Environmental Impact Assessment

Project Number: 41924
July 2014
Document Stage: Final

Nam Ngiep 1 Hydropower Project (Lao People's Democratic Republic)

Appendix A: Biodiversity Baseline Assessment Report

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

Nam Ngiep 1 Hydropower Project

Biodiversity Baseline Assessment Report

NAM NGIEP 1 POWER COMPANY LIMITED

July 2014

0200749

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FINAL REPORT

NAM NGIEP 1 POWER COMPANY LIMITED

Biodiversity Baseline Assessment Report

July 2014

Reference 0200749

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

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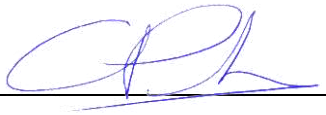
Signed: 

Position: IAP Partner

Date: 23 July 2014

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Acronyms and Abbreviations

ADB	Asian Development Bank
CR	Critically endangered (IUCN Red List)
DBH	Diameter at breast height
DD	Data deficient (IUCN Red List)
DFRM	Department of Forest and Resource Management
DoF	Department of Forestry
EDL	Electric du Laos
EGAT	Electricity Generating Authority of Thailand
EIA	Environmental Impact Assessment
EN	Endangered (IUCN Red List)
ERIC	Environmental Research Institute, Chulalongkorn University
ERM	Environmental Resources Management ERM-Siam Co. Ltd.
ha	hectares
IAP	(Project's) Independent Advisory Panel
IFC	International Finance Corporation
IHA	International Hydropower Association
IP	Indigenous People
IR	Involuntary Settlement
IUCN	International Union for Conservation of Nature
Kansai	Kansai Electric Power Company Inc.
km	kilometre
kV	kilovolts
LC	Least concern (IUCN Red List)
LHSE	Lao Holding State Enterprise
LMD	Lower mixed deciduous
m	metre
MSL	Mean Sea Level
MW	Megawatt
NDVI	Normalised difference vegetation index
NE	Not evaluated (IUCN Red List)
NNP1 Project	Nam Ngiep 1 Hydropower Project
NNP1PC	Nam Ngiep 1 Power Company
NPA	National Protected Area
NT	Near threatened (IUCN Red List)
NUL	National University of Lao
PAFO	Provincial Agriculture and Forestry Office of Bolikhamxay
PDR	People's Democratic Republic
PKK	Phou Khao Kouay
PPA	Provincial Preserved Area
PS6	Performance Standard 6 (IFC)
SPS	Safeguard Policy Statement
TISTR	Thailand Institute of Scientific and Technological Research
ToR	Terms of Reference
UMD	Upper mixed deciduous
VU	Vulnerable (IUCN Red List)
WWF	Worldwide Fund for Nature

EXECUTIVE SUMMARY

The Nam Ngiep 1 Hydropower Project (NNP1 Project) involves construction and operation of a 290 megawatt (MW) hydroelectric power generation facility on a build-operate-transfer basis at the Nam Ngiep River, Lao PDR. The Project will generate 262 MW of its capacity for export to Thailand and 20MW for domestic supply.

The purpose of this report is to provide an updated baseline assessment (following submission of the Project environmental impact assessment) of the biodiversity values relevant to the Project in response to the Terms of Reference (ToR) provided by ADB.

The Project area

The Project area is defined as the area potentially directly and indirectly affected by the Project components. The components include two reservoirs each impounded by a separate dam serving two separate power stations, transmission line and resettlement area. The main power station is designed to re-regulate and stabilise the Nam Ngiep River discharge from the main power station for the safety to the downstream area of the re-regulation dam. The main dam inundation area is 70 km in length, and includes a total surface area of 66.9 km^2. The transmission line will span between the main powerhouse and the Ban Nabong substation near Vientiane.

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

Terrestrial ecoregions are natural ecological communities with shared species, dynamics and environmental conditions and offer a useful way of understanding the biodiversity within an area (ADB & UNEP, 2004). The ecoregion associated with the Project area is characterised by a variety of forest associations including montane hardwoods, mixed conifer-hardwood forests, open montane forests, and open conifer forests (Wikramanayake *et al.*, 2002). These forests have been subject to heavy logging pressure and much of the forest cover of central Lao PDR is subject to existing forestry operations, or occurs within approved forest leases. Slash and burn agriculture is a land use that is still practiced widely in central Lao PDR, including the Project area (ERM 2013b).

This report uses available information (from desktop, preliminary field surveys, targeted field surveys and consultation with species specialists) to describe the biodiversity values in accordance with the requirements of ADB Environmental Safeguard Policy. A combination of field survey, desktop review, village interview, consultation with species specialists and geospatial analysis was undertaken to describe the existing characteristics of the Project

area of influence. Preliminary field sampling was undertaken in 2007 and in the wet and dry seasons of 2013. Additional targeted surveys were undertaken specific to threatened primate species and threatened fish species in 2013/2014.

The vegetation within the Project area is dominated by forest (natural habitat) and fallow land vegetation (modified habitat). The deciduous forest land cover dominates the Project area, representing approximately 36 per cent of the footprint. Young and old fallow land is also highly represented with 16 and 21 per cent respectively. Condition assessment of the Project area indicated that over 80 per cent of the Project area is classified as moderate or high NDVI (or photosynthetic capacity).

Terrestrial flora and fauna species diversity was recorded to be high in comparison to other areas in the region. A total of thirteen flora and thirty-five fauna species listed as critically endangered, endangered or vulnerable on the IUCN Red List of Threatened Species were reported (by interview, secondary data or direct observation) as known or may occur within the Project area. This includes the critically endangered flora species *Dipterocarpus turbinatus* and the Northern white-cheeked gibbon (*Nomascus leucogenys*).

Aquatic ecology surveys were also undertaken in 2007, 2013 and 2014. In general, river habitats were fast flowing with greater water depth and flows during the wet season. Dry season river habitats exhibited riffle zones which were flooded during the wet season. The river bed was generally dominated by sand and gravel. Villagers use the river environment for fishing and other activities and cattle were observed in the waterbody.

The fish community of the Mekong River is one of the largest in the world with most of the production based on migratory river species (Poulsen *et al.*, 2004). Fish migration is an important component for many fish species life cycle. The EIA (ERI, 2009) noted that the fish community detected in 2007 contains species common to the Mekong tributaries and was dominated by Cyprinid species. Cyprinid family species were reported to adapt to different environments in various sections of the river, and this family was also the dominant group detected during 2013 survey. The EIA assessment noted that of the larger species detected, many are migratory species of the lower Mekong basin that move upstream during the wet season spawning activities (EIA citing Poulsen *et al.,* 2004). These larger species, such as mud carp (*Cirrhinus molitorella*) and Asian red tailed catfish *(Hemibagrus wyckioides*) were detected in 2007 and 2013 surveys. The surveys noted a number of juvenile individuals of the migratory species suggesting that the Nam Ngiep River plays a role in providing habitat for these species' reproductive cycle (EIA citing Lowe-McConnell, 1995).

It is evident that villagers in the Project area regularly use local terrestrial and aquatic biodiversity – e.g. as a food source. However, the dependence on natural resources varies by village and is largely associated with accessibility. For example, remote villages tend to rely more heavily on medicinal plants as access to pharmaceuticals is limited. The biodiversity values of the area provide ecosystem services such as hunting and gathering, medicinal plants and materials, timber products, fishing and cultural services.

ADB SPS Habitat Categories

Land cover mapping for the Project area identified a number of vegetated cover classes. The grassland, old fallow land, young fallow land, rice paddy, slash and burn land, and urban classes are considered to be modified habitats while bamboo, deciduous forest and evergreen forest areas are considered to be natural habitats in accordance with the ADB SPS habitat categories assessment.

Assessment for critical habitat within the Project area was undertaken for species considered to be candidates based on desktop and field survey review. Using baseline data and consultation with species experts the species were screened against the determination criteria and quantitative thresholds. No species were determined likely to have critical habitat within the Project area. The area downstream of the Project area is recognised for the large river and floodplain habitat values for migratory fish species.

Candidate Offset Sites

Four candidate offset sites have been identified in the Biodiversity Offset Design Report for the Project. This report investigated the biodiversity values of each of the candidate offset sites such that their ecological suitability to provide a biodiversity offset can be assessed. The sites described include parts of the Nam Ngiep catchment (Upper Nam Ngiep), stretches of the Nam Xan River between Nam Lao and Bolikhan, the Huay Ngua PPA and Phou Khao Kouay Protected Area. The candidate sites have been identified as part of the offset design process and details are provided in the related report.

The candidate offset sites vary in site and character. Each site has been described in terms of land cover, vegetation condition, flora species, fauna species and threatened species. In general, a number of the sites display characteristics similar to the Project area biodiversity.

1 INTRODUCTION

1.1 BACKGROUND

The Nam Ngiep 1 Hydropower Project (NNP1 Project) involves construction and operation of a 290 megawatt (MW) hydroelectric power generation facility on a build-operate-transfer basis at the Nam Ngiep River, Lao PDR. The NNP1 Project site is located on the Nam Ngiep River, in the provinces of Vientiane, Xieng Khouang and Bolikhamxay, approximately 145 kilometres (km) northeast from the city of Vientiane or 50 km north from Pakxan District, as shown in *Figure 1.1*.

The Project will generate 262 MW of its capacity for export to Thailand and 20MW for domestic supply. The Project will be funded predominantly by private sector funds. The Nam Ngiep 1 Power Company (NNP1PC) is the proponent of the proposal.

An Environment Impact Assessment (EIA) was compiled for the Project in 2012 to identify and quantify the potential impacts of the Project, assess their significance and consider mitigation measures. Following reviews, the Kansai Electric Power Company Inc. (Kansai) was requested by the Asian Development Bank (ADB) and the Project's Independent Advisory Panel (IAP) to investigate the biodiversity offset requirements for the NNP1 Project and has contracted Environmental Resources Management ERM-Siam Co. Ltd (ERM) to undertake these studies.

The investigation for biodiversity offsets has been triggered by the Policy Principles of *ADB Safeguard Policy Statement, Environmental Safeguards* (ADB, 2009). The ADB requirements include the design of appropriate biodiversity offset measures to achieve at least a "no net loss" of biodiversity values.

The ADB provided a Terms of Reference (ToR) specific to the preparation of a *Baseline Biodiversity Assessment Report* and *Biodiversity Offset Design Report* for the Project. This report is the *Baseline Biodiversity Assessment Report*.

250000 300000 350000

2200000 2150000 2100000 2050000 2000000

400000

Legend

- Nam Ngiep Catchment Boundary
- Lao Province Boundary (Current)
- Lao PDR Boundary

Nam Ngiep 1 Hydropower Project:

- Inundation Area
- Re-settlement Area
- Re-regulation Dam
- Proposed Access Road
- Proposed Transmission Line
- Proposed Access Road (Transmission Line)

N

0 10 20 30Km

1:750,000

Basemap: ESRI Street
Datum: WGS84

Houamuang
Muang Yong
Muang Peun
Muang Ven
Muang O
Ban Houali
Ban Ko Kieng
Houaphan
Ban Houay Tieng
Muang Xamtong
Ban Pak Mene
Ban Songhak
Ban Naxa
Ban Ban
Ban Niang
Ban Chuong La
Ban Sen Done Mong
Ban Sen Kom
Muang Souy
Ban Len
Phonsavan
Xiangkhoang
Nong Het
Ban Nampit
Ban Nammadao
Ban San Tong
Ban Patan Noy
Muang Phoun
Ban Phatang
Ban Muangngat
Ban Done
Muang Thathom
Ban Vang-An
Songkeo
Xaysomboun
Muang Mok
Ban Houaykap-Lang
Ban Houay Pamon
Ban Tiasi
Muang Huang
Ban Keo Song Lay
Ban Hatkham
Bolikhamxai
Borikhan
Ban Hatkonong
Ban Nong Khay
Nam Ngum Reservoir
Vientiane
Tourakom
Ban Saka
Ban Keun
Ban Thabok
Bung Kan
Ban Thana
Ban Paksa
Ban Na Inh Noi
Ban Hatkiang
Ban Non
Vientiane Prefecture
Ban Thong-Noy
Phon Phisai
Vientiane Airport
Ban Sieo
Nong Khai
Ban Lao
Ban Kong Khan
Ban Wan
Ban Phu Din
Nam Ngum
Nam Ngiep
Xaisomboun
Mekong River
Thailand
Lao People's Democratic Republic
Sakon Nakhon
Nong Khai
2095
2267
2230
2096
2092
2026
222
212
211
2020
13
10
7

Client:	Nam Ngiep Power Company Ltd.		
Drawing No:	0185065b_EIA_REV_EXEC_G001_R0.mxd		
Date:	24/04/2014	Drawing Size: A3	
Drawn By:	TC	Reviewed By: DN	

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Figure 1.1 - The Project Location

Nam Ngiep 1 Hydropower Project
Environmental Impact Assessment Revision

Environmental Resources Management ANZ

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

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1.2 PROJECT DESCRIPTION

NNP1 consists of two reservoirs each impounded by a separate dam serving two separate power stations. The Project components are shown in *Figure 1.2*.

The Project will operate a main power station and a re-regulation power station. The main power station is designed to re-regulate and stabilise the Nam Ngiep River discharge from the main power station for the safety to the downstream area of the re-regulation dam. The re-regulation power station is designed to generate 19.6 MW per annum.

The main dam creates a reservoir with the normal water level at 320 m and minimum operating level at EL 296.0 m. The effective storage capacity is 1192 Mm^3 at normal water level 320 m. The dam inundation area is 70 km length, and includes a total surface area of 66.9 km^2.

The project components and the location where each biodiversity assessment is present is summarised in *Table 1.1*.

Table 1.1 Project components and assessment

Item	Components/Description	Biodiversity assessment documentation
Project components		
Main dam site	• Main Power Station and Powerhouse; • Spillway with gates; • Inundation area.	Baseline provided in this report. Impact assessment and mitigation measures provided in EIA.
Re-regulation dam	• Re-regulation Power Station and Powerhouse; • Spillway without gates; • Saddle dams; • Intake; • Penstock; • Tailrace; • Dam control centre; • Switchyard.	Baseline provided in this report. Impact assessment and mitigation measures provided in EIA.
230 kV Transmission Line	Transmission line between main powerhouse and Ban Nabong Substation.	IEE NNP1 Transmission Line from the Main Dam to Vientiane. Provided as appendix to EIA and not assessed in this report.
Resettlement area		Baseline provided in this report. Impact assessment and mitigation measures provided in EIA.
Access road network	Access road from Ban Nomsomboun to the main dam wall. The access road network includes: • upgrade of existing road from Ban Nomsomboun to Ban Hat Gniun through the Huay Ngua Provincial Preserved Area (21.2 km) • upgrade of the existing JICA Road from Ban Hat Gniun to dam	Baseline, impact assessment and management measures defined in IEE Access Road from Ban Nomsomboun to the Main Dam. Baseline biodiversity value information is included in this report for completeness.

Item	Components/Description	Biodiversity assessment documentation
	site (9.25 km) • construction of two permanent roads including road from Ban Hat Gniun to the dam site (11.16 km) • construction of a network of temporary roads from Ban Hat Gniun to the dam site (16.81 km) • bridges and culverts at four locations • associated infrastructure including workers camp, batching plants and quarries to facilitate road construction.	
Others aspects of project area of influence		
115 kV transmission line	Transmission line between the re-regulation powerhouse and Pakxan substation being developed by Electricite du Laos (EdL).	Assessment is the responsibility of EdL. When available, a revised project description and timeline for preparation of environmental assessments will be included in the IEE for the 230 kV transmission line.
Areas and communtiies potentially affected by cumulative impacts	Communities within Nam Ngiep catchment, to the confluence of NPP1 River with Mekong River.	EIA (including cumulative impact assessment)

The NNP1 project has been developed on a 'Built Operate and Transfer' basis with the Government of Lao PDR. The project will generate and sell electricity to EGAT and EDL for 27 years under a concession provided by Government of Lao PDR and the Power Purchase Agreements with EGAT and EDL respectively.

344000
346000
348000
350000
2064000
2062000
2060000

N
0 0.5 1 1.5Km
1:22,500

Project Layout: Kansai Electric
Datum: WGS84

Nam Xai
H. Mvang
Nam Tak

Access Road
Borrow Area
Access Road
Borrow Area
Ban Hat Gniun
Borrow Area
Re-regulation Powerhouse
Re-regulation Reservoir
Ban Hatsaykham
Re-regulation Dam
Access Road
Dike
Sub-contractor Camp
Administration Office
Disposal Area
Disposal Area
Disposal Area
Disposal Area
Concrete Plant
Main Powerhouse
Disposal Area
Inundation Area
Main Dam
Quarry
Aggregate Crushing Plant
Disposal Area
Disposal Area

Client:	Nam Ngiep Power Company Ltd	
Drawing No:	0185065b_EIA_REV_CH1_G002_R0_F1.2.mxd	
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Figure 1.2 - Location of Main Features of Nam Ngiep 1 Hydropower Project (NNP1PC 2013)

Nam Ngiep 1 Hydropower Project
Environmental Impact Assessment Revision

Environmental Resources Management ANZ

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

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1.3 ADB TERMS OF REFERENCE

The ADB provided ToR identified four key objectives:

1. *Provide updated baseline biodiversity data in NNP1 project affected* areas covering the: inundation area, downstream of the reservoir, downstream of the regulating and construction quarry site.

2. *Provide comprehensive baseline biodiversity data* covering Nam Xan River (140 km-stretch) and a nearby National Protected Area (NPA) as the potential biodiversity offset area;

3. *Assess the suitability of a biodiversity offset to address any residual impacts on biodiversity* and associated natural habitats from the NNP1 projects in order to achieve "no net loss or a net gain of the affected biodiversity". This will take into consideration the ecological, social, legal, institutional and financial viability and value of establishing a biodiversity offset at the target sites.

4. *Recommend and design biodiversity offset measures*. This will include identifying suitable sites/areas, designing biodiversity offsetting activities, quantifying conservation benefits and gains, developing operational management plans and associated legal, institutional arrangements, roles and requisite capacities, calculating budgets and designing suitable financial arrangements, developing stakeholder participation programs, benefit mechanisms and compensation requirements, and establishing appropriate monitoring and evaluation arrangements.

1.4 PURPOSE OF THIS REPORT

The purpose of this report is to provide an updated baseline assessment of the biodiversity values relevant to the Project in response to the Terms of Reference (ToR) provided by ADB. This report is intended to meet the first two objectives of the ToR, by describing the biodiversity of NNP1 affected areas as well as the biodiversity of candidate offset sites (including Nam Xan River as described in objective two).

This report will document updated baseline biodiversity assessment required to revise the Project EIA and finalise the Biodiversity Offset Design Report. The Biodiversity Offset Design Report will be compiled to satisfy the final two objectives of the ADB ToR.

This report should be read in conjunction with the EIA for the Project. The remainder of the EIA provides additional detail on a number of assessment components which are not necessarily provided in detail in this report. In particular:

- EIA Appendix B Biodiversity Offset Design Report;
- EIA Appendix C Cumulative Impact Assessment Report;

- Appendix D Environmental Flow Assessment Report; and
- Appendix F IEE for Transmission Line.

2 BIODIVERSITY VALUES ASSESSMENT METHODS

2.1 RELEVANT ASSESSMENT STANDARDS

2.1.1 Asian Development Bank

The ADB Safeguard Policy Statement (SPS) (June 2009) outlines the requirements that the borrower/clients are required to meet when delivering environmental safeguards for project supported by the ADB.

Environmental assessment requirements are identified, including the basis for the assessment process. Specific to biodiversity conservation and sustainable natural resource management the borrower/client:

'will assess the significance of Project impacts and risks on biodiversity and natural resources as an integral part of the environmental assessment process…. The assessment will focus on the major threats to biodiversity, which include destruction of habitat and introduction of invasive alien species, and on the use of natural resources in an unsustainable manner. The borrower/client will need to identify measures to avoid, minimise, or mitigate potentially adverse impacts and risks and, as a last resort, propose compensatory measures, such as biodiversity offsets, to achieve no net loss or a net gain of the affected biodiversity.'

Primarily the revised EIA documents the significance of Project impacts and management of potentially adverse impacts, with this report providing the baseline data to facilitate the impact assessment. The policy statement describes habitat area categories to be considered including modified habitat, natural habitat and critical habitat. The Asian Development Bank Environmental Safeguards Good Practice Source Book (the 'Source Book') (ADB 2012) contain specific requirements for different habitat types that relate to their likely conservation value.

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

2.1.2 International Finance Corporation Performance Standard 6

The International Finance Corporation (IFC) Performance Standards establish a range of social and environmental obligations to be met by recipients of IFC financing. Governance of the Performance Standards is the responsibility of the IFC. There are eight IFC Performance Standards of which Performance Standard 6 (PS6) is relevant to this biodiversity assessment.

IFC PS6 defines the parameters of biodiversity and ecosystem services which will be considered when assessing the Project against the IFC Performance

Standards. This includes the identification and consideration of biodiversity values that include habitat values, threatened species, ecosystem services, protected areas and invasive species. PS6 outlines the objective of no net loss of biodiversity in natural and modified habitats and a net gain of biodiversity in Critical Habitats, where feasible. The PS6 also identifies the need to consider use of offsets to compensate for residual impacts to biodiversity as a result of the Project, but only after the mitigation hierarchy has been applied to the fullest extent practicable.

Threatened Species

Threatened species are identified in PS6 as those listed on the IUCN Red List of Threatened Species. The IUCN Red List of Threatened Species provides taxonomic, conservation status and distribution information on plants and animals that have been evaluated using the IUCN Red List categories and criteria. The criteria identify three categories of threatened species:

- Critically Endangered (CR);
- Endangered (EN); and
- Vulnerable (VU).

Five additional categories of plants and animals are included in the IUCN Red List including:

- Extinct;
- Extinct in the Wild;
- Near Threatened (NT);
- Least Concern (LC);
- Those for which data is insufficient Data Deficient (DD); and
- Those which have not been evaluated (NE).

Species categorised as CR, EN and VU are considered to be at a heightened risk of extinction and are awarded an elevated level of consideration under the IFC Performance Standards.

Critical Habitat

One of the key provisions of IFC PS 6 is the identification of 'Critical Habitat'. IFC PS6 defines Critical Habitats as areas with high biodiversity value, including (i) habitat of significant importance to Critically Endangered and/or Endangered species; (ii) habitat of significant importance to endemic and/or restricted-range species; (iii) habitat supporting globally significant concentrations of migratory species and/or congregatory species; (iv) highly threatened and/or unique ecosystems; and/or (v) areas associated with key evolutionary processes. Critical Habitat may not be limited to pristine or highly biodiverse areas but rather may include modified and natural habitats

across the broader landscape that supports the biodiversity values that trigger the Critical Habitat designation.

2.2 *REGIONAL BIODIVERSITY CONTEXT*

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

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

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

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

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

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

2.3 *INVESTIGATION AREAS*

A number of locations, summarised below, were assessed as part of this baseline biodiversity assessment. Within this report the following terminology applies:

- Study area – the area encompassing all areas assessed for biodiversity values. This includes the Project area and candidate offset sites and surrounds (*Figure 2.1*).

- Project area – the area potentially directly and indirectly affected by the Project (*Section 3*). This area is consistent with the Project 'area of influence' in accordance with the ADB SPS. It includes the footprint of disturbance of the various project components (direct impact area) as well as areas of the wider Nam Ngiep River catchment (indirect impacts).

- Candidate offset sites – the areas investigated to provide potential offset sites. This included consideration of the biodiversity values at four locations: the Upper Nam Ngiep River, Nam Xan River, Huay Ngua Provincial Preserved Area (PPA) and the Phou Khao Kouay (PKK) National Protected Area (NPA). The extent and characteristics of these areas is further described in *Section 4*.

The study area components are described in *Table 2.1* and shown in *Figure 2.1*.

Note that areas shown in *Table 2.1* estimate the area of direct impact or coverage (in the case of candidate offset sites). The area of influence includes the wider Nam Ngiep River catchment and has less defined extent. The impact assessment considers the magnitude and significance of both direct and indirect impacts in order to assess impact to the area of influence.

Table 2.1 Summary of Study Area

	Study Area	Area (ha)
Project area	Main Dam site and inundation area	6,798
	Resettlement Site	467
	Re-regulation Dam	699
	Access Road network (estimated footprint of 4.75 m from centreline)	52[1] (Length 58 km)
	Lower Nam Ngiep (downstream of the dams)	-
Candidate Offset Sites	Upper Nam Ngiep River (outside inundation area)	127,176
	Nam Xan River	Length – 85 km
	Huay Ngua PPA	5,860
	Phou Khao Kouay NPA	181,306

1. Based on length of 58 km, and width of 4.75 m from centreline.

250000 300000 350000 400000

2150000 2100000 2050000

Legend

- Nam Ngiep Catchment Boundary
- Waterbody
- Road
- City or Town
- Lao PDR Boundary
- National Park Boundary

Nam Ngiep 1 Hydropower Project:

- Inundation Area
- Re-regulation Dam
- Re-settlement Area
- Proposed Access Road
- Proposed Access Road (Transmission Line)
- Proposed Transmission Line

N 0 10 20 30Km

1:600,000

Basemap: Bing Maps
Datum: WGS84

Phoukout
Phonsavan
Nonghet
Muang Khoun
Phaxai
Nam Ngum
Nam Ngiep
Thathom
Vang Vieng
Nam Song Diversion
Nam Ngum 2 Reservoir
Nam Ngum Reservoir
Hinheup
Ba. Donkha
Nam Ngum Reservoir
Longxan
Thinkeo
Phonhong
Nam Ngum Reservoir
Nam Leuk reservoir
Phou Khao Khouay National Protected Area
Nam Mang 3 Reservoir
Ban Keun
Mekong River
Pakxan
Nam Xan
Hai
Tha Ngon

bing

Client:	Nam Ngiep Power Company Ltd.		
Drawing No:	0185065b_EIA_REV_CH2_G006_R0_F2.1.mxd		
Date:	01/05/2014	Drawing Size: A3	
Drawn By:	TC	Reviewed By: DN	

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

Figure 2.1 - Biodiversity Study Area

Nam Ngiep 1 Hydropower Project
Environmental Impact Assessment Revision

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2.4 *BASELINE BIODIVERSITY SURVEY*

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

- Flora and fauna survey across the Study area;
- Desktop sources (published and grey literature, available reports, geospatial datasets and species profiles);
- Geospatial datasets including remote sensing data;
- Species expert consultation;
- Detailed flora survey of the access road corridor; and
- Targeted threatened species survey.

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

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

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

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

The direct and indirect data sources are described in this section.

2.4.1 *Direct Biodiversity Data Sources*

NNP1 Environmental Impact Assessment 2012

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

ERIC surveyed the Project area in March and October 2007 in order to identify threatened species occurring in or near the Project area, and whether the

project has potential to impact their habitats. The assessments were carried out through visual inspection (direct data), interviews with villagers (indirect data) and utilisation of secondary data sources. Detailed survey methodology for this component is provided in *Annex A*. Results of the surveys reported that current clearing and general habitat disturbance has resulted in many species not occurring in the Project area.

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

Thailand Institute of Scientific and Technological Research Biodiversity Survey 2013

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

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

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

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

Sampling locations are shown in *Figure 2.2*. Detailed survey methodology for this component is provided in *Annex B*.

