A	Prohibited List 1
Hill Myna (Nok Sa Li Ka)	Gracula religiosa	A	A	Managed List 2
Parakeets (Nok Keo)	Psittacula spp.	A	A	Managed List 2
Brown-breasted bulbul (Nok Khuak)	Picnonotus xanthorrhous	A	A	-
Flying squirrel sp. (Baang)	Trogopterus/ Hylopetes sp.	A	A	Prohibited List 1
Spotted necked dove (Nok Khao)	Strepelia tranquebarica	A	A	Managed List 2
Greater Coucal (Nok Kot)	Centropus sinensis	A	A	-
White-rumped Shama (Nok Tem Poun)	Copsychus malabaricus	A	A	-

Note: - **A** = Indicates "Appearance". **N** = Indicates "Disappearance".

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

- "Out Side Project Area" meaning that the upper areas where the forest is sill abundant especially in the Nam-Et Phou Loey NBCA (See the Picture 4.3.10).

5.3 Forestry Survey

The specific objectives of the survey were:

- Describe the status of flora in the survey area and identify any high value habitat or rare and endangered species.
- Describe use of flora and forest type resources in the survey area by the local community.
- Assess the impacts of the hydroelectric power project on flora and plants used in the project impact area, particularly on high value habitat and rare/endangered species, or on species of particular importance to the local community.
- Recommend management and mitigation measures that will minimize any adverse effects of the hydroelectric power project on flora, forest type and resource use.
- To observe the importance species of plants in villages used along the Nam Khan 2 Hydroelectric Power Project and also the exiting sites near the project area.
- Focus on the value of commercial trees and investigate forest types and medicinal plants used within project area.

- To consider the endangered species of flora in that area and exiting sites.
- To inspect and manage for geology, topography and also tourism.

5.3.1 General Information on Land Use and Forest Cover in Lao PDR and Northern Part

Lao PDR has one of the most pristine forest ecosystems in Southeast Asia. It is estimated that half of its woodlands consist of tropical forest, in particular the primary forest. According to the Report on the Assessment of Forest Cover and Land Use during 1992-2002 *(Department of Forestry, MAF, July 2005)* we see that forested area covers about 71.6% (17 million ha) of the total national land area which includes:

- Current Forest[5], which is relatively rich and has canopy density of 20% and more, covers 41.5% (9.8 million ha) of the total land area,
- Temporary Unstocked Forest covers 25.6% (6.1 million ha),
- Bamboo Forest covers 2.3% (0.5 million ha), and
- Fallow Forest or past shifting cultivation area covers 2.2% (0.5 million ha).

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, approximately 28% of the total land area is covered by the Current Forest[6], while 66.5% is covered by Potential Forest[7], an approximately 1% is other wooded area, about 1.5% is permanent agriculture land and other non-forest area is covered more than 3%. For Luangprabang Province, an approximately 13% of the total land area of the province is covered by the Current Forest which include Mixed Deciduous Forest (MD) about 12.7% and a little bit of Dry Dipterocarp Forest (DD) and Dry Evergreen Forest (about 0.1%). Meanwhile about 81% is covered by Potential Forest, 0.3% is other wooded area, an approximately 13% is permanent agriculture land and about 4.6% is other non-forest areas or other land use types.

5.3.2 Methodology applied for Data Collection

As it has been mentioned above, the method involved in assessing the biological environment was to compile all maps and available literature on the land use and forest resources of the region and in particular the survey area forest cover and land use within the project area. The main method used in this survey is similar to the method used for wildlife survey including the use of questionnaire-based interviews with villagers especially the senior persons who have experiences

[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 compose Upper and Lower Dry Evergreen Forests, Upper and Lower Mixed Deciduous Forests, Gallery Forest, Coniferous Forest, Mixed Broadleaved and Coniferous Forest, and Dry Dipterocarp Forest (DOF, July 2005).

[6] 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.

[7] 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.

with the vegetation and non-timber forest products. The villages were questioned in relation to the land use as well as the lists of vegetation and NTFPs.

However, in order to fulfill the objectives of the study particularly the primary or field data collection the temporary sample plots 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 dominated area or the good sample area that located in the reservoir area. The data collection temporary sample plots were divided into 3 types according to their shapes and size as follows.

(1) The circular sample plots with a radius of 17.85 meters (0.1 hectare) from which the data of trees whose diameters at breast height (dbh) equal and above 15 centimeter were collected. Other significant information recorded included tree species, circle or diameter and height as well as the data on bamboo types including number of the clumps, stems per clump found in the plot. All data related to wildlife were also recorded within this kind of sample plot such as the sighted animals, foot-prints, nests, burrows, hair or feathers, molts, sound and so on.

(2) the square plot of 5x5 meters (25 square meters) were established in the middle of the circular one from which the information of small trees and/or saplings (a tree whose dab is less than 15 centimeters and whose height exceeds 1.3 meters), tree species, number of tree and their average height as well as all NTFP species were recorded.

(3) The square plots of 2x2 meters will be established within the square plot of 5x5 meters from which the data concerning sapling or seedlings (all undergrowth vegetation); species, number of trees or seedlings of each species as well as the all NTFPs were also recorded.

5.3.3 Vegetation Type and Classification

Several forest classification schemes have been proposed for Lao PDR. The classification of forest types for this study was based on the classification of the Forest Inventory and Planning Division, Department of Forestry since 1982, and the preliminary national forest record, which was developed primarily for forest conservation purposes. This classification system provides one of the most reliable descriptions of vegetation types in Southeast Asia, while allowing the addition of site-specific detail such as species composition. In addition, this classification system formed the basis for forest protection and management through the land allocation process and is thus the most commonly used forest classification system in Lao PDR. The principles of the classification are also based on lavational distribution; dominate phonology, rainfall pattern, and conifer presence. There are several categories of forest classification in this system. The Box 1 below shows the classification and definition and each forest or land use type.

Box 1: Definition of Land Use and Forest Types

1. Current Forest:

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. The natural forests are classified into forest types which compose Upper and Lower Dry Evergreen Forests, Upper and Lower Mixed Deciduous Forests, Gallery Forest,

Coniferous Forest, Mixed Broadleaved and Coniferous Forest, and Dry Dipterocarp Forest.

- **Dry Evergreen Forest (DE):** The Dry Evergreen Forest type has a lower proportion of evergreen trees than the Evergreen type, 50% -80%. Except for 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.
- **Mixed Deciduous Forest (MD):** In the Mixed Deciduous Forest type the deciduous tree species represent more than 50% of the stand. The forest storey's are not as dense as those of evergreen types and most of the seedlings and saplings are deciduous trees. Most often bamboo 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 a lot of climbers, and it could be difficult to distinguish this forest type from the Dry Evergreen type. In dry regions the difference can be clearly seen. The 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 being characteristical 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 such species.

2. Potential Forest:

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. Potential Forest is consisted of Unstocked, Bamboo and Ray.

- **Unstocked Forest (T):** Unstocked Forest Areas are previously forested 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 of clear cut until one year after it has been abandoned. Areas being prepared for clear-cut but not yet clear-cut and areas that have been abandoned for more than 1 year should not be classified as Ray.
- **Other Agricultural Land (OA):** Agricultural land being used for other agricultural purposes than agricultural crop cultivation, i.e. grazing of cattle, 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 been 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).

The Amended Forestry Law No. 06/NA, dated 24th December 2007 classifies the forest in Lao PDR into three categories such as Conservation Forest, Protection Forest and Production Forest. The details definition of each category of such forest is as follow:

Conservation Forest – is the forest classified for the utilization purposes of conserving the nature, preserving plant and animal species, forest ecosystem and other valuable sites of natural, historical, cultural, tourism, environmental, educational and scientific importance. Conservation Forest consists of National Conservation Forest and Conservation Forest at Provincial, District and Village levels.

Protection Forest –is forest classified for the utilization purposes of protecting water sources, river banks, road sides, preventing soil erosion, protecting soil quality, strategic areas for national defense, protection from natural disasters, environment protection and so on. This type of forest is mainly located in the areas of important water resources (such as the head of water catchments), in certain catchments area streams or rivers and in the high slop or steep areas. The forest must be kept intact to protect the integrity of water resources.

Production Forest – is the natural forest and planted forest classified for the utilization purposes of areas for production, and wood and forest product business to satisfy the requirements of national socio-economic development and people's living. This type of forest is available for people to use, with permitted uses including the collection of timber, and non-timber forest products. However, the policy for this forest allocation is that it must be used in a sustainable way.

5.3.4 Description of Vegetation in the Survey Area

The project area in this paper means that the areas are covered only the proposed reservoir area that will be inundated including the dam site and powerhouse. The project area lies within only one province; Luangprabang in the northern Lao PDR, one of the three main physiographic units in the country, characterized by rugged hill topography upto 1,800 m in altitude. The Lao landscape has historically been dominated by dense forest and, despite more recent clearance, still retains significantly more forest coverage than neighboring countries. The original forests of the Northern Highlands were predominantly dry evergreen and mixed deciduous as well as mixed broadleaved and coniferous. However, shifting cultivation has removed much of the original forest and large areas of fallow land and unstocked forest, bamboo and other secondary vegetation are now present.

Mostly tree species were recorded in the survey area. The forest types are classified according to the Land Use Planning Program classification of the Department of Forestry as mentioned above (see Box 1 above). 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 experience the most impact from the proposed hydropower development.

A forest cover and land use map has been produced based on analysis of satellite imagery and aerial photographs. From this more detailed mapping work, the following findings were produced. There is no extensive area (more than 5 km^2) of primary forest in the hydropower study areas that were mapped. The land is a medley of vegetation communities with agricultural practices heavily impacting on species composition (eg. slash and burn can convert mixed evergreen and deciduous forest into unstocked forest) and maturity in the land use and forest types of Nam Khan 2 Hydroelectric Power Project, and provide some differentiation between

levels of habitat and plant community structures, the forest categories have been adopted as follows.

According to the land use and forest cover map 2002 we found that at the 475 masl full supply level (Full Reservoir Load), the land use and forest types that will be directly affected by flooding are included; approximately 0.6% is Mixed Deciduous, while about 72% is covered by unstocked forest and almost 0.8% is bamboo forest, about 0.1% is scrub forest and 10.3% of grass land.

As mentioned above, from the field survey we found that some areas especially along the two bank sides of Nam Khan river where are quite flat land and easily accessible have been changed in terms of land use types due to slash and burn for shifting cultivation as well as conversion for tree (Teak and Rubber) plantation of the local people. From the 2002 satellite image map (forest cover map) it was indicated that most areas along the two sides of Nam Khan river were covered by the different types of forest such as MD, but after the field check it was found that most of such types of forest have been changed into unstocked forest, swidden areas and tree plantation as well as other agricultural land such paddy field.

Table 4: Land Use and Forest Types in the Nam Khan 2 Reservoir Area with FSL 475 masl

Land Use types	**Areas (ha)**	**%**
Upper Mixed decidious	19	0.6
Dry Dipterocarp	17	0.5
Bamboo	26	0.8
Unstocked Forest	2,397	72.7
Ray	131	4.0
Savannah	216	6.6
Scrub	2	0.1
Rice Paddy	143	4.4
Other Agriculture Land	6	0.2
Grassland	338	10.3
Total Areas	**3,296**	**100.0**

Note: This focuses on the proposed Nam Khan 2 Reservoir where to be inundated only.

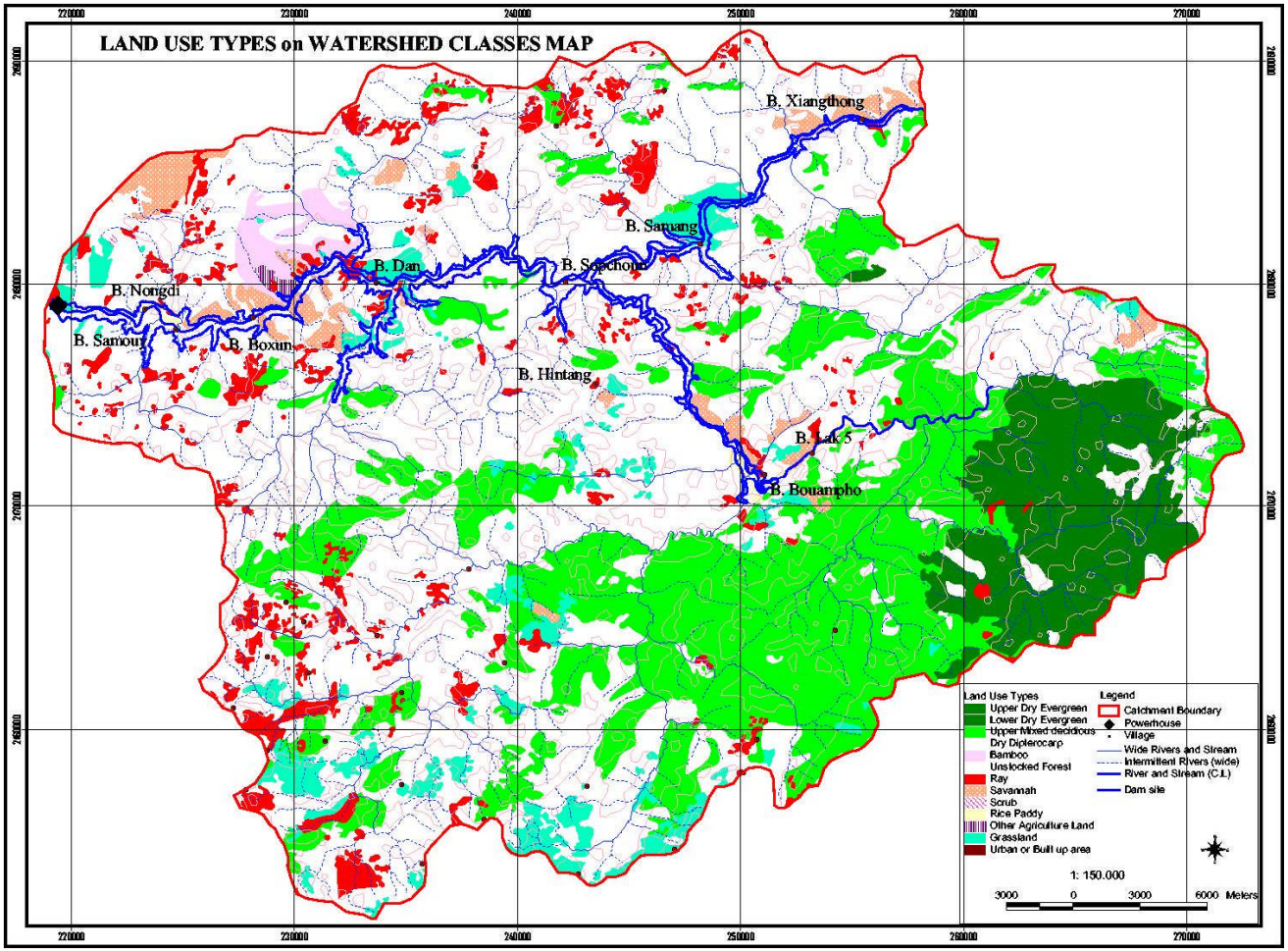

Figure 10: Maps show the Land Use and Forest Types at the 475 masl of FSL in 2009

5.3.5 The Main Tree Species (with DBH ≥ 15 cm)

All tree species were recorded in the sample plots that have been set-up in the survey area 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). 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 experience the most impact from the proposed hydropower development.