Forest and Vegetation Survey

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

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

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

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

Terrestrial Fauna Survey

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

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

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

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

placed under tree canopies or cross creeks. Some species of mammals were identified from local hunters.

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

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

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

Aquatic Biota Survey

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

- collection of phytoplankton and zooplankton species using multiple plankton net surveys at each location, followed by preservation, identification and laboratory analysis at TISTR;

- collection of benthos at multiple replicate sites using an Ekmann dredge, followed by identification and abundance counts at the TISTR laboratories; and

- capture and identification of fish species within the main rivers and their tributaries using the help of local fishermen using multi-mesh gillnets, electrofishing, cast nets, gun and hook, as well as discussions with fishermen and other information sources.

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

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

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

proposed access road area with the ten closest trees recorded and measured. The outcomes of NUL assessment have been incorporated in baseline data and description.

Dr Phaivanh Phiapalath Endangered Primate Survey 2013

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

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

Dr Kottelat Fast Water Habitat Survey 2014

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

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

Mr Terry Warren Critically Endangered Fish Species Habitat Assessment 2014

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

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

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

1. Investigation into the likely species distribution within the Nam Ngiep watershed through villager interviews;

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

2.4.2 Indirect Biodiversity Data Sources

Desktop Review

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

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

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

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

Geospatial Analysis

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

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

The imagery outputs provide a NDVI in grid formation (5m x 5m) across the Project area and candidate offset sites. For the Project condition classes (for a range of NDVI) were defined and applied to each forest type. The condition classes are shown in *Table 2.2*. These condition classes were used to refine land cover calculations. Area within the Impacted NDVI range was removed from the habitat area calculations.

Table 2.2 Condition Class NDVI Range

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

Limitations

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

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

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

Species Specialist Consultation

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

Key input was provided by Dr J.W Duckworth, Dr M Kottelat, Dr P Phiapalath and Mr T Warren. Comment was provided on some species texts however it is acknowledged that the final content remains the responsibility of the report compilers.

A number of primate species were determined candidates for critical habitat and Dr Phiapalath of the IUCN SSC Primate Specialist Group was engaged to undertake further site survey and advice relating to critical habitat for primate species. The method of assessment and discussion relating to habitat value is provided in *Annex D* and the advice has been incorporated into the critical habitat assessment. Similarly, Dr Kottelat was engaged to undertake additional fast water habitat fish surveys and Mr Warren was engaged to undertake additional targeted village interviews. The results of which have been incorporated into the critical habitat assessment and summary reports provided in Annex *E*.

Social and Cultural Surveys

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

It should be noted that the ecosystem services assessment in this report does not replace the consultation or social assessment undertaken for the project, rather draws upon findings of consultation for the purposes of identifying ecosystem services only.

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

with relevant community representatives (e.g. hunters, gatherers); while the market surveys involved visual surveys and informal discussions with stall operators.

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

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

Other sources reviewed included:

- NNP1 Social Impact Assessment Draft Report, which provided initial baseline information for the Project area (2012);
- Physical Cultural Resources: Preliminary Archaeological Survey in the proposed Nam Ngiep 1 Hydropower Project (NNHP-1), an archaeological survey report written in October 2007 provided by Mr Viengkeo Souksavatdy, Deputy Head of the Archaeology Department, MICT;
- Village surveys to determine the socio-economic context for the biodiversity offsets. This included focus groups and in-depth interviews with relevant representatives from communities in the Project area and proposed offset catchment;
- Market surveys in the Project area and proposed offset catchment to further understand and quantify the threat to flora and fauna; and
- Engagement with relevant stakeholders (e.g. representatives from government and non-governmental organisations) to confirm local land use activities, including the presence and use of biodiversity.

330000 340000 350000 360000 370000 380000

2110000 2100000 2090000 2080000 2070000 2060000 2050000 2040000

Nam Ngiep

Thathom

Nam Xan

Mekong River

bing

Legend

- Nam Ngiep Catchment Boundary
- Waterbody
- Road
- City or Town
- Lao PDR Boundary

Nam Ngiep 1 Hydropower Project:

- Inundation Area
- Re-regulation Dam
- Re-settlement Area
- Proposed Access Road

Survey Locations:

- Wildlife Survey Location
- Forest Survey Location
- Aquatic Survey Location

N

0 1.5 3 4.5Km

1:200,000

Basemap Bing Maps
Datum: WGS84

Client:	Nam Ngiep Power Company Ltd.	
Drawing No:	0185065b_BIODIV_G004_R0.mxd	
Date:	01/05/2014	Drawing Size: A3
Drawn By:	TC	Reviewed By: DN

Figure 2.2 - Sampling Locations

Nam Ngiep 1 Hydropower Project
Baseline Biodiversity Assessment Report

Environmental Resources Management ANZ

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3 PROJECT AREA BIODIVERSITY VALUES

3.1 OVERVIEW

The following section summarises the key biodiversity values identified during in the baseline assessment of the Project area. It provides an overview of the biodiversity values associated with the Project area to enable determination of impact assessment associated with the project activities and for the determination of biodiversity offsets. The impact assessment is documented in Chapters 6 and 10 of the EIA.

Specifically, a description of habitats within the Project area in accordance with the terminology defined by the ADB Safeguard Policy Statement is provided. The Project area is made up of the components described in *Section 1.2* and shown in *Figure 1.2*.

Lao PDR is approximately 41 per cent covered by forest and is considered one of the most biodiversity rich countries in Southeast Asia (World Bank, 2005). In general, the main dam inundation area (inundation area approximately 6798 ha) is located in mountainous terrain with some intermittent narrow plains. There are high mountains on both sides of the river. Downstream of the main dam is a valley with slopes less steep than the upstream reaches as the river widens and the relief flattens downstream of the re-regulation dam (approximately 700 ha). Forest vegetation dominates the Lao PDR and the Project area.

3.2 TERRESTRIAL BIODIVERSITY VALUES

3.2.1 Vegetation

Land Cover

Using land cover mapping (DFRM, 2010), natural and modified habitats can be identified within the Project area. *Table 3.1* summarises the land cover shown in *Figure 3.1* and identifies the habitat category of each land cover type.

Natural habitat is an environment where the biological communities are largely formed by native plant and animal species and where human activity has not modified the areas primary ecological functions (ADB, 2012). The natural habitats within the Project area include deciduous forest, evergreen forest and bamboo vegetation.

Modified habitat is altered natural habitat, often formed by the removal of native species for harvesting, land conversion and/or introduction of alien flora and fauna species (ADB, 2012). The modified habitats within the Project area include young and old fallow land, slash and burn, rice paddy, grassland and urban areas. The Project EIA (ERI, 2009) identified during field reconnaissance and village interviews that a large portion of the main dam and re-regulation dam inundation areas has already been disturbed by

conversion of forest land to other land use types (predominantly agriculture) as well as burning for hunting and illegal logging.

Overall, the vegetation within the Project area is dominated by forest (natural habitat) and fallow land vegetation (modified habitat). The deciduous forest land cover dominates the Project area, representing approximately 36 per cent of the footprint. Young and old fallow land is also highly represented with 16 and 21 per cent respectively.

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

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

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

Table 3.1 Landcover within the Project areas

Land Cover	ADB Habitat Class		Area (ha)				Total (ha)	% of Total
			Main dam inundation	Re-regulation dam inundation	Resettle-ment	Access Road*		
Deciduous Forest (DF)	N	Deciduous forest occurs when deciduous tree species represent more than 50% of the stand. The forest storeys are not as dense as those of evergreen type. Deciduous Forest includes both upper and lower deciduous forest types and this definition is based on relative altitude, forest occurring above 200 m is classified as Upper Mixed deciduous Forest and deciduous forest occurring at an altitude 200 m and below is classified as Lower Deciduous Forest.	2690	131	56	19	**2896**	**36%**
Evergreen Forest (EF)	N	Area dominated by trees where 75% or more of the tree species maintain their leaves all year. Canopy is never without green foliage.	488	24	0	2	**514**	**6%**
Bamboo (B)	N	Bamboo area where the overstorey has a crown cover less than 5%.	236	127	132	7	**502**	**6%**
Old Fallow Land (OFL)	M	Land that has been ploughed and tilled and left un-seeded during a growing season.	1321	194	163	12	**1678**	**21%**
Young Fallow Land (YFL)	M	Land that has been recently ploughed and tilled and left un-seeded during a growing season.	1036	143	82	5	**1261**	**16%**
Slash and Burn (SB)	M	Slash-and-burn is a description of land that has been subjected to an agricultural technique which involves cutting and burning of forests or woodlands to create fields.	328	27	19	1	**374**	**5%**
Rice Paddy (RP)	M	Areas permanently being used for rice cultivation.	107	5	15	1	**127**	**2%**
Grassland (G)	M	Unfertile or degraded land on which no trees or shrubs grow. It might be an area that is too dry for tree growth that has been covered by grasses. It could also be an area that has originally been covered by trees, but has been heavily disturbed by cutting and fire and gradually depleted.	108	0	0	0	**108**	**1%**

Land Cover	ADB Habitat Class		Area (ha)				Total (ha)	% of Total
			Main dam inundation	Re-regulation dam inundation	Resettle-ment	Access Road*		
Urban Area (U)	M	Urban Areas include all areas being used for permanent settlements such as villages, towns, public gardens etc. It also includes roads having a width of more than 5 m and areas under electric high power lines.	38	3	0	<1	**41**	**1%**
Water (W)	-	The land cover class Water includes rivers, water reservoirs (i.e. ponds and dams for irrigation and hydro power) and lakes. Water reservoirs and lakes with an area of 0.5 ha and rivers should be at least 10m wide to be classified as Water.	368	42	0	<1	**410**	**5%**
Rock (R)	-	Unfertile or seriously degraded land on shallow soil and rocky areas on which neither trees nor grasses can grow.	1	0	0	0	**1**	**<1%**
Cloud	-	Cloud indicates limitations in the dataset from shadows and cloud contained in the aerial imagery.	4	0	0	<1	**4**	**<1%**
Shadow	-	Shadow indicates limitations in the dataset from shadows and cloud contained in the aerial imagery.	16	0	0	1	**16**	**<1%**
Impacted Natural Habitat (NDVI)			*57*	*3*	*0*	***1***	***60***	***1%***
Total			**6798**	**699**	**467**	**49**		

ADB Habitat Class: M = modified; N = Natural
*Access Road calculations based on 9.5 m wide road corridor.

Forestry Classification Mapping

Forestry classification mapping identifies both protection forest and production forest across the Project area. *Figure 3.2* depicts the extent of protected and production forest within the Project area and shows that greater than half of the Project area is mapped as National Protected Forest. Protection forest is described as:

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

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

Vegetation Condition

The NDVI features recorded in Rapideye Imagery provides an index of vegetation density and condition at the time of image capture. It indicates the photosynthetic capacity of the land surface cover and has been used to refine the vegetation type extents into an additional level of detail. The NDVI across the Project area is shown in *Figure 3.3* and the area of each classification is summarised in *Table 3.2, Table 3.3, Table 3.4* and *Table 3.5*.

Over 80 per cent of the Project area is classified as moderate or high NDVI. Up to 5 per cent of the Project area is classified as impacted NDVI. The following tables summarise the vegetation condition for each Project area component.

Table 3.2 Vegetation Condition within the Main Dam (inundation area) (ha)

Forest type	Code	Impacted (- to 0)	Low (0 - 0.4)	Moderate (0.4 - 0.6)	High (0.6 - 0.8)
Deciduous Forest	DF	31	154	1091	1445
Evergreen Forest	EF	20	38	266	184
Old Fallow Land	OFL	10	93	573	644
Young Fallow Land	YFL	19	217	549	250
Bamboo	B	5	21	67	147
Slash and Burn	SB	10	171	96	51

Forest type	Code	Impacted (- to 0)	Low (0 - 0.4)	Moderate (0.4 - 0.6)	High (0.6 - 0.8)
Rice Paddy	RP	5	72	27	2
Water	W	237	80	39	12
Grassland	G	8	34	51	16
Urban Area	U	1	31	6	0
Rock	R	1	0	0	0
Cloud		2	1	0	1
Shadow		8	5	2	0
Total (ha)		**357**	**917**	**2767**	**2752**
% of Total		**5%**	**13%**	**41%**	**41%**

Table 3.3 Vegetation Condition within the Re-regulation Dam (ha)

Forest type	Code	Impacted (- to 0)	Low (0 - 0.4)	Moderate (0.4 - 0.6)	High (0.6 - 0.8)
Deciduous Forest	DF	1	10	75	47
Evergreen Forest	EF	2	5	16	4
Old Fallow Land	OFL	2	30	139	24
Young Fallow Land	YFL	1	14	101	27
Bamboo	B	0	11	59	57
Slash and Burn	SB	0	7	15	4
Rice Paddy	RP	0	4	1	0
Water	W	32	7	2	0
Urban Area	U	0	3	0	0
Total (ha)		**38**	**91**	**408**	**163**
% of Total		**5%**	**13%**	**58%**	**23%**

Table 3.4 Vegetation Condition within the Resettlement Site (ha)

Forest type	Code	Impacted (- to 0)	Low (0 - 0.4)	Moderate (0.4 - 0.6)	High (0.6 - 0.8)
Deciduous Forest	DF	0	8	39	10
Old Fallow Land	OFL	0	37	106	20
Young Fallow Land	YFL	0	25	48	10
Bamboo	B	0	19	77	36
Slash and Burn	SB	0	5	12	2
Rice Paddy	RP	0	7	7	1
Total (ha)		**0**	**101**	**289**	**79**
% of Total		**0%**	**22%**	**62%**	**17%**

Table 3.5 Vegetation Condition within Access Road Network (ha)

	Impacted (- to 0)	Low (0 - 0.4)	Moderate (0.4 - 0.6)	High (0.6 - 0.8)
Ban Nomsomboun – Ban Hat Gniun	<1	11	6	<1
JICA Road	<1	2	4	<1
Permanent Roads Ban Hat Gniun	<1	1	6	3
Temp Roads Ban Hat Gniun	<1	2	8	5

300000 310000 320000 330000 340000 350000 360000

2120000 2110000 2100000 2090000 2080000 2070000 2060000 2050000 2040000 2030000

Legend

- Evergreen Forest (Current Forest)
- Deciduous Forest (Current Forest)
- Deciduous Forest Plantation (Current Forest)
- Bamboo (Potential Forest)
- Old Fallow Land (Potential Forest)
- Young Fallow Land (Potential Forest)
- Slash and Burn Land (Potential Forest)
- Rice Paddy
- Grassland
- Swamp
- Rock
- Barren Land
- Urban Area
- Water
- Other Land
- Cloud
- Shadow
- Nam Ngiep Sub-catchment Boundary
- Watercourse
- City, Town or Village

Nam Ngiep 1 Hydropower Project:

- Inundation Area
- Re-regulation Dam
- Re-settlement Area
- Proposed Access Road

Thathom

Xiengmi

Mekong River

N

0 2.5 5 7.5Km

1:250,000

Land Cover: DFRM
Datum: WGS84

Client:	Nam Ngiep Power Company Ltd.	
Drawing No:	0185065b_BIODIV_G005_R0.mxd	
Date:	13/09/2013	Drawing Size: A3
Drawn By:	TC	Reviewed By: DN

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

Figure 3.1 - Land Cover within the Project Area

Nam Ngiep 1 Hydropower Project
Baseline Biodiversity Assessment Report

Environmental Resources Management ANZ

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

ERM

280000 290000 300000 310000 320000 330000 340000 350000 360000 370000

2160000 2150000 2140000 2130000 2120000 2110000 2100000 2090000 2080000 2070000 2060000 2050000 2040000

Phoukout
Phonsavan
Nam Ngum
Muang Khoun
Phaxai
Nam Xan
Thathom
Nam Ngiap
Mekong River

Legend

- Nam Ngiep Catchment Boundary
- Waterbody
- Road
- City or Town

Nam Ngiep 1 Hydropower Project:

- Inundation Area
- Re-regulation Dam
- Re-settlement Area
- Proposed Access Road

Forest Zone:

- National Protection Forest
- Production Forest

N

0 4 8 12Km

1:350,000

Basemap: Bing Maps
Datum: WGS84

Client:	Nam Ngiep Power Company Ltd.		
Drawing No:	0185065b_BIODIV_G006_R0.mxd		
Date:	06/09/2013	Drawing Size: A3	
Drawn By:	TC	Reviewed By: DN	

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

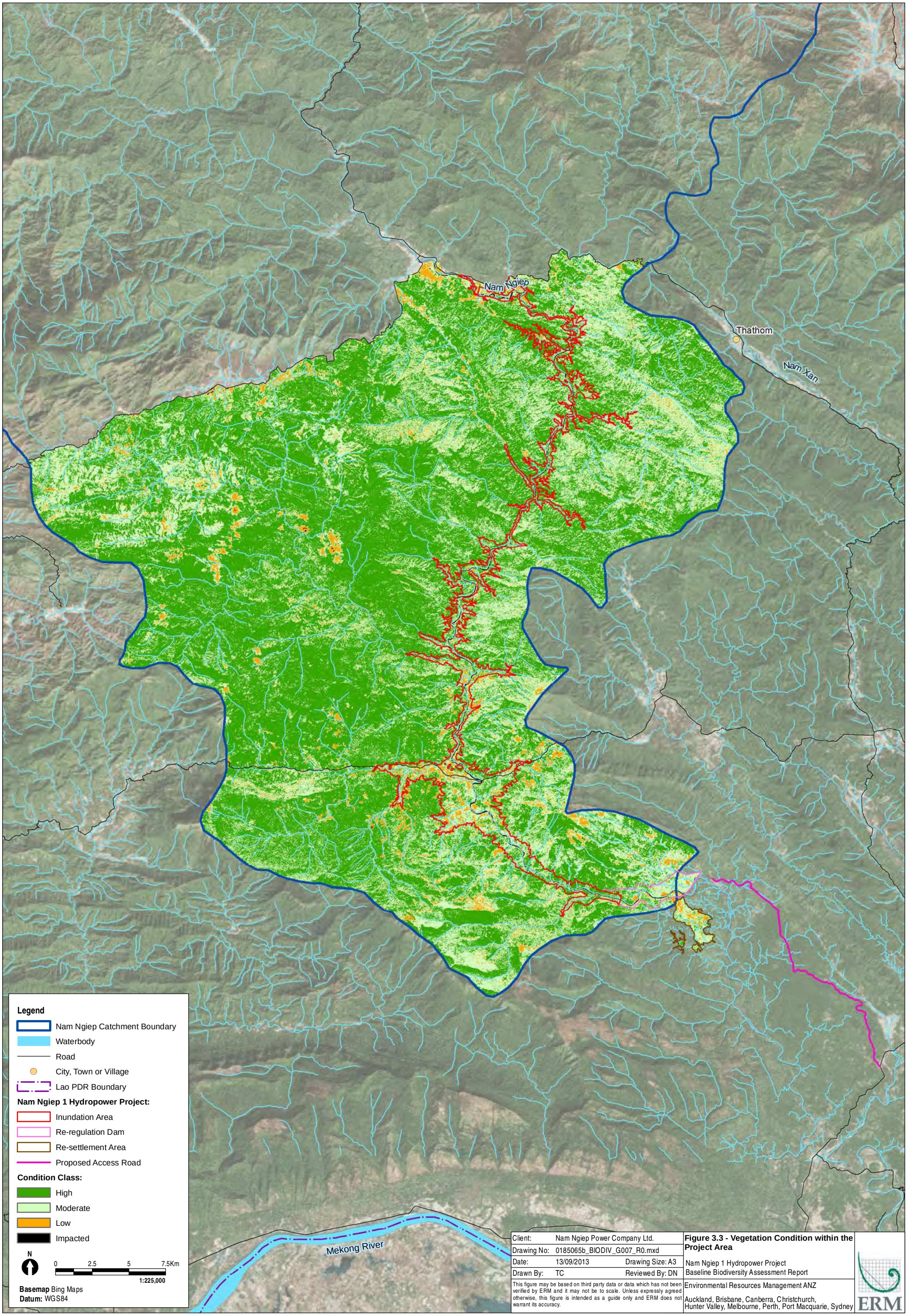
Figure 3.2 - Forestry Classification Mapping within the Project Area

Nam Ngiep 1 Hydropower Project
Baseline Biodiversity Assessment Report

Environmental Resources Management ANZ

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

ERM



Client:	Nam Ngiep Power Company Ltd.	
Drawing No:	0185065b_BIODIV_G007_R0.mxd	
Date:	13/09/2013	Drawing Size: A3
Drawn By:	TC	Reviewed By: DN

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

Figure 3.3 - Vegetation Condition within the Project Area

Nam Ngiep 1 Hydropower Project
Baseline Biodiversity Assessment Report

Environmental Resources Management ANZ

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

ERM

Ground-truthed Vegetation Communities/Habitat

Detailed ground-truthing was undertaken within the proposed access road corridor only in preparation for construction activities. In general detailed ground-truthing determined, with respect to the representation of natural habitat, that the landcover mapping provides an over-estimate of the extent of natural habitat.

Ground-truthing results for the access road corridor for the Ban Nomsomboun to Ban Hat Gniun section of the proposed road identified substantially less natural habitat (47% natural habitat) than detected in land cover mapping (61% natural habitat). Similarly, ground-truthing of the JICA Road results (11% natural habitat) were less than indicated on land cover mapping (22% natural habitat).

The flora survey undertaken of the access road by NUL, ground-truthed the land cover mapping to confirm the presence of natural or modified habitat in accessible areas of the access road network. *Table 3.6* summarises the habitat description for segments of the access road, as provided in the draft field report from the corridor flora survey (Phengsintham 2013). *Table 3.4* of the Access Road IEE report summarises the modified and natural habitat areas.

Table 3.6 Vegetation descriptions from road corridor flora survey (Phengsintham 2013)

Road Segment	Vegetation Description
Ban Nomsomboun to Huay Ngua PPA	Primarily modified habitat on left and right sides, except TSP no5 on the left hand side, where regeneration forest occurs across for approximately 500 m of the access road.
Inside Huay Ngua PPA	Huay Ngua PPA primarily consisted of lower mixed deciduous forest (LMD). Within the corridor, the average DBH in LMD is 38 cm and average distance 9.3 m. In comparison, outside the corridor, the average DBH was 34.5 cm and the average distance 7.8m. A total of 114 Mai Yang Khao (*Dipterocarpus turbinatus* – Critically Endangered, IUCN list) have previously been recorded. 21 items were cleared by the EDL (pole installation), 29 exist within the road corridor; and the remaining will be preserved by NNP1PC and PAFO. Removal of Mai Yang Khao could be replaced by replanting the species inside the PPA, supporting the provincial office to improve Huay Ngua PPA through reforestation and providing a check point during road construction.
JICA road	JICA road passes through Ban Hat Gnuim and Hatsaykham villages. The sections is primarily modified forest, except two points (TSP no35 and no40), which are small patches of UMD. The Average DBH 43 cm and average distance 7.08 m for TSP no35. This vegetation type represented the dense vegetation (UMD) at the site, but the forest was disturbed by historical logging activities, shifting cultivation (ray) and other agricultural activities.
P2 and T12	Three TSPs were established. The area between ICA road and TSP no43 was primarily Fallow Forest. Between TSP no43 and TSP no45 vegetation was primarily disturbed UMD to the right of the road, and Fallow Forest to the left of the road. This vegetation represented the highest quality dense vegetation, however the forest was disturbed by historical logging activities, shifting cultivation (ray) and fired in May 2013.

Road Segment	Vegetation Description
T7, T8 and T9 Access Road	Eight TSPs were surveyed in these access roads. The area included young fallow forest, plantation area and mixed deciduous forest. The average DBH in UMD was 44.8 cm and the average distance 9.48m. In comparison, outside the corridor the average DBH was 28 cm and distance about 6.36m.

Source: direct summary of Draft Land Use Study prepared by Pheng Phengsintham (Local botanist and Lecturer of the National University of Laos) (November 2013).

3.2.2 Flora Species

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

Sampling undertaken during the 2013 survey by TISTR recorded the diversity of vascular plants in the main dam inundation area (upper Nam Ngiep) was greater in comparison to all other areas sampled for the Project, with at least 509 species recorded. The primary vegetation types at each of the components of the Project is summarised in *Table 3.7* based on the 2013 TISTR survey results. A full species list is provided in *Annex F.*

Table 3.7 Primary Forest Type at Project area

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

For the forest types the forest canopies are divided in 3 classes. The dominant species for each survey locations are summarised in *Table 3.8*.

Table 3.8 Dominant Flora Species in Project area

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

IUCN Listed Species

A total of thirteen species of plants listed as critically endangered, endangered or vulnerable under the IUCN Red List were recorded within the Project area during 2007 ERI and/or 2013 TISTR surveys. These include one species listed as critically endangered, seven as endangered and five as vulnerable (*Table 3.9*).

Table 3.9 IUCN Listed Flora Species Recorded in the Project Area

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

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

3.2.3 Fauna Species

The main dam inundation area was surveyed for fauna during the 2007 survey by ERI with additional data collected in 2013 by TISTR at eight key survey locations (including the candidate offsets sites).

The diversity of fauna in the main dam inundation area (upper Nam Ngiep) was high in comparison to other areas sampled in 2013 by TISTR. Habitats varied in condition with human disturbance evident in areas downstream of the main dam. The habitat and species detected at each of the main surveyed areas are summarised in *Table 3.10*. A full list of flora species is provided in Annex F, and a list of fauna species is provided in Annex G. Threatened species are discussed separately below.

Table 3.10 Fauna Habitat in the Surveyed Areas

Survey Location	Forest Type Description
Main Dam Inundation Area	The upper area of the Nam Ngiep River is dominated by primary forest. Site surveys detected (through interviews with villagers or direct observation) at least 46 mammals species, 50 bird species, 28 reptiles species and 10 amphibian species.
Resettlement Site	The resettlement area is mostly and heavily disturbed as a result of slash and burn activities. There is evidence of some regeneration and secondary growth. Site surveys detected (through interviews with villagers or direct observation) at least 9 mammals species, 24 birds species, 19 reptiles species and 8 amphibian species.
Lower Nam Ngiep	This area is mostly disturbed and dominated by agricultural landuse. There is high human activity in this area. Site surveys detected (through interviews with villagers or direct observation) at least 12 mammals species, 27 birds species, 21 reptiles species and 7 amphibian species.

Restricted Species

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

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

A number of these species were recorded during field surveys in the Project area undertaken by ERI (2007) and TISTR (2013). Species listed as Restricted are considered candidates for critical habitat (Section *3.5*).

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

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

Annex G shows the results.

Table 3.11 No. 0360/MAF Restricted Fauna Species Reported

Common Name	Scientific Name	No. 060/MAF Status	IUCN Status	Main Dam Inundation	Re-settlement Site	Re-regulation Dam Inundation	Lower Nam Ngiep	Access Road
Mammals								
Asian small-clawed otter	*Aonyx cinera*	R	VU	x				
Golden jackal	*Canis aureus*	R	LC	x				
Southwest China serow	*Capricornis milneedwardsii*	R	NT	✓				
Dhole	*Cuon alpinus*	R	EN	x				
Sun bear	*Helarctos malayanus*	R	VU	x				x
Smooth-coasted otter	*Lutrogale perspicillata*	R	VU	x				
Northern white-cheeked gibbon	*Nomascus leucogenys*	R	CR	✓				
Bengal slow loris	*Nycticebus bengalensis*	R	VU	x				
Pygmy slow loris	*Nycticebus pygmaeus*	R	VU	x				
Leopard	*Panthera pardus*	R	NT	x				x
Tiger	*Panthera tigris*	R	EN	x				
Asiatic golden cat	*Pardofelis temminckii*	R	NT	x				x
Leopard cat	*Prionailurus bengalensis*	R	LC	x				
Sambar deer	*Rusa unicolor*	R	VU	✓				x
Himalayan black bear	*Ursus thibetanus*	R	VU	x				
Birds								
Greater hornbill	*Buceros bicornis*	R	NT					x
Greater coucal	*Centropus sinensis*	R	LC	✓	✓	✓	✓	✓
Siamese fireback	*Lophura diardi*	R	LC					x
Silver pheasant	*Lophura nycthemera*	R	LC	✓				x
Grey peacock-pheasant	*Polyplectron bicalcaratum*	R	LC					x
Red-breasted parakeet	*Psittacula alexandri*	R	LC					✓

Common Name	Scientific Name	No. 060/MAF Status	IUCN Status	Main Dam Inundation	Re-settlement Site	Re-regulation Dam Inundation	Lower Nam Ngiep	Access Road
Reptiles								
Reticulated python	*Broghammerus reticulatus*	R		✓	x		x	x
King cobra	*Ophiophagus hannah*	R	VU	x			x	
Big-headed turtle	*Platysternon megacephalum*	R	EN	x				x

IUCN Status: CR – Critically Endangered; EN – Endangered; VU – Vulnerable; NT – Near Threatened; LC – Least Concern
No. 060/MAF Status: R - Restricted
✓ = Direct record; x = Indirect record

IUCN Listed Species

The fauna species have been categorised by the IUCN (2012) and a number listed on the IUCN Red List have been recorded within the Project area. The 2013 (TISTR) surveys recorded one species, the Northern white-cheeked gibbon listed as critically endangered within the Project area at the main dam inundation area. A number of other species were reported through indirect records. Species listed as critically endangered or endangered are considered candidates for critical habitat and these species records have been investigated further in *Section 3.5*.

Overall, the direct and indirect records identified:

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

Table 3.12 summarises the species recorded.

Table 3.12 IUCN Fauna Species Reported within the Project Area

Family/Common Name	Scientific Name	2012 EIS		TISTR Survey				Primate survey		IUCN Status/ No. 060/ MAF Status
		Inside Project area	Outside Project area	Upper Nam Ngiep	Lower Nam Ngiep	Huay Ngua	Resettlement Site	Inside Project Area	Outside Project Area	
MAMMALS										
Northern white-cheeked gibbon	*Nomascus leucogenys*			✓					✓	CR/R
Dhole	*Cuon alpinus*	x	x	x						EN/R
Asian elephant	*Elephas maximus*	x	x			x				EN
Sunda pangolin	*Manis javanica*	✓	x	x			x			EN
Tiger	*Panthera tigris*	x	x	x						EN/R
Fishing cat	*Prionailurus viverrinus*	x	x			x				EN
Red-shanked douc langur	*Pygathrix nemaeus*		x							EN
Phayre's leaf monkey	*Trachypithecus phayrei*	x	x	x				✓		EN
Asian small-clawed otter	*Aonyx cinerea*			x						VU/R

Family/Common Name	Scientific Name	2012 EIS		TISTR Survey				Primate survey		IUCN Status/ No. 060/ MAF Status
		Inside Project area	Outside Project area	Upper Nam Ngiep	Lower Nam Ngiep	Huay Ngua	Resettlement Site	Inside Project Area	Outside Project Area	
Binturong	*Arctictis binturong*	x	x	x						VU
Gaur	*Bos gaurus*	x	x			x				VU
Sun bear	*Helarctos malayanus*		x	x		x				VU/R
Smooth-coated otter	*Lutrogale perspicillata*			x						VU/R
Stump-tailed macaque	*Macaca arctoides*	x	x	x						VU
Northern pig-tailed macaque	*Macaca leonina*			x						VU
Clouded leopard	*Neofelis nebulosa*					x				VU
Bengal slow loris	*Nycticebus bengalensis*	x	x	x						VU/R
Pygmy slow loris	*Nycticebus pygmaeus*	x	x	x						VU/R
Sambar deer	*Rusa unicolor*	✓	x	x		x				VU/R
Himalayan black bear	*Ursus thibetanus*	✓	x	x		x				VU/R
Large spotted civet	*Viverra megaspila*					x				VU
BIRDS										
White backed vulture*	*Gyps bengalensis*		x							CR
White winged duck	*Cairina scutulata*		x			x				EN
Green peafowl	*Pavo muticus*					x				EN
Rufous-necked hornbill	*Aceros nipalensis*		x							VU
Imperial eagle	*Aquila heliaca*	✓	x			x				VU
REPTILES										
Elongated tortoise	*Indotestudo elongata*									EN
Big-headed turtle	*Platysternon megacephalum*			x		x				EN/R
Southeast Asian softshell turtle	*Amyda cartilaginea*			x	x		x			VU
Southeast Asian box turtle	*Cuora amboinensis*									VU
Snail-eating turtle	*Malayemys subtrijuga*			x			x			VU
Impressed tortoise	*Manouria impressa*					x				VU
Indo-Chinese spitting cobra	*Naja siamensis*			x	x		x			VU

Family/Common Name	Scientific Name	2012 EIS		TISTR Survey				Primate survey		IUCN Status/ No. 060/ MAF Status
		Inside Project area	Outside Project area	Upper Nam Ngiep	Lower Nam Ngiep	Huay Ngua	Resettlement Site	Inside Project Area	Outside Project Area	
King cobra	*Ophiophagus hannah*	x	x	x	x					VU/R
Siamese temple turtle	*Siebenrockiella crassicollis*			x						VU

IUCN Status: CR – Critically Endangered; EN – Endangered; VU – Vulnerable;
No. 060/MAF Status: R - Restricted
✓ = Direct record; x = Indirect record; blue x = noted within Huay Ngua PPA Area MP;
* = species may be considered congregatory

3.4 AQUATIC BIODIVERSITY VALUES

3.4.1 Hydrological Features

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

The flow regime of an aquatic ecosystem plays a role in the health and productivity of the system and for some species, flows can trigger movement during some periods. The Nam Ngiep River has a catchment area of 3700 km^2 with the river approximately 160 km in length (Kansai, 2012). Flows of the river are influenced by the monsoon dominated weather which divides the year into clearly defined wet and dry periods. Peak discharges (200-325 m^3/s) occur between June and September with lowest discharge volumes (50-75 m^3/s) in February to April.

Upstream of the main dam site is mountainous terrain with intermittent narrow plains which are inhabited. High mountains are found on both sides of the Nam Ngiep River and tributaries, providing continuous supply of large amounts of water throughout the year.

Between the main dam and the re-regulation dam, the terrain on both sides of the river widens and consequently forms flatter plains. Downstream of the re-regulation dam, the terrain is predominately flat and slopes gradually towards the Mekong River. In this area, the Nam Ngiep River runs parallel to the Nam Xan before it merges with the Mekong River at Pakxan.

3.4.2 Aquatic Habitats

Aquatic riverine and tributary habitats were assessed during TISTR 2012 site surveys. Seasonal variation was observed in terms of water depth, clarity, flow and wetted width. Habitat characteristics recorded are summarised in *Table 3.13*.

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

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

Aquatic plants were not recorded at all sites and when recorded were noted to be sparse.

Table 3.13 TISTR Aquatic Ecology Sampling Area Habitat Characteristics

Sampling Area	Aquatic habitat features
Main Dam Site (Upper Nam Ngiep) Dry Season  Wet Season 	• main river and tributary habitats • in tributary areas, the watercourse is dried to small pools in the dry season • the main river current flows rapidly in the wet and dry season • river depth in dry season 1-3m (shallower in riffle zone where water flows fastest), wet season 3-5m • river bed is sand and gravel with some boulders • aquatic plants present sparsely • water level is high during the wet season flooding all banks and vegetation • riparian zone is mainly original forest with agriculture close to communities • water is clear with greenish brown colour in the dry season, turbid and reddish brown in the wet season • surrounding landuse is agriculture and communities • villagers use waterbody for fishing, cattle swim
Lower Nam Ngiep Dry Season  Wet Season 	• main river habitat • river depth in dry season 2-3 m (shallower in riffle zone where water flows fastest), wet season 4-5m depth • width of the river is approximately 50-100 m in dry season, 100-150 during wet season • river bed is sand and small gravel • aquatic plants present sparsely on the river bank in the dry season • water is turbid and reddish brown in wet season • riparian zone is mainly covered by big trees and bamboos • upper zone has communities where people and cattle share the river in terms of swimming and washing. People always fishing

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

3.4.3 Aquatic Biota

Fish

Three separate fish surveys have been undertaken (ERIC 2007, TISTR 2013, Kottelat 2014), a targeted habitat survey and a number of village interviews have been undertaken to inform the understanding of the fish biota within the Nam Ngiep River and its tributaries.

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

The EIA noted that the fish community detected by ERIC in 2007 contains species common to the Mekong tributaries and was dominated by Cyprinid species. Cyprinid family species are reported to adapt to different environmental conditions in various sections of the river, and this family was also the dominant group detected during the 2013 TISTR survey. Species detected in 2007 in juvenile phase included Mackerel barb (*Opsarius pulchellus*), Swamp barb (*Puntius brevis*), *Rasbora borapetersis*, Slender rasbora (*Rasbora danioconius*), Salmon carp (*Raimas guttatus*) and *Poropuntius spp*. A full species list is provided in *Annex H.*

Targeted fast water survey in the Nam Ngiep detected 56 species (53 within the main dam inundation area and 34 outside the main dam inundation area). Among the 53 species of the main dam inundation area, two species are new to science and an additional four species are potentially new to science (confirmation required) (Kottelat 2014). The new species must be considered as endemic to the Nam Ngiep in the absence of any other data. Although endemic, each of the species was also detect outside the main dam inundation area.

The species detected considered to be endemic to Nam Ngiep include:

- *Schistura sp*. n. 'Nam Youak';
- *Schistura sp*. n. 'slender';
- *Danio sp*. n.;
- *Poropuntius sp*. n.;
- *Oreoglanis delacouri*; and
- *Schistura crabro*.

Additional details relating to the endemic species identified is provided in Annex *E* and *I*.

IUCN Listed Species

Aquatic surveys across the Project area detected ten species listed as critically endangered, endangered or vulnerable on the IUCN Red List (summarised in

Table 3.14). Species listed as critically endangered or endangered are considered candidates for critical habitat and these species records have been queried further in *Section 3.5*. Species listed a Restricted under the Regulation of the Ministry of Agriculture and Forestry No. 0360/MAF or endemic are also considered candidates for critical habitat and as such *Wallago leeri* has also been included as a candidate species.

Table 3.14 IUCN Listed Fish Species reported within the Project area

Family/Common Name	Scientific Name	TISTR Survey				Fast water survey	IUCN Status
		Upper Nam Ngiep	Lower Nam Ngiep	Huay Ngua	Resettlement Site		
Giant barb	*Catlocarpio siamensis*			x			CR
Leaping barb	*Laubuca caeruleostigmata*	13					EN
	Luciocyprinus striolatus					x	EN
Striped catfish	*Pangasianodon hypothalamus*			x			EN
Thicklipped barb	*Probarbus labeamajor*			x			EN
Mrigal carp	*Cirrhinus cirrhosus*		2				VU
	Hemimyzon confluens					I, O	VU
	Labeo pierrei					x	VU
	Rhinogobius albimaculatus					O	VU
Bandan sharp-mouth barb	*Scaphognathops bandanensis*			3			VU
Jaguar loach	*Yasuhikotakia splendida*		1	4			VU

Fast water survey: I = detected within the inundation area; O = detected outside the inundation area
IUCN Status: CR – Critically Endangered; EN – Endangered; VU – Vulnerable;
counts = Direct record; x = Indirect record; blue x = noted within Huay Ngua PPA Area MP

Migratory Species

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

- Annual movement between inundated floodplains (where most fish production originates) and dry season refuges;
- Movement into spawning areas within the river system (usually upstream) from dry season refuges, generally upon start of flooding; and
- Passive migration of fish fry downstream from spawning areas.

The ERIC 2007 assessment noted that of the larger fish species detected, many are migratory species of the lower Mekong basin that move upstream during the wet season spawning activities (EIA citing Poulsen *et al.*, 2004). These larger species, such as mud carp (*Cirrhinus molitorella*) and Asian red tailed catfish *(Hemibagrus wyckioides*) were detected in 2007 (ERIC) and 2013 (TISTR) surveys. The surveys noted a number of juvenile individuals of the migratory species suggesting that the Nam Ngiep River plays a role in providing habitat for the reproductive cycle (EIA citing Lowe-McConnell, 1995).

During the targeted fast water survey, two of the species recorded are known to be long distance migrators (i.e. into other tributaries of the Mekong River). This included *Labeo pierrei* and the mud carp.

Table 3.15 Migratory Fish Species that may occur within the Project area

Family/Common Name	Scientific Name	TISTR Survey				Fast water survey
		Upper Nam Ngiep	Lower Nam Ngiep	Huay Ngua	Resettlement Site	
Horseface loach	*Acantopsis choirorhynchos*	1	7	38		
Java barb	*Barbonymus gonionotus*	20	6	2		
Mud carp	*Cirrhinus molitorella*	8				x
Asian red tailed catfish	*Hemibagrus wyckioides*	2				
	Henicorhynchus lineatus	4	1			
	Henicorhynchus ornatipinnis	13				
	Hypsibarbus venayi	2	1			
	Labeo pierrei					x
Shark minnow	*Luciosoma bleekeri*	15	20			
	Mystacoleucus atridorsalis	5	10	2		
Marbled goby	*Oxyeleotris marmorata*		5			
	Scaphognathops bandanensis			3		
Sikuk barb	*Sikukia gudgeri*	6	10	32	1	

Fast water survey: I = detected within the inundation area; O = detected outside the inundation area
counts = Direct record; x = Indirect record; blue x = noted within Huay Ngua PPA Area MP

3.5 ADB SPS HABITAT CATEGORIES

Modified Habitat

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

Land cover mapping for the Project area identified a number of vegetated cover classes. The grassland, old fallow land, young fallow land, rice paddy, slash and burn land, and urban classes are considered to be modified habitats. *Figure 3.1* shows the distribution of these modified landuses within the Project area.

Natural Habitat

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

Land cover mapping for the Project area identified a number of vegetation cover classes. The bamboo, deciduous forest and evergreen forest areas are considered to be natural habitats for the purposes of this assessment. *Figure 3.1* shows the distribution of these natural habitat landuses within the Project area. Bamboo is a native species in Lao however it is noted that it can be invasive and used for commercial purposes. For the purposes of this assessment, the precautionary approach has been applied and bamboo areas have been considered as natural habitat.

Critical Habitat

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

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

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

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

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

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

- Criterion 4: Highly threatened and/or unique ecosystems;

- Criterion 5: Key evolutionary processes.

Assessment of the Project area has not identified any highly threatened and/or unique ecosystems, or key evolutionary processes. As such the assessment focusses on the relevance of Criterion 1-3. Each of the candidate species has been assessed for the critical habitat determination criteria 1-3 using the literature and field survey data collected in the Project area as well as expert advice.

Table 3.16 provides the threshold criteria used to guide the determination (IFC 2012).

Table 3.16 Quantitative thresholds for critical habitat criteria 1-3

Criterion	Tier 1	Tier 2
1. Critically endangered (CR) / Endangered (EN) species	a) Habitat required to sustain ≥10 percent of the global population of a CR or EN the species/subspecies where there are known, regular occurrences of the species and where the habitat could be considered a discrete management unit for that species b) Habitat with known, regular occurrences of CR or EN species where that habitat is one or 10 or fewer discrete management sites globally for that species	c) Habitat that supports the regular occurrence of a single individual of a CR species and/or habitat containing regionally- important concentrations of a Re-listed EN species where that habitat could be considered a discrete management unit for that species/subspecies d) Habitat of significant importance to CR or EN species that are wide-ranging and/or whose population distribution is not well understood and where the loss of such a habitat could potentially impact the long-term survivability of the species e) As appropriate, habitat containing nationally/regionally important concentrations of an EM, CR or equivalent national/regional listing.

Criterion	Tier 1	Tier 2
2. Endemic / Restricted range species	a) Habitat known to sustain ≥95 percent of the global population of an endemic or restricted-range species where that habitat could be considered a discrete management unit for that species (e.g. a single-site endemic)	b) Habitat known to sustain ≥1 percent but ≤95 percent of the global population of an endemic or restricted-range species where that habitat could be considered a discrete management unit for that species, where data are available and/or based on expert judgement.
3. Migratory / Congregatory species	a) Habitat known to sustain, on a cyclical or otherwise regular basis, ≥95 percent of the global population of a migratory or congregatory species at any point of the species' lifecycle where that habitat could be considered a discrete management unit for the species	b) Habitat known to sustain, o a cyclical or otherwise regular basis, ≥1 percent but ≤95 percent of the global population of a migratory or congregatory species at any point of the species' lifecycle and where that habitat could be considered a discrete management unit for that species, where adequate data are available and/or based on expert judgment c) For birds, habitat that meets BirdLife International's Criterion A4 for congregations and/or Ramsar Criteria 5 or 6 for Identifying Wetlands of International Importance d) For species with large but clumped distributions, a provisional threshold is set at ≥5 percent of the global population for both terrestrial and marine species e) Source sites that contribute ≥1 percent of the global population of recruits.

The species information was collated and analysed against the relevant critical habitat criteria (individual species detail provided in *Annex I*). A summary of the analysis is provided below. The summary includes an identification of the landcover types likely to be suitable habitat for the species, estimate of the extent of habitat within the direct impact area of the Project, and summary of the assessment.

The species screened against the determination criteria and quantitative thresholds include IUCN listed species, species considered endemic or listed as Restricted in the Regulation of the Ministry of agriculture and Forestry No. 0360/MAF and species considered to be migratory.

Throughout the assessment it was identified that a number of species, although candidates according to the above criteria, are not native species to Lao PDR. Although the conservation status of these species is recognised globally, they are not necessarily considered priorities for conservation efforts outside their native distribution.

Table 3.17 Candidate Species Critical Habitat Assessment Summary

Species	Habitat Type Codes	Criteria	Record		Record Location	Habitat within project area (ha)	Key Threats	Likely Critical Habitat in Project area	Assessment Outcome
			Direct	In-direct					
Flora									
Afzelia xylocarpa	EF, DF	1	✓		Upper and lower Nam Ngiep, main dam inundation, re-regulation dam inundation, resettlement area, Huay Ngua PPA	3410	Harvest for timber, medicinal, pulp	No	Specialists advice from Dr Pheng Phengsintham indicates that the species distribution in Lao PDR includes Vientiane capital, Phouhin Namno National Biodiversity Conservation Area (pers. comm. 7/12/2013). Given the distribution of known records it is considered unlikely that the Project area sustains >10 per cent of the global population (Tier 1), or, habitat of significant important or containing nationally important concentrations (Tier 2).
Anisoptera costata	EF, DF	1	✓		Huay Ngua PPA, lower Nam Xan, access road	3410	Economic value, use in construction	NA	Not native to Lao PDR.
Dalbergia oliveri	EF, DF	1	✓		Upper Nam Ngiep, main dam inundation, re-regulation dam inundation, resettlement area, Huay Ngua PPA, upper Nam Xan	3410		NA	Not native to Lao PDR.
Dipterocarpus alatus	EF, DF	1	✓		Upper and lower Nam Ngiep, Huay Ngua PPA, lower Nam Xan, access road	3410	Habitat loss, harvest fur timber and resin use and medicinal	NA	Not native to Lao PDR.

Species	Habitat Type Codes	Criteria	Record		Record Location	Habitat within project area (ha)	Key Threats	Likely Critical Habitat in Project area	Assessment Outcome
			Direct	In-direct					
Dipterocarpus turbinatus	EF, DF	1	✓		Upper Nam Ngiep, main dam inundation, re-regulation dam inundation, Huay Ngua PPA, lower Nam Xan	3410	Harvest for resin	No	This species has been noted within a number of the Project area survey locations and affords a distribution across a number of countries outside Lao PDR. Given the distribution of known records it is considered unlikely that the Project area sustains >10 per cent of the global population (Tier 1), or, habitat of significant important or containing nationally important concentrations (Tier 2).
Hopea ferrea	DF	1	✓		Upper Nam Ngiep	2896	Commercial timber trading	NA	Not native to Lao PDR.
Shorea roxburghii White meranti	EF, DF, B	1	✓		Upper and lower Nam Ngiep, resettlement area, Huay Ngua PPA, upper and lower Nam Xan	3912		No	This species has been noted within a number of the Project area survey locations and affords a distribution across a number of countries outside Lao PDR. Given the distribution of known records it is considered unlikely that the Project area sustains >10 per cent of the global population (Tier 1), or, habitat of significant important or containing nationally important concentrations (Tier 2).
Vatica cinerea	B, R, G, SB	1	✓		Access road	985		NA	Not native to Lao PDR.
Mammals									
Aonyx cinerea Asian small-clawed otter	W	1		✓	Upper Nam Ngiep	410	Hunting, habitat degradation	Unlikely	There is no situational reason to expect an anomalously high survival of the species in the Project area and the record is a weak indication of the species, though it cannot be excluded and as such threats to the species should be managed throughout the Project construction and operation and within any Biodiversity Offset Design. Current information does not confirm critical habitat (Tier 1 or 2).

Species	Habitat Type Codes	Criteria	Record		Record Location	Habitat within project area (ha)	Key Threats	Likely Critical Habitat in Project area	Assessment Outcome
			Direct	In-direct					
Canis aureus Golden jackal	DF	1		✓	Upper Nam Ngiep	2896	Hunting	No	The species has a large global range; Lao PDR is on the edge of this. Numbers in the Project area are likely insignificant given the much larger, and growing populations in Thailand and probably Cambodia. As such the Project area is considered unlikely sustain >10% (Tier 1) of the population or of significant important to the species (Tier 2).
Capricornis milneedwardsii Southwest China serow	EF, DF, B, R	1		✓	Upper Nam Ngiep	3913	Hunting, degradation of habitat (clearing for timber and firewood)	No	Serows plausibly remain widespread and locally common in the Project area, but this is equally true of much of hilly north and central Lao PDR. The Project area is only a small proportion of the nation's total such habitat and as such would not be expected to constitute one of 10 discrete management units (Tier 1) or an area of significant importance (Tier 2).
Cuon alpinus Dhole	EF, DF	1		✓	Upper Nam Ngiep	3410	Hunting	No	Dholes plausibly remain widespread and perhaps even locally common in the Project area; but this is equally true of much of hilly north and central Lao PDR. The Project area is only a small proportion of the nation's total such habitat and as such would not be expected to constitute one of 10 discrete management units (Tier 1) or an area of significant importance (Tier 2).
Elephus maximus Asian elephant	EF, DF, G, SB, OFL, YFL, B	1		✓	Upper Nam Ngiep, Huay Ngua PPA, Nam Xan	7333	Hunting	No	The location of the indirect records is mainly to the east of the Project area and to the north, outside the Project area. Similarly there are a number of locations noted for the species other countries. As such, the Project area is not considered likely to be part of one of 10 discrete management units (Tier 1) or an area of significant importance (Tier 2).

Species	Habitat Type Codes	Criteria	Record		Record Location	Habitat within project area (ha)	Key Threats	Likely Critical Habitat in Project area	Assessment Outcome
			Direct	In-direct					
Helarctos malayanus Sun bear	EF, DF	1		✓	Upper Nam Ngiep, Huay Ngua PPA, Nam Xan	3410	Hunting	No	Sun bears plausibly occur in the Project area; but this is equally true of much of Lao PDR. The Project area is only a small proportion of the nation's total such habitat and as such would not be expected to constitute one of 10 discrete management units (Tier 1) or an area of significant importance (Tier 2).
Lutrogale perspicillata Smooth-coated otter	W	1		✓	Upper Nam Ngiep	410	Hunting	No	Current information does not confirm critical habitat (Tier 1 or 2), though the precautionary approach should be considered and the threats to the species should be managed throughout the Project construction and operation and within any Biodiversity Offset Design.
Manis javanica Sunda pangolin	EF, DF,OF L, YFL, U	1		✓	Upper and lower Nam Ngiep, Huay Ngua PPA, Nam Xan	6390	Hunting	No	There is some uncertainty associated with the indirect data sources for the species as there can be confusion between *Manis javanica* and other pangolin species. Current information does not confirm critical habitat (Tier 1 or 2), though given the uncertainty the precautionary approach should be considered and the threats to the species should be managed throughout the Project construction and operation and within any Biodiversity Offset Design.
Nomascus leucogenys Northern white-cheeked gibbon	EF	1	✓		Upper Nam Ngiep	514	Hunting	No	Key habitat areas for the species are reported by Dr Phaivanh Phiapalath at Phou Thin, Phouru Pha Noy, Phou Pha Hua and Phou Sam Liem. These locations are outside the Project area though must be considered for potential indirect impacts. The Project area is not identified as one of 10 discrete management units (Tier 1) or an area of significant importance (Tier 2) however threat management should be considered to manage potential indirect impacts.

Species	Habitat Type Codes	Criteria	Record		Record Location	Habitat within project area (ha)	Key Threats	Likely Critical Habitat in Project area	Assessment Outcome
			Direct	In-direct					
Nycticebus bengalensis Bengal slow loris	EF, DF	1		✓	Upper Nam Ngiep	3410	Hunting, habitat loss	No	This loris plausibly remains widespread and common in the Project area, but this is equally true of much of Lao PDR. The Project area is only a small proportion of the nation's total such habitat and as such would not be expected to constitute one of 10 discrete management units (Tier 1) or an area of significant importance (Tier 2).
Nyctocebus pygmeaeus Pygmy slow loris	EF, B, OFL, YFL	1		✓	Upper Nam Ngiep	3955	Exploitation, habitat loss	No	This loris plausibly remains widespread and common in the Project area, but this is equally true of much of Lao PDR. The Project area is only a small proportion of the nation's total such habitat and as such would not be expected to constitute one of 10 discrete management units (Tier 1) or an area of significant importance (Tier 2).
Panthera pardus Leopard	EF, DF, G	1		✓	Upper Nam Ngiep, Huay Ngua PPA	3518	Hunting	No	Given the large range of the species, uncertainty of records and secondary information from local village representatives it is unlikely that the Project area and immediate surrounds supports greater than 10 per cent of the global population (Tier 1) or habitat of significant importance (Tier 2). The key threat to the species is hunting and although current information does not confirm critical habitat and there is uncertainty of the relevance of the village interview data, the precautionary approach should be considered and the threats to the species should be managed throughout the Project construction and operation and within any Biodiversity Offset Design.