A vegetation map has been produced based on analysis of satellite imagery and aerial photographs before field survey is carried out. From this more detailed mapping work, the following findings were produced. According to the field reconnaissance survey and villagers' interview, a larger portion of the study area has been already significantly disturb many years ago by conversion of forest land into other land use types such as slash and burn for agricultural cultivation, burning for hunting and so on especially within and around the proposed reservoir and dam site. However, within the area there are still remaining some commercial tree species that are belonged to different types of forest. In the land use and forest types of Nam Khan 2 Hydropower Project, there are only two main forest types; Mixed Deciduous and unstocked Forests and some dominant indigenous species have been found as indicate in the Table below:

Table 5: Forest Types and Main Tree Species were found in the Project Area

No	Forest Types	Scientific Name	Lao Name	Classification
1.	**Mixed**	1) Pterocarpus pedatus	May Dou	Special List
	Deciduous	2) Holarrhaena antidysenterica	May Mouk	Managed List 3
	Forest	3) Bombax anceps	May Ngew Paa	Managed List 3
		4) Anogeissus acuminate	May Ben Mone	Managed List 3
		5) Spondias pinnata	May Mak Kok	Managed List 3
		6) Croton joufra Roxburgh	May Pao	-
		7) Duabanga sonneratioides	May Ten	Managed List 1
		8) Tetrameles nudiflora	May Saphoung (May Phung)	Managed List 3
		9) Dysoxylum binectariferum	May Kuang Deng	Managed List 1
		10) Cananga latifolia	May Ka Seng	Managed List 3
		11) Alpinia galangal	May Khaa Deng	-

No	Forest Types	Scientific Name	Lao Name	Classification
		12) Elaeocarpus sp	May Bi My	-
		13) -	May Hak Duang	-
		14) -	May Sai	-
		15) Magnonia strobilifera	May Ket Lin	-
		16) -	May Paa	-
2.	**Unstocked and Degraded Forests**	1) Pterocarpus pedatus	May Dou	Special List
		2) Afzelia xylocarpa	May Tae Kha	Special List
		3) Xylia kerrii	May Deng	Special List
		4) Duabanga sonneratioides	May Ten	Managed List 1
		5) Tetrameles nudiflora	May Saphoung (May Phung)	Managed List 3
		6) Lagerstroemia florribunda	May Peuay Khao	Managed List 1
		7) Gmella arborea	May Xor	Managed List 2
		8) Bombax anceps	May Ngew Paa	Managed List 3
		9) Pelthopholum dasyrhachis	May Sa Fang (Sa Kham)	Managed List 2
		10) Anogeissus acuminate	May Ben Mone	Managed List 3
		11) Spondias pinnata	May Mak Kok	Managed List 3
		12) -	May Deua Pong	-
		13) Ehretia sp.	May Tin Tang	-
		14) Cassia fistula L.	May Khoun	-
		15) Cratoxylum formosum	May Tew Kuang (Khao)	Managed List 3

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 above tree species are focused only for the tree with DBH of equal and more than 15 Cm.

5.3.6 The Average Number and Volume of stand Trees (with DBH ≥ 15 cm)

According to the field survey especially for the trees with DBH of 15 centimeters and more, it was found that within the Mixed Deciduous Forest there are about 16 tree species, while within Unstocked Forest there are only 15 main tree species. The number of trees and an average volume for each tree species per one hectare were calculated based on the different types of forests as indicates in Table below:

Table 6: Average Number and Volume of Tree Species per Hectare

No	Forest Types	Scientific Name	Lao Name	No. of Tree per Hectare	Average Volume per Hectare (m^3)
1.	**Mixed**	1) Pterocarpus pedatus	May Dou	10	1.556
	Deciduous	2) Holarrhaena antidysenterica	May Mouk	5	1.379
	Forest	3) Bombax anceps	May Ngew Paa	7	15.822
		4) Anogeissus acuminate	May Ben Mone	15	1.200
		5) Spondias pinnata	May Mak Kok	5	0.302
		6) Croton joufra Roxburgh	May Pao	10	0.444
		7) Duabanga sonneratioides	May Ten	15	26.785
		8) Tetrameles nudiflora	May Saphoung (May Phung)	20	74.850
		9) Dysoxylum binectariferum	May Kuang Deng	5	1.752
		10) Cananga latifolia	May Ka Seng	5	2.815
		11) Alpinia galangal	May Khaa Deng	5	0.414
		12) Elaeocarpus sp	May Bi My	6	3.364
		13) -	May Hak Duang	4	2.484
		14) -	May Sai	10	23.782
		15) Magnonia strobilifera	May Ket Lin	8	2.905
		16) -	May Paa	5	1.394

No	Forest Types	Scientific Name	Lao Name	No. of Tree per Hectare	Average Volume per Hectare (m^3)
	Average Number and Volume of Trees per Hectare for Mixed Deciduous Forest			***135***	***161.248***
2.	**Unstocked and Degraded Forests**				
		1) Pterocarpus pedatus	May Dou	5	3.788
		2) Afzelia xylocarpa	May Tae Kha	5	2.981
		3) Xylia kerrii	May Deng	2	2.282
		4) Duabanga sonneratioides	May Ten	10	2.092
		5) Tetrameles nudiflora	May Saphoung (May Phung)	4	11.605
		6) Lagerstroemia florribunda	May Peuay Khao	5	15.029
		7) Gmella arborea	May Xor	2	0.233
		8) Bombax anceps	May Ngew Paa	6	10.899
		9) Pelthopholum dasyrhachis	May Sa Fang (Sa Kham)	3	0.559
		10) Anogeissus acuminate	May Ben Mone	5	6.153
		11) Spondias pinnata	May Mak Kok	2	0.326
		12) -	May Deua Pong	2	0.124
		13) Ehretia sp.	May Tin Tang	7	2.303
		14) Cassia fistula L.	May Khoun	2	0.124
		15) Cratoxylum formosum	May Tew Kuang (Khao)	2	0.699
	Average Number and Volume of Trees per Hectare for Unstocked Forest			***62***	***59.197***

Note: The average Number and Volume of the above tree species per one hectare are for the stand trees with the diameter below heart (DBH) of equal and more than 15 cm.

5.3.7 Average Number of Tree Species (with DBH <15 cm and >1.3 meters of height)

As it has been mentioned above, all tree species with DBH less and more than 15 centimeters were recorded in the sample plots especially within the proposed reservoir area during the field survey. However, for the tree species with diameter below heart (DBH) of less than 15 centimeters and the height of more than 1.3 meters are shown in the Table below:

Table 7: The Main Tree Species and Average Number of Trees per Hectare

No	Forest Types	Scientific Name	Lao Name	No. of Tree per Hectare
		1) Fokina kawai hajata	May Len	5
1.	**Mixed**	2) Pterospermum megalocarpum	May Ham Ao	4
	Deciduous	3) Dysoxylum binectariferum	May Kuang Deng	2
	Forest	4) Castanopsis annamonsis	May Khi Mou	6
		5) Dipterocarpus turbinatus	May Nhang (Yang Dong)	4
		6) Spondias pinnata	May Mak Kok	3
		7) Cratexylon prunifolium	May Tew Nam	6
		8) Eugeinia componggensis	May Mak Wa (Dong)	2
		9) Anogeissus acuminate	May Ben Mone	3
		10) Stereospermum fimbriatum	May Khe Paa (Khe Khao)	4
		11) Lagerstroemia florribunda	May Peuay Khao	8
		12) Terminalia corticossa	May Peuay Leat (Nam)	5
		13) Eugeinia compongensis	May Mak Wa (Wa Dong)	2
		14) Duabanga sonneratioides	May Ten	3
		15) Sterculia villosa	May Sa (May Por)	5
		16) Keteleria tonkinensis	May Nhan (May Yan)	6
		17) Ehretia sp. (Symplocos sp.)	May Tin Tang	3
		18) Symplocos recemosa Roxburgh	May Meuat (Meuat Ae)	12

No	Forest Types	Scientific Name	Lao Name	No. of Tree per Hectare
		19) Ficus fistulosa	May Mak Deua	3
		20) -	May Hou Kuang	2
		21) Lagerstroemia villosa Wall.	May Kheo Mou	3
		22) Pterocarya tonkinensis Dode (???)	May Som	2
	Average Number of Trees per one Hectare for MD Forest			***93***
2.	**Unstocked and Degraded Forests**			
		1) Cassia garrettiana	May Khi Lek Dong	4
		2) Coruga piñata	May Sa Khaam	3
		3) Dillenia Spp.	May Saan	5
		4) Cratexylon prunifolium	May Tew Deng (Nam)	18
		5) Symplocos recemosa Roxburgh	May Meuat Ae	7
		6) -	May Khop	4
		7) Pterospermum megalocarpum	May Ham Ao	6
		8) Gmelia arborea	May Sor	3
		9) Terminalia corticossa	May Peuay Leat (Nam)	21
		10) Lagerstroemia florribunda	May Peuay Khao	11
		11) Eugeinia compongensis	May Mak Wa (Wa Dong)	7
		12) Sterculia villosa	May Sa (May Por)	4
		13) Anogeissus acuminate	May Ben Mone	9
		14) Castanopsis annamonsis	May Kor Khi Mou	3
		15) Ehretia sp. (Symplocos sp.)	May Tin Tang	5
		16) Pentacme suavis (P. siamensis)	May Phao	6
		17) Bauhinia species generally	May Sieu	5
		18) Lagerstroemia villosa Wall.	May Kheo Mou	3

No	Forest Types	Scientific Name	Lao Name	No. of Tree per Hectare
	Average Number of Trees per Hectare for Unstocked Forest			**124**

Note: The average Number of the above tree species per one hectare is focused on the trees with the diameter below heart (DBH) of less than 15 centimeters and height of more than 1.3 meters.

5.3.8 The Use of Forest Products

Generally, forest products especially NTFPs play an important role in the rural economy, as they provide: 1) animal proteins (from wild meat, fish, frogs, shrimp, soft-shelled turtles, crabs and mollusks), 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, mandamus, bloom-grass, paper mulberry), 4) traditional medicines and 5) cash income (from the sale of NTFP species). However, NTFPs collection within project area for most villagers is only for daily food and household utilization, not for sale, due to the area is far away from the town and market.

Basically, all plant species were divided into timber and non-timber forest products (NTFPs; Plate 7), and then categorized according to the use. Note that some plants have been classified in more than one category of use. 79 are trade species (local), 12 species are used as fiber, 8 species as medicinal plants, 21 species are excaudate (resin, darner, gum and sap), 62 species are used as firewood, and 3 species are poisonous plants. People use plants are also utilized as timber products for construction. Ten important species used by local people in the villages were identified by the survey consultants on the basis of the quantity of product collected in combination with the risk of plant extinction. The ten species are also included in the most important NTFPs recorded at the National level (Khamphai 2000 and Lamxay 2000) which are included cardamom (2 species), Beberin (Haem), Agar wood (Ked Sana), Rattan (including rattan shoot; 4 main species), Bamboo (shoots and poles) (3 species), and Broom grass, which is traded at the national and regional level. Other species, such as Mak Neng, edible mushrooms, and a variety of barks that local people use for chewing and dyeing, are also important NTFPs. The use of the eight species is described below.

Rattans (Palmae sp.) (4 species) are very important products used for local consumption as food and for sale. The local price is 5,000-10,000 kip/kg. They can be found in evergreen forests, mixed deciduous forest, dry dipterocarp and also unstocked forests.

Ked Sana (Aquilaria crassna) is a very important trade plant. All parts of the wood of Ked Sana are used to extract perfumed essential oils. 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 the natural 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.

Bamboo shoots (3 species) are an important NTFPs for local people, used mainly for food and partly as a saleable resource. In terms of quantity, these species are the most heavily collected species in the study area. They are used as daily food, especially in the rainy season (May to October). They are distributed from along the streams up to the hills, and are widespread throughout the study area.

5.3.9 Status of the Study Area

- **Vegetation**

The ranges of habitats in this area are still well connected with larger more intact areas in the more isolated mountain ranges, thus allowing for some species to maintain healthy populations, especially more generalist species. For habitat specific species, many are still limited in numbers and continue to be under threat from destroying activities.

- **Resource Uses**

A map has been prepared to show the main non-forest timber product resource use in the study area. Resource use in all villages in the study area is influenced by the reliance of local people on subsistence-based agriculture. While agricultural activities include both paddy rice and shifting cultivation, the limited availability of lowland areas means that the latter is still commonly practiced. Villagers supplement these agricultural activities with the harvest of natural resources, such as hunting wildlife and gathering forest products. Hunting is a traditional element of rural livelihoods in Lao PDR and has long been practiced in addition to agricultural activities.