Species	Habitat Type Codes	Criteria	Record		Record Location	Habitat within project area (ha)	Key Threats	Likely Critical Habitat in Project area	Assessment Outcome
			Direct	In-direct					
Panthera tigris Tiger		1		✓	Upper Nam Ngiep		Trade, habitat loss	No	Given the large range of the species, uncertainty of records and secondary information from local village representatives it is unlikely that the Project area and immediate surrounds supports greater than 10 per cent of the global population (Tier 1) or habitat of significant importance (Tier 2). The key threat to the species is hunting and although current information does not confirm critical habitat and there is uncertainty of the relevance of the village interview data, the precautionary approach should be considered and the threats to the species should be managed throughout the Project construction and operation and within any Biodiversity Offset Design.
Pardofelis temminckii Asiatic golden cat	EF, DF	1		✓	Upper and lower Nam Ngiep, Huay Ngua PPA	3410	Hunting	No	This species plausibly persists, perhaps widely, in the Project area, but this is equally true of much of Lao PDR. The Project area is only a small proportion of the nation's total such habitat and as such would not be expected to constitute one of 10 discrete management units (Tier 1) or an area of significant importance (Tier 2).
Prionailurus bengalensis Leopard cat	EF, DF	1		✓	Upper Nam Ngiep	3410	Hunting	No	Leopard cat plausibly remains widespread and perhaps locally common in the Project area; but this is equally true of much of Lao PDR. The Project area is only a small proportion of the nation's total such habitat and as such would not be expected to constitute one of 10 discrete management units (Tier 1) or an area of significant importance (Tier 2).

Species	Habitat Type Codes	Criteria	Record		Record Location	Habitat within project area (ha)	Key Threats	Likely Critical Habitat in Project area	Assessment Outcome
			Direct	In-direct					
Prionailurus viverrinus Fishing cat	W	1		✓	Huay Ngua PPA, Nam Xan, Upper Nam Ngiep	410	Wetland destruction and degradation	No	There is no reason to think that Fishing cat inhabits the Project area, but equally it cannot be excluded that it does so. However, the Project area's habitat is not distinct in any way from typical Lao hill-country. The Project area is only a small proportion of the nation's total such habitat and as such would not be expected to constitute one of 10 discrete management units (Tier 1) or an area of significant importance (Tier 2).
Pygathrix nemaeus Red shanked douc langur	EF	1		✓	Upper Nam Ngiep	514	Hunting	No	The Project area is outside the range of the species and targeted primate survey in 2013 did not detect the species.
Rusa unicolor Sambar		1		✓	Upper Nam Ngiep, Huay Ngua PPA			No	If the reports that Sambar is locally common in the Project area are accurate, the area may be important habitat on a national scale. There are large remaining populations in some other countries and as such the Project area is not considered to sustain >10% of the global population (Tier 1) or of significant importance (Tier 2).
Trachypithecus phayrei Phayre's leaf monkey	EF, DF, B, SB	1		✓	Main dam inundation, upper and lower Nam ngiep	4286	Hunting	No	At the national level it is implausible that the Project area supports close to 10 per cent of the population, given that it comprises far less than 10% of the species' presumed present area of occupancy in today's Lao PDR.
Ursus thibetanus Himalayan black bear	EF, DF, B, SB	1		✓	Upper Nam Ngiep, Huay Ngua PPA	4286	Hunting	No	The Project area's habitat is not distinct in any way from typical Lao hill-country. The Project area is only a small proportion of the nation's total such habitat and as such would not be expected to constitute one of 10 discrete management units (Tier 1) or an area of significant importance (Tier 2).

Species	Habitat Type Codes	Criteria	Record		Record Location	Habitat within project area (ha)	Key Threats	Likely Critical Habitat in Project area	Assessment Outcome
			Direct	In-direct					
Birds									
Aceros undulates Wreathed hornbill	EF, DF	1		r	-	3410	Hunting	No	Wreathed hornbill plausibly still occurs in the Project area but probably only in low numbers. Its status is similar across large parts of Lao PDR. The Project area is only a small proportion of the nation's total such habitat and as such would not be expected to constitute one of 10 discrete management units (Tier 1) or an area of significant importance (Tier 2).
Buceros bircornis Great hornbill	EF, DF	1		✓	Huay Ngua PPA, Nam Xan	3410	Hunting	No	Great hornbill plausibly still occurs in the Project area but probably only in low numbers. Its status is similar across large parts of Lao PDR. The Project area is only a small proportion of the nation's total such habitat and as such would not be expected to constitute one of 10 discrete management units (Tier 1) or an area of significant importance (Tier 2).
Cairina scutulata White winged duck	W	1		✓	Upper Nam Ngiep, Huay Ngua PPA	410	Hunting, habitat degradation	No	White winged duck might possibly still occur in the Project area but at best only in very low numbers. Despite major loss of habitat in the last half century, tracts similar in extent and condition to the Project area remain in many parts of Lao PDR. The Project area is only a small proportion of the nation's total such habitat and as such would not be expected to constitute one of 10 discrete management units (Tier 1) or an area of significant importance (Tier 2).
Centropus sinensis Greater coucal	EF, DF, SB, G, U	1	✓	✓	Upper and lower Nam Ngiep, resettlement site, Huay Ngua PPA, upper and lower Nam Xan	3933	Hunting	No	Greater coucal is probably abundant over the deforested and degraded parts of the Project area. This is so across Lao PDR so the Project area is only a small proportion of the nation's total such habitat and as such would not be expected to constitute one of 10 discrete management units (Tier 1) or an area of significant importance (Tier 2).

Species	Habitat Type Codes	Criteria	Record		Record Location	Habitat within project area (ha)	Key Threats	Likely Critical Habitat in Project area	Assessment Outcome
			Direct	In-direct					
Gyps bengalensis White backed vulture	SB, U, G	1		✓	Upper Nam Ngiep	523	Hunting, veterinary drugs	NA	Given the ease of finding this species when present and the high levels of survey in the general region of Lao PDR within which lies the Project area, there is no chance that the interview reports collected in fact refer to a resident population of this or any other vulture.
Lophura diardi Siamese fireback	EF, B, SB	1		✓	Huay Ngua PPA, Nam Xan	1390	Habitat conversion	No	Siamese fireback is very likely to occur, perhaps widely, in the Project area. Nonetheless, the Project area constitutes an insignificant proportion of suitable habitat across Lao PDR, so does not constitute critical habitat.
Lophura nycthemera Silver pheasant	EF	1		✓	Huay Ngua PPA, Nam Xan	514	Habitat conversion	No	Silver Pheasant is very likely to occur, perhaps widely and commonly, in the Project area. Nonetheless, the Project area constitutes an insignificant proportion of suitable habitat across Lao PDR, so does not constitute critical habitat.
Pavo muticus Green peafowl	EF, DF, B, G, SB	1		✓	Huay Ngua PPA	4394	Hunting	No	Assuming that the interview reports are in error, there is no reason to consider that the Project area constitutes critical habitat. However, the rather anomalous survival of the small population around Ban Nakhaty, Phou Khao Khoay NPA, emphasises the possibility that other remnants may also survive, and it cannot be excluded that the Project area might support one. Such a population could be significant at the national level rather than a global level.
Polyplectron bicalcaratum Grey peacock pheasant	EF	1		✓	Huay Ngua PPA, Nam Xan	514	Habitat conversion	No	Grey Peacock Pheasant is very likely to occur, perhaps widely and commonly, in the Project area. Nonetheless, the Project area constitutes an insignificant proportion of suitable habitat across Lao PDR, so does not constitute critical habitat.

Species	Habitat Type Codes	Criteria	Record		Record Location	Habitat within project area (ha)	Key Threats	Likely Critical Habitat in Project area	Assessment Outcome
			Direct	In-direct					
Psittacula alexandri Red-breasted parakeet	DF	1		✓	Huay Ngua PPA	2896	Trade	No	Accepting the likelihood of this species' occurrence in the Project area, it is however unlikely, that in the context of the much larger numbers remaining in parts of Central and South Lao PDR, that the Project area could comprise critical habitat.
Ichthyophaga humilis Lesser fish eagle	W	1		r	-	410	Habitat loss, persecution	No	With no information on the status in the Project area no firm decision can be made. Numbers, if any, in the Project area are probably too few for the area to constitute critical habitat; but if there are surprisingly large numbers there, then it possible would be critical habitat.
Reptiles									
Broghammerus reticulatus Reticulated python	EF, DF, SB, U	1		✓	Upper and lower Nam Ngiep, Huay Ngua PPA, resettlement site, upper and lower Nam Xan	3825	Exploitation	No	Given that the Lao PDR population is not considered to be of global significance and that is it widespread it is unlikely that the Project area sustains greater than 10 per cent of the global population or is one of 10 discrete management sites globally for the species (Tier 1). The baseline information does not provide an indication that the habitat is of significant importance, or that records are part of an important concentration (Tier 2).
Indotestudo elongate Elongated tortoise	EF, DF	1		r	-	3410	Trade	No	Given that the Lao PDR population is not considered to be of global significance and that is it widespread it is unlikely that the Project area sustains greater than 10 per cent of the global population or is one of 10 discrete management sites globally for the species (Tier 1). The baseline information does not provide an indication that the habitat is of significant importance, or that records are part of an important concentration (Tier 2).

Species	Habitat Type Codes	Criteria	Record		Record Location	Habitat within project area (ha)	Key Threats	Likely Critical Habitat in Project area	Assessment Outcome
			Direct	In-direct					
Ophiophagus hannah King cobra	EF, DF, B			r		3912	Trade	No	Given that the Lao PDR population is not considered to be of global significance and that its habitat is widespread it is unlikely that the Project area sustains greater than 10 per cent of the global population or is one of 10 discrete management sites globally for the species (Tier 1). The baseline information does not provide an indication that the habitat is of significant importance, or that records are part of an important concentration (Tier 2).
Platysternon megacephalum Big-headed turtle	W	1		✓	Upper Nam Ngiep, Huay Ngua PPA, upper Nam Xan	410	Hunting	No	The species inhabits narrow stream (<1m wide) which is likely to be restricted in headwaters of waterways. The key threat to the species will relate to an improvement of access to the area for illegal wildlife collection rather than an impact to habitat. Although current information does not confirm critical habitat, the Project may contribute to the species threats. As such the precautionary approach should be considered and the threats to the species should be managed throughout the Project construction and operation and within any Biodiversity Offset Design.

Species	Habitat Type Codes	Criteria	Record		Record Location	Habitat within project area (ha)	Key Threats	Likely Critical Habitat in Project area	Assessment Outcome
			Direct	In-direct					
Fish									
Catlocarpio siamensis Giant barb	W	1, 3		✓	Huay Ngua PPA	410	Over-harvest, habitat fragmentation	Unlikely	The species was not detected during seasonal or targeted fast water habitat surveys within the Project area. Potential habitat for the species is more likely to occur downstream of the reservoir, and as such the Project threat relates to the modification of the topography of its habitat and alteration of the flow pattern (especially disruption of daily and annual cycle) impacting spawning sites and the reproduction of the species. Environmental Flows Assessment identifies flow release regime to manage downstream flows for maintaining normal river functions to manage this threat to potential habitat.
Laubuca caeruleostigmata Flying minnow		1, 3	✓		Upper Nam Ngiep and lower Nam Xan	410		Unlikely	Species profile information identifies the importance of flood areas and large river environments. If the species is present downstream of the reservoir where this habitat occurs, the alteration of the flow pattern (especially disruption of daily and annual cycle) may have an indirect impact. Environmental Flows Assessment identifies flow release regime to manage downstream flows for maintaining normal river functions to manage this threat to potential habitat.

Species	Habitat Type Codes	Criteria	Record		Record Location	Habitat within project area (ha)	Key Threats	Likely Critical Habitat in Project area	Assessment Outcome
			Direct	In-direct					
Luciocyprinus striolatus	W	1		✓	Upper Nam Ngiep, main dam inundation, Nam Xan	410	Alteration of morphology, habitat degradation	No	Species population size is not well documented. The specialist studies undertaken identified a number of locations where the species is known by local villagers that have not been previously reported in literature. As this species is not considered a long distance migrator, the upper and middle Nam Ngiep may be considered a management unit. Village interview indicate that although rare there are regular occurrences of the species in the Nam Ngiep. Collation of information regarding the distribution of the species, and as such the location of populations, identified at least 14 river basins where there are known records of the species occurring. As such this population is not one of 10 or fewer discrete management sites globally for the species (Tier 1). Given challenges associated with existing threat conditions in the Nam Ngiep and the presence of other management units more likely to support the recovery of the species, the population is not considered to be a regionally-important concentration (Tier 2). Further detail on this species is provided in Annex I.
Pangasianodon hypophthalmus Striped catfish	W	1, 3		✓	Huay Ngua PPA	410	Exploitation, habitat degradation	Unlikely	Species profile information suggests that the species utilises main or larger river channels and floodplain areas and undertakes long distance migrations and as such more confirmation of presence of the species is required. If the species is present downstream of the reservoir where this habitat occurs, the alteration of the flow pattern (especially disruption of daily and annual cycle) may have an indirect impact. Environmental Flows Assessment identifies flow release regime to manage downstream flows for maintaining normal river functions to manage this threat to potential habitat and monitoring would be required.

Species	Habitat Type Codes	Criteria	Record		Record Location	Habitat within project area (ha)	Key Threats	Likely Critical Habitat in Project area	Assessment Outcome
			Direct	In-direct					
Probarbus labeamajor Thicklipped barb	W	1, 2, 3		✓	Huay Ngua PPA	410	Exploitation, habitat degradation	No	The species is not known to occur in the Project area part of the catchment. Species profile information suggests that the species utilises main or larger river channels. Should the record be correct, the habitat in the lower reaches of the Nam Ngiep River may be susceptible to indirect impacts from the propose dam, however the area is unlikely to represent >10% of the habitat within the Mekong. The Project area is not considered to be critical habitat for the species (Tier 1).
Wallago leeri	W	2		r	Huay Ngua PPA	410		NA	Species habitat is listed as rocky rapids in large streams and rivers. Fish have been previously been misidentified in the Mekong as *W. leeri* that are more likely *W. micropogon*. Targeted fast water habitat survey did not detect the species *W. micropogon*.
New to science species (*Schistura sp*. n. 'Nam Youak', *Schistura sp*. n. 'slender', *Danio sp*. n., *Poropuntius sp*. n.)	W	2	✓		Main dam inundation, upper Nam Ngiep and for some lower Nam Ngiep and Nam Xan	410		No	Four species mainly observed in small streams and headwaters. Four species mainly observed in larger stream habitat. None of the species is known only from the area to be inundated. The project area is not considered to be of significant importance (Tier 2) to the species given the availability of intact tributary habitat above the FSL.

Species	Habitat Type Codes	Criteria	Record		Record Location	Habitat within project area (ha)	Key Threats	Likely Critical Habitat in Project area	Assessment Outcome
			Direct	In-direct					
Migratory fish species	W	3	✓	✓			Restriction of movement and access to habitat	Unlikely	Potential habitat for Mekong migratory species may occur in reaches of the Nam Ngiep downstream of the dam infrastructure. The migratory species detected a generally species requiring large river or floodplains habitats. Due to the nature of the gorge where the dam is located the majority of this habitat is located downstream of the dam rather than within the inundation areas. Indirect impacts to downstream habitats relating to environmental flows will need to be considered during impact assessment.

The downstream aquatic biodiversity has been highlighted within the critical habitat assessment as an area where indirect impacts may be of significance. The impact to this area, downstream biodiversity and fish biomass will require consideration in the impact assessment.

No likely critical habitat was identified within the Project area.

3.6 ECOSYSTEM SERVICES

It is evident that villagers in the Project area regularly use local terrestrial and aquatic biodiversity – e.g. as a food source. However, the dependence on natural resources varies by village and is largely associated with accessibility. For example, remote villages tend to rely more heavily on medicinal plants as access to pharmaceuticals is limited.

The following section describes the uses and cultural values placed on (and/ or associated with) biodiversity by local villagers in the Project area. Much of the data is from village and market surveys undertaken by ERM in February and March 2013. *Annex J* contains the results of the socio-economic survey that have been used to inform the assessment of ecosystem services.

3.6.1 Hunting and Gathering

Villagers, both Loa and Hmong people, hunt and gather. This is done primarily for household consumption. However, when surplus exists, it is sold within the village or neighbouring villages.

Although the norm is to consume the materials locally, there are a small number of species that are collected for sale. Access to markets from villages is limited due poor road access, so external sales are to intermediaries who travel to the villages.

Hunting for small animals is common across all villages. Villagers rarely admitted to hunting larger animals as all were aware this is illegal. Bamboo traps are predominantly used for capturing squirrels and rats, though hunting dogs, firearms and knives are also reportedly used.

Hmong families tend to hunt together while lowland Lao hunt individually or in small groups of either men or women. Hunting activity is no longer a daily activity, and is only triggered when a change from chicken or fish is desired or a ceremony requires it (i.e. a wedding or Hmong New Year). Villagers will generally travel as far as the need to hunt and gather though based on survey data this is unlikely to be further than 3-5 kilometres from the village (i.e. walking distance).

Villagers have noted that availability of naturally occurring resources, especially forest animals and fish, has been declining in recent years.

3.6.2 Medicinal Plants and Materials

Usage, and therefore dependence, appears to be predicated on access to health services - the easier the access to pharmaceuticals, the lower the usage of natural medicines. In the Project area, villages have indicated a preference for pharmaceuticals but said natural medicines were generally used in the first instance.

3.6.3 Timber Products

Timber products are actively sourced from the forests by villagers and commercial operators. For instance the local villagers were observed sourcing and processing hardwood into planks near the proposed dam site.

3.6.4 Fishing

When compared to hunting, fishing occurs on a more regular basis. This is largely because of the close proximity of villages to waterways.

Fishing may have been more important for income generation in earlier times though with greater availability of alternative protein sources and reported reduction in stock availability and size, villages have adapted.

Fish is generally caught only for household consumption, but it is also a common item used in inter-household exchange and transactions. Surplus fish tends to be sold at below market rates suggesting such transactions may more likely be part of a local gift economy rather than a commercial transaction. This being said, it was common to hear that small fish are eaten at home while big fish, when found, are sold.

The most common fishing method is with a cast weighted net, an item commonly seen in most houses. Larger nets are used during the rainy season to catch larger fish that swim up river from the Mekong River. At Hatsaykham, the survey team observed other methods such as scaring fish into a net hung across a short section of the river and gathering by hand. Other equipment observed in villages included lines, hooks and spear guns. Fishing takes place at established riverside sites at which small shelters are built.

3.6.5 Cultural Services

Most of the villages surveyed in the Project area have been settled only relatively recently signalling a lesser dependence on cultural services provided within proximate ecosystems. While length of residence is not an exclusive factor in determining usage and dependence, the less time people have to form attachments to aspects of an ecosystem, the less significant these features are likely to be. Indeed the relatively new nature of the villages acts to sever any bonds that people may have with prehistoric features within the environment such as tangible objects (i.e. stone tools, brass or ceramic objects) and intangible knowledge (i.e. creation myths or site specific rituals). This is

not to say that the cultural values villagers derive from the ecosystem are insignificant, it is to signal that what values they do use are likely severable and reproducible elsewhere.

Numerous locally collected polished stone tools have been found in the Project area indicating human occupation in the area occurred between 4,000 and 12,000 years ago. However, most of the existing villages were settled in the early-1980s and 1990s.

The most significant social, religious and cultural sites people were able to identify (during the surveys) in villages in the Project area were grave sites. Reflecting the severable nature of connections people have with grave sites, villagers indicated that the ancestor spirits associated with such grave sites are transferrable to a new location through the performance of a complex ceremony conducted by the village shaman (called a Yao in the surveyed villages).

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

Naturally occurring bamboo is used by both Lao and Hmong to make an animist symbol that is hung above doorways to ward off evil spirits.

4 CANDIDATE BIODIVERSITY OFFSET SITES

4.1 OVERVIEW

This section discusses the biodiversity values of each of four candidate offset sites which have been proposed for this Project including parts of the Nam Ngiep catchment (Upper Nam Ngiep), stretches of the Nam Xan River between Nam Lao and Bolikhan, the Huay Ngua PPA and Phou Khao Kouay Protected Area (PKK) (*Figure 4.1*). The candidate offset sites have been described such that their ecological suitability to provide a biodiversity offset can be assessed. The suitability assessment is documented in the Biodiversity Offset Design Report for the Project.

250000
300000
350000
400000
2150000
2100000
2050000

Legend

- Catchment Boundary
- Waterbody
- Road
- City or Town
- Lao PDR Boundary

Nam Ngiep 1 Hydropower Project:

- Inundation Area
- Re-regulation Dam
- Re-settlement Area
- Proposed Access Road

Candidate Offset Sites:

- Nam Ngiep Offset Area
- Huay Ngua Provincial Protected Area
- Phou Khao Khouay National Protected Area
- Nam Xan Offset - River Centreline

N
0 10 20 30Km
1:600,000

Basemap: ESRI World Imagery
Datum: WGS84

Phoukout
Nonghet
Phonsavan
Muang Khoun
Phaxai
Nam Ngum
Nam Ngiep
Nam Ngiep Catchment
Thathom
Nam Xan Catchment
Vang Vieng
Nam Song Diversion
Nam Ngum 2 Reservoir
Nam Xan
Hinheup
Ba. Donkha
Nam Ngum Reservoir
Longxan
Thinkeo
Phonhong
Nam Leuk reservoir
Nam Mang 3 Reservoir
Pakxan
Ban Keun
Mekong River
Hai
Tha Ngon

Client:	Nam Ngiep Power Company Ltd.	
Drawing No:	0185065b_BIODIV_G007a_R0.mxd	
Date:	17/01/2014	Drawing Size: A3
Drawn By:	TC	Reviewed By: DN

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

Figure 4.1 - Map of Offset Sites

Nam Ngiep 1 Hydropower Project
Baseline Biodiversity Assessment Report

Environmental Resources Management ANZ

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

ERM

4.2 UPPER NAM NGIEP

4.2.1 Overview

The biodiversity values of the Upper Nam Ngiep investigation area are similar to those described in the Project area (*Section 3*). Sampling locations for the baseline field surveys in 2007 and 2013 were restricted to adjacent to the waterway and, as such, it is considered that many terrestrial species detected during these surveys may utilise the habitats outside the inundation area and in the wider Nam Ngiep catchment area. Many of the fauna species identified during survey are highly mobile and habitat preferences are not restricted to riparian areas. These species have potential to move to forested and other natural habitats locally.

4.2.2 Vegetation

Land Cover

Using land cover mapping (DFRM, 2010), natural and modified habitats, in accordance with ADB definition, can be identified within the Upper Nam Ngiep candidate offset site. The Upper Nam Ngiep is dominated by natural habitat (76 per cent) with almost half of the area deciduous forest land cover. There is limited urban area. *Table 4.1* summarises the land cover shown in *Figure 4.2* and identifies the habitat category of each land cover type.

Table 4.1 Land Cover within the Upper Nam Ngiep Candidate Offset Site

Land Cover	ADB Habitat Class	Total Area (ha)	% of Total
Deciduous Forest	Natural	59,078	46%
Evergreen Forest	Natural	37,666	30%
Bamboo	Natural	5,735	5%
Old Fallow Land	Modified	15,165	12%
Young Fallow Land	Modified	3,496	3%
Slash and Burn	Modified	1,500	1%
Rice Paddy	Modified	169	<1%
Water	-	122	<1%
Grassland	Modified	3,900	3%
Urban Area	Modified	7	<1%
Rock	Natural	161	<1%
Cloud	-	30	<1%
Shadow	-	149	<1%
	Total	**127,178**	

Forestry Classification Mapping

Forestry classification mapping identifies both protection forest and production forest in the Upper Nam Ngiep. *Figure 4.3* depicts the extent of protected and production forest and shows that greater than half of the offset site is mapped as National Protected Forest.

Vegetation Condition

The NDVI across the Upper Nam Ngiep is shown in *Figure 4.4* and the area of each classification is summarised in *Table 4.2*.

Over 96 per cent of the Project area is classified as moderate or high NDVI. Almost 65 per cent of the area is mapped as high NDVI. Less than 1 per cent of the area is classified as impacted NDVI.

Table 4.2 Vegetation Condition within the Upper Nam Ngiep Candidate Offset Site

Forest type	Impacted (- to 0)	Low (0 - 0.4)	Moderate (0.4 - 0.6)	High (0.6 - 0.8)
Deciduous Forest	16	1209	19,614	38,240
Evergreen Forest	11	1008	13,447	23,200
Old Fallow Land	2	370	3148	11,643
Young Fallow Land	2	265	1493	1735
Bamboo	5	181	1526	4021
Slash and Burn	4	556	551	389
Rice Paddy	2	106	53	9
Water	52	39	21	9
Grassland	6	412	1913	1569
Urban Area	0	6	1	0
Rock	0	65	87	9
Cloud	0	4	17	10
Shadow	4	57	72	16
Total (ha)	**104**	**4278**	**41943**	**80850**
% of Total	**<1%**	**3%**	**33%**	**64%**

Thathom

Legend

- Nam Ngiep Sub-catchment Boundary
- Watercourse
- City, Town or Village

Nam Ngiep 1 Hydropower Project:

- Inundation Area
- Re-regulation Dam
- Re-settlement Area
- Proposed Access Road

Land Cover:

- Evergreen Forest (Current Forest)
- Deciduous Forest (Current Forest)
- Bamboo (Potential Forest)
- Old Fallow Land (Potential Forest)
- Young Fallow Land (Potential Forest)
- Slash and Burn Land (Potential Forest)
- Rice Paddy
- Grassland
- Rock
- Urban Area
- Water
- Cloud
- Shadow

N

0 2.5 5 7.5Km

1:200,000

Basemap Bing Maps
Datum: WGS84

Client:	Nam Ngiep Power Company Ltd.	
Drawing No:	0185065b_BIODIV_G008_R0.mxd	
Date:	11/09/2013	Drawing Size: A3
Drawn By:	TC	Reviewed By: DN

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Figure 4.2 - Land Cover within the Upper Nam Ngiep Candidate Offset Site

Nam Ngiep 1 Hydropower Project
Baseline Biodiversity Assessment Report

Environmental Resources Management ANZ

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

ERM

310000 320000 330000 340000 350000

2120000 2110000 2100000 2090000 2080000 2070000 2060000 2050000

Nam Ngiep

Thathom

Nam Xan

Legend

- Nam Ngiep Catchment Boundary
- Road
- Watercourse
- City, Town or Village
- Proposed Access Road

Nam Ngiep 1 Hydropower Project:

- Inundation Area
- Re-regulation Dam
- Re-settlement Area

Forest Zone:

- National Protection Forest
- Production Forest

N

0 2.5 5 7.5Km

1:200,000

Basemap: Bing Maps

Client:	Nam Ngiep Power Company Ltd.		
Drawing No:	0185065b_BIODIV_G009_R0.mxd		
Date:	10/09/2013	Drawing Size: A3	
Drawn By:	TC	Reviewed By: DN	

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

Figure 4.3 - Forestry Classification Mapping within the Upper Nam Ngiep

Nam Ngiep 1 Hydropower Project
Baseline Biodiversity Assessment Report

Environmental Resources Management ANZ

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

ERM

310000 320000 330000 340000 350000

2120000 2110000 2100000 2090000 2080000 2070000 2060000 2050000

Nam Ngiep

Nam Xan

Thathom

Legend

- Nam Ngiep Catchment Boundary
- Waterbody
- Road
- City, Town or Village
- Lao PDR Boundary

Nam Ngiep 1 Hydropower Project:

- Inundation Area
- Re-regulation Dam
- Re-settlement Area
- Proposed Access Road

Condition Class:

- High
- Moderate
- Low
- Impacted

N

0 2.5 5 7.5Km

1:200,000

Basemap Bing Maps
Datum: WGS84

Client:	Nam Ngiep Power Company Ltd.		
Drawing No:	0185065b_BIODIV_G010_R0.mxd		
Date:	10/09/2013	Drawing Size: A3	
Drawn By:	TC	Reviewed By: DN	

Figure 4.4 - Vegetation Condition within the Upper Nam Ngiep Candidate Offset Site

Nam Ngiep 1 Hydropower Project
Baseline Biodiversity Assessment Report

Environmental Resources Management ANZ

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

ERM

4.2.3 *Flora Species*

As described, the Upper Nam Ngiep is the area adjacent to the main dam inundation and re-regulation dam inundation areas which have been surveyed (see Section *3.2.2*). The land cover mapping shows similar vegetation covers across the catchment area and, as such, it is likely that many flora species recorded during surveys (2013) within the Project area will also occur within the wider Upper Nam Ngiep area.

Deciduous forest types were recorded during Project area surveys and this vegetation is likely to be similar to the Upper Nam Ngiep. The deciduous forest types were present in terms of mixed deciduous forest and lower mixed deciduous forest at the main dam inundation and re-regulation dam inundation areas. The dominant species recorded within these forest types during the 2013 survey by TISTR within the Project area are summarised in *Table 4.3* and are considered likely to occur within the Upper Nam Ngiep.

Table 4.3 Dominant Flora Species in vegetation communities similar to the Upper Nam Ngiep Candidate Offset Site

Canopy class	Dominant species
Mixed Deciduous Forest	
Top canopy (20-35m)	*Pometia pinnata*, *Duabanga grandiflora*, *Lagerstroemia calyculata*, *Toona ciliata*, *Pterospermum diversifolium.*
Middle canopy (10-15m)	*Nephelium hypoleucum*, *Mitrephora tomentosa*, *Baccaurea ramiflora*, *Saracia indica*, *Arenga weaterhoutii*.
Lower canopy (<10m)	saplings and seedling of the higher canopies
Lower Mixed Deciduous Forest	
Top canopy (~10m)	*Macaanga denticulata*, *Maesa ramentacea*, *Milletia acutiflora*, *Lagerstoemia calyculata*. The common species of bamboo found in the area, which are *Gigantochloa albociliata*, *Pseudostachyum polymorphum*, *Bambusa bambos*.

IUCN Listed Species

A total of nine species of plants listed as critically endangered, endangered or vulnerable under the IUCN Red List were identified within the upper Nam Ngiep area during 2007 and/or 2013 surveys. These include one species listed as critically endangered, five as endangered and three as vulnerable (*Table 4.4*).

Table 4.4 IUCN Listed Flora Species recorded in the Upper Nam Ngiep Candidate Offset Site

Scientific Names	IUCN Status
Dipterocarpus turbinatus	CR
Afzelia xylocarpa	EN
Dalbergia oliveri	EN

Scientific Names	IUCN Status
Dipterocarpus alatus	EN
Hopea ferrea	EN
Shorea roxburghii	EN
Dalbergia cochinchinensis	VU
Hopea odorata	VU
Ternstroemia wallichiana	VU
IUCN Status: CR – Critically Endangered; EN – Endangered; VU – Vulnerable	

4.2.4 Fauna Species

As identified for the flora species, many of the fauna species detected during TISTR surveys of the main dam inundation area have potential to utilise the habitat of the Upper Nam Ngiep. The diversity of fauna is expected to be high given the large intact area of habitat and the results obtained from surveys of the Project area. The Upper Nam Ngiep River is dominated by primary forest. The fauna habitat in this area is in good condition in comparison to other areas surveyed. Site surveys during 2013 (TISTR) detected (through interviews with villagers or direct observation) at least 46 mammals species, 50 bird species, 28 reptiles species and 10 amphibian species.

IUCN Listed Species

The fauna species have been categorised by the IUCN (2012) and a number have been recorded within the Project area. The 2013 TISTR surveys recorded one species, the Northern white-cheeked gibbon (*Nomascus leucogenys*) listed as critically endangered within the Project area and as such it is considered possible these species may also inhabit the Upper Nam Ngiep.

Overall, the direct and indirect records identified:

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

Table 4.5 summarises the species recorded.

Table 4.5 ***IUCN Fauna Species reported within the Upper Nam Ngiep Candidate Offset Site***

Family/Common Name	Scientific Name	Direct Record	Indirect Record	IUCN Status
MAMMALS				
Northern white-cheeked gibbon	*Nomascus leucogenys*	✓		CR
Dhole	*Cuon alpinus*		✓	EN
Asian elephant	*Elephas maximus*		✓	EN
Sunda pangolin	*Manis javanica*		✓	EN
Tiger	*Panthera tigris*		✓	EN
Fishing cat	*Prionailurus viverrinus*		✓	EN
Red-shanked douc langur	*Pygathrix nemaeus*		✓	EN
Phayre's leaf monkey	*Trachypithecus phayrei*	✓		EN
Asian small-clawed otter	*Aonyx cinerea*		✓	VU
Binturong	*Arctictis binturong*		✓	VU
Gaur	*Bos gaurus*		✓	VU
Sun bear	*Helarctos malayanus*		✓	VU
Smooth-coated otter	*Lutrogale perspicillata*		✓	VU
Stump-tailed macaque	*Macaca arctoides*		✓	VU
Northern pig-tailed macaque	*Macaca leonina*		✓	VU
Bengal slow loris	*Nycticebus bengalensis*		✓	VU
Pygmy slow loris	*Nycticebus pygmaeus*		✓	VU
Sambar	*Rusa unicolor*		✓	VU
Himalayan black bear	*Ursus thibetanus*		✓	VU
BIRDS				
White backed vulture	*Gyps bengalensis*		✓	CR
White winged duck	*Cairina scutulata*		✓	EN
Rufous-necked hornbill	*Aceros nipalensis*		✓	VU
Imperial eagle	*Aquila heliaca*		✓	VU
REPTILES				
Big-headed turtle	*Platysternon megacephalum*		✓	EN
Southeast Asian softshell turtle	*Amyda cartilaginea*		✓	VU
Snail-eating turtle	*Malayemys subtrijuga*		✓	VU
Indo-Chinese spitting cobra	*Naja siamensis*		✓	VU
King cobra	*Ophiophagus hannah*		✓	VU
Siamese temple turtle	*Siebenrockiella crassicollis*		✓	VU
FISH				
Leaping barb	*Laubuca caeruleostigmata*	✓		EN
	Luciocyprinus striolatus		✓	EN

IUCN Status: CR – Critically Endangered; EN – Endangered; VU – Vulnerable.

4.3 NAM XAN

4.3.1 Overview

The Upper Nam Xan River, on the west bank of the river, is covered by primary forest, deciduous forest. On the east bank of the river is the production forest, where the larger trees have been previously harvested and there is evidence of re-succession recovery. There are stretches of the river that are currently mostly vegetated with a relatively low population density, poor vehicular access, and steep riparian terrain.

The Nam Xan candidate offset site has been the subject of consultation with Lao PDR representatives and following consultation the option of this area as use for offsetting has been discounted. The area is predominantly mapped as production forest which is an important resource for Lao PDR and unlikely to be suitable for conversion to reserve status.

Field surveys collected some species information summarised below however it is unlikely this site will be investigated further.

4.3.2 Flora

The Nam Xan River area consists of upper mixed deciduous forest, mixed with dry evergreen forest species in the upper area. Canopy cover in the upper Nam Xan area recorded 80-90 per cent while the lower Nam Xan area recorded 50-60per cent canopy cover. Surveys undertaken by TISTR in the area in 2013 identified at least 468 species.

For the forest types the forest canopies are divided in 3 classes. The dominant species for each survey (2013) locations are summarised in *Table 4.6*.

Table 4.6 Dominant Flora Species in Nam Xan Candidate Offset Site

Canopy class	Dominant species
Upper Nam Xan River Upper Mixed Deciduous Forest	
Top canopy (22-30m)	Consists of large trees such as *Palaquium poilanei*, *Duabanga grandiflora*, *Pterospermum litorale*, *Lagerstroemia calyculata*,
Middle canopy (8-15m)	Contains saplings of the higher canopy or small trees such as *Crateva magna*, *Alangium chinense*, *Shorea roxburghii*, *Vatica odorata*,
Lower canopy (<15m)	Saplings and seedling of the trees in the higher canopies, for example, *Elaeocarpus sphaericus*, *Litsea glutinosa*, *Baccaurea ramiflora*, *Stereospermum fimbriatum*
Lower Nam Xan River Disturbed Mixed Deciduous Forest	
Top canopy (20-30m)	*Lagerstroemia calyculata, Tetrameles nudiflora*, *Hopea ferrea*, *Castanopsis argyrophylla*, *Garuga pinnata*, *Parkia sumatrana*, *Crudia chrysantha*, *Calleya atropurpurea, Toona ciliata*
Middle canopy (10-20m)	*Crateva magna*, *Trewia nudiflora*, *Carallia brachiata*, *Albizia lucida*, *Dalbergia cultrata*
Lower canopy (~10m)	Consist of saplings and seedling of the higher canopies. Some species belong to dry evergreen forest, such *as Murraya paniculata*, *Streblus ilicifolius*, *Leea rubra*, *Caryota mitis*

IUCN Listed Species

A total of ten plant species listed under the IUCN Red List were recorded during vegetation surveys in Nam Xan in 2013. These are shown in *Table 4.7.* This includes:

- Two species listed as critically endangered;
- Five species listed as endangered; and
- Three species listed as vulnerable.

Table 4.7 IUCN Listed Flora Species Recorded within Nam Xan Candidate Offset Site

Scientific Names	Status
Aquilaria crassna	CR
Dipterocarpus turbinatus	CR
Afzelia xylocarpa	EN
Anisoptera costata	EN
Dalbergia oliveri	EN
Dipterocarpus alatus	EN
Shorea roxburghii	EN
Hopea odorata	VU
Morinopsis capillaris	VU
Ternstroemia wallichian	VU

4.3.3 Fauna

The upper Nam Xan area contains the second highest species diversity in comparison to the other surveyed areas during 2013 surveys (TISTR). A total of 123 species of wildlife including 39 species of mammals, 43 species of birds, 28 species of reptiles, and 13 species of amphibians. In this area the river bank is dominated by deciduous forest while the east bank is production forest where trees are being harvested.

The lower Nam Xan area recorded at least 110 species including 35 mammal species, 40 bird species, 24 reptile species and 11 species of amphibian.

Common fish species detected in the Nam Xan River during surveys in 2013 (TISTR) included Golden poropuntius (*Poropuntius normani*), Dwarf snakehead (*Channa gachua*), Swamp barb (*Puntius brevis*), Sikuk barb (*Sikukia gudgeri*) and Sidestripe rasbora (*Rasbora paviana*).

A full fauna species list is provided in *Annex G.*

Restricted Species

The recent surveys (TISTR 2013) in Nam Xan detected the following species listed in the Regulation of the Ministry of Agriculture and Forestry No. 0360/MAF:

- Twenty-seven mammal species (12 restricted (List I), 15 protected (List II));
- Nine bird species (6 restricted (List I), 3 protected (List II));
- Nine reptiles (3 restricted (List I), 6 protected (List II));
- One fish (protected (List II)); and
- No amphibians.

Annex G provides a description of the results.

IUCN Listed Species

The recent surveys (TISTR 2013) in Nam Xan detected the following species listed as critically endangered, endangered or vulnerable on the IUCN Red List:

- Thirteen mammal species (1 critically endangered, 3 endangered and 9 vulnerable);
- Five reptiles (1 endangered and 4 vulnerable); and
- Four fish species (2 endangered and 2 vulnerable).

Table 4.8 IUCN Listed Fauna Species Recorded within Nam Xan area

Common Name	Scientific Name	Direct Record	Indirect Record	IUCN Status
Mammals				
Northern white-cheeked gibbon	*Nomascus leucogenys*		✓	CR
Asian wild dog, dhole	*Cuon alpinus*	✓		EN
Sunda pangolin	*Manis javanica*		✓	EN
Phayre's leaf monkey	*Trachypithecus phayrei*		✓	EN
Asian small-clawed otter	*Aonyx cinerea*		✓	VU
Binturong	*Arctictis binturong*	✓		VU
Sun bear	*Helarctos malayanus*	✓		VU
Smooth-coated otter	*Lutrogale perspicillata*		✓	VU
Stump-tailed Macaque	*Macaca arctoides*		✓	VU
Northern pig-tailed macaque	*Macaca leonina*		✓	VU
Bengal slow loris	*Nycticebus bengalensis*		✓	VU
Pygmy slow loris	*Nycticebus pygmaeus*		✓	VU
Sambar deer	*Rusa unicolor*	✓		VU
Reptiles				
Elongated tortoise	*Indotestudo elongata*		✓	EN
Southeast Asian softshell turtle	*Amyda cartilaginea*		✓	VU
Southeast Asian box turtle	*Cuora amboinensis*		✓	VU

Common Name	Scientific Name	Direct Record	Indirect Record	IUCN Status
King cobra	*Ophiophagus hannah*	✓		VU
Siamese temple turtle	*Siebenrockiella crassicollis*		✓	VU
Fish				
Flying minnow	*Laubuca caeruleostigmata*	✓		EN
	Luciocyprinus striolatus		✓	EN
Wild common carp	*Cyprinus carpio*	✓		VU
Bandan sharp-mouth barb	*Scaphognathops bandanensis*	✓		VU
IUCN Status: CR – Critically Endangered; EN – Endangered; VU – Vulnerable.				

4.3.4 Aquatic

The Nam Xan River surveyed in 2013 habitats exhibited a gravel substrate with variety in depth and flow seasonally. During the wet season water was approximately 1-3m depth and up to 150 m wide in area where the wetted width is 100m during the dry season. Reaches recorded areas with larger rock and riffle zones as well as beach and island areas where aquatic plants grow sparsely. In general the substrate is dominated by gravel. In the upper area there are settlements with fish cultivation in the lower area. Sand and gravel is harvested in some reaches. *Figure 4.5* shows the habitat within the Nam Xan River.

Figure 4.5 Top: Lower Nam Xan River (dry season), Upper Nam Xan Tributary (wet season); Bottom: Upper and Lower Nam Xan River (wet season) (TISTR 2013)

350000 360000 370000 380000 390000 400000

2130000 2120000 2110000 2100000 2090000 2080000 2070000 2060000 2050000 2040000

Legend

- Nam Xan Catchment Boundary
- Waterbody
- Road
- City, Town or Village

Nam Ngiep 1 Hydropower Project:

- Inundation Area
- Re-regulation Dam
- Re-settlement Area
- Proposed Access Road

Forest Zone:

- National Protection Forest
- Production Forest

N

0 2.5 5 7.5Km

1:250,000

Basemap: Bing Maps
Datum: WGS84

Nam Gnan
Namchong-Namgneup
Namchong-Namgneup
GnotNamxan NamPeuak
GnotNamxan NamPeuak
Thathom
Nammo
Nam Gnem
Nam Xan
Namchong-Namgneup
Nammo
Nam Mang
Phak Beak
Phoupasang-Punghok
Phoupasang-Punghok
Nam Lat
Phak Beak
Phak Beak
Ba.Pakgnoun
Phoutume
Nam Kap
Mekong River

Client:	Nam Ngiep Power Company Ltd.		
Drawing No:	0185065b_BIODIV_G011_R0.mxd		
Date:	10/09/2013	Drawing Size: A3	
Drawn By:	TC	Reviewed By: DN	

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Figure 4.6 - Forestry Classification Mapping within the Nam Xan Area

Nam Ngiep 1 Hydropower Project
Baseline Biodiversity Assessment Report

Environmental Resources Management ANZ

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

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4.4 HUAY NGUA PPA

4.4.1 Overview

The Huay Ngua PPA (the PPA) was established in 2010 and is located to the east of the Nam Ngiep River between Borikham and Hat Kham. The preserved area is approximately 5,430 ha. There are five villages with a total population of 4,302 made up of Laoloum, Laosoung and Keummou ethnic groups. The groups are located in scattered settlements living near highland rice fields and rivers. The villagers use local terrestrial and aquatic biodiversity however dependence varies (Provincial Conservation Division, 2010).

The PPA is an important part of a wildlife corridor between PKK and along the Nam Ngiep River. The area is considered significant for aquatic and wildlife habitat (Provincial Conservation Division, 2010) as well as providing a research site of Province Agriculture and Forestry School. The PPA currently does not have any formal management arrangements in place to facilitate its management. A management committee under Central, Provisional or District levels of government has not been established. A Management Plan for the PPA has been prepared but it has not been implemented as no funding currently exists to pay for the management actions it contains. The priority actions to manage the PPA included in the plan are related to:

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

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

Forest resources have played an important role in the economics of the surrounding province contributing to almost 30% of the total province economy in 2000. Although production of forest products is important for the province, environmental values remain important and the forest is considered a place for production and collection of food for the rural population as well as a source of traditional medicine (Provincial Conservation Division, 2010).

4.4.2 *Vegetation*

Land Cover

Using land cover mapping (DFRM, 2010), natural and modified habitats, in accordance with the ADB definition, can be identified within the Huay Ngua candidate offset site. The Huay Ngua is dominated by natural habitat (83 per cent) which is mapped as deciduous forest. *Table 4.9* summarises the land cover shown in *Figure 4.7* and identifies the habitat category of each land cover type.

Table 4.9 Land Cover within the Huay Ngua Candidate Offset Site

	ADB Habitat Class	Total Area (ha)	% of Total
Deciduous Forest	Natural	4,853	83%
Old Fallow Land	Modified	833	14%
Slash and Burn	Modified	31	1%
Rice Paddy	Modified	11	<1%
Cloud	-	80	1%
Shadow	-	52	1%
	Total	**5,860**	

Vegetation Condition

The NDVI across the Huay Ngua PPA is shown in *Figure 4.8* and the area of each classification is summarised in *Table 4.10*.

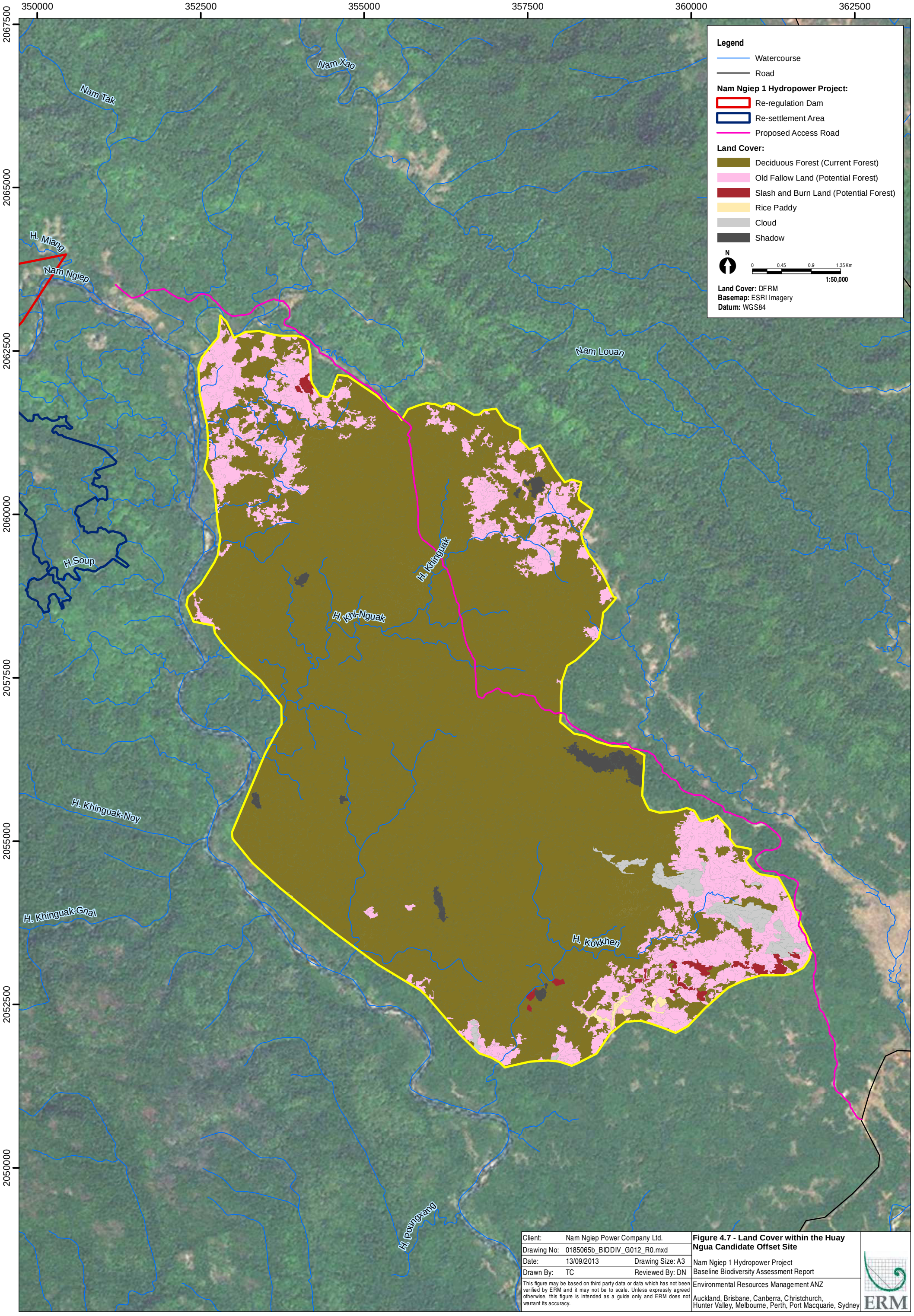
Over 94 per cent of the Huay Ngua is classified as moderate or high NDVI. The majority of the area is classified as moderate (71 per cent). Less than 0.1 per cent of the area is classified as impacted NDVI.

Table 4.10 Vegetation Condition within the Huay Ngua Candidate Offset Site

Forest type	Impacted (- to 0)	Low (0 - 0.4)	Moderate (0.4 - 0.6)	High (0.6 - 0.8)
Deciduous Forest	4	131	3558	1161
Old Fallow Land	22	120	518	173
Slash and Burn	5	14	12	0
Rice Paddy	0	7	4	0
Cloud	11	22	36	10
Shadow	0	1	40	12
Total (ha)	**42**	**295**	**4168**	**1356**
%of Total	**1%**	**5%**	**71%**	**23%**

Aquatic Habitats

The Huay Ngua aquatic habitats can be described as tributary habitat. The aquatic habitats sampled were very shallow during the dry season. No aquatic plants were observed. The substrate is dominated by sand and small gravel. The riparian zone in this area is original forest dominated by bamboo. No disturbance was observed.


350000
352500
355000
357500
360000
362500
2067500
2065000
2062500
2060000
2057500
2055000
2052500
2050000
Nam Xao
Nam Tak
H. Miang
Nam Ngiep
Nam Louan
H.Soup
H. Khinguak
H. Khi-Nguak
H. Khinguak-Noy
H. Khinguak-Gnai
H. Kokkhen
H. Poungxang
Legend
Watercourse
Road
Nam Ngiep 1 Hydropower Project:
Re-regulation Dam
Re-settlement Area
Proposed Access Road
Land Cover:
Deciduous Forest (Current Forest)
Old Fallow Land (Potential Forest)
Slash and Burn Land (Potential Forest)
Rice Paddy
Cloud
Shadow
N
0 0.45 0.9 1.35 Km
1:50,000
Land Cover: DFRM
Basemap: ESRI Imagery
Datum: WGS84
Client: Nam Ngiep Power Company Ltd.
Drawing No: 0185065b_BIODIV_G012_R0.mxd
Date: 13/09/2013 Drawing Size: A3
Drawn By: TC Reviewed By: DN
This figure may be based on third party data or data which has not been verified by ERM and it may not be to scale. Unless expressly agreed otherwise, this figure is intended as a guide only and ERM does not warrant its accuracy.
Figure 4.7 - Land Cover within the Huay Ngua Candidate Offset Site
Nam Ngiep 1 Hydropower Project
Baseline Biodiversity Assessment Report
Environmental Resources Management ANZ
Auckland, Brisbane, Canberra, Christchurch, Hunter Valley, Melbourne, Perth, Port Macquarie, Sydney
ERM

350000 352500 355000 357500 360000 362500

2067500 2065000 2062500 2060000 2057500 2055000 2052500 2050000

Nam Xao
Nam Tak
H. Miang
Nam Ngiep
Nam Louan
H.Soup
H. Khinguak
H. Khi-Nguak
H. Khinguak-Noy
H. Khinguak-Gnai
H. Kokkhen
H. Poungxang

Legend

- Huay Ngua Provincial Protected Area
- Watercourse
- Road

Nam Ngiep 1 Hydropower Project:

- Re-regulation Dam
- Re-settlement Area
- Proposed Access Road

Condition Class:

- High
- Moderate
- Low
- Impacted

N

0 0.5 1 1.5Km

1:50,000

Land Cover: DFRM
Basemap: ESRI Imagery
Datum: WGS84

Client:	Nam Ngiep Power Company Ltd.	
Drawing No:	0185065b_BIODIV_G013_R0.mxd	
Date:	13/09/2013	Drawing Size: A3
Drawn By:	TC	Reviewed By: DN

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

Figure 4.8 - Vegetation Condition within the Huay Ngua Candidate Offset Site

Nam Ngiep 1 Hydropower Project
Baseline Biodiversity Assessment Report

Environmental Resources Management ANZ

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ERM

4.4.3 Flora Species

The climatic conditions (low temperature, high humidity and high winds) have led to dense growth of several plant species such as rosewood, mai kebe, mai ngang (*Dipterocarpus alatus*), maid tae (*Sindora cochinchinensis*), mai peuy (*Lagerstroemia calyculata, Lagerstroemia floribunda*) and mai bark (*Anisoptera costata*) (Provincial Conservation Division, 2010).

Sampling undertaken during 2013 surveys by TISTR recorded 451 species of vascular plants in the Huay Ngua PPA sampling locations. Vegetation is dominated by mixed deciduous forest with some areas of mixed evergreen forest and secondary growth of mixed deciduous forest. Canopy cover is approximately 60-70 per cent. The forest canopies are divided in 3 classes. The dominant species are summarised in *Table 4.11*.

Table 4.11 Dominant Flora Species in Huay Ngua Candidate Offset Site

Canopy class	Dominant species
Top canopy (20-35m)	*Anisoptera costata, Lagerstroemia calyculata, Shorea roxburghii, Irvingia malayana, Alstonia glaucescens, Schima wallichii, Vitex pinnata, Stereospermum fimbriatum*
Middle canopy (10-20m)	*Acronychia pedunculata, Peltophorum dasyrachis, Nauclea orientalis, Microcos tomentosa, Mallotus paniculatus, Gonocaryum lobbianum, Cratoxylum formosum*
Lower canopy (<10m)	*Croton cascarillicdes, Breynia glauca, Ardisia helferiana, Glycosmis pentaphylla, Melicope pteleifolia, Allophylus cobbe, Salacia chinensis*

IUCN Listed Species

A total of 11 plant species listed under the IUCN Red List were recorded during vegetation surveys in Huay Ngua in 2013. These are shown in *Table 4.12*. This includes:

- One species listed as critically endangered;
- Six species listed as endangered; and
- Five species listed as vulnerable.