Hunting has recently become less common in the study area due to declines in timbers and wildlife as well as collections of firearms by village authorities in 1999. As traditional hunting techniques are still permitted, it remains a source of food for some people as well as a source of additional income, though hunting of protected species is prohibited irrespective of the hunting technique used. Hunting appears to vary with an individual's age in that middle-aged and older men are more experienced than younger men with traditional hunting techniques, so hunters may now tend to be older men. However, since the forest which is seen as the wildlife habitat has been destroyed and converted, therefore, within the project area there is no any significant wildlife still remain except some small species of reptiles, amphibians and birds as mentioned in Table above.

Hunting grounds in the study area can extend from the immediate village surrounds up to the less disturbed forests in the mountains. With hunting, gathering of Non-Timber Forest Products (NTFPs) is done in areas close to the village, the vicinity area and more distant areas harboring the rarer species. Some NTFPs, such bamboo shoots, young rattan cane, palm and other

vegetables, may be collected daily for household consumption and sale especially for those the villages locate near to the town or main road. NTFPs that are important for trade purposes are becoming less common and villagers may have to travel greater distances to harvest them. This is the case for herbs, currently the most important trade NTFP in the study area, as it is becoming locally rare due to over-extraction and lack of sustainable management system.

In summary, timber and NTFP resources in the study area are locally available and important in supporting the subsistence livelihoods of villagers. The main threat to this current use is collecting without proper management and technical assistance. Unregulated extraction in the absence of appropriate management systems will reduce timber and NTFP resources and potentially lead to local extinctions (e.g. Bialai - Sanseviera zeylania etc.).

Bamboos and Bamboo Shoots (5 main species)**:** They are an important NTFP for local people; there are some main species that used mainly for food and partly as a saleable resource. The common species that found within Mixed Deciduous and Unstocked Forests are included May Phay Paa (Bambusa arundiana var. spinosa), May Phay Nam or Phay Ka Sa (Bambusa flexuosa Munro), May Lay (Gigantochloa albociliata Munro Kurz), May Phang (Dendrocalamus lonoifimbriatus) and May Xang (Dendrocalamus membranaceus Munro). In terms of quantity, these species are the most heavily collected species in the study area. In terms of bamboo-shoots, they are used as daily food, especially May Lay (Gigantochloa albociliata Munro Kurz) in the rainy season (June to September), the other rest species are used as temporary housing and household consumption such as using for weaving, fencing and so on. They are distributed from along the streams up to the hills, and are widespread throughout the study area. Since the field survey was conducted in the dry season, therefore the data concerning bamboo-shoot is not available. However, according to the villagers' interview we found that the main bamboo shoot species which are used for daily food is May Lay (Gigantochloa albociliata Munro Kurz), May Phay Paa (Bambusa arundiana var. spinosa) and May Phay Nam or Phay Ka Sa (Bambusa flexuosa Munro). The distribution of all these species could be averaged as follow:

Table 8: 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 Mixed Deciduous (MD) Forest					
1	May Phay Paa	Bambusa arundiana var. spinosa	3	15	45
2	May Lay	Gigantochloa albociliata Munro Kurz	24	20	480

3	May Phang	Dendrocalamus lonoifimbriatus	6	18	108
	Sum Average for all species in MD Forest		***33***	***18***	***594***
For the Unstocked Forest					
1	May Phay Paa	Bambusa arundiana var. spinosa	10	16	160
2	May Phay Nam (Ka Sa)	Bambusa flexuosa Munro	6	20	120
3	May Lay	Gigantochloa albociliata Munro Kurz	12	22	264
4	May Phang	Dendrocalamus lonoifimbriatus	5	15	75
5	May Xang	Dendrocalamus membranaceus Munro	9	16	144
	Sum Average for all apecies in Unstocked Forest		***42***	***18***	***756***

Rattans (Palmae sp.): In terms of Rattans (Palmae sp.) especially found in DE and MD forests, there are five main species that used mainly for local consumption as food which included Nhot-Nhe (Calumus sp., C. tenuis Roxburgh), Nhot-Boun (Daemonorops schmidtii), Nhot-San (Rhapis species generally), Nhot-Wai (Calumus sp.) and Nhot Tao (Wallichia gracilis Beccari). They can be found in evergreen and mixed deciduous forests and even in the unstocked forest especially in the rainy season and earlier of dry season.

Mushrooms: in terms of mushrooms, some mushroom species are well grown in the Unstocked and Mixed Deciduous Forests, but only in early of rainy season. Since the field survey was carried out in the dry season, therefore, the data concerning mushroom and bamboo-shoot were not available. However, from the villagers interview we see that within the project area there are some main species of mushroom were found and most of them are for food such as Het Hu Nou (Auricularia polytricha-Montagne-Saccardo), Het Khao (Lentinus sp.), Het Bot (Lentinus kurzianus Curr., L. praerigidus), and etc.

Apart from the above main species of NTFPs, there are some species that play important roles for local villagers' livelihood were also found within the project area such as wild vegetables, wild fruits and wild groundnuts (see Table below). Most of these NTFPs are seen as the important sources of food for most local villagers who live traditionally dependent on natural resources for support their livelihoods especially where the forest is still abundant. Table below shows the main species of plants and NTFPs found within the Project Area.

Table 9: Main species of Plants and NTFPs found within the Project Area

No	Name of the main NTFP Species found within and around the project area	
	Lao Name	**Scientific Name**
I.	**Mixed Deciduous Forest (MD)**	
1	Mak Neng (Cardamom)	Amomum Xanthioides Wallich
2	Wan Lai	Neolourya pierrei Rod
3	Kam Langseuakhong	Ziziphus attopoensis Pierre
4	Kha Khom	Alpinia Malaccensis
5	Tao	Wallichia gracilis Baccari
6	Boun (Rattan)	Calumus sp
7	Wai (Rattan)	Rattans generally
8	Wai Thoun (Rattan)	Calamus sp
9	Wai Noy (Rattan)	Calamus javensis Blume
10	Kheua Wai Din	Combretum decandrum Roxburgh
11	Houa Ka Pouk	Colocasia gigantean Hook. f.
12	Phak Wan	Melientha Suavis Pierre
13	Dok Pheung	Orchidaceae
14	Phak Ii Leud	Piper albospicum DC,P.lotot C.
15	Khem (Bloom grass)	Thysanolaena latifolia (Roxburgh ex Hornem) Honda
16	Het Khao (Mushroom)	Lentinus.sp
17	Het Tan (Mushroom)	Auricularia sp
18	Het Bot (Mushroom)	Lentinus kurzianus curr
19	Phak Kud Paa	Cythea spinulosa wall
20	Ya Nang	Limacia traindia Mers
21	Kheua Haem (Beberin)	Coscinium fenestratum(Gaertner)
22	Teuy	Pandanus species generally

No	Name of the main NTFP Species found within and around the project area	
	Lao Name	**Scientific Name**
23	San	Rhapis species generally
II.	**Unstocked Forest (T)**	
1	Mak Deua	Ficus species generally
2	Khi Lek Paa	Cassia javanica L.subsp
3	Laou (Bloom grass)	Erianthus arundinaceus(Retzius)
4	Man Paa (Groundnut)	Adinandra laotica Gagnepain
5	Man Koy (Groundnut)	Discorea hippida Dennstedt
6	Khaa Paa	Alpinia Malaccensis
7	Kheua Wai Din	Combretum decandrum Roxburgh
8	Wai Thun (Rattan)	Calamus sp
9	Wai Noy (Rattan)	Calamus javensis Blume
10	Por	Sterculia species generally
11	Boun (Rattan)	Calumus sp
12	Wai Lai (Rattan)	Neolourya pierrei Rod
13	Mak Huat	Lepisanthes rubiginosa (Roxburgh) Leenh
14	Kheua Hang Kuang	Ancistrocladus tectorius (Loureiro)Merrill
15	Koud Paa	Cythea spinulosa wall
16	Ya Nang	Limacia traindia Mers
17	Phak Wan	Melientha Suavis Pierre
18	Het Khao (Mushroom)	Lentinus.sp
19	Het Ka Tan(Mushroom)	Auricularia sp
20	Het Bot (Mushroom)	Lentinus kurzianus curr
21	Het Puak (Mushroom)	Temitomycetes species,Agaricus

No	Name of the main NTFP Species found within and around the project area	
	Lao Name	Scientific Name
22	Wai (Rattan)	Rattans generally
23	Man Paa (Groundnut)	Fagraea fragrans Roxburgh
24	Phak Ii Leud	Piper albospicum DC,P.lotot C.
25	Kuay Paa	Musa acuminata colla,M paradisiaca L
26	San	Rhapis species generally

Note: Some of the above plants and NTFPs are collected from field survey and some are collected from villager's interview especially the seasonal NTFP species.

5.3.10 National NBCAs, Protection Forests and Production Forests Nation-wide

National Biodiversity Conservation Areas has been established for several years by PM's Decree Nº 164/1993, firstly established 18 NBCAs covering approximately 10% of the land area of the country, a further two (Dong Phou Vieng and Xe Sap) were added in 1995-1996 plus two corridor areas. The current area totals 3.4 million hectares or 14.3% of the country's area. In addition, provinces and districts have also designated their own conservation areas and protection forests bringing the overall national total to 5.34 million hectares or 22.6% of the total land area.

Management System of Forests

Ministry of Agriculture and Forestry (MAF) has overall responsibility for management of all categories of forest including those NBCAs. Responsibility is delegated to the Department of Forestry (DOF), with the Forest Resource Conservation Division (FRCD) in the role of technical unit. From DOF (FRCD) decentralized responsibilities are with the Provincial Agriculture and Forestry Division (PAFO) and the District Agriculture and Forestry Extension Offices (DAFEO) who manage the conservation forests, aquatic animals and wildlife within their jurisdiction.

However, as the result of conversion of land use and forest types, some of the land and forests within the project area have been disrupted by human activities (logging, slash and burn cultivation and others), and therefore it is unlikely there would be any forest conservation of any kind still existed.

Amongst throughout the country, there are 20 NBCAs. However, the project area situates well outside and some distances away from the nearest NBCAs. The project area does not contain any

form of protected areas or forests of any kind hence impose no thread to NBCA or protected areas or forests in this region (see Picture below).

Table 10: Summary of Production, Biodiversity Conservation & Protection Forests in the Whole 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).

However, although the project area does not adjoin any NBCAs, it covers some important habitat areas, including villages conservation forests as well as special spirit pool forests that is a unique geological site Due to the steepness of these areas and the pattern of settlement concentrating on more accessible land, some vegetation has remained relatively intact, and some areas especially above the reservoir where inaccessible that providing important habitat for a range of species.

Additionally, the area is under pressure from logging and hunting activities, continuing patterns of shifting cultivation. In the more remote and steep areas there are patches of pristine forest especially in Mixed Deciduous Forest, they are located, however, outside of the reservoir area. These are in areas difficult to access by boat or by foot (more than a day's walk). Hunting is reduced in areas that are difficult to access on foot.

According to the three categories of the Forest Map, we see that Nam Khan 2 HEP is located at the proposed protection forest which to be officially established soon by the Lao government. Currently the study on establishment of such mentioned Protection Forest which is carrying out by the Department of Forestry is now ongoing and to be proposed to the government for endorsement soon.

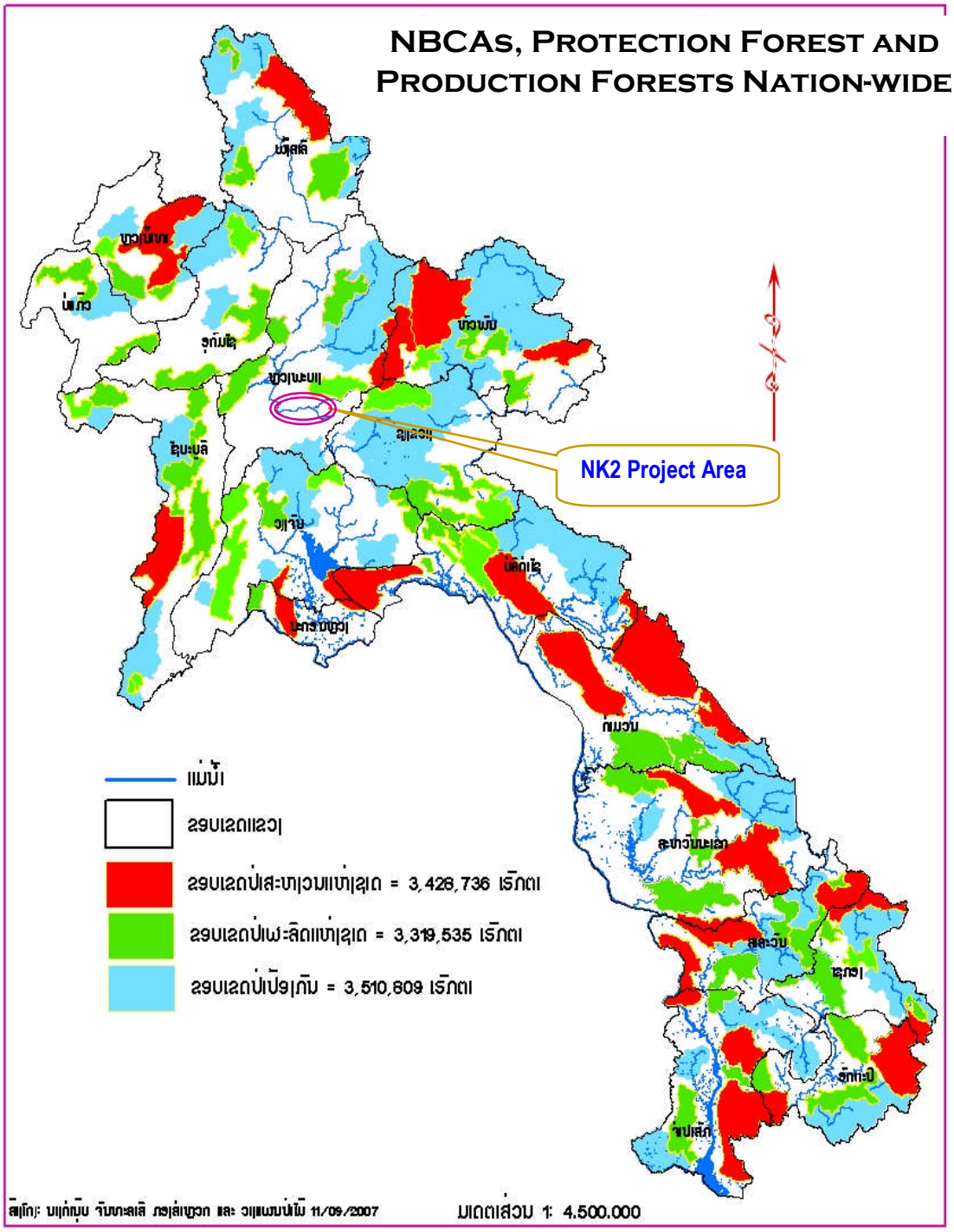

Figure 11: Map shows the Location of Three Forest Categories Nationwide and Project Site

Source: Department of Forestry (2007)

5.3.11 Fisheries and Aquatic Habitat Survey

The specific objectives of the survey were to:

- Identify the status of fisheries and determination of the project impact area limits from a fisheries perspective and prepare mitigate measure
- Provide the baseline aquatic habitat and fisheries, fish habitats and related species (fish habitat at the waterfalls, rapids, riffles, runs, forest streams, estimate to the number of fish species, which standing stock per habitat type within the Nam Khan river and its tributaries such as Nam Seng river.
- Find out different fish species (local names and taxonomic names) in Nam Khan River project area.
- Compile the Socio-economic values of fishing yield in the Nam Khan including levels of fish consumption, and the value of fish in average cash income per year.

The survey also collected information of the fishery through interviews with the concerned authorities, focus group discussion with the residents, and fishermen in major of all villages in the project area. Observations of fishing sites were conducted with residents, who have experience fishing and who are familiar with the names of indigenous fish species and fishing activities, were conducted in the Nam Khan area.

5.3.11.1 Migration of Fish Species

The Nam Khan is a main tributary of Mekong River. The Mekong River and its tributaries are valuable resources for Lao PDR. The major species of fish migrating between the Mekong River and its tributaries as well as Nam Khan River, as shown below:

Figure 12: Species of Fish migrating between the Mekong River and its tributaries including the Nam Khan River.

No.	Local names	Taxonomic names	Remarks
1	Pa bou mat	Pangasius larnaudei	
2	Pa I tou	Morulius sp. Or spp	
3	Pa ka	Pristolepis fasciata	
4	Pa khao	Wallago attu	
5	Pa khop khong	Parambassis	
6	Pa khe	Bagrius sp.	
7	Pa kheung	Hemibagrus wyckioides	
8	Pa khi lai	Labiobarbus sp	

No.	Local names	Taxonomic names	Remarks
9	Pa khoun	Wallgo leeri	
10	Pa kot	Hemibagrus remurus	
11	Pa mak mang	Sikukia gudgeri	
12	Pa nou	Helicohagus waadersi	
13	Pa nyone khi none	Laides sp. Or spp.	
14	Pa nyone thamada	Pangasius macronema	
15	Pa nyone thong khom	Pangasius pleurolaenia	
16	Pa pak	Hypsibarbus sp. or spp.	
17	Pa phan	Schitrua or Nemacheilus sp.	
18	Pa pak	Hypsibarbus sp. or spp.	
19	Pa phan	Schitrua or Nemacheilus sp.	
20	Pa phia	Morulius sp. or spp.	
21	Pa sakang	Puntioplites sp.	
22	Pa sa-ngeng	Mystus spp.	
23	Pa yang	Pangasius bocourli	

Source: MRC (2000).

5.3.11.2 Fish species in the project site

According to the field survey and villagers' interview it was found that none of the villages reported that they had standing water for agricultural areas, have no fish stocked within rice fields because the villages do not have flat plain area for rice paddy and agricultural areas. The large scale of fishing gears are unfound and used in this study area, undertook business activities related to middle and large scale on fisheries. Information was gathered on the common resources of the villages. It is clearly that all of the villages expect to have at least one aquatic resource for conservation zone within one to two kilometers. However, data show no significant relationship availability of agricultural land and fisheries activities could be found in this study area.

Overall, involvement in capture fisheries is quite high and hunting activities still reported. All villages are reported to be dependent on fishing for both food and income.

Conservation zones or deep pools can be found in this study, the conservation zones have been difined by villagers, the purpose of conservation zone was invariably to save the area as a breeding ground for fish and sustainable use in the future. However, the deep pools normally are depth between 6 – 10 m (dry season). Deeppools are defined as significantly area for fish habitat use in the dry season during which it may become disconnected from the main river. A deep pool is only one resources of ecologically as a waterpool or water stock being of significance for fish conservation and increase a number of fish population and fish species" (Chan et al, 2005). Restricted season is presented of study area, especially villages were implementing restricted fishing season during reproduction season-late June to July and November to December. Indeed, the advices on appropriate seasons come partly from the department of Forestry, Ministry of Agricultural and Forestry, but in some villages they have made their own regulations. Banning of fishing activities in an area or of an entire fishery for a certain period of time, usually to protect juveniles or spanners are adopted.

As for restricted fishing gears are reported to banned using dynamite, electricity shocked and any poison to catch fish. All of the villages are considered prohibiting using certain gears that can kill a lot of fish during fish migration times (e.g. big bag net with small scale size) or any activities that can be damaged to fish population during reproduction period. Fishing gear are including its accessories and practices that have a destructive impact on the ecosystem, including fragile habitat, immature and juvenile species of commercial importance, unwanted fish and other animals.

Restricted of species is no reported in this study area during surveyed period. Missed of any found and understanding could be happened in this study without any mistakes are possibility occur. However, we are please apology for our missed information.

5.3.11.3 Fish species diversity caught in project area

The GIS analysis of stream data of Watershed Classification Project, MRC noted that a mountainous region, Luangprabang province is rich in aquatic resources with 1,053 km of riverbanks to major rivers, 7,284 km length of medium rivers and 17,722 km of small rivers and streams. This information that provides high numbers of fish and fish species, 178 individuals who had recently been fishing responded to the question of the most important fish species and other aquatic animals in their most recent catch and habitat were used to cath. These data give an indication of the importance of various species of fish and aquatic animals in the fishery. But they also gave only indication of timing catch and most important species for economic values. Table 11 shows 53 total species number of occurrences of species caught in various habitats.

Table 11: Fish Species Lists are presented in project area

No	Local Name	Scientific Name	Nam Khan
1	Ian	Monopterus albus	X
2	Pa Douk En	Clarias batrachus	X
3	Pa Douk Oui	Clarias macrocephalus	X
4	Pa Fa	Himantura chaophraya	X
5	Pa Siew, Pa Saed	Esomus merfallicus	X
6	Pa Siew	Barbichthys nitidus	X
7	Pa Siew Ao	Oxygaster piontoni	X
8	Pa Siew Ao	Opsarius koratensis	X
9	Pa Siew	Rasbora aurotaenia	X
10	Pa Ngon	Laides hexanema	X
11	Pa khee Hia, Duksi	Akysis leucorhynchus	X
12	Pa Ladmaew	Anguilla mamorata	X
13	Pa Boo	Oxyeleotris marmorata	X
14	Pa Nin	Oreochromis niloticus	X
15	Pa Khao Pe	Puntius brevis	X
16	Pa Khup kong	Parambassis siamensis	X
17	Pa Khaokom	Systomus orphoides	X
18	Pa Nai	Cyprimus carpio	X
19	Pa Mom	Scaphiodontichthys acanthopterus	X
20	Pa Mang	Barbonymus gonionotus	X
21	Pa Chad	Poropuntius cf. laoensis	X
22	Pa Kheung	Hemibagrus wyckioides	X
23	Pa Kot	Mystus nemurus	X

No	Local Name	Scientific Name	Nam Khan
24	Pa Hien	Labeo rohita	X
25	Pa Nam, Langnam	Mystacoleucus cf. marginatus	X
26	Pa King, Kiengfai	Onychostoma meridionale	X
27	Pa Chad dam	Poropuntius bolovenensis	X
28	Pa Sakang	Puntioplites falcifer	X
29	Pa Pak Nouad	Hypsibarbus malcolmi	X
30	Pa Pak Taleuang	Hypsibarbus pierrei	X
31	Pa Phia	Morulius barbatula	X
32	Pa Wa	Bangana behri	X
33	Pa Ladmaew	Anguilla marmorata	
34	Pa Kha Ngeng kanglai	Mystus atrifasciatus	
35	Pa Phao, Pa Saii	Mekongina erythrospila	X
36	Pa Phan lay	Schitura sp.1	X
37	Pa Phan Ui	Schitura nicholsi	X
38	Pa Khe	Bagarius yarrelli	X
39	Pa Pae, Pa Tid Hin	Homaloptera sp	X
40	Pa Kuan	Channa cf. marulius	X
41	Pa Khom	Osteochilus lini	X
42	Pa Khor	Channa striata	X
43	Pa Khor Kang	Channa gachua	X
44	Pa Khee Hia	Pseudomystus siamensis	X
45	Pa Lad	Mastacembelus favus	X
46	Pa Lot	Macrognathus siamensis	X
47	Pa Mat, Pa Mak	Trichopsis vittata	X

No	Local Name	Scientific Name	Nam Khan
48	Pa Pao lay	Tetraodon leiurus	X
49	Pa Keng	Cirrhinus prosemion	X
50	Pa Pai	Labeo chrysophekadion	X
51	Pa Khao	Wallago attu	X
52	Pa Sout	Hampala macrodepidota	X
53	Pa keo	Clupeichthys aesarnensis	X

Dominant species found in the survey area include, Pa khe, and Pa kheung. Other than these species of fish, different species, such as crabs, snails, prawns, frogs and aquatic insects were found. These species are frequency found in wet and dry season in the project area.

IUCN Red lists of Fish in Lao PDR

Poulsen et al (2004) stated that, 50 priority migratory fish species in the Mekong river system has been developed by fishery programme of Mekong River Commission (MRC). A total of 53 species of fish were reported to occur in this study area. During the field work, there were a number of fish species identified that are significant in terms of biodiversity conservation. The following table lists each fish deemed as threatened, rare or endangered from a regional perspective and where the fish identified were located. The categorization is from the IUCN listings of fish species that are rare, threatened or endangered species in the region. In addition, some fish are categorized as either very important for local economic value, or as selected species which describes fish that are seen as significant from a national perspective (see Table 12).

Table 12: Significant of Fish species identified in Nam Khan and Nam Seng Rivers

Local Name	Scientific Name	Family Name	Interviewed and Location found
Pa Khe	Bagarius yarelli	Sisoridae	Ban Viengkham, Nam Seng
Pa Kheung	Hemibagrus wyckioides	Hemibagrus	Ban Huakeng, Nam Khan
Pa Fa lai	Amphotistius laosensis	Dasyatidae	Ban Donxay, Nam Khan
Pa Latmaew	Anguilla marmorata	Anguillidae	Ban Hatken

Reptiles and Amphibian species in project area

There is many species of amphibian and reptiles reported, but in our studied period, we only have found some species that occur and present in this survey. Recent surveys by the surveyors, supplemented with specimen and photographic contributions of other villagers, there have recorded about 13 species of reptiles and amphibians in study area**.**

Table 13: Fauna Species Lists occurred in project area

Local Name	Scientific Name	English Name	Nam Khan
Khiet		Frog/toad	X
Kop	Paa microlineata	Dai chang asian frog	X
Ngou dang hae	Enhydris jagorii	Striped water snake	X
Ngou din	Ramphotyphlops braminus	Brahminy blind snake	
Ngou hau	Naja kaouthia	Monocellate cobra	X
Ngou kiko	Lygosoma guadrupes	Snake	
Ngou luam	Morelia reticulatus	Reticulatet python	
Ngou pa	Enhydris enhydris	Rainbow water snake	X
Ngou sa	Gerarda prevositiana	Snake	X
Ngou sing	Xenochrophis piscator	Chequered keelback snake	X
Ngou tham than	?	Snake	
Tao ngap	Cuora amboinensis	Asian box turtle	
Tao sam san	Damonia subtrijuga	Malayan snail-eating turtle	
Hoi Choup	?	“Kissed snail”	X
Ngou kan pong	?	Snake	X
Eung	?	Frog	
Ngou phao kaba	Viper spp	Snake	
Ngou keo	?	Snake	X
Hoi pak kuang	Pomacea Canaliculata	Golden Apple snail	

Local Name	Scientific Name	English Name	Nam Khan
Kapou	?	Crab	X
Kuang	Macrobrachium rosenbergii	Prawn / Freshwater shrimp	X
Kipom	Calotes versicolors	Garden fence lizard	X
Total number of species			***13***

Fishing Gears

The fishing gears used in this area are similar to those employed elsewhere in whole country, it not much different. Although, the fishing methods and fishing gears were interviewed and observed in this study, there are many types of fishing gear in use, while each is designed for a particular river environment or fish species and they can be classified to mode an action. All kinds of fishing gears and different methods that can be used and applied in different areas as depends on seasonal and available areas (see Table 15)

Table 14: The description of fishing gears general used

No.	Lao name	English name	Nam Khan River
1	Bet Sit	Pole with single hook and line	X
2	Bet khan/Bet Pak	Pole with single hook and line	X
3	Bet Peak	Long lines with hooks, bottom set	X
4	Bet Pom	Drifting hook with float	X
5	Hae	Cast net	X
6	Lahn	Hand baskets	X
7	Lop	Bamboo snaring, Horizontal trap	X
8	Laem Teng	Harpoon	X
9	Maung/Mong/Mawng	Gill nets	X
10	Pauk/Pa pauk	Bamboo line nets	X
11	Sa wing	Scope net (for shrimps)	X

12	Chan	Woody box trap, standing trap	X
13	Kadung/Sadung	Lift net	
14	Sum/Soum	Plunging trap	
15	Sai	Cylindrical traps	
16	Tont	Bamboo line and basket of end	
17	Tum	Bamboo basket trap	
18	Dang	"Mosquito net" on frame	
19	Kheuang	Scope basket (for shrimps)	
20	Aun	Seine net	
21	Toeng	Bag net	
	Total number of fishing gears		***12***

5.3.11.4 aquatic Habitat

Village-level capture fisheries are widely recognized as vital components in rural economies and represent a vital part of food-security for subsistence-oriented rural dwellers in Lao PDR. Almost no temporary water body remains isolated from invasion by aquatic organisms including hundreds of different fish species, crabs, snails, prawns, frogs and aquatic insects. With detailed indigenous knowledge of seasonal movements, spawning locations and feeding requirements, Lao villagers target aquatic organisms in their various habitats using a diverse range of home-made and purchased fishing gears as stated in Table 18 above. Aquatic products form essential ingredients in many traditional rural food preparations and are often preserved by fermenting or drying during periods of excess harvest.