Table 4.12 IUCN Listed Flora Species Recorded within Huay Ngua Candidate Offset Site

Scientific Names	Status
Dipterocarpus turbinatus	CR
Afzelia xylocarpa	EN
Anisoptera costata	EN
Dalbergia oliveri	EN
Dipterocarpus alatus	EN
Shorea roxburghii	EN
Vatica cinerea	EN
Cycas pectinata	VU
Dalbergia cochinchinensis	VU
Hopea odorata	VU
Syzygium vestitum	VU
Ternstroemia wallichian	VU
IUCN Status: CR – Critically Endangered; EN – Endangered; VU – Vulnerable	

4.4.4 Fauna Species

A total of 38 terrestrial species of fauna from 19 families, and 31 genera were recorded from the field surveys in 2013 surveys in Huay Ngua PPA by TISTR. This includes one species of mammal, 29 species of birds, three species of reptiles, and six species of amphibians. Species diversity of animals in this area is lowest among the total study areas due to the lack of secondary data, all records were obtained by direct observation during the field surveys.

Common fish species detected in the Nam Xan River during surveys in 2013 included Spiny barb (*Mystacoleucus marginatus*), Sikuk barb (*Sikukia gudgeri)*, Horseface loach (*Acantopsis choirorhynchos*), and Long fin mystus (*Mystus singaringan*). Of these species the Sikuk barb and Long fin mystus are known full migrant species.

The Houy Ngua Provincial Preserved Area Management Plan reports (indirect data) fauna species occurring within the PPA to include wild pig, munjac, clouded leopard (*Pardofelis nebulosa*), civet, flying squirrel as well as Green peafowl (*Pavo muticus*), Hill myna (*Gracula religiosa*), Red junglefowl (*Gallus gallus*) and the Siamese fireback (*Lophura diardi*).

Overall, the TISTR surveys and indirect data reported:

- Nine amphibian species;
- Fifty-nine bird species;
- Twenty-seven mammal species;
- Nine reptile species; and
- Thirty-nine fish species (including twelve species considered to be migratory).

A full species list is provided in *Annex G (terrestrial fauna)* and *Annex H (aquatic biota)*.

Restricted Species

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

The 2013 TISTR surveys (direct data) and indirect data sources identified the following species listed as Restricted in the Regulation of the Ministry of Agriculture and Forestry No. 0360/MAF:

- Two mammal species;
- Six bird species;
- One reptile;
- One fish;
- No amphibians.

Annex G and *Annex H* provide a description of results for terrestrial fauna and aquatic biota, respectively.

IUCN Listed Species

Three IUCN Red List critically endangered, endangered or vulnerable fauna species were recorded within the Huay Ngua PPA area during 2013 surveys by TISTR while PAFO surveys identified 16 species listed as critically endangered, endangered or vulnerable on the IUCN Red List that may occur within the Huay Ngua PPA.

Table 4.13 IUCN Listed Fauna Species Recorded within Huay Ngua PPA

Common Name	Scientific Name	Direct Record	Indirect Record	IUCN Status
Mammals				
Asian elephant	*Elephas maximus*		✓	EN
Fishing cat	*Prionailurus viverrinus*		✓*	EN
Gaur	*Bos gaurus*		✓	VU
Malayan sun bear	*Helarctos malayanus*		✓	VU
Clouded leopard	*Neofelis nebulosa*		✓	VU
Sambar deer	*Rusa unicolor*			VU
Himalayan black bear	*Ursus thibetanus*		✓	VU
Large spotted civet	*Viverra megaspila*		✓	VU
Birds				
White-winged duck	*Cairina scutulata*		✓*	EN
Green peafowl	*Pavo muticus*		✓	EN

Common Name	Scientific Name	Direct Record	Indirect Record	IUCN Status
Imperial eagle	*Aquila heliaca*		✓	VU
Reptiles				
Big-headed turtle	*Platysternon megacephalum*		✓	EN
Impressed tortoise	*Manouria impressa*		✓	VU
Fish				
Giant barb	*Catlocarpio siamensis*		✓	CR
Striped catfish	*Pangasianodon hypophthalmus*			EN
Thicklipped barb	*Probarbus labeamajor*		✓	EN
Bandan sharp-mouth barb	*Scaphognathops bandanensis*	✓		VU
Jaguar loach	*Yasuhikotakia splendida*	✓		VU

CR = Critically endangered, EN = Endangered, VU = Vulnerable

*Specialist consultation identified potential for unreliable record

4.5 PHOU KHAO KOUAY

4.5.1 Overview

Phou Khao Kouay, or 'Buffalo Horn Mountain', is a Protected Area near Vientiane in central Laos. The area spans 2000 square kilometres over three provinces, with an elevation range of 200m - 1761m. The landscape ranges from sandstone cliffs and river gorges to rugged mountain slopes. Layered sandstones are visible as linear outcrops and large boulders along steep slopes. There are also extensive flat uplands of exposed sandstones with little or no soil development (Salter & Bouaphanh, 1990). The PKK NPA has a monsoonal climate similar to the rest of Central Laos with a mean annual temperature of 26.6 C. The wet season extends from May to October with a distinct dry season during from November to April.

4.5.2 Vegetation

Land Cover

Using land cover mapping (DFRM, 2010), natural and modified habitats, in accordance with the ADB definition, can be identified within the PKK candidate offset site. The PKK is dominated by natural habitat (73 per cent) which is a mixture of deciduous forest, evergreen forest, coniferous forest, mixed coniferous forest, scrub and bamboo. *Table 4.14* summarises the land cover shown in *Figure 4.9* and identifies the habitat category of each land cover type.

Table 4.14 Land Cover within the PKK Candidate Offset Site

Forest Type	ADB Habitat Class	Total Area (ha)	% of Total
Deciduous Forest	Natural	76,001	42%
Evergreen Forest	Natural	43,262	24%
Coniferous Forest	Natural	1,563	1%
Mixed Coniferous/Broadleaved Forest	Natural	702	<1%
Scrub, Heath	Natural	2,779	2%
Bamboo	Natural	5,832	3%
Swamp	Natural	148	<1%
Rock	Natural	1,638	1%
Old Fallow Land	Modified	22,413	12%
Agriculture Plantation	Modified	63	<1%
Young Fallow Land	Modified	11,762	6%
Slash and Burn	Modified	1,274	1%
Rice Paddy	Modified	857	<1%
Water	-	2,376	1%
Grassland	Modified	3,098	2%
Barren Land	Modified	102	<1%
Urban Area	Modified	157	<1%
Other Land	Modified	127	<1%
Cloud	-	6,952	4%
Shadow	-	200	<1%
	Total	**181,306**	

Vegetation Condition

The NDVI across the PKK is shown in *Figure 4.10* and the area of each classification is summarised in *Table 4.15*.

Over 87 per cent of the PKK is classified as moderate or high NDVI. Less than 2 per cent of the area is classified as impacted NDVI.

Table 4.15 Vegetation Condition within the PKK Candidate Offset Site

Forest Type	Impacted (- to 0)	Low (0 - 0.4)	Moderate (0.4 - 0.6)	High (0.6 - 0.8)
Deciduous Forest	204	4498	34272	37027
Evergreen Forest	344	4505	25445	12968
Coniferous Forest	14	782	674	93
Mixed Coniferous/Broadleaved Forest	1	332	329	39
Scrub, Heath	4	1619	1063	92
Old Fallow Land	78	1141	6647	14547
Agriculture Plantation		0	9	54

Forest Type	Impacted (- to 0)	Low (0 - 0.4)	Moderate (0.4 - 0.6)	High (0.6 - 0.8)
Young Fallow Land	104	2365	4618	4676
Bamboo	54	353	918	4506
Slash and Burn	22	377	468	407
Rice Paddy	15	639	158	45
Swamp	74	52	18	4
Water	1920	335	83	38
Grassland	2	881	1559	657
Barren Land	7	59	32	4
Urban Area	4	93	51	9
Other Land	12	76	30	9
Rock	55	1048	502	32
Cloud	113	1209	3692	1939
Shadow	0	27	110	63
Total (ha)	**3027**	**20391**	**80678**	**77209**
% of Total	**2**	**11**	**44**	**43**

250000 260000 270000 280000 290000 300000 310000 320000 330000 340000

2070000 2060000 2050000 2040000 2030000 2020000 2010000

Legend

Land Cover:

- Evergreen Forest (Current Forest)
- Deciduous Forest (Current Forest)
- Coniferous Forest (Current Forest)
- Mixed Coniferous/Broadleaved Forest (Current Forest)
- Bamboo (Potential Forest)
- Old Fallow Land (Potential Forest)
- Young Fallow Land (Potential Forest)
- Slash and Burn Land (Potential Forest)
- Scrub, Heath
- Rice Paddy
- Agriculture Plantation
- Grassland
- Swamp
- Rock
- Barren Land
- Urban Area
- Water
- Other Land
- Cloud
- Shadow
- Phou Khao Khouay National Protected Area
- City, Town or Village
- Lao PDR Boundary

Nam Ngiep 1 Hydropower Project:

- Inundation Area
- Re-regulation Dam
- Re-settlement Area
- Proposed Access Road
- Nam Ngiep Sub-catchment Boundary

Xiengmi
Longxan
Papek
Thabok
Na
Nakhai
Nangommay
Xienglaena
Ban Natan
Hai
Veunthan
Palai
Somsamay
Mekong River

N
0 2.5 5 7.5Km
1:250,000

Land Cover: DFRM
Basemap: Bing Maps
Datum: WGS84

Client:	Nam Ngiep Power Company Ltd.		
Drawing No:	0185065b_BIODIV_G014_R0.mxd		
Date:	13/09/2013	Drawing Size: A3	
Drawn By:	TC	Reviewed By: DN	

Figure 4.9 - Land Cover within the PKK Candidate Offset Site

Nam Ngiep 1 Hydropower Project
Baseline Biodiversity Assessment Report

Environmental Resources Management ANZ
Auckland, Brisbane, Canberra, Christchurch, Hunter Valley, Melbourne, Perth, Port Macquarie, Sydney

ERM

250000 260000 270000 280000 290000 300000 310000 320000 330000 340000

2070000 2060000 2050000 2040000 2030000 2020000 2010000

Legend

- Phou Khao Khouay National Protected Area
- Nam Ngiep Sub-catchment Boundary
- Waterbody
- Road
- City, Town or Village
- Lao PDR Boundary

Nam Ngiep 1 Hydropower Project:

- Inundation Area

Condition Class:

- High
- Moderate
- Low
- Impacted

Xiengmi
Longxan
Nam Ngum Reservoir
Nam Leuk reservoir
Nam Mang 3 Reservoir
Papek
Nam Thon
Thabok
Na
Nakhai
Nangommay
Ban Natan
Xienglaena
Mekong River
Hai
Nam Ngum River
Veunthan
Palai
Somsamay
Pakxapmai

N
0 2.5 5 7.5Km
1:250,000

Basemap: Bing Maps
Datum: WGS84

Client:	Nam Ngiep Power Company Ltd.	
Drawing No:	0185065b_BIODIV_G015_R0.mxd	
Date:	13/09/2013	Drawing Size: A3
Drawn By:	TC	Reviewed By: DN

Figure 4.10 - Vegetation Condition within the PKK Candidate Offset Site

Nam Ngiep 1 Hydropower Project
Baseline Biodiversity Assessment Report

Environmental Resources Management ANZ

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

ERM

4.5.3 *Flora Species*

The central portion of the park contains the lower basins of the Nam Leuk and Nam Mang. This area is predominantly upper dry evergreen forest. This forest has plant families and genera typical for other parts of Southeast Asia, such as the genera Dipterocarpus and Shorea. Mixed deciduous forest is found on lighter, shallow soils. Large stands of coniferous forest, usually monospecific stands of *Pinus merkusii*, grow on shallow, nutrient deficient, sandy soils, particularly in the western portion of the park, where it occurs in association with extensive, fire-climax grasslands.

4.5.4 *Fauna Species*

IUCN Listed Species

Information regarding the PKK identified a number of IUCN Red List species to occur including:

- Ten mammal species (1 critically endangered, 4 endangered and 5 vulnerable).

Table 4.16 IUCN Listed Fauna Species Known within PKK Candidate Offset Site

Scientific Name	Family/Common Name	IUCN Status
Nomascus leucogenys	Northern white-cheeked gibbon	CR
Cuon alpinus	Asian wild dog, dhole	EN
Elephas maximus	Asiatic elephant	EN
Manis javanica	Sunda pangolin	EN
Trachypithecus phayrei	Phayre's leaf monkey	EN
Aonyx cinerea	Asian small-clawed otter	VU
Bos gaurus	Gaur	VU
Helarctos malayanus	Malayan sun bear	VU
Macaca leonina	Northern pig-tailed macaque	VU
Nycticebus bengalensis	Bengal slow loris	VU
Ursus thibetanus	Himalayan black bear	
IUCN Status: CR – Critically Endangered; EN – Endangered; VU – Vulnerable		

4.6 *SOCIO-ECONOMIC AND CULTURAL*

The following section provides an overview of the socio-economic activities and cultural values associated with the potential offset sites. This information is largely drawn from village and market surveys undertaken by ERM in July 2013. The location of villages surveyed is shown in *Figure 4.11*.

310000 320000 330000 340000 350000 360000 370000 380000

2130000 2120000 2110000 2100000 2090000 2080000 2070000 2060000 2050000 2040000 2030000 2020000

B. Pou
Thathom
B. Pak Yong
B. Kan Yong
B. Pak Haueng
Ba. Pakgnoun
Borikham Market
B. Don
B. Somseun
Pakxan
Thabok Market
Thabok
Mekong River
Na

Legend

- Nam Ngiep Catchment Boundary
- Nam Xan Catchment Boundary
- Waterbody
- Road
- City, Town or Village
- Lao PDR Boundary

Survey Locations:

- Village
- Market

Nam Ngiep 1 Hydropower Project:

- Inundation Area
- Re-regulation Dam
- Re-settlement Area
- Proposed Access Road

N

0 2.5 5 7.5Km

1:300,000

Basemap Bing Maps
Datum: WGS84

bing

Client:	Nam Ngiep Power Company Ltd.	
Drawing No:	0185065b_BIODIV_G015_R0.mxd	
Date:	12/09/2013	Drawing Size: A3
Drawn By:	TC	Reviewed By: DN

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

Figure 4.11 - Socio-economic and Cultural Survey Locations

Nam Ngiep 1 Hydropower Project
Baseline Biodiversity Assessment Report

Environmental Resources Management ANZ

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

ERM

4.6.1 Hunting and Gathering

Hunting is generally done for household consumption; while any surplus is sold to intermediaries. However, from time to time, hunting is done to generate money, when required to cover household expenses such as clothing and education. It is typically the smaller species that are consumed within the household, while the larger animals are sold to intermediaries.

Male hunters normally go hunting individually, unless big animals such as cow or deer are needed for events (e.g. weddings) during which males will hunt in groups of four to five to hunt big animals. Females usually hunt in groups of four to five.

Hunting frequency ranges from two to three times per week to once a month in most villages. However, male hunters from Ban Don mentioned that they have not hunted for the past six years – i.e. since hunting become illegal.

Frequently caught species include small animals such as squirrels, birds, bamboo rats and the lesser mouse deer; however, once in a while larger animals such as the Rusar Unicolor, Southern Red Munjak and Pangolin are caught.

According to villagers, the most prized mammal species is the Pangolin, the price for which ranges from 100,000 KIP (13 USD) to 1 million KIP (130 USD) per kilogram. This is because of its rarity and medicinal purpose – it is believed to have sexual stimulation powers and is preferred alive.

Hunters reported that the availability of resources has been declining since around 2000. The villagers believe that the cause of the decline is the increasing number of new settlers who have migrated to the village areas and started accessing the existing natural resources.

In addition to hunting, many women collect materials from the forests (i.e. gather). A number of species are collected, including mushrooms and bamboo shoots, and are collected baseon their growing season d. Female gatherers reported that they visit forests more often at the start of the rainy season (i.e. May) given that the bamboo shoots and ground vegetation are abundant and ripe at this time of year.

Flora species were, again, primarily used for household consumption and only surplus is sold to intermediaries. However, from time to time, specific species will be requested by intermediaries, such as Nor boon (1,000 KIP (15 cent) per piece) and Nor Xang (50,000 KIP (7 USD) per kilogram). These are the most prized plants due to their taste.

Instead of selling materials collected, females typically engage in other activities, such as planting rice or textile production, in order to provide family income.

4.6.2 Fishing

Villagers indicated that fishing is mainly the role of females rather than males. The majority of fish caught are consumed within household. Only surplus or the prized species are sold to intermediaries. Hence, family income derived from selling fish is relatively low - ranging from 0 to 20 per cent.

In terms of species, female hunters typically catch cat fish and scale fish. The Pla Pann is reported to be the most prized species – it can attract up to 130,000 KIP (17 USD) per kilogram at market.

Females indicated that they go fishing more often during the rainy season as species that dwell in Mekong River flow downstream to the Nam Ngiep and Nam Xan rivers during this period.

Regarding availability of fish, villagers indicated that resources have been declining due to the increasing number of people fishing. Villagers noted many of these people are fishing for commercial purposes, not household consumption.

4.6.3 Cultural services

Most of the villages identified two specific cultural sites deemed important to their way of life - village temples and cremation sites. The cultural sites are typically located in close proximity to the village, but are communally owned by the village. For example, Ban Don reported to have village temple named Ban Don Chaiyaram. Religious ceremonies are held at the site from time to time. The villagers reported to do in Buddhist merits such as release fish, turtles at the temple.

When asked, the villagers indicated that the sites can be moved elsewhere or destroyed and rebuilt elsewhere. In order for this to occur, compensation in the form of land or money is required. The only exception was the Ban Hat Seung Tom, a historic cultural site where artefacts are buried, in Ban Pakheaung. The site was established prior to the founding of the village itself.

As for intangible heritage, no significant sites were identified. This is partly due to the fact that the village residences were largely lowland Laos who are Buddhist; accordingly, religious ceremonies are conducted in village temples. Another possible underlying factor is that the villagers did not settle in the area until after the Laotian Civil War (1953 – 1975).

5 CONSERVATION SIGNIFICANT VALUES SUMMARY

5.1 PROJECT AREA

The Project area is located along the Nam Ngiep River which is a major watercourse draining into the Mekong River. The Nam Ngiep River flows through a mountainous region to a gorge at Hat Gniun, which is the proposed location for the main dam wall. Surrounding the river the vegetation is dominated by deciduous forest land, representing approximately 36 per cent of the footprint. Young and old fallow land is also highly represented with 16 and 21 per cent respectively. In terms of vegetation condition the Project area is dominated by vegetation cover that shows moderate to high photosynthetic capacity.

The vegetation present provides habitat for a number of flora and fauna species, including species listed on the IUCN Red List as Critically Endangered, Endangered or Vulnerable, species listed as Restricted in the Lao PDR Regulation of the Ministry of Agriculture and Forestry No. 0360/MAF, and species that are migratory and endemic. These species have been considered as candidates for critical habitat in accordance with SPS.

As part of the baseline assessment each candidate species has been assessed against the quantitative thresholds of the performance standard for the relevant criteria. Species information sourced from desktop review, field survey results, village interviews and specialist consultation was used to determine the importance of the Project area for each candidate species, and in turn the likelihood of the Project area be considered critical habitat.

The outcomes of the assessment and specialist consultation did not identify any areas of critical habitat for flora or fauna species.

5.2 CANDIDATE OFFSET SITES

Four candidate offset areas were investigated to determine the biodiversity values represented. Following impact assessment for the Project, an appropriate offset site, or combination of, will be selected. The Biodiversity Offset Design Report will document this process.

In comparison to the biodiversity values of the Project area, the candidate offset sites demonstrate biodiversity values similar to the candidate offset sites. The table below summarises some key biodiversity features for comparison. As would be expected given the proximity to the Project area the Upper Nam Ngiep candidate offset site exhibited biodiversity values most similar to the proposed disturbance area.

Table 5.1 Project area (footprint) and Candidate Site Comparison of Key Features

Feature	Project area	Upper Nam Ngiep	Nam Xan*	Huay Ngua PPA	PKK
Area of natural habitat	3,912 ha	102,479 ha	No data	4,853 ha	131,925 ha
Area of high condition vegetation	3,002 ha	80,850 ha	No data	1,356 ha	77,209 ha
Area of medium condition vegetation	3,488 ha	41,943 ha	No data	4,168 ha	80,678 ha
No. of IUCN listed flora species	13	9	10	11	No data
No. of IUCN terrestrial fauna species that may occur	35	35	18	12	10
No. of IUCN aquatic fauna species that may occur	9	9	4	7	No data
* Further analysis of the Nam Xan catchment was not completed as it was discounted as a candidate offset area					

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Annex A

Environmental Research Institute 2007 Survey Method

The following method is an excerpt from Chapter 3 of the Nam Ngiep 1 Hydropower Project Environmental Impact Assessment Draft Report prepared by: Environmental Research Institute, Chulalongkorn University, October 2009.

A.1 TERRESTRIAL ECOLOGY/WILDLIFE

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

A.1.1 Objectives of Study

1. Investigate the diversity, abundance, and distribution of wildlife in the Project area, and any use of the wildlife by local residents.
2. Assess environmental impacts that the proposed project may have on wildlife, their food sources, and their habitat.
3. Draw up appropriate mitigating measures to protect against probable negative impacts on wildlife.

A.1.2 Method of Study

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

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

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

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

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

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

A.2 FOREST, VEGETATION COVER

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

A.2.1 Objectives of Study

1. Study forest characteristics particularly tree species, density, and timber volume as well as saplings and seedlings in the inundation area and in the resettlement area.
2. Assess the economic value of timber to be cut in the reservoir and the resettlement areas.
3. Evaluate impacts on forest resources that may be caused by the project.
4. Recommend mitigating measures to minimize impacts on forest resources and ecosystems.

A.2.2 Method of Study

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

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

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

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

1. A circular sample plots with a radius of 17.85 meters (0.1 hectare total area) from which data on trees of DBH equal to and above 10 centimeter were collected. Other significant information recorded included tree species, their diameter and height, and bamboo types, including number of clumps and stems per clump found in the plot.
2. Square plots of 5x5 meters (25 square meters) were established in the middle of the circular plots. Information on small trees and/or saplings (trees whose DBH is less than 10 centimeters and whose height exceeds 1.3 meters), tree species, number of tree and their average height as well as NTFP species was recorded from these plots.
3. Square plots of 2x2 meters were established within the larger square plots of 5x5 meters. Data concerning plants and vegetation including sapling or seedlings (all undergrowth vegetation), focusing on species of trees or seedlings of each species as well as NTFPs were recorded in these plots. The main concern was on the diversity of plants and NTFPs species, not the numbers or density of the saplings and seedling or plants, since the time available for field data collection was limited, and also since some of the data, especially that on NTFPs were being collected through interviews with villagers.

A.2.3 Forest and Vegetation Classification

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

Box 1 Definition of Land Use and Forest Types

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

Current Forest includes natural forests and plantation forests. It is used to refer to land with a tree canopy cover of more than 20% and area of more than 0.5 ha. The trees should be able to reach a minimum height of 5 m. The basis for the distinction between forest and other land use groups is the

crown density. Natural forests are classified into forest types, which are Upper and Lower Dry Evergreen Forests, Upper and Lower Mixed Deciduous Forests, Gallery Forest, Coniferous Forest, Mixed Broadleafed and Coniferous Forest, and Dry Dipterocarp Forest.

- ***Dry Evergreen Forest (DE):*** The Dry Evergreen Forest type has a lower proportion of evergreen trees than the Evergreen type, 50% -80%. Except in disturbed stands there is very little bamboo. Soil is usually deep. The forest consists of a considerable number of species, of which 2 to 3 species tend to be predominant.

- ***Mixed Deciduous Forest (MD):*** In the Mixed Deciduous Forest, deciduous tree species represent more than 50% of the stand. The forest storeys are not as dense as those of evergreen types and most of the seedlings and saplings are deciduous trees. Bamboo often occurs in this type of forest.

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

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

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

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

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

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

2. Potential Forest:

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

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

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

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

3. Other Land Use Types:

- ***Savannah (SH):*** is an area where the soil conditions are unsuitable for tree growth as well as for agriculture production. The tree cover in the Savannah should be at least 1% but not more than 20%. The trees are drought resistant and mostly short with graminaceous and herbaceous plants forming an under storey. Savannahs should not be confused those grass covered areas that sometimes occur after shifting cultivation. Normally, the Savannah does not occur on steep slopes but in plains.

- ***Scrub Forest (SR):*** This is an area covered with scrub and stunted trees. The soil is shallow and rocky.

- ***Barren Land and Rock (R):*** Unfertile or seriously degraded land on shallow soil and rocky areas on which neither trees nor grasses can grow.

- ***Grassland (G):*** Unfertile or degraded land on which no trees or shrubs grow. It might be an area that is too dry for tree growth that has been covered by grasses. It could also be an area that has originally been

covered by trees, but has been heavily disturbed by cutting and fire and gradually depleted. One reason for the absence of trees could be that larger areas have been deforested and the seed supply from surrounding forest has ceased. Areas burnt every year to grow fodder or for hunting purposes could also be classified as Grassland. That type of Grassland can be found on higher elevations in the Northern part of Laos. Grassland can also occur on deep sand with a high moisture content.

- ***Swamp (SW):*** Swamps are areas where the soil is saturated with water. The soil may basically be fertile but the lack of oxygen limits its agriculture or forest capacity. The Swamp could have a high ecological or environmental value and the flora and fauna may be rich.

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

4. *Other Agricultural Land (OA):*

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

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

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

A.3 AQUATIC BIOTA

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

A.3.1 Objectives of Study

1. Review secondary data of aquatic biota and habitats from preliminary reports and the collect primary data from the field.
2. Assess potential impacts on aquatic biota in the Project area and downstream.
3. Recommend mitigation measures, including monitoring programs.