In parallel with endogenous impacts, the various exogenous factors place pressures on indigenous fishery resources. The regulation of natural waterways, and other massive manipulations of the environment for irrigation and hydropower generation, brought irreversible alterations to many aquatic habitats, block migratory pathways to historical spawning and feeding grounds and caused dramatic shifts in comparatively stable species compositions. Changes in upland and lowland agricultural patterns, a reduction in dry-season stream flows,

caused partly by the logging of remote catchment areas, have negative impacts on fish populations.

5.3.11.5 Aquatic habitat in the project site

During the survey, sampling was carried out to acquire detailed data for natural bases understanding of stock trends and of migration, and spawning and feeding patterns.

From the site observation and discussion with local fishermen, it was found that there are many different fish habitats within Nam Khan and Nam Seng rivers especially within the proposed reservoir area. Fish habitat was found in the different forest streams, and main tributaries of Nam Khan. During the survey, it was found that some species of fish habitat were in the small area of natural lake and paddy field that is to be inundated.

5.3.11.6 Fisheries in the Project area

Fishing is an important activity throughout Lao PDR. In Luangprabang Province almost every household especially in the remote area along the river is engaged in fishing activities both for subsistence and for income generation. Fishing is undertaken mainly for household consumption with occasional surpluses being sold in local markets, on the roadside, or to neighbours. Fresh fish are consumed during the rainy season, some of which they can fish on the Nam Khan River or on some ponds in the project area. In the dry season, villages produce dried or fermented fish (Paa daek). All species of fish are used for human consumption.

Men fish in the mornings and evenings, before they leave for the fields and after they return. Most fish are caught by cast nets in the rapids, or by deep-water gill nets. Bait and hooks are also used, but to a lesser extent. Boys and sometimes women search the banks and shallows for frogs, aquatic insects and small fish that supplement the family's diet. The list from 1 to 12 in Table 15 show the fishing gears have been used related to fishing activities of local people within the project area.

The survey enhances the picture of catch and consumption aspects of fisheries in all villages of the project area, analyzing fishing patterns down to the household level. All villages in the reservoir flooding area have robust fisheries and this represents the large part of the protein in their diet.

There are some differences among villages. It cannot be assumed that characterizing overall fish dependence at the village level reflects the differences in fishing skill and in other areas.

It is observed that fishing activity in the project area is primarily for subsistence - not for their major household income. Many villages conduct alternative occupations. Growing crops, livestock rearing, and making handicrafts continue to be a significant source of income in the villages in the vicinity of the project area. Most villages' livelihoods are dependant on the natural resource base, such as slash and burn agriculture for shifting cultivation, and fishing is only a part of their livelihood**.**

5.3.11.7 Zooplankton and Macro-invertebrate

Zooplankton

Zooplankton is widely distributed and present in most water bodies in the world. Zooplankton constitutes the food source of organisms at higher tropic levels, and some are of high economic value in lake ecosystems. Since the majority is filter feeders, this serves to cleanse the water column of suspended matter and hence contributes significantly to the improvement of water quality. Additionally, some studies show that certain species of zooplankton are usually considered to be useful indicators of water quality, tropic status and pollution. Cladocerans, copepods and rotifers are the main groups of zooplankton. The zooplankton community is composed of both primary consumers, which feed on bacteria and phytoplankton, and secondary consumers, which feed on other zooplankton. Zooplankton link the primary producers (Phytoplankton) with larger organisms at higher tropic levels, and they are important as food for forage fish species and for larval stages of all fish.

Zooplankton are excellent indicators of environmental conditions because they respond to low concentrations of dissolved oxygen, high level of nutrient and non-living organic matter, and toxic contaminants. The main group of zooplankton, especially Crustacea and Urotatorea, have long been assessed quantitatively and considered useful in evaluating environmental quality (Crivelli Catsadorakis, 1997). Recently, zooplankton have been used increasingly in biological monitoring programs. For example, zooplankton were used as indicators in an ecological health assessment for estuaries in Australia (Deeley and Paling, 1999).

Macro-invertebrate

Macro invertebrates are invertebrates which can be seen without the aid of a hand lens or microscope and are often used as one of the primary indicators of water quality. Some macro-invertebrates, such as stoneflies, mayflies and water pennies, require a high level of dissolved oxygen and their abundance is an indication of good water quality. Other macro-invertebrates can survive at a lower dissolved oxygen level because they can come to the surface to get oxygen through a breathing or "snorkel" tube or carry a bubble of air with them around their bodies or under their wings. Several species of macro-invertebrates are indicative of water systems with lower dissolved oxygen levels and include aquatic worms and leeches. Lower dissolved oxygen levels are often associated with polluted waters while higher levels indicate good quality water.
The main objective of the study is to investigate, and data collection of plankton and macro-invertebrate in Nam Khan 2 Hydropower project according to detail scope of work outlined in the TOR. The scope of works are included the data collection and scientific analysis of aquatic ecology in the Nam Khan river basin for 12 sampling stations.

Methodology

Zooplankton

Three samples were collected at each site. One was taken near the left bank of the river, at a distance of about 4-5 m from the water edge. A separate sample was taken at a similar distance from the right bank, and another form the middle of the river. The samples were taken at least 1 m from potentially contaminating substances such as debris and aquatic plants, and at least from vertical banks. Quantitative samples were collected at a depth of 0-5 m in a bucket having volume of 10 L. the 10 L of river water collected was filtered slowly through a plankton net (mesh size of 20 µm) to avoid any overflow. The sample water was transferred to a plastic jar and immediately fixed with 4% formaldehyde.

In the laboratory each sample was filtered via a net with a mesh size of 20 µm and rinsed with distilled water, and then settled in a graduated cylinder. Excess water was discarded until about 50 ml of water and settled material remained. This was transferred into a Petri dish and examined under the stereomicroscope at a magnification of 40 x to identify a large species of zooplankton (> 50 µm in diameter). The smaller species and details of a lager species were examined on a microscope slide under a compound microscope at a magnification of 100-400 x. All individuals collected were counted and identified to the lowest level of taxonomy possible, generally species.

Macro-invertebrate

At each site, macro-invertebrate samples were usually taken on only one side of the river. In most instances this wad depositional side where because of the gradual shelving of the bottom that occurs in this setting in contrast to the steeper bottom that is characteristic of the erosional side. In addition, the depositional side tends to support more aquatic vegetation, which also provides more habitats suitable for invertebrates.

Both sweep and kick sampling methods were used. A D-frame net with 30 cm x 20 cm opening and mesh size of 475 µm was used for both sweep and kick sampling. Sweep sample were taken along the shore at interval of about 1.5 m from the water's edge and swept the net toward the bank 10 times near the substrate surface. Kick sampling was done off-riverbank in rapid current. Sampling involved kicking the substrate in an area of 30 x 30 cm, or using fingers to disturb this area, for about 20 second. Three kick and three sweep samples were taken per site, unless there was no suitable habitat for kick sampling, in which case six sweep samples were taken.

The net was inverted and its contents emptied into a metal sorting tray, with any material adhering to the net being wash off with clean water. Invertebrates were picked from the tray with forceps and placed in a jar of 70% ethanol. Small samples were kept in 30 ml jars and large

samples in 150 ml jars. In the laboratory, the samples were identified under a stereo-microscope with a 2x-4x objective lens and a 10x eyepiece. Identification was done to the lowest taxonomic level that could be applied accurately, which was usually genus.

Results and Conclusion

Plankton

A total of 719 individuals were collected in the zooplankton and phytoplankton samples taken at the 12 sites examined in April and May 2008. These comprised 53 species in 33 genera and 17 families. The zooplankton included 4 main groups: Copepoda, Rotifera, Cladocerans and Protozoa (1). Rotifera had the most taxa (26 species, 16 genera and 10 families comprising 49.05% of the total zooplankton taxa collected).

Table 15: Total number of taxa of zooplankton recorded for 12 sites sampled in April and May 2008.

Group	Number of taxa
Copepoda	3
Rotifera	26
Cladocerans	21
Protozoa	1
Phytoplankton	2
Total	**53**

Cladocerans were found at 1-7 sites while Rotifera and Copepoda were found at 1-5 sites. Some taxa have a wide distribution from fresh water to brackish water (Crustacea: Rotifera: Brachionidae) whereas others were only found at some sites. Species composition was dominated by the Rotifera (families Mytilinidae) and Cladocerans (families Chydoridae).

Species richness

Taxon richness at a site varied widely at the 12 sites sampled. Richness ranged from 6 to 13 taxa (Table below). As with number of taxa, the number of individuals was highest at site PX (165

individuals/sample). The Rotifera, Cladocera were richness families with 26 and 21 taxa, respectively.

The number of taxa was highest at site Hadkhang, Pakseng and Sopjo (SJ) 13 taxa, Taxa richness was lowest at site Pakseuang (PS) and Hadkhene(6 taxa).

Table 16: Zooplakton taxon richness and abundance (individuals/10L) at site sampled.

Site	No. of taxa	Abundance
PS	6	15
PH	7	16
HKe	9	24
HKa	13	80
SJ	11	53
PX	13	165
KM	7	20
HV	8	14
HKH	6	15
SJO	13	98
TV	9	26
VK	7	163

Abundance

Abundance at a site also varied at the 12 sites sampled. Abundance ranged from 14 to165 individuals. As with number of taxa, the number of individuals was highest at site PX (165 individuals/sample). Site VK also had high abundance (163 individuals/sample). The dominant species present were those well adapted to nutrient-rich conditions and belonged to the families Mytilinidae (Rotifera) and Chidoridae (Cladocera). The lowest abundance was at HV (14 individuals/sample) where there was no Copepoda present.

Macro-invertebrate

A total of 1441 individuals were collected in the macro-invertebrate samples taken at the 12 sites. These comprised 82 species in 79 genera and 52 families. The macro-invertebrate included 13 groups: Acoida, Coleoptera, Collembola, Decapoda, Diptera, Ephemeroptera, Hemiptera, Mesogastropoda, Mytiloida, Neogastropoda, odonata, Plecoptera, and Tricoptera. Ephemeroptera had the most taxa (23 species, 21 genera and 10 families) comprising 28,04% of the total macro-invertebrate taxa collected).

The Acoida, Collembela, Mytiloida, Neogastropoda and Plecoptera had only one taxa, which was recorded at some sites.

Ephemeroptera (Cinygmina sp.) were recorded at 1-9 sites while Decapoda were found 1-7, sites, Coleoptera and Diptera were found 1-5 sites, Hemiptera and Mesogastropoda were found 1-4 sites and Odonata and Tricoptera were found 1-2 sites. Species composition was dominated by the Decapoda (families Atyidae (Caridina sp.) and Hemiptera (family Gerridae (Naboandelus sigtus).

Table 17: Total number of taxa of macro-invertebrates recorded for 12 sites sampled.

Group	Number of taxa	Group	Number of taxa
Acoida	1	Mesogastropoda	12
Coleoptera	13	Mytiloida	1
Collembola	1	Neogastropoda	1
Decapoda	3	Odonata	4
Diptera	8	Plecoptera	1
Ephemeroptera	23	Tricoptera	6
Hemiptera	8	***Total***	***82***

Species richness

Taxon richness at a site varied widely at the 12 sites sampled. Richness ranged from 1 to 23 taxa (Table 23). The Ephemeroptera, Coleoptera and Mesogastropoda were richness families with 23, 13 and 12 taxa, respectively.

The number of taxa was highest at site Pakxeng (PX) 26 taxa. Taxa richness was lowest at site Houakeng (HKe) (9 taxa) (Table 19).

Table 18: Macro-invertebrate taxon richness and abundance (individuals/sample) at site sampled**.**

Site	No. of taxa	Abundance
PS	10	115
PH	12	69
HKa	10	60
HKe	9	27
SJ	17	220
PX	26	177
KM	15	67
SV	16	162
HKH	24	196
SJO	14	79
TV	17	175
VK	22	94

VI IMPACT ASSESSMENT

6.1 Physical and Biological Environment

6.1.1 Air

Construction Period. The main impact to air quality during construction will be from increased dust levels from construction machinery, tunnel construction, rock blasting, foundation excavation, cement mixing, and road construction. The construction activity will generate airborne dust as well as NOX, SOX and particulate matter. The air quality impacts will, however, be limited and localized to the different project sites. Road dust from transport and wind generated dust from project areas may lead to impacts on crops, animals, villages and houses located nearby. Due to the fact that few people live close to the construction sites, the impact is considered as limited. To mitigate dust problems the main access road, from Highway 13 North to the dam and further and power station will be gravel paved. Other sections of the service roads in the vicinity of permanent houses should also be considered gravel paved. Water will be sprayed on the service roads and construction sites, during hot and dry periods at least

twice a day. All trucks with construction material should be covered. The traffic on access and service roads should be regulated, in order to minimize the air pollution.

Operational Period. During operation the air pollution is expected to be very limited, and the main source will be vehicle emissions and dust from traffic on unpaved roads. In addition there might be some dust from construction sites before they are properly re-vegetated. Traffic on new roads to the resettlement areas will give a general increase in air pollution along these roads, mainly located in areas without proper roads today.

6.1.2 Noise

Construction Period. During construction, noise will be generated from vehicular movements, sand and aggregate processing, concrete mixing, excavation machinery, construction noise and blasting. Noise levels in the construction area from machinery and vehicles are estimated to be from 80 to 95 DBA at a distance of 15 m, which is higher than the Lao Standards 70 DBA (December, 2009) . Due to very few people living near the construction sites, impacts from the estimated noise levels is assessed to be at a low level. Noise disturbance will be experienced by the people living along the main road into the Project area, due to increase in traffic from transport of goods and workers. The main potential impact of high noise levels will be on construction workers. Mitigation measures for noise impacts on construction workers will include standard occupational health and safety practices such as ear protection and enforcement of exposure duration restrictions. Blasting activity should be limited or restricted during nighttime, if noise levels are unacceptable for people living in the vicinity and to reduce impacts on wildlife.

Operational Period. During operation, noise will mainly be generated in the power station. Noise reduction measures will be taken, where required to reduce the noise levels. Mitigation measures for noise impacts on workers will include standard occupational health and safety practices such as ear protection.

6.2 Hydrology

6.2.1 Reservoir

The Full Supply Level (FSL) of the reservoir will be at El. 475 m that will create a reservoir witan area of about 37.9 km^2 and store a total volume of water of 1,366 million m^3. The drawdown of the reservoir to the Minimum Operating Level (MOL) at El. 455 m will be 25 m. At the MOL the volume of the dead storage 1,078 million m^3. The volume of water to be used for electricity generation, between FSL and MOL, will be 635 million m^3. This equals approximately ……% of the mean annual inflow volume to the reservoir.

The reservoir will be operated for seasonal regulation of the inflow, generally such that the reservoir will be filled up to the FSL during the wet season, from August to October, and be drawn down to the MOL at the end of the dry season (May).

6.2.2 Flow in Nam Khan 2 downstream power station outlet

In general, on daily or monthly basis, the flow downstream the power plant will be increased in the dry months of the year when the water level in the reservoir is generally going down. Correspondingly, the flow downstream will be decreased during the wet months when the reservoir is filled up. In the dry months, such an operation of the reservoir will secure a somewhat higher flow and higher water levels in the river, in theory all the way down to the sea. In periods with daily inflow to the reservoir less than the maximum turbine discharge, the most likely operation will include peaking.

The power plant will operate during daytime and stop during the night. Such peaking due to demand for electricity will depend on the size of the inflow each day and the amount of water stored in the reservoir, but could typically be operation for 10 to16 hours and stop for 8 to 12 hours on a daily basis. In addition to peaking due to demand, in very dry periods the power plant will not be able to operate more than in part of the day due to technical limitations in the turbines. Peaking will cause daily fluctuations in flow and water levels in the river downstream of the power station outlet. The magnitude of water level fluctuations will vary along the river, depending on the actual cross-sections at different locations.

In addition the daily water level variations will depend on the size of the turbine flow each day, and to some extent on the general flow situation in the river. However, Nam Khan is mainly dominated by quite steep riverbanks. The variations in water levels due to peaking will therefore be almost the same, regardless the initial water level in the river. Just downstream of the power house outlet the water level will change quite suddenly after a start or stop in the power station. Further downstream from the power plant the changes in the water levels will not be so rapid.

6.3 Soil

6.3.1 Construction Period

Soil will be impacted due to (i) loss of topsoil, (ii) failure to refill and re-vegetate borrow areas and temporarily used land, (iii) erosion, (iv) soil contamination by products used for the Project, and (v) failure to re-utilize displaced earth during the construction period. As much of the land cover of the Project has grass and shrub vegetation and is on slopes it is prone to erosion and soil-slides. All top soil will be scraped off while preparing project areas (including during scaling and planning of surfaces) and stored for re-use in rehabilitating temporary acquired land and spoil areas. Sand will be acquired from the riverbank where there is no top soil. The soil and rock pits (quarry) will be filled and appropriately planted with trees, shrubs and grasses. Disposal areas will be well marked and monitored so that appropriate procedures for disposal of different agents and waste materials are followed to minimize soil contamination. In all cases erosion can be minimized by regular rehabilitation of areas not in use for Project activities during construction. Rehabilitation will include (i) re-grading and immediate re-vegetation (using fast-growing species and different functional groups of plants for keeping soil in place) of slopes to minimize erosion, (ii) use of top soil removed and stockpiled from Project areas, (iii) installation of sediment runoff control devices, (iv) erosion and re-vegetation success monitoring. Soil erosion and siltation will be minimized by preventive measures and appropriately engineered

storm water diversion, on a case-by-case basis. All Project areas will be 'greened' by planting of trees and were appropriate shrubs and grasses to reduce erosion during the construction period. Road constructions will potentially lead to erosion which will be minimized by suitable road engineering techniques and road edge buffer re-planting. All excavated rock and aggregate will be used in construction where possible, while the spoil will be deposited in an area with minimum landslide potential, multilayered and covered with soil, and planted with trees, shrubs and grasses.

6.3.2 Operational Period

During operation, potential impact to soil could occur from spillage of hazardous wastes and materials, including hydrocarbons, and from localized scour at the water outlet. Soil contamination will be prevented by installing oil separators at wash down and refueling areas, and by installing secondary containment at fuel storage sites. All hazardous wastes and hazardous materials will be stored in properly designed storage facilities.

6.4 Water Quality

VI.4.1 Impacts in the Construction Phase

In this phase the water flow will be approximately as it was before. As there has been no damming yet during construction, and the river is still passable for fish, there will be almost no upstream impacts during this period. During the construction phase, the following activities can affect the water quality and aquatic life negatively:

- Erosion due to road building, construction work in the dam area, from the machine parking area, construction workers living area, spoil rock deposit area, soil deposits, clear logged areas, and accidental water releases
- Sedimentation in the slow flowing river stretches, with shall owing of deep pools
- Reduced primary production due to siltation of periphyton producing substrates, as well as due to reduced light penetration of the water column from increased turbidity.
- Run off from crushed and ground rock material from the drilling, blasting and stone crushing plant (quarry).
- Sanitary effluents from the construction worker's camp
- Oil and chemical spills
- Leaching of ammonia and nitrogen from the tunnel blasting and spoil rock deposits
- Temperature effects are not expected
- Dry-ups during filling the reservoirs

6.4.1 Impacts in the Operation Phase

Upstream of the dam

Impact on eutrophication

Eutrophication will may be a problem in the Khan 2 reservoir. The low soil fertility in the catchment, the low population and the low agricultural activities, will result in an oligotrophic reservoir. The reservoir will during the first 3-5 years be somewhat more productive due to release of nutrients from the inundated terrestrial catchment.

Downstream of the dam

In the first years after the damming there will be a lot of erosion taking place in the reservoir, and the silt and clay fraction of this erosion material will also impact the river downstream. This impact will disappear after 3-5 years.

The erosion from the land will also increase in general due to increased human activity in the area, more erosion prone roadsides, deforestation, agricultural land, excavating, quarries, etc.
It may happen that the reservoir, in shorter periods, has to discharge large amounts of water through the spillway. Such events might cause erosion in the downstream river. The reservoir will retain coli form bacteria from the upstream, and will also retain sediment particles after the first initial erosion period is over. The water coming out of the reservoir will thus be clearer than the water entering the reservoir. In the first 2-3 years after the damming the water coming out of the reservoir will have low oxygen content due to decomposition of organic material from the inundated terrestrial catchment. This water will also contain high levels of bio-available nutrients for a period of 2-3 years, which will cause some eutrophication impacts downstream. These effects will last only 2-3 years.

The temperature downstream the power plant will be 2-3 degrees lower than it was before, but further downstream it will reach the average air temperature relatively quick, so this is not regarded as a concern.

6.4.2 Aquatic Ecology

Upstream of the Dam

Impact on aquatic habitats

The inundation will accomplish a loss of river habitat of 60 km, which will be replaced by a lake with large water level fluctuation (25 m between Full Supply Level (FSL) and Minimum Operation Level (MOL)). All life in the littoral zone will die due to the periodical dry ups. The regulation zone will be heavily eroded rendering back a denuded, inorganic, desert like zone of sand, gravel and stones where nothing can grow. Inorganic erosion material will settle in the reservoir bottom and reduce the nutritional value of bottom sediments for the bottom dwelling animals.

In the first years after the regulation the fish productivity will be relatively good because of food and nutrients from the inundated terrestrial land. Over time fish productivity will be markedly reduced, and the potential for fish harvest will be low.

Impact on biodiversity

Only a few fish species will succeed in adapting to the lake life. In the reservoir the biodiversity of fish will be reduced by. However, most of these species will survive in small populations in the upstream part of the river and in the tributaries. The creation of the dam will eradicate the long distance migrants from the upstream areas of the watershed. This will particularly affect the *Anguilla marmorata*, but there are probably few other long distance migrants as far from the sea to the Nam Khan dam site. It should be noted that there is no exhaustive survey done on aquatic life, so precise impacts are hard to determine.

Downstream of the Dam

The regulation will have a large impact on the aquatic life downstream. Some migratory from Mekong species, will disappear due to the barrier effect of the dam. Periphyton, bottom animals and fish will decline, both in production and in biodiversity.

Due to lack of sufficient baseline knowledge it is difficult to estimate the reductions in fish yield further downstream in Nam Khan 2. The additional study should be undertaken a special study on downstream fish yield after the Project is commissioned in order to prepare appropriate mitigation measures if the study shows significant losses in the fish yield.

6.4.3 Terrestrial Ecology

6.4.3.1 Flora

As pointed out and shown by field surveys for this EIA the vegetation cover of the Project areas has been subject to human influence over a long period of time. Subsistence use is not the main cause of loss of primary forest as is illegal logging by outsiders. The slash and burn practice which is that of the ethnic groups has also had its toll on the forest systems. Overall the value of the forest resources in the Project are poor, and even for local use (timber) it is not of high quality and people resort to logging from higher elevations and better forested areas. Wood for fuel abounds in the area and thus forests and woodlands will be encroached upon for this resource if no alternative fuel resources are available.

Due to the overall plant cover status of the Project Area, which is largely open forest and grassland dominated, it is prone to erosion as the soils are not all bound solidly by vegetation. Soil will be exposed and be erosion prone in many locations due to Project activities and this impact will be common across all Project areas.

6.4.3.2 Fauna

Impacts to the terrestrial fauna will either be related to the physical clearance of the reservoir and disturbance or degradation of forested ecosystems resulting from increased population (mainly

workers but also camp followers) and improved access. The later is seen to be more significant due to the relatively poor ecosystems directly lost to the Project and that there are forest resources in the vicinity of the Project Area which are already subject to illegal logging and wildlife hunting. Forest protection and environment awareness will have to be enhanced to reduce impacts related to an increased worker population and accessibility to forested areas. Sanctions will need to be imposed and regulations enforced. Based on the current information there appear to be no migration routes that will be blocked by project inundation. Project areas like disposal areas, power station and switchyard, and transmission lines can impact fauna species but precautions can be taken and thus risks minimized.

6.5 Potential Impacts specific to Nam Khan 2 Project Area

6.5.1 Reservoir

Habitat loss and fragmentation are direct effects of the dam and the reservoir that is created. However, habitats may also be lost as a result of the induced activities related to forest clearance and change, isolation of habitats, and the creation of assess.

Forest clearance. Forest clearance means a loss of biodiversity, loss of area available for wildlife species for feeding and breeding, and increasing erosion vulnerability. Main habitats in reservoir are of the secondary and small vegetation along the river banks and spotted forested areas on the slopes. During the vegetation clearance activities, forest contractors will be legitimately entering the Project areas to extract economically important trees, among others, and clear vegetation up to the 475 m a.s.l line. During these clearing activities there will be increased pressure on vegetation and thus the habitat above the 475 m line – these areas have the more intact forests and more matured and valuable trees. It will be difficult to identify logs extracted from above the 475 m line unless there is constant supervision of the contractor. The areas most at risk will be those where the forest is richest and particularly patches and mature trees of the economically valuable and threatened tree,

Noise and vibration from Project activities and exploitation activities may also disturb some wildlife species living along the river.

Direct loss of some species. There is no doubt plant species will be lost due to inundation and Project activity needs. As shown by field surveys and explained in earlier sections the impact to the threatened plant species is seen as minimal due to the wide distribution and generally lower quality in the reservoir. Faunal species that are only found in the inundated areas will not be able to away from the reservoir area. However the fauna in reservoir area is not rich or unique primarily due to the quality of habitat and most of the species are common with wide distributions. In other words none of these species are restricted to areas with specific ecological conditions. Most of larger size species will be able to move out from the flooded area. A number of small animals (e.g. some rodents and small lizards) will be lost if they do not have the rapid mobility required to escape from forest clearance and flooded water. Since there are no exhaustive long term surveys completed on flora and fauna species in these areas precise species loss and impacts are not quantifiable.

Habitat isolation/fragmentation. Although some main rivers will get larger than usual as a result of inundation, habitat isolation is not likely an important impact in the reservoir area, because rivers and streams are already natural barriers in the project area. Flooding will change the aquatic habitat conditions from river to a lake and it also change as a result of increased humidity in the area of the dam. This may have some effect on the vegetation structure and composition of the area and indirectly impact animals dependent on these habitats. No migration paths are known to be blocked by the inundation.

Creating access to the forests. Access by water in Nam Khan will be created as a result of the inundation in reservoir communes. Since access into the forests will be easier by boat, hunters and loggers in the area may be tempted to gain access to the forest products of the area.
The dam and low river stretch will make it difficult for the transport of timber downstream as is often done at present. However, forest products may be removed from the forests first by using the waterway before transferring to the road for transport.

Changes in riparian and aquatic habitats. The riparian habitat will be altered in the low flow stretch. Terrestrial fauna living near rivers and stream may have to change their feeding grounds and breeding behavior (if associated to local sites) partly due to the change in vegetation riparian habitats. The creation of a lake by the filling of the reservoir usually results in increasing the bird numbers and species.