A.3.2 Method of Study

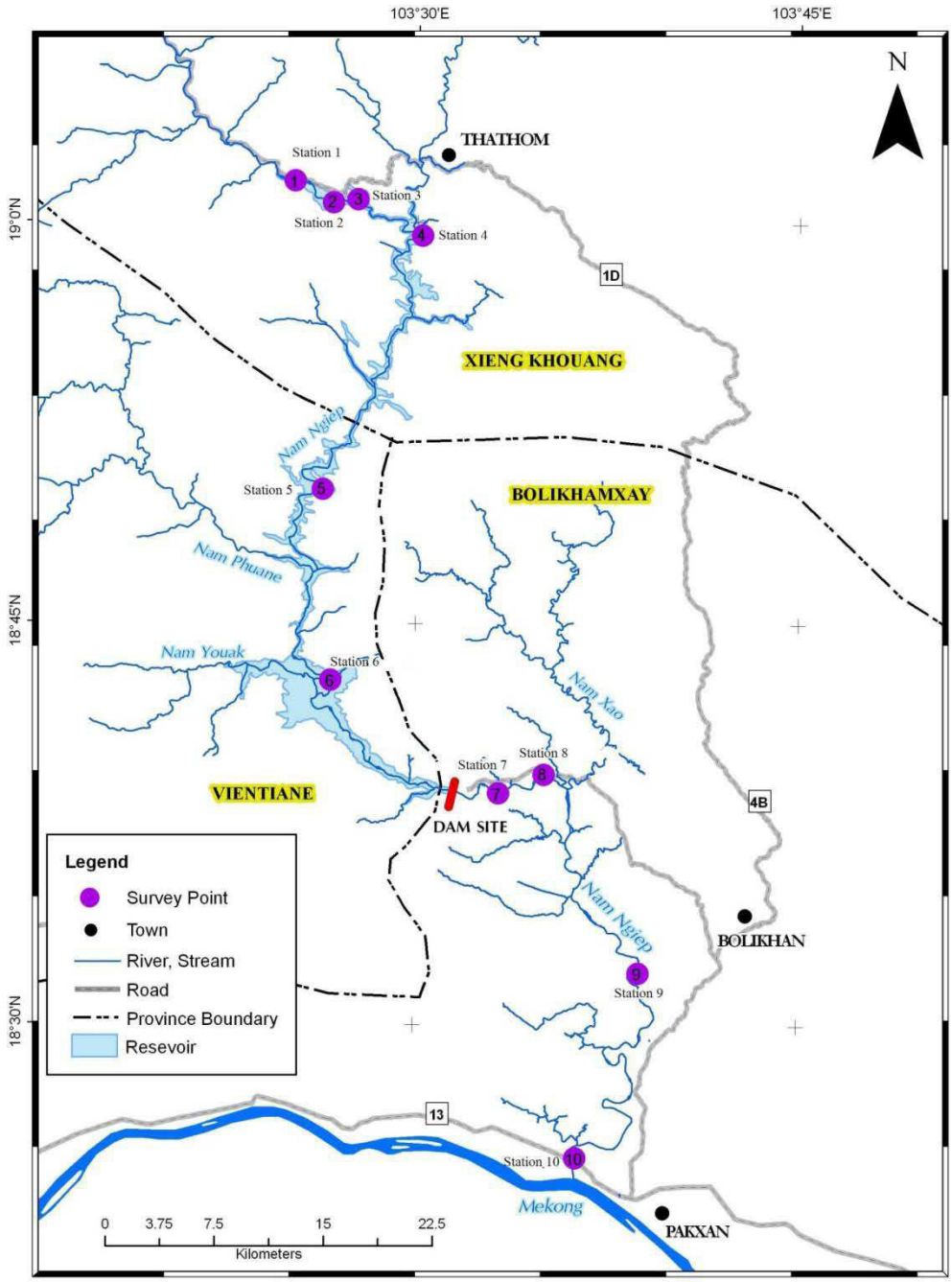
Sampling Station

Dry season survey along Nam Ngiep River was conducted in January 2008 at ten stations: six located downstream from the proposed dam and the other four located upstream (Table 6.1 and Figure 3-2).

Table A.1 Fish and Fisheries Survey Locations along the Nam Ngiep River

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

Figure A.1 ***Fish and fisheries survey locations along the Nam Ngiep River***



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

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

Fish Sampling

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

Plankton Sampling

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

Benthic Sampling

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

A.4 WETLAND

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

A.4.1 Objectives of Study

1. Identify location and pattern of wetlands found in the Project area. This information serves as baseline data for future comparison of land cover changes or wetland habitat losses due to the project.
2. Detect changes of location and patterns of wetlands and the impacts of project development on wetlands. This is useful for assessment of impact on the wetlands after project development.
3. Propose mitigation measures to reduce adverse impacts on wetlands. The proposed measures are helpful to establish future rehabilitation and restoration programs for damaged wetlands during and after the project development.

A.4.2 Method of Study

1. Compile information on wetlands from Lao and international literatures.
2. Acquire both primary and secondary data to evaluate wetlands in the Project area.
3. Assess possible impacts of the project on identified wetlands.
4. Prepare protection and mitigation measures and propose monitoring plans

Annex B

Thailand Institute of Scientific and Technological Research Biodiversity 2013 Survey Method

The following method was provided by The Thailand Institute of Scientific and Technological Research.

B.1 SURVEYS

Field investigations were undertaken in four key areas associated with the Project:

- NNP1 Project area;
- Nam Xan River Catchment;
- Huay Ngua Provincial Preserved Area; and
- Houy Soup Resettlement Site.

Surveys were undertaken by three teams comprising 25 people targeting separate taxa: vegetation (two teams of 7), terrestrial wildlife (one team of 6) and aquatic biota (one team of 5).

B.1.1 Forest and Vegetation Survey

The Forest and Vegetation Survey was designed to assess the overall status, quality, and conservation significance of existing forest/vegetation types, taking into consideration global, national and local conservation priorities; and to assess the diversity and availability of Non Timber Forest Products (NTFPs). In summary, the Forest and Vegetation Survey included the study of species diversity and the conservation status of vascular plants based on field survey and literature review. Specifically it included:

- review of literature obtained from secondary sources, including flora journals and reports on other surveys of the area;
- a vascular plant survey of 9 Study Sites (the main dam inundation, re-regulation dam inundation, resettlement site, Huay Ngua Provincial Preserved Area, Upper Nam Ngiep River and Lower Nam Ngiep River, the Upper Nam Xan River, Lower Nam Xan River, and Transmission line);

B.1.2 Methods

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

The sampling plots consist of 3 types of temporary plots:

1) A circular sample plot with a radius of 17.85 meters (or 0.1 ha): data of trees which are diameter at breast height (DBH) $\geq$ 10 centimeters were recorded. Other significant information were recorded and measured such as tree species, DBH, total height, timber quality, number of log (1 log = 5 m timber), and bamboo species, including number of clumps and stems per clump.

2) Square plots of 5x5 meters (25 square meters or 0.0025 ha) were established in the middle of the circular plots. Information of small trees and/or saplings (trees whose DBH < 10 centimeters and whose height >1.3 meters), tree species, number of tree, and height, as well as NTFP species were recorded from these plots.

3) Square plots of 2x2 meters (4 square meters or 0.0004 ha) were established within the larger square plots of 5x5 meters. Data concerning plant species, number of seedling, and undergrowth vegetation was recorded.

Analyses of the data collected included specialised laboratory investigations to establish identification of voucher specimens. Quantitative analysis of the data included analysis of tree density, frequency, volume, of tree species and was determined as per Curtis and McIntosh (1950). Timber volume ($\overline{\boldsymbol{V}}$) per survey plot was estimated using Thannarin (1999). Relative density (RD_i), Relative dominance (RB_i) and Relative frequency (RF_i) of a given species were also calculated. Important value Index (IVI_i) was used to determine the overall importance of each species in the community structure was calculated from the (Curtis, 1959). A Complex index of a particular forest type (CI) was also calculated and Species diversity and dominance of a given species were evaluated using Shannon–Weaver (1963) index of diversity) *H'*).

A forest status assessment was undertaken considering the environmental factors within the forest including forest impact assessment including wood density, volume, composition, functions of the forest, and ecological value of forests and external factors. External factors include areas of forest cover, conservation and management, and anthropogenic activities in the study areas.

B.1.3 Timing

Surveys were completed during the dry season March 2013 and wet season July 2013.

B.1.4 Terrestrial Wildlife Survey

The Terrestrial Wildlife survey aimed to describe the baseline wildlife diversity of the impact zones for the purposes of assessing the potential Project impacts to terrestrial wildlife. Survey and sampling work involved

developing an inventory of wildlife species (amphibians, reptiles, birds, and mammals).

B.1.5 Locations

A total of eight study areas were assessed for the Wildlife Surveys and included, the Resettlement site, Huay Ngua Provincial Preserved Area, Nam Ngiep River, Nam Xan River, Upper Nam Ngiep River, Lower Nam Ngiep River, Upper Nam Xan River, and Lower Nam Xan River.

Locations	Name of Stations	Co-ordination (Zone 48 – WGS84	
		X	Y
Phase I			
1. Huay Ngua Provincial Preserved Area	W-HN 1	356228	2059137
2. Nam Ngiep River	W-NN 1	339152	2090130
3. Resettlement site	W-NN 2	334859	2077355
4. Nam Xan River	W-NX 1	370097	2056174
Phase II			
1. Lower Nam Ngiep River	W-NN1	350224	2063700
2. Upper Nam Ngiep River	W-NN2	339168	2090130
3. Upper Nam Xan River	W-NX1	373166	2082542
4. Lower Nam Xan River	W-NX2	370849	2058609

B.1.6 Methods

The methodology adopted in the wildlife survey was included a literature review of previous publications, papers, reports, internet, etc., relating about wildlife within the study areas. The Wildlife inventory of each group was collected through the following techniques:

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

    i. Amphibians and reptiles: species searches were undertaken in habitats such as under logs, rocks, bark as well as digging in the buttress of trees. At night, spotlighting was used to detect nocturnal species along rivers, around poundages, and within tree canopies.

    ii. Birds: were directly observed using binoculars during day time. Some species of birds were identified using call identification during the morning or evening, when they are the most active. Birds were also caught using mist-nets under tree canopies or cross the creeks these were identified, photographed, and released.

    iii. Mammals: were observed from their signs such as tracks, scats, scratches on trees, burrows, etc. small mammals, were captured

using live-traps or Sherman's traps. Bats were surveyed at night using mist-net and harp traps placed under tree canopies or cross creeks. Some species of mammals were identified from local hunters.

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

2) Indirect count: was used to obtain supplementary information on wildlife by interviewing local residents who lived in or near by the Project area. Some local villagers may hunt animals for food or for sale. Local households as well as local markets were also sampled.

Habitat evaluation: was undertaken recording information on plant species acting as the sources of food and cover. Plants used for foraging and their frequency of observation will be utilised from the forest inventory.

Species Diversity: Wildlife identification of each group using keys and descriptions from the standard references (Corbet & Hill (1992), Francis (2008), and Lekagul & McNeely (1988); avian species were mainly referred to Lekagul & Round (1991) and Robson (2002); reptiles species were identified base on Taylor (1963) and Cox *et al.*, (1998); and amphibian species were classified using Taylor (1962) and Chan-ard (2003).

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

B.1.7 Timing

Surveys were completed during the dry season March 2013 and wet season July 2013.

B.1.8 Aquatic Biota Survey

The Aquatic Biota survey aimed to determine the baseline fish biodiversity and aquatic resources of the Project Affected Area and the proposed offset sites. Sampling was conducted at different locations in Nam Ngiep, Nam Xan, Huay Ngua PPA and the Houy Soup resettlement area. This included 5 sampling sites (NNg1 through to NNg5) upstream of the proposed main dam and 3 sampling sites (NNg6 through to NNg8) downstream of the proposed main dam in the Nam Ngiep Catchment, 5 sampling sites (NX1 through to NX5) in the Nam Xan Catchment, 2 sampling sites (HN1 and HN2) in the Huay Ngua PPA and 2 sampling sites (RA1 and RA2) in the Houy Soup resettlement area.

In summary, the Aquatic Biota Surveys included:

- Collection of phytoplankton and zooplankton species using multiple plankton net surveys at each location, followed by preservation, identification and laboratory analysis at TISTR;

- Collection of benthos at multiple replicate sites using an Ekmann dredge, followed by identification and abundance counts at the TISTR laboratories; and,

- capture and identification of fish species within the main rivers and their tributaries using the help of local fishermen using multi-mesh gillnets, electrofishing, cast nets, gun and hook, as well as discussions with fishermen and other information sources.

Annex C

Species Specialist Acknowledgements

Table C.1 Species Specialist Input

Specialist	Relevant Species	Comment
Pheng Phengsintham (National University of Laos)	Flora species	Engaged to ground truth the access road and provide specialist comment for some candidate threatened flora species
Ajay Desai (Asian Elephant Specialist Group)	Asian elephant	Provided comment relating to the global and regional population, behaviours and threats. Provided advice to contact Lao PDR elephant specialist
Kham khoun Khounboline (WWF Greater Mekong)	Asian elephant	Provided specialist comment relating to the known elephant populations near the Nam Ngiep River and proximal important areas for the species
Daniel Challender (Pangolin Specialist Group)	Sunda pangolin	Provided alternative contact
Dr Christine Breitenmoser (IUCN Cat Specialist Group)	Cats	Provided alternative contact
Anthony Rylands (IUCN/SSC Primate Specialist Group)	Phayre's leaf monkey, Northern white cheeked gibbon, Red-shanked langur	Provided alternative contact
Carola Borries (Research Associate Professor)	Phayre's leaf monkey	Provided alternative contact
Dr Benjamin Rawson (IUCN/SSC Primate Specialist Group)	Northern white cheeked gibbon	Provided specialist comment relating to the number of known populations, expected habitat preferences and paucity of data in Lao PDR. Made recommendations for further targeted survey
Dr Phiavanh Phiapalath (IUCN/SSC Primate Specialist Group)	Phayre's leaf monkey, Northern white cheeked gibbon, Red-shanked langur	Engaged to undertake targeted threatened primate species survey in the project area and provide specialist comment (see report in Annex *D*)
Dr Will Duckworth (Independent Researcher)	All mammals, birds and some reptiles	Engaged to review species profiles and comment on critical habitat status for bird and mammal species. Provided specialist comment and feedback to refine species profiles
Dr Peter Paul van Dijkp (Tortoise and Freshwater Turtle Specialist Group)	Big headed turtle	Provided specialist comment relating to likely habitat areas in the Project area based on habitat preference and threats to the species as a result of the Project.
Adre Botha (IUCN/SSC Vulture Specialist Group)	White backed vulture	Provided alternative contact
Richard Hearne (IUCN SSC Duck Specialist Group)	White-winged duck	No advice
Baz Hughes	White-winged	No advice

Specialist	Relevant Species	Comment
(Wildfowl and Wetlands Trust)	duck	
Professor Gordon McGregor Reid	Fish species	Provided contacts
Dr Maurice Kottelat	Fish species	Engaged to review species profiles and comment on critical habitat status for fish species. Highlighted data gaps and subsequently engaged to undertake fast water habitat survey and report findings. Provided specialist comment for all fish species and feedback to refine species profiles.

Annex D

Targeted Primate Survey

Nam Ngiep 1 Hydropower Development Project

Surveys of Endangered Primate in the Inundation Area of Nam Ngiep 1 Project

Phaivanh Phiapalath, PhD

January 6, 2014

Table of Contents

1. Introduction

This report has been compiled to present results of surveys undertaken from 14 December 2013 to the 18 December 2013 for the presence, distribution and populations of endangered primate species within the inundation area of Nam Ngiep 1 Project (NNP1).

The NNP1 project is located in the triangle of Bolikhamxay, Xiengkhuang and Vientiane Province. This survey is a targeted survey to provide additional information to the EIA report as requested by the ADB to ensure that the endangered primate species and their associated habitats are identified and understood to allow for appropriate mitigation measures if any adverse impacts are identified.

Nam Ngiep Project 1 (NNP1) has an output of approximately 269 MW, the main project component consist of a relatively small reservoir (ca. 7,000 ha) with a width (0.5 km) and a length of the reservoir (ca. 70 km). The Nam Ngiep hydropower dam has its reservoir level of ca. 75 m above the river base or ca. 320 m above sea level. It is high terrace dam but narrow reservoir. There are only 6 villages and ca. 2,500 people to be resettled which is considered small population.

Nam Ngiep River flows through rocky mountain valleys as steep valleys in most parts. The river has four main tributaries, the Nam Chae, Nam Phong, Nam Siam and Nam khai as key watersheds. Another seven small tributaries have also been identified as important watersheds for NNP1. Along the river itself the proposed inundation area topography and land uses varies from section to section.

The majority of the project area is mixed deciduous forest and evergreen forest in upper mountains. The lower areas or foothills especially the upstream of Nam Chae and downstream of Nam Houy Keng Ngon are dominated by fallows, current slash and burn practice, and logging activities. According to the riparian forest characteristic the whole inundation area can be classified into 5 sections as following:

Table 1. Habitat description by sections

Section	Name of location range	Habitat description
1	Upstream of Nam Chae	Degraded habitat, fallows, bananas leaves, weeds
2	Nam Chae to Houy Kao	Some fallows, degraded habitat due to previous and current logging activity.
3	Houy Kao to Houy Keng Ngon	Quite good habitat, hilly valley, healthy riparian forest and also uphill mountains of both sides
4	Houy Keng Ngon to Houy heuafan	Some fallows and new slash and burn on the left bank and mid-lower mountain, all fallows in right bank, some logging activity.
5	Downstream of	Degraded habitat presence of grassland due to over slash

	Houy heuafan	and burn, some logging activity.

There are 11 villages located within the proposed inundation area, mainly in the upper part of the reservoir but only three villages in the lower reservoir. Due to these settlements the forest habitats of upper and lower reservoir have been modified.

NNP1 is situated in a remote area and as such a number of endangered species have been identified as potentially occurring within the project locality. Three endangered primate species have been identified from the previous biodiversity survey work as potentially occurring within the proposed inundation area of the NNP 1. This survey was conducted to establish the presence of these species and their related habitats within the inundation area.

2. Objective

- To conduct survey of Northern white cheeked Gibbon, Red-shanked Douc Langur and Phayre's Leaf Monkey in the inundation area;
- To obtain a population of the target primate species in the inundation area;
- Identify critical habitat that suitable for the target species in the project area.

3. Survey Species

Lao PDR is considered one of richest countries in terms of biodiversity in Southeast Asia. There are 24 National Protected Areas (NPAs) declared that are of conservation significance (see Fig. 1). The national protected area covers 15% of the country. Also, 49 national protection forests and over 100 provincial and district protected areas. These conservation forests support populations of critically and endangered wildlife species. Apart from these designated protected areas and protection forest it has production forest and also non-protected area. The NNP1 project area is within a non-protected area.

The Nam Ngiep project 1 area is a remote area that has been identified as potential habitat for three endangered primate species including Northern White-cheeked Gibbon, Red-shanked Douc Langur and Phayre's Leaf Monkey.

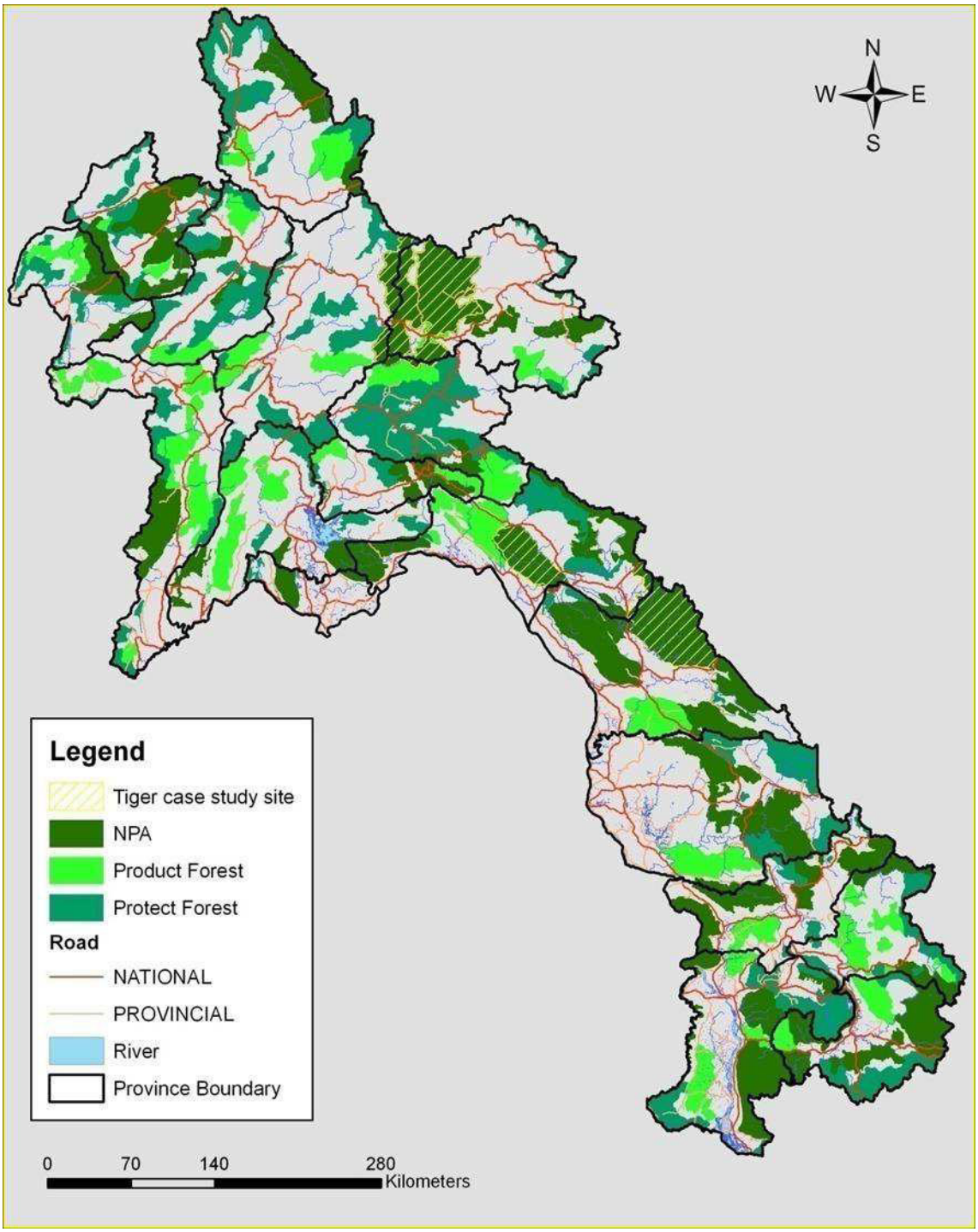


Figure 1. Map of three forest types in Lao PDR

Northern White-checked Gibbon *(Nomascus leucogenys)* - Critical Endangered

Globally: this species is critically endangered, found only in Lao DPR, China and Vietnam. Lao PDR holds nearly all of the world's remaining wild Northern White-cheeked Gibbons and may hold all the viable populations. In southern China, Xishuanbanna, Yunnan Province, close to Luang Namtha Province (Fan Pengfei *et al.* 2009) was confirmed but very low as it is probably on the verge of extinction in the wild. While, in Vietnam it has recently only been recorded in a few forests close to the Lao border, but the viability of all remaining populations is questionable. As such it is an outstanding global priority for conservation of this species.

Regionally: this species is endemic to southern China especially in Lao PDR. Within Laos, the species has been exist from northern part of Nam Kading NPA in Bolikhamxay Province which a range crossing from west at Mekong to northeast at Annamite Mountain Range as around northern Nam Kai Nam Theun NPA. Entirely this section up the northern country wide is believed to have only Northern white-cheeked Gibbon except the west of Mekong River where the distribution of White-handed Gibbon and Western Black crested Gibbon.
Nationally: the population of Northern white-cheeked Gibbon in Lao PDR is quite large as globally important population. It has a distribution range from the far north east of Lao PDR to the area of the Nam Kading River in Nam Kading NPA (Thinh *et al.,* 2010). There are several National Protected Areas (NPA) that the species' range within Lao PDR including Nam Et–Phou Louey NPA representing surely the largest patch of little-encroached and effectively managed habitat for the species. It is reported about 15 groups (WCS, 2010) found in a small proportion of the NPA but the entire gibbon population has not been estimated. Nam Kading may also hold considerable populations of this species. In both Nam Kading and Nam Et-Phou Louey NPAs the crested gibbons are key species for management and ongoing conservation is confirmed through donor support and technical input from the Wildlife Conservation Society (WCS). Populations of this species is persist in the Nam Xam NPA. The small numbers in Phou Den Din NPA, Phou Khao Khoay NPA, Phou Sabot Pongchong and Phou Phanang NPA. In addition, Thinh *et al.* (2010a) considered that *N. leucogenys* still exists outside the NPA system in northern Lao PDR in Oudomxay Province, Vangvieng District and also northern Bolikamxay Province that joins with Vientiane Province.

This species spends most time in trees and prefer most in evergreen forest. They give song in early morning and most active from November to March. They need the habitat, canopies connected for traveling. They feed on wild fruits as *Ficus* tree is best but they do rarely descend on the ground. Where a wide river that has no gallery forest of both sides closing to each other is a barrier for the species to cross so most a wide river such as Nam Ngiep River is already a barrier for the gibbon groups present in both river sides. It has a home range of ca. 40 ha but depends on habitat quality. Where best habitat quality and high

density of gibbon groups their home range is smaller than other site with low habitat quality. Estimated records of groups size of gibbons in Laos are at Hin Namno NPA is 3.8 (Phiapalath, 2009) and 3.6–3.8 for the Western Black crested Gibbon in Nam Kan NPA (Geissmann, 2007).

Red-shanked Douc Langur *(Pygathrix nemaeus)* - Endangered Species

Globally: this species is endemic to Indochina as only Lao PDR, Vietnam and Cambodia. In Vietnam, Red-shanked Douc Langur was found in Bach Ma National Park (Pham, 1993b), Phong Nha Ke Bang National Park (Pham *et al*., 2000), Phu Mat Nature Reserve (Lippold, 1998), Kong Cha Rang Nature Reserve, Kon Khi Kinh Nature Reserve (Lippold, 1995), and Son Tra Nature Reserve (Lippold, 1977; 1995). These places are mainly in Vietnam's Central Highlands with altitude between 500–1,000 m above sea level (Timmins and Duckworth, 1999).

Regionally: this species is just the same status as the global status since it is endemic to only the Indochina which cannot be found elsewhere in the world.

Nationally: In Lao PDR, their habitats lie between 14˚25´ and 18˚25´ N as Nam Kading NPA is the most northern range of the species (Timmins and Duckworth, 1999). By province, the species distribution is in Bolikhamxay Province toward southern provinces. They can be found along the Vietnam border in the east, from Nam Chat catchment to the Cambodian border in the south (Timmins and Duckworth, 1999). Recently, the species has been recorded in Laos and that confirmed at 12 locations ranging from 200 to 1,500 m a.s.l., (Timmins and Duckworth, 1999). Specifically, Nakai-Nam Theun National Protected Area and Hin Namno National Protected Area support the largest population of the species in the world (Duckworth *et al.*, 1999; Timmins and Duckworth, 1999). A small to medium population of Red-shanked Douc Langur has also been reported at other eight sites in Laos including Nam Kading National Protected Area in Bolikhamxay Province, Phou Xang He and Dong Phouvieng in Savannakhet Province, Xe Bang Nuan and Sesap in Saravanh Province, Dong Hua Sao in Champasak Province, Dong Ampham and Nam Kong in Attapeu Province, and Phou Ahyon in Sekong Province (Duckworth *et al*., 1999; Timmins and Duckworth, 1999).

Red-shanked Douc Langur is found in similar habitats to Vietnam including limestone habitats (Duckworth *et al*., 1999; Timmins and Duckworth, 1999; Walston and Vinton, 1999). The Red-shanked Douc Langur is mainly found in primary forests but also in secondary forests. They can adapt to variety of forest types including semi-evergreen, hill evergreen, sub-montane evergreen, mixed deciduous, mixed evergreen and closed broad-leaved tropical forests (Lippold, 1998).

Red-shanked Douc Langur is diurnal and arboreal, as is normally found in the group of colobids, spending a major proportion of their daytime for feeding in the wild (Lippold, 1995) – both leaves and fruits. Also, the species mainly lives in the mid to upper levels of the forest canopy. Groups of Red-shanked Douc Langurs reportedly move through the forest canopy along established routes. An adult male is the group leader and all group members follow when he moves. Females and infants are often found in the center and juvenile males bring up the rear during their locomotion (Lippold, 1995; 1998).