6.5.2 Construction Areas and Roads

Forest Clearance and Creating access to the forests. Easy access to the forest in the watershed areas will be created as a result of the new access roads to the dam site and to the resettlement areas. Illegal timber logging and harvesting NTFP activities may increase if enforcement activities for forest protection are not in place. With the new access road this area and higher slopes of mountain and adjacent mountains are the most vulnerable: becoming highly attractive for illegal logging, hunting and NTFP harvesting. All types of clearance of forest increases erosion vulnerability, fragmentation (in some cases, as mentioned above) and access to nearby forested areas. An area of disturbed closed forest will be cleared around the dam site, power house, corridor for access road to construction areas and resettlement areas.

Creating high demand for firewood, timber and NTFPs. The demand for firewood and timber will increase due to increased energy requirements for cooking for both workers, camp followers, and other incoming households and restaurants. Using timber for house construction both in working camps and service area may also be increased. Creating options for non-timber/wood use cooking and heating options may be important in helping reduce the pressure of firewood and timber. Exploitation of forest vegetables, fruits and medicinal plants will increase to meet the demand for NTFPs in the area during the construction period.

Disturbance and Noise to Wildlife. Disturbance of wildlife communities from the increased activity resulting from the dam construction, whether it comes in the form of noise or increased access by people can be a significant form of stress upon the populations particularly if they are sensitive species. The following changes in behavior may result: avoidance of the most disturbed

area, changes in feeding pattern, increased susceptibility to predation as a result of stress and loss of condition, and changes in breeding patterns.

During the construction period, the general level of noise in the project area will increase considerably. The noise will be derived from following sources: 1) blasting in the quarry and construction areas; 2) earth moving equipment at the dam site itself, and earth-fill sites and quarries; 3) construction traffic along both east and west banks of the Bung river; and 4) general increase in traffic in project area. Noise in construction area and blasting in the quarry will consist of impulsive noise and vibration events that will impact fauna inhabiting the surrounding watershed areas. Large animals will move away from working area and may be caught by hunters while actively moving away toward to the closed forests upstream of Nam Khan River.

Siltation. Rock mining, soil borrowing, work in auxiliary areas, dam site, power house and new road construction will result in erosion and siltation through the weakening of slopes and exposure of soil.

Water quality. It will be necessary to have an appropriate sewage and waste treatment system and disposal sites for solid waste in the Project Area. Polluted water can have adverse affects on riparian vegetation and aquatic fauna.

Electrocution. The powerhouse area will be exposed to heavy construction activities and also experience habitat destruction and alteration as will most of the areas under construction. Moreover, the switchyard area located close to the power house can create problems to wildlife and to birds in particular. Switchyard and sub-station areas in general are disposed to electrocution problems like those found in connection to transmission and distribution lines.

6.5.3 Transmission lines

Forest clearance. A transmission line of 115 kV with a corridor of about 30 m will connect the power station to Louangprabang Substation. The impacts of the 115 kV line are related to habitat loss, fragmentation and creating access to the forest. Based on its location on the map, a straight line is designed from the switch yard through the Highway 13 North and then it will run along the access roads to the Louangprabang Substation. An area of closed forest on the ridge of mountain will be lost and experience fragmentation due to the transmission line corridor.

Creating access to the forests. The maintenance of transmission lines will also create easy pathway conditions for people to enter the forest. Timber trees and plants yielding NTFPs will be at risk because of potential in increased illegal logging, hunting and harvesting of NTFPs. Steadily increasing environmental stress has made mortality factors to birds and animals more important than that once considered insignificant. Clear-felled power line corridors in the forested areas can have far reaching fragmentation and habitat changing effects that might affect fauna. Habitat fragmentation is identified as one of the main threats to biodiversity. It has been stressed that power-line corridors may be particularly damaging to some groups of species, both terrestrial and birds. Clear-felled areas of up to 40 meters open by forested areas while dissecting contiguous ones. The main problems associated with wildlife and transmission lines are related to (i) electrocution, (ii) bird collisions, and (iii) fragmentation (barrier) effect of the cleared areas

and habitat destruction. Note that the building of roads can also have some of the similar impacts.

6.5.4 Construction Workers Camps and Administration area

A number of the induced impacts of the dam will have a more lasting influence upon the populations of flora and fauna than habitat loss and disturbance. Direct mortality of individual species may not be important at a population or overall biodiversity level, providing that the populations are able to withstand the continual off-take. However, if they can not sustain these losses over a longer period the overall populations are at risk, and in this case particular threatened species may decline. Thus certain activities induced by the Project may give rise to a reduction of the overall biodiversity of the area, especially related to overexploitation of forest and land resources. In addition in all cases exploitation of the natural resources will give rise to disturbance, so even if the animals are not killed they will still be disturbed and be increasingly wary of any humans.

Creating high demands for firewood, timber and NTFPs. As with wildlife, demand for firewood and timber will increase due to increased energy requirements for cooking for both workers and other incoming households and restaurants. Using timber for house construction both in working camps and service area may also be increased. Creating options for non-timber use cooking and heating options may be important in helping reduce the pressure of firewood and timber. Exploitation of forest vegetables (e.g., bamboo and rattan shoots) will probably increase to meet the demand for NTFP in the area during the construction period. To meet the demand from markets villagers will be asked to provide forest products, while some workers may go out to collect for their own consumption or sale. Increased opportunities for additional income from NTFPs and ease of access into the area will encourage both local and outside collectors. The collection of plants or plant based NTFPs also encourages small scale hunting and trapping.

Creating high demand of wildlife use. The demand for wildlife products is high in Northern Provinces, and hunting in the forest with traps and dogs is the principal source of supply.
Recent wildlife surveys and our field observations indicate that the main customers for Wildlife meat restaurants are businessmen, government employees and visitors from outside areas. In this light the increase in workers and visitors to Xieng Ngeun District in relation to the Nam Khan 2 HPP is likely to induce an explosion of demand for wildlife.

To meet the demand from markets villagers will be asked to provide wildlife products while some workers may go out to hunt for their own consumption or sale. Increased opportunities for additional income from hunting and ease of access into the area will encourage local and outside hunters.

Pollution. It will be necessary to have an appropriate sewage and waste treatment system and disposal sites for solid waste in the Project Area. It will also be necessary to monitor and control the treatment and disposal during the construction and operation phases for preventing the pollution of Nam Khan River water. Polluted water can have adverse affects on riparian vegetation and aquatic fauna reliant on the water source.

6.5.5 Resettlement areas

Forest clearance. An area of about 200 ha of forest and grassland near Pa Pang will be cleared for resettlement and agricultural land. The resettlement areas for the other villages will also require clearance of forest land. Habitat quality in the studied resettlement areas (R1 and R2) is poor with mainly of vegetation. The impact is seen to be minimal due to the general poor quality of the area. It should be mentioned that clearing of the area will increase erosion vulnerability and thus open and unused areas should be vegetated (agricultural species) as soon as possible. These areas are not likely important habitat for wildlife populations or for key wildlife species.

Changed accessibility. There are several aspects to be considered with the increased accessibility caused by people entering and living the in the watershed and Project Area during the construction period. Illegal logging, increased NTFP exploitation, mining and hunting are major concerns. Illegal loggers are usually outsiders and not the villagers. During the operation period accessibility will be related to better roads and increased population in the area.

Disturbance from construction activities. Noise and vibration from explosive activities may disturb some wildlife species along the Nam Khan. Therefore impacts from blasting, noise and vibration in the Project Area are not high but have to be minimized where possible. Forest patrolling, guards and imposing of sanctions will be necessary to control illegal activities in the Reserve.

VII SUMMARY OF POTENTIAL IMPACTS

Table below summarizes potential project impacts. It should again be noted that these potential impacts are ranked according to Nam Khan 2 Project severity/magnitude without taking into account the possibilities for reducing or avoiding the impacts by mitigation measures. The mitigation or compensation measures are discussed in the Environmental Monitoring and Management Plans (EMMPs) Report.

In the ranking the impacts the following categories and symbols have been used:

- Minor
- Moderate
- And Major

Table 19: Construction Impacts

Issue	Potential Impacts	Receptors	Significance	Mitigation measures
Soil erosion and land degradation	Construction activities on the river bed, sand excavation, and construction of the dam will disturb soils and may lead to soil erosion and compaction and increased turbidity and sedimentation in downstream.	Land resources Terrestrial habitats Aquatic habitats	Minor to Moderate	Develop and implement construction site environmental management guidelines, to include site erosion control measures Installation, monitoring of, and regular emptying of sediment traps in surface drains in around roads and construction areas Sand excavation from the riverbed should be limited to the dry season when flows are low to limit the amount of sedimentation downstream Minimize removal or disturbance of the reverie forest at the dam site and in the reservoir area until inundation begins, and maintain vegetative buffer zones alongside river and drainage channels Minimize soil disturbance and excavation during wet season
Land take	Permanent land-take for reservoir, dam and related structures and access roads, and temporary land-take for construction camps and borrow pits.	Land resources Terrestrial ecology	Major	
Disruption to local drainage patterns	Localized disruption to water users and reverie habitats as existing channel is re-routed around dam construction site.	Local reverie habitats Local water users	Minor (in context of overall scale of works)	(Where necessary) facilitate access to re-routed channel for existing users
Reverie habitat alteration	Construction of the dam will result in disturbance of in stream aquatic habitat within the impounded reach.	Aquatic habitats, fauna and vegetation	-Major	Minimize footprint of riverbed and shoreline disturbance.
	Construction of the dam and diversion reach will result in disturbance of in stream aquatic habitat downstream of the dam and diverted reach	Aquatic habitats, fauna and vegetation	-Moderate	As above
Effects on vegetation	Direct loss and/or disturbance of vegetation will occur as a result of : 1) Equipment operations and clearing for storage areas and administrative space 2) Construction of the transmission lines 3) Upgrading the site access roads	Terrestrial habitats, fauna and vegetation; Aquatic habitats	- Moderate	Minimize removal or disturbance of vegetation `around construction areas Replant native vegetation in disturbed areas immediately following construction Implement education programmes for construction workers about minimising the footprint of construction camp and work areas clearance only necessary width of construction ROW

Issue	Potential Impacts	Receptors	Significance	Mitigation measures
	4) Inundation of the reservoir			
	Sand mining/construction will create dust, which can build up on vegetation and stunt vegetative growth	Terrestrial habitats and vegetation; Aquatic vegetation	- Minor	• Develop and implement dust management plan
Effects on fauna - displacement	Construction-related noise and increased human activity (influx of workers), will result in temporary displacement of disturbance-sensitive fauna	Terrestrial habitats and Fauna	- Moderate	• Develop and implement a Protected Area Management Plan • Locate camp in already disturbed habitat if possible • Implement noise minimization measures for construction • Develop and implement camp management plan
	The worker camps near the dam site will displace and disturb fauna in affected areas.	Terrestrial habitats and Fauna	- Moderate	• Develop and implement a management plan [to include control of poaching and burning, wildlife awareness and education]. • Locate camp in already disturbed habitat if possible.
	Forested islands formed in the reservoir and floodplain during inundation will limit the movement of individual animals as well as individual/ population interactions.	Terrestrial habitats and Fauna	- Moderate	▪ Develop and implement wildlife rescue/management Plan ▪ Selective harvesting of economical trees prior to inundation
	Inundation will displace animals from reservoir area into surrounding habitats, causing crowding (i.e., "Crowding of the Arc effect"	Terrestrial habitats and Vegetation	- Moderate	▪ Develop and implement wildlife rescue/management plan
Effects on fauna – direct mortality	The temporary diversion dam and main dam will block migration of some fish species.	Aquatic fauna	- Minor	▪ Implement fish passage facilities in dams.
	Construction activities will cause direct mortality of less mobile wildlife through interaction with construction equipment or humans.	Terrestrial fauna Aquatic fauna	- Minor	▪ Implement wildlife awareness training programme for workers
	Displaced animals could face increased hunting pressure from construction workers and villagers	Terrestrial fauna	- Major	▪ Develop and implement a Plan to include control of poaching and burning, wildlife awareness and education.

Issue	Potential Impacts	Receptors	Significance	Mitigation measures
	Upgraded site access roads could increase human access (in addition to construction workers) to the park, thereby increasing wildlife disturbance and hunting pressure.	Terrestrial habitats, fauna and vegetation; Aquatic fauna	-Moderate	▪ Prohibit development of spur roads off main access roads. ▪ Develop and implement site access plan to prohibit public access on site access roads
	Inundation will result in displacement or drowning of animals.	Terrestrial habitats, fauna; Aquatic fauna	-Moderate	▪ Develop and implement wildlife rescue/management plan [including rescue and fire management] ▪ Begin inundation after the dry season once hibernating have species have emerged
Effects on fauna – fragmentation of habitats	Presence of the dam and reservoir will fragment and alter aquatic and terrestrial habitats in the vicinity of the project, resulting in reduced habitat quality and effectiveness for aquatic and terrestrial wildlife	Terrestrial habitats, fauna and vegetation; Aquatic habitats, fauna and vegetation	- Moderate	• Purchase a suitable offset area and place under national protection
Secondary impacts from displacement of people	Resettlement (human movement and resettling) will result in loss of terrestrial habitats and mortality or displacement of wildlife species that are intolerant of human disturbance.	Terrestrial habitats, fauna and vegetation	- Moderate	▪ Develop and implement an appropriate plan ▪ Incorporate environmental criteria into site selection criteria for resettlement areas.

Table 20: Operation Impacts

Issue	Potential Impacts	Receptors	Significance	Mitigation measures
Changes in river flow regime	Flow regulation will create an un-seasonal flow (and hence water level) regime in the river downstream, with generally increased low (base) flows and reduced flood flows. Rapid variation in flows and levels may also occur with sluice gate operation.	• Downstream surface water resources • Downstream reverie habitats • Downstream water users (including floodplain agriculture)	Moderate	• Design of partially seasonal operational release regime (if feasible) • Avoid rapid fluctuations in downstream flow (e.g. through safety and awareness programme) • Regular (preferably continuous) flow monitoring downstream of dam • Replenish nutrients in floodplain agricultural areas with controlled application of fertilizers • Adopt the appropriate minimum release to downstream
Water levels in the reservoir	Operation of the reservoir (magnitude and duration of water level fluctuations) will affect the species composition and density of vegetation may communities in the littoral zone.	• Terrestrial habitats, fauna and vegetation • Aquatic habitats, fauna and vegetation	Moderate	• Develop and implement operational plan that includes managing the reservoir drawdown to optimize native vegetative growth in littoral zone.
Surface water quality	In addition to being a navigation hazard, submerged vegetation deplete reservoir oxygen levels and promote algal and weed growth, damaging fisheries and impairing dam operation and navigation. It could also result in hydrogen sulphate production, which may corrode turbines, harm aquatic organisms and produce noxious odors.	• Reservoir fisheries • Dam infrastructure • Downstream aquatic habitats • Local communities	Minor-moderate	• Clear the biomass that will be flooded by selective forest clearing and the commercial salvage of forest products • Detailed dam design to minimize release of anoxic bottom waters • Monitor nutrient (N & P) concentrations in reservoir
	Although the reservoir is not considered to be at risk of eutrophication under present conditions, it would capture nutrient runoff from any future uncontrolled agricultural development upstream, possibly promoting algal and weed growth in the future. There is also a risk of the bioaccumulation of pesticides within the reservoir if these are used extensively.	• Reservoir fisheries • Dam infrastructure	Minor – moderate	• Monitor and promote improved land management practices in upper watershed (forestry conservation, prevention of overgrazing, fertilizer and pesticide misuse etc) • Include watershed management measures as part of the development of catchment area • Above WQ monitoring to include pesticides • Include 'nuisance' plant monitoring programme
	Increased water temperature in the reservoir, particularly during the dry season when inputs are minimal, could	Aquatic habitats and fauna	- Minor	As above

Issue	Potential Impacts	Receptors	Significance	Mitigation measures
	decrease dissolved oxygen concentrations and impact the composition of aquatic flora and fauna.			
	Continued elevation of pollution concentrations from motorized vehicles could increase polluted runoff	• Terrestrial habitats, fauna and vegetation • Aquatic habitats, fauna and vegetation	- Minor	• Adopt watershed management measures
	Increased human population will discharge new waste streams to the reservoir	Terrestrial habitats, fauna and vegetation; Aquatic habitats, fauna and vegetation	-Minor	• Adopt watershed management measures
Sedimentation and erosion	The reservoir will retain sediment that is transported from upstream tributaries, causing increased turbidity (reduced light penetration) in the water column and increased silt deposition on the bottom of the reservoir.	Aquatic habitats, fauna and vegetation	- Moderate	• Adopt watershed management measures .
	Poor catchment management practices in upper watershed could increase soil erosion and sedimentation in the reservoir.	• Dam infrastructure (reservoir lifespan)	Minor-moderate	• Monitor and promote improved land management practices in upper watershed (forestry conservation); • Initiate and maintain sustained sediment transport monitoring programme.
	Uncontrolled activities on reservoir margin could increase bank erosion, increasing sedimentation in the reservoir.	• As above	Minor-moderate	• Prohibit anthropogenic activity around water's edge.
	Sediment releases from dam will change river morphology downstream, affecting turbidity and flow velocities, and reducing nutrient replenishment on floodplain. Depletion of coarse substrate due to reduced sediment load will also reduce fish spawning habitat and substrate for invertebrates.	• Downstream surface water resources • Downstream riverine habitats • Downstream water users (including floodplain agriculture)	Moderate	• Develop and implement plan to enhance downstream habitat measures downstream of the dam • Replenish nutrients in floodplain agricultural areas with controlled application of fertilizers; • Consider alternative livelihoods for floodplain agriculturalists • Adopt sediment and erosion monitoring plan
Groundwater quality and yield	Raised water table around reservoir (and possibly downstream) could result in chemicals leaching into groundwater (and hence affected community supplies) from the soil, e.g. manganese, iron, calcium and sodium.	• Local groundwater resources • Local communities	Minor to Moderate	• Monitor groundwater chemistry in representative selection of community wells
	Raised water table may increase local borehole yields.	• As above	Minor (positive)	• None

Issue	Potential Impacts	Receptors	Significance	Mitigation measures
	Raised water table could result in soil Stalinization and/or iron pan formation in low-lying areas around reservoir and	• Land resources	Minor to Moderate	• Relocation of affected farmers and/or promotion of good soil and water conservation techniques
	downstream, degrading and reducing fertility of soils.	Agricultural soils		and practices in affected areas.
Ecological changes	Presence of the reservoir will change habitat conditions from reverie to lacustrine, causing a reduction in numbers and diversity of reverie fish, algae, and macro invertebrates and an increase the number and diversity of lacustrine species (phytoplankton, zooplankton, lacustrine fish and macro invertebrates).	Terrestrial habitats, fauna and vegetation; Aquatic habitats, fauna and vegetation	+ or – Moderate	▪Develop and implement long-term wildlife and ▪ vegetation monitoring programme.
	The reservoir will increase the perimeter of the shoreline, thereby increasing littoral habitat.	Terrestrial habitats, fauna and vegetation	+Moderate	▪ No mitigation measures necessary
	The reservoir will provide habitat for aquatic vegetation and flood-tolerant plants, including non-native (and potentially invasive) aquatic species.	Aquatic vegetation	+ or – Moderate	▪ Develop and implement operational plan that includes managing the reservoir drawdown to optimize native vegetative growth in littoral zone ▪ Plant Sectarian and other species in the littoral zone [at FSL] to increase fodder available for hippos and other wildlife
	Presence of the reservoir and enhanced (year-round) base flow downstream of the dam will raise the water table and alter the micro-climate in the areas immediately surrounding the reservoir	Terrestrial habitats, fauna and vegetation	+ Minor	▪ No mitigation measure necessary – collection of met. data to monitor any changes in microclimate.
	Presence of the reservoir could provide a breeding ground for insect disease vectors.		Minor	▪ Regular monitoring and implementation of chemical control programme if necessary
	Regulated flows downstream of the dam will alter species composition and density of aquatic and terrestrial fauna and vegetation.	Terrestrial habitats, fauna and vegetation; Aquatic habitats, fauna and vegetation	- Major	▪ Adapt flow regimes to mimic the natural seasonal flooding regime ▪ Apply continuous minimum release flow.
	Alteration of the natural annual flood regime downstream of dam will alter input of organic material and coarse debris in the floodplain.	Terrestrial habitats, fauna and vegetation; Aquatic habitats, fauna and vegetation	- Moderate	▪ Annually deposit nitrate rich fertilizer along floodplain downstream of dam
	Riparian wetlands could become uplands due to lack of flooding reducing the	Terrestrial habitats, fauna and vegetation;	- Minor - Moderate	▪ Purchase a suitable offset area and place under national protection.

Issue	Potential Impacts	Receptors	Significance	Mitigation measures
	terrestrial and aquatic fauna that spawn, rear and/or breed in riparian wetlands.	Aquatic habitats, fauna and vegetation		
	Soils will become more acidic downstream due to depleted organic matter, which could alter the vegetation species composition and density.	Terrestrial habitats, fauna and vegetation	- Minor – Moderate	▪ Annually deposit nitrate rich fertilizer along floodplain downstream of dam.
Effects on fauna	The change in habitat condition from reverie to lacustrine will alter the aquatic and terrestrial habitat and species composition associated with the reservoir	Terrestrial habitats, fauna and vegetation; Aquatic habitats, fauna and vegetation	- or + Moderate	▪ Develop and implement long-term wildlife and ▪ vegetation monitoring programme
	Submerged tree trunks and other flooded vegetation in the reservoir could increase the habitat available for benthic macro invertebrates and fish, and increase nutrients available to the aquatic fauna.	Aquatic habitats, fauna and vegetation	+Negligible-Minor	▪ Although biomass should be reduced by selective ▪ forest clearing – a substantial amount of vegetation should be retained and flooded
	The project will increase the amount of water in the river and associated tributaries immediately upstream of the reservoir, increasing the availability of aquatic habitats for aquatic and terrestrial wildlife.	Terrestrial habitats, fauna and vegetation; Aquatic habitats, fauna and vegetation	+ Minor	▪ No mitigation measure necessary
	The reservoir and continuous minimum release flows to downstream of dam will provide a year-round water source for aquatic and terrestrial wildlife.	Terrestrial fauna	+ Moderate	▪ No mitigation measure necessary
Secondary impacts from displacement of people and new land use practices	Resettled people and associated land uses (farming, hunting, fishing, burning, harvesting of forest product) will place increased pressure on natural resources in and round resettlement areas	Terrestrial habitats, fauna and vegetation; Aquatic fauna	-- Minor-Moderate	▪ Develop and implement a appropriate ▪ Purchase a suitable offset area and place under national protection. ▪ Incorporate environmental criteria into site selection criteria for resettlement areas.
Climate related impacts	Elevated year-round humidity will occur around the reservoir, creating a micro-climate that may affect local vegetation and create breeding ground for insect disease vectors.	Local terrestrial ecology Local communities	Minor	▪ Environmental health monitoring
	The emission of greenhouse gases from reservoirs due to	Global climate	Minor	▪ Consider selected clearance of vegetation prior to

Issue	Potential Impacts	Receptors	Significance	Mitigation measures
	rotting vegetation and carbon inflows from the catchment may be a significant source of global GHG emissions			inundation
	The construction of a future water supply dam upstream in Burkina Faso may reduce the viability of Bui at the current planned operating level.	Dam infrastructure	Minor	▪ Promote and support integrated water resources management and cooperation through above Commission

7.1 Analysis of Alternatives

Initial investigations and project selection process

The Nam Khan and their tributaries had attracted the interest of hydro power project developers already many years ago. The area had been studied for the potential development of a hydro power project. However the Nam Khan is engaged rivers. No hydrological or meteorological data are available for the river valleys and no topographical maps are available for the area.

Desk studies had been carried out based on available large scale area maps and the limited geographical, topographical, and other relevant information. Based on these desk studies it was evaluated that the only feasible project would be to develop a Hydro Power Project in the lower reaches of the rivers, with a dam across the valley, not too far upstream from the confluence of the Nam Khan 2 with the Mekong.

Due to the inaccessibility of the area, the topography, and the largely variation in available flow (from high flows during wet season to dry season with almost no flow) alternate approaches to develop a hydro power project, e.g. to build a smaller run of the river hydro power plant were discarded already in the earliest stages of project studies.

The further upstream that a potential project will be located the smaller the catchment area becomes and less power can be produced. Even if a smaller scale project could be envisioned further upstream, this would not necessarily reduce impacts on the fishery, or the affected villages, however certainly it would not utilize the available water-resource as efficiently.

There are not many additional tributaries further downstream of the confluence between the Nam Khan 2 and Mekong, which means there is not much potential for additional gain in energy.

Furthermore, the slope of the river bed becomes less steep towards the confluence with the Mekong, which means that there is not much potential for more gain of head further downstream the river. The river valley also widens up and the slopes of the valley become flatter, which means that further downstream a bigger and higher dam would be required, which would be more expensive.

During the Pre-feasibility study all available information of the project area was reviewed and a field investigation trip was performed in order to confirm conclusions related to the project so far. This review and field investigations confirmed potential feasibility for the development of a hydro power project with a dam in the area downstream of the Nam Khan 2. Some potential dam sites were identified to be investigated further during the Feasibility Study.

In short; based on acquired information and considering available options, the prevailing topographic conditions limit the development of schemes along the mainstream of the Nam Khan 2 River to the development plan as proposed by the Mekong Committee, with a hydropower station and dam in the vicinity below the confluence of Nam Khan 2.

During the feasibility study topographical and geological field investigations were made in order to confirm suitability of the selected dam sites, and to select the best one out of the three. No significant geological problems are reported for the Nam Khan 2 River at the selected dam site. Hydrological studies were performed in parallel to the field investigations, in order to confirm the hydrological potential for the suggested project, and to provide the needed basic data and characteristics that are required as input for the design of the project.

Potential Impact of the selected project

The Nam Khan 2 basin has been selected for development because it has some of the poorest inhabitants and is an area with one of the smaller population densities in Laos. Hence the potential social benefit to cost ratio of hydro electricity production is one of the highest in the Lao PDR. Despite the low population density, relatively speaking and in contrast to most other Provinces, slash and burn agriculture produces almost as much output as lowland cultivation. Accordingly it makes sense to undertake hydroelectricity projects in the Nam Khan 2 Basin.

It is recognized that the project will have an impact on the Nam Khan 2 basin fishery that the impact is likely to increase the further a project is located downstream. The area of spawning ground per unit length of river is likely to increase the further upstream one goes, however it increases proportionally more than the corresponding increase of the upstream catchment area. Whereas the potential power productions of the Nam Khan 2 River in the uplands decreases approximately in proportion to the decrease in catchment area. Accordingly the ratio of power production to the area of spawning grounds affected by hydroelectric projects is expected to increase the further the project is located downstream.

The size of the reservoir of 37.9 km² is not large in comparison to a catchment area of 5,221 km² and in comparison to the expected power produced. Consequently, for this project, the social and environmental impact on the area is not considered to be very big, relative to the power produced.

Hydrological investigations show that in the Nam Khan 2 area there is potential of high capacity floods due to tropical storms. Therefore, a hydro power project with a reservoir (which can act to a certain extent as a buffer) and a large spill way capacity are ideal means to control potentially high capacity floods.

No-Project Alternative

The No-Project Alternative addresses the effects of not implementing the proposed Nam Khan 2 Hydropower Project. The No-Project analysis must discuss the existing conditions as well

as what would be reasonably expected to occur in the foreseeable future if the project were not approved, based on current plans and consistent with available infrastructure and community services. For this analysis, the No-Project Alternative is not equivalent to existing conditions, as it must account for growth and development that is foreseeable within the next 10 years as Laos targets to escape from least developed country by using strategy of Poverty Reduction Programme. The No-Project scenario represents future conditions without the proposed project. In order to assess this future conditions scenario, certain assumptions must be made**.**

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