This species spends most time in trees and prefer most in evergreen forest. They need the habitat with connected canopies for crossing. Where a wide river it is a barrier for the species to cross from one to another side because this specie is usually not descending on the group. This species is reported they descend on ground for feeding on ground in begin dry season (Phiapalath, 2009) and also use mineral licks (Rawson et al., 2011). Group size of Red-shanked Douc Langur varies depending on habitat and human disturbance. In the past, they lived in groups of 30–50 individuals (Lippold, 1995) in Vietnam. Groups as large as 50 individuals have been reported in Kong Cha Rang Nature Reserve and Kon Khi Kinh Nature Reserve (Lippold, 1995). It is normally a group size ranging18-40 in Lao PDR (Phiapalath, 2009). Nevertheless, in areas with high pressure of human activity, the group size is much smaller, with as few as 4-5 individuals (Lippold, 1998). The home range of the species ranges is ca. 250 ha (Phiapalath, 2009).

Phayre's Leaf Monkey *(Trachypithecus phayri)* - Endangered Species

Globally: this species is found in many countries including India, Bangladesh, China, Thailand, Laos and Vietnam (Bleisch, 2008; Ruggeri and Timmins, 1996). Population of this species is quite large as expand beyond Southeast Asia.

Regionally: this species is quite good population in the region and distributed in all countries except Cambodia. Thailand has three areas that this species reported (Houy Khakhaeng and Phou Khieo National Park and northern country (Borries et al. 2011). It is also found in central and northwest Vietnam.

Nationally: although Phayre's leaf Monkey live in evergreen forest and mixed deciduous forest. This species distributes in central to northern Laos (Timmins *et al*., 2011) as reported in 7 NPAs, mainly Phou Dendin, Nam Et-Phou Loey, Nam Phoui, Nam Kan NPA, Phou Phanang, Phou

Kha Ya (Duckworth et al. 2009, Phiapalath, 2012).

This species spends a majority of time in trees and descend to the ground for using mineral licks usually once for every two weeks. The species feed on leaves including bamboo buds and wild fruits. A group size of this species is quite large as ca. 30 individuals in Nam kan NPA but range 15-30. The home range according to the study group in Phou Kieo National Park is about 80 ha (Pages et al. 2011).

4. International Standard and Requirement

As to ensure sustainable investment and development there are several key international environmental standards for which the NNP1 project must follow:

- IFC Performance Standard 6
- ADB Environment and Social Safeguard (2009)
- World Bank Safeguard Policy

Under these environmental standards a project area must determine the presence of three habitat categories *Modified habitat, Natural habitat, Critical habitat.* These habitats may contain a large population of some or more fauna and flora as the habitat may support some critical ecosystem.

The international standards are concerned about the loss of critical habitats that could result in a reduction of a population of critically or endangered species. The IFC standard 6 recognizes that protecting and conserving biodiversity; maintaining ecosystem services and; sustainably managing living natural resources are fundamental to sustainable development.

Critical habitat are areas with High biodiversity value or High Conservation Value (HCV), including habitat required for the survival of critically endangered or endangered species according to IUCN Redlist 2013. It can be areas having special significance for endemic or restricted-range species; sites that are critical for the survival of migratory species; supporting globally significant concentrations, evolutionary processes or provide key ecosystem services; and areas having biodiversity of significance. Also, it is about those areas of international recognition such as Ramsar Site, World Natural Heritage including National Parks and National Protected Areas. Similarly, ADB and World Bank safeguards have to ensure the environmental soundness and sustainability of projects and to support the integration of environmental considerations into the project decision-making process (reference?).

No project activities should be undertaken unless;

(i) there are no measurable adverse impacts such as critical habitat;

(ii) the project is not anticipated to lead to a reduction in the population of any recognized endangered or critically endangered species;
(iii) (iii) no mitigation measures are designed to achieve at least no net loss of biodiversity and;
(iv) any lesser impacts are mitigated.

If a project is located within a legally protected area, implement additional programs to promote and enhance the conservation aims of the protected area. In an area of natural habitats, there must be no significant conversion or degradation, unless;
(i) alternatives are not available;
(ii) (ii) the overall benefits from the project substantially outweigh the environmental costs, and
(iii) (iii) any conversion or degradation is appropriately mitigated. A combination of actions, such as post-project restoration of habitats, offset of losses through effective conservation action.

5. Survey Methods

5.1 Survey Area and Locations

The survey area was the proposed inundation area with a focus on potential habitats of the target species starting from Nam Chae to the proposed dam site. The survey area for each site was within 1-2 km from the inundation area or the river. Four survey clusters were established in the proposed inundation area and surveys were conducted by five sub-survey teams (see Fig. 2).

Specific survey routes designed where potential habitats, mineral licks and where the species have been reported by local hunters. The survey was designed to cover all potential habitats associated with the inundation area.

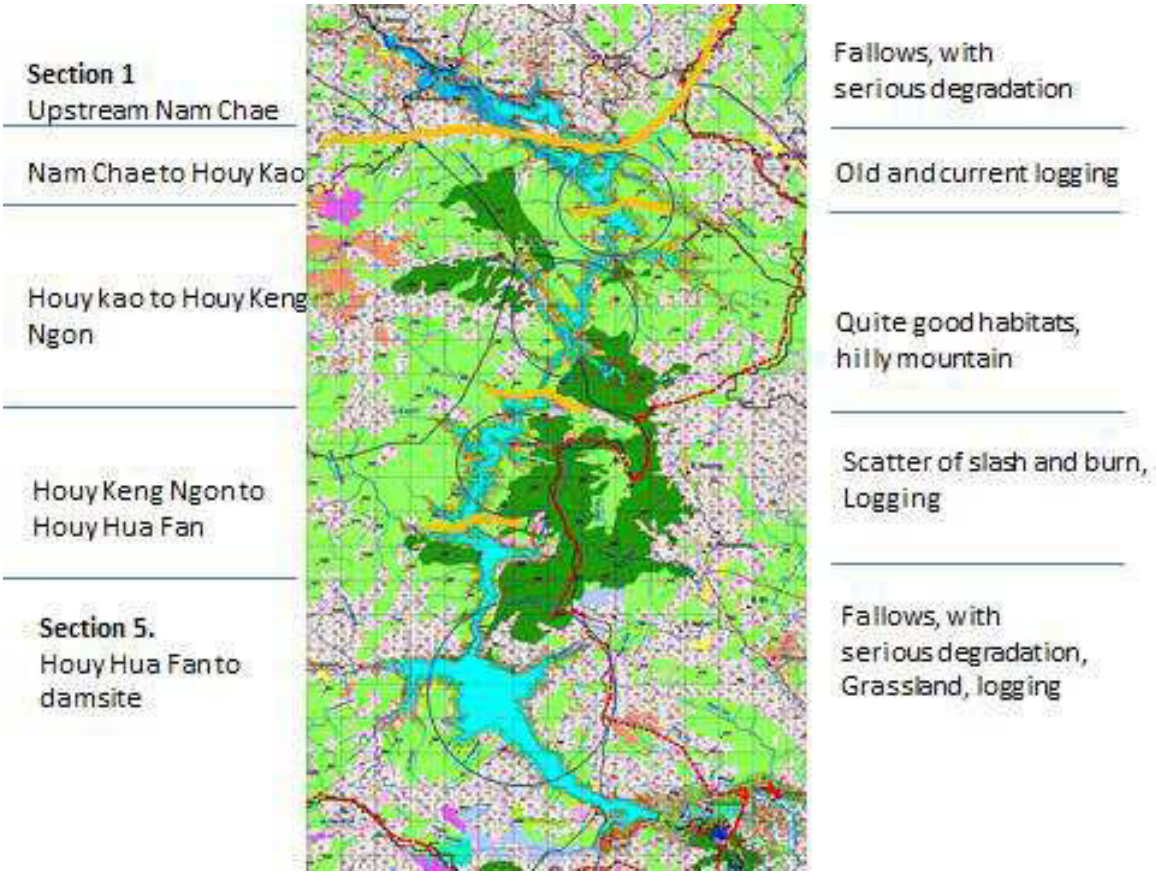


Figure 2. Map of the survey clusters

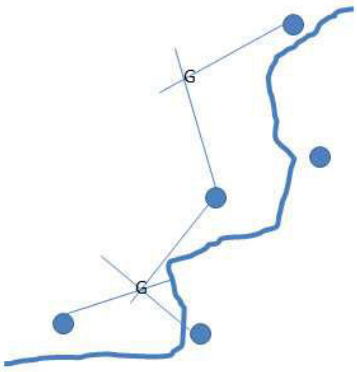
5.2 Survey Technique

Primate survey was conducted through direct field establishing listening post for gibbons and reconnaissance surveys for non-vocal primate. Additional data from village interviews was collected with boat men, hunters and elders in Ban Pou, Ban Sop phouan and Ban Sop Youak.

The surveys undertaken for other primate species which are quite different for gibbons as non-vocalization primates such as Red-shanked Douc Langur and Phayre's Leaf Monkey.

For the gibbon survey a listening post was established by each sub-team at predetermined locations that were selected based on vegetation type prior to the field trip. A total of 20 listening surveys were conducted in 5 listening posts. Each sub-team survey site were separated by about 2 km and camps were set at determined locations, waypoints to be recorded in their GPS. A short training session took place prior to departure at Ban Pou. All the sub-teams moved from the first survey cluster at Nam Chae down to the first survey cluster at downstream of Ban Sop Youak. The technique is to listen to gibbon song in early morning from 5.50 am to 7.30 am, using listening post data form. Song types and times, bearing from listen post and approximate distance were recorded. In areas with high

gibbon population more than one group would be heard. When gibbon songs are heard coming from different directions they are considered to be different groups if they start in different time. If from the same direction and same distance although more than one song, we will consider that it would be just one group. If a good call is heard we conclude that it is a group, otherwise a solo song is considered likely individual male. The distance of gibbon song locations are roughly estimated based upon how loud the song is heard, but no more than 2 km.



Given a small reservoir along the river straight, the survey for Douc Langur and Phayre's Leaf Monkey was for the total count technique as each sub-team to search for the target animals in their areas of responsibility within 1-2 km. In early morning while two persons recording gibbon song and other two people were surveying within 2 km around the camp. We used 7 sub-survey teams per day made a total of 28 sub-survey team days. Encounter a group of the target animals the site location, species and individuals of the group were recorded.

Figure 3. A sub-team 2 on listening post

Also, the two persons who had finished listening post they then started survey walk which each sub-team agreed who to go which direction from the camp and returned at 10.30 am. Direct observation, using binoculars for scanning through forest canopies or detect from seeing trees moving. Any evidence of the target species was recorded such as feeding at mineral licks by Phayre's Leaf Monkey. Data forms and guidebooks were used for the survey.

The distance from camp to camp was 2 km. Each team arrived next camp before 4.00pm and prepared their camp. Noise at camp was minimised to not disturb gibbons in the area as this would result in animals not singing in the morning.

A team wrap up was conducted in Ban Sop Youak on Dec 18, 2013 to the sub-teams findings. Each sub-team checked local names and recorded key waypoints.

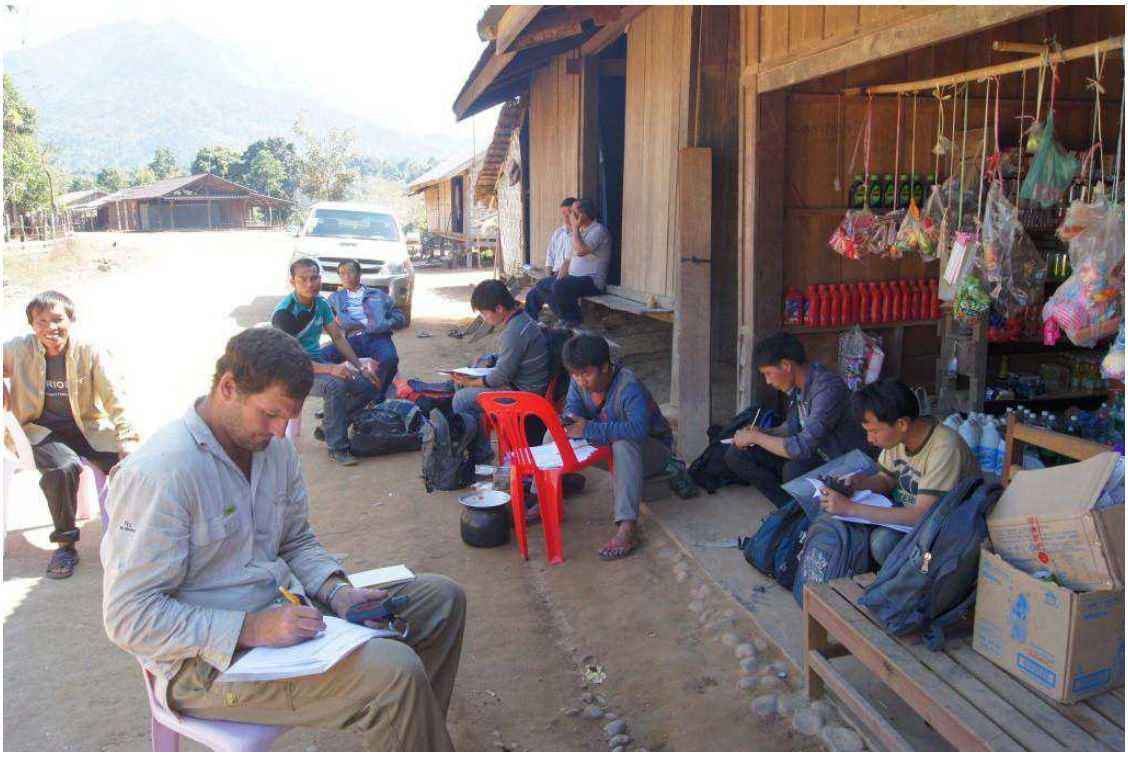


Figure 4. Data summary and wrap up at Ban Sop Youak

5.3 Data Analysis

Gibbon population

In principle, a number of groups recorded and average group size of the gibbon groups as the group size to be recorded from at least two cross-lines by two sub-teams. However, the survey found only two gibbon records at single listening post so we did not necessarily analyze the data.

Douc langur and Phayre's Leaf Monkey

As the total count technique for rare species which is based on a sum of total number of groups and individuals counted by sub-teams. However, we found only one evidence of the Phayre's Leaf Monkey but no douc langur was recorded nor reported during the survey.

5.4 Survey schedule

The field work started in Dec 13-18, 2013 as 4 days used for forest survey work.

Table 2. Itinerary

Date	Activity	Location
Day 1	Travel to Paksan	Paksan town
Day 2	Travel to Ban Pou, conducted short training and left for fieldwork by boat.	Ban Pou
Day 3	First camp, conducted listening post and survey walk. Completed the first survey cluster, continue to other survey clusters	
Day 4	Field survey continued	
Day 5	Field survey continued	
Day 6	Field survey continued, travel to Ban Sop Youak, wrap up and then Vientiane	
Day 7	Debrief to technical team of NNP1	NPP1 Office
Day 8	Present results to senior and manager teams of NNP1	NPP1 Office, video Conference with ERM team
Day 9	Prepared technical report	VTE
Day 10	Prepared technical report	VTE
Day 11	Present results of the surveys to ADB teams	NPP1 Office, video Conference with ADB
	Revise the draft report	
Jan 9	Submit the report	ERM,

5.5 Participants

There are about 49 participants include boatmen and from 6 organisations including Wildlife Conservation Association (WCA) as main technical assistance, ERM, NNP1, government officers (Thathom District, Xiengkhuang), solders of Thathom District, local villagers including boatmen.

Table 3. List of participants

No	Participant	Position	Organisation
1	Phaivanh Phiapalath	Consultant. Team Leader	Wildlife Conservation Association
2	Adam Greenhagh	Consultant	ERM
3	Mickxaykone Phiemmala	Team leader Assistant	Wildlife Conservation Association
4	Sisuthone Oupaxayorvanh	Team leader Assistant	Wildlife Conservation Association

5	Vilaysack Itiem	Team leader Assistant	Wildlife Conservation Association
6	Mr. Vongphanit Viengkeo.	Technician	DoNRE, Hom District.
7	Mr. Thongmee Boualapha	Head	DAFO, Thathom District
8	Mr. Va jeu xoing	Villager	Ban Sopyouak
9	Mr. Thong ku yang	Villager	Ban Sopyouak
10	Mr. Chao xoing	Villager	Ban Sopyouak
11	Mr. Tou xoing	Villager	Ban Sopyouak
12	Mr. Kaiy xoing	Villager	Ban Sopyouak
13	Mr. Bee xoing	Villager	Ban Sopyouak
14	Mr. Pao Dau her	Villager	Ban Soppouan
15	Mr. Lai phone lor	Villager	Ban Soppouan
16	Mr. Khamkai	Villager	Ban Pou
17	Mr. Ny	Villager	Ban Pou.
18	Mr. Ket	Villager	Ban Phiengta
19	Mr. Pheng	Villager	Ban Phiengta
20	Mr. Somphet	Villager	Ban Hatsamkhone
21	Mr. Chomphet	Villager	Ban Hatsamkhone
22	Mr. Air.	Villager	Ban Pou.
23	Mr. Hong	Boatman	Ban Pou
24	Mr. Lob	Boatman	Ban Pou
25	Mr. Thone	Boatman	Ban Pou
26	Mr. Syvone	Boatman	Ban Pou
27	Mr. Lou	Boatman	Ban Pou
28	Mr. Vieng	Boatman	Ban Pou
29	Mr. Puen	Boatman	Ban Pou
30	Mr. Aoth	Boatman	Ban Phiengta
31	Mr. Phouang	Boatman	Ban Phiengta
32	Mr. Phong	Boatman	Ban Phiengta
33	Mr. Aon	Boatman	Ban Pou
34	Mr. Xiengken	Boatman	Ban Pou
35	Mr. Peuy	Boatman	Ban Pou
36	Mr. Symone	Soldier	Thathom District
37	Mr Khammy	Soldier	Thathom District
38	Mr. Bounsouk	Soldier	Thathom District
39	Mr. Khamla	Soldier	Thathom District
40	Mr. Somvang	Soldier	Thathom District
41	Mr. Xaysomphet	Soldier	Thathom District
42	Mr. Somsay	Soldier	Thathom District
43	Mr. Soulivanh	Soldier	Thathom District
44	Mr. Ngon	Soldier	Thathom District
45	Mr. Vanhthaxay	Soldier	Thathom District
46	Mr. Souksavanh	Staff	NNP1PC
47	Ms. Chanmaly	Staff	NNP1PC
48	Mr. Chao xoing	Villager	Ban Sopyouak

49	Mr. Tou xoing	Villager	Ban Sopyouak

Figure 5. Boat trip arrangement and camping

5.6 Equipment

Table 4. List of equipment

No	Equipment
1	GPS (7 units)
2	Compass (5 units)
3	Topo map of a scale: 1:50,000
4	Cameras (5) and video (1)
5	Binoculars (5 units)
6	Compass (5 units)
7	Tape recorders
8	Guidebooks
9	First Aid Kit (5 units)
10	Hand held Talki walki (5 units)
11	Satellite phone (2 units)

6. Results

6.1 Description of habitats

Majority of the habitats along the reservoir straight have been modified to agricultural land especially the upper and lower reservoirs. The area that is far from settlement such as from Houy Kao to Houy Keng Ngon remains good riparian forest.

6.1.1 Habitats in the inundation areas

According to the field observation and reconnaissance surveys the habitats along the reservoir straight can be classified into 5 sections (see Fig. 2) as following:

Section 1: Upstream of Nam Chae, this section is large but not in our survey cluster due to existing habitats have been seriously degraded by conversion to agricultural area. Various ages of fallows including existing hill rice field were observed. This section is quite gentle so both foothills and upper mountain have been totally converted. Bananas trees were observed scattered along the section.

Figure 6. Degraded riparian habitat and fallows

Section 2: Nam Chae to Houy Kao where the first survey cluster took place. This section is small and considered degraded habitat as the foothills were converted to agricultural land and change in forest canopies due to logging. Old logging road was observed in Upper Mountain of this section. It is mixed deciduous as highly dominated by bamboo forest. One mineral lick (Pong Chae) was found in this section. However, no evidence of wildlife using this mineral lick were identified and that consequently was overgrown with weeds. One small area of salt soil was found in this section.

Figure 7. Degraded forest habitats

Figure 8. Degraded forest canopies and old logging road

Figure 9. Old mineral licks (Pong Chae) and salted soil

Section 3: Houy Kao to Houy Keng Ngon where the second survey cluster took place. This section is large and considered good forest habitat as mixed deciduous forest in lower valley and evergreen in Upper Mountain. Riparian forest is still in good condition and also Upper Mountain although some old logging road was found in this section. The left bank of this section, a high density of fig trees were found as this tree is critically important for any wild animals by providing fruits all year round, fig trees were found along the survey routes of the team 1 of day 2 (T1.2). Also, the right bank a portion of evergreen forest away in uphill mountains was reported a presence of gibbons and Phayre's Leaf Monkey.

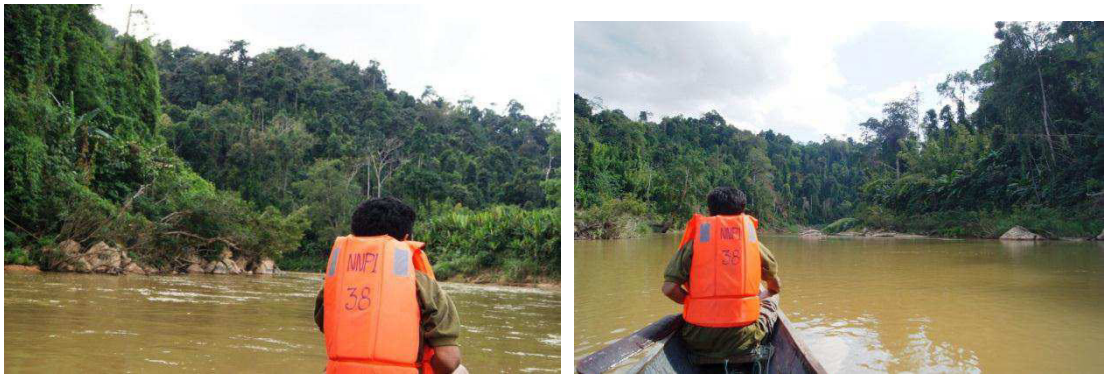


Figure 10. Good riparian forest

Figure 11. Good forest habitat

Figure 12. Fig tree (Ficus, Moraceae)

Section 4: Houy Keng Ngon to Houy huafan where the third survey cluster took place. This section is considered degraded forest habitat as portion of hill rice fields and fallows was found especially the right bank of the river has been totally converted to agricultural land while only new hill rice field found in scatter in the left bank. Evergreen in Upper Mountain remain some good habitat in the left bank such as Pha Phanong which team 3 reached the area and considered good evergreen forest (UTM 2081230/334861).

Figure 13. Portions of hill rice filed and fallow

Figure 14. Portion of forest habitat conversion

Section 5: Houy Huafan to Damsite where the fourth survey cluster tool place. This section is large and considered degraded forest habitat due to slash and burn practice such as the team 3 camped at Phou Khapha (UTM: 2068418/334585) certified as all follow in the

lower area. Most lower valleys were converted to agricultural land but some portion of evergreen forest can be found in Upper Mountains. Logging was observed in this section.

Figure 15. Degraded forest habitat

Figure 16. Habitat conversion, grassland

In conclusion, the proposed flooded area is not considered natural habitat, and consists of mainly old fallows, agricultural land and some riparian forest. There was no critical habitats or terrestrial ecosystem identified in the project area. The mineral licks are considered part of critical habitats, however, evidence of recent use was not recorded. Upper Mountain areas where the distribution of evergreen forest species was more abundant would be classed as a critical habitat if a number of endangered wildlife species are present, however given the lack of species presence and the relative condition of these areas only small population of endangered species is found in the area.

6.1.2 Records of the Endangered Primate Species

No Red-shanked Douc Langur was found nor reported. Nam Ngiep Project 1 is not in the distribution range of the species. the survey map is found in Annex.

Two records of gibbons during the survey from songs in morning. The first record by sub-team 2 at Houy Kao area heard gibbon song from northeast for about 1.5 km away and second record by sub-team 1 Houy Chili area heard gibbon song from northeast for about 2 km away. The local villagers believed that the second song would be from Phou Phahua. These groups were heard from upper mountains of the left bank.

Table 5. Listing post records of Northern White-cheeked Gibbon

Date	Location name	Coordinates		Time of song		Direction, Bearing	Distance (km)
		N	E	start	finish		
17/12/2013	Houy Kao	2069000	337719	6.10	6.30	NE, 60°	>1.5 km
18/12/2013	Houy Chili	2074329	334263	7.05	7.20	NE, 44°	2 km

According to the provisional data, 5 groups of this species were reported throughout the project area – both sides but predominately in the upper mountain areas which are away from the inundation area. There will be two groups in evergreen forest of Phou Thin and Phou Sam Liem of the far right bank and other three groups in evergreen forest of Phou Phahua and Phanoy of the left bank. Populations of this species are already fragmented by the river and habitat conversion.

One evidence of Phayre's Leaf Monkey was recorded on December 16, 2013 by sub-team 5 at Pong Chor (mineral lick) UTM: 2096370/342601 from hand prints as were found on the bamboo tree. The hand print of this animal is smaller and longer hand print compared to other sympatric primate. During the survey this species was well reported and that it was shot occasionally by hunters. One was shot last year at Houy Khai which a picture of the dead animal was taken.


Figure 17. Handprint of Phayri

According to the provisional data, there are about 10-13 groups present in the NNP1 watershed as below:

Location	Estimate Group	Left or right bank
1. Houy Chae area	1	left
2. Houy San area	1	right
3. Houy Khai area	3	right
4. Houy So area	1	left
5. Houy Lang Nong area	1	right
6. Pong Chor area	2	left
7. Houy Wai area	1	right
8. Pong Dinkhao area	1	left
9. Phou Phaheua	2	left
10. Phou Phanoy	2	left

About 6 groups of Phayri were reported in the right bank and other 7 groups in the left bank. The populations of Phayre's Leaf Monkey in both sides of Nam Ngiep River have already been fragmented.

Phayre's Leaf Monkey used mineral licks as part of its behavior ecology. The animal uses a mineral lick for food digesting. Mineral licks were surveyed and identified along the river. There are 10 mineral licks, of which 3 mineral licks are used by wild animals including Pong Xang, Pong Chor, and Pong Din kao. These mineral licks are known by local villagers. The mineral licks that are not used by wild animals today are due to the habitats surrounding the mineral licks being converted. Mineral lick is not only important for this langur but also other wildlife species particularly ungulate group.

Figure 18. Pong Sa, old mineral lick

No	Name of mineral licks	Coordinates (UTM)	Elevation (m)	Remarks
1	Pong Chae	2101417/0342528	319	flooded
2	Pong Sa	2101338/0342220	320	flooded
3	Pong Xang	2096370/0342601	316	flooded
4	Pong Chor	2096591/0343145	314	flooded
5	Pong Din deng	2099057/0342108		flooded
6	Pong Lang nong	2092468/0337406		flooded
7	Pong Houy hok			
8	Pong Din kao	2078410/0329472		flooded
9	Pong Keua	2005021/0334840		flooded
10	Pong Houy Chili			

These mineral licks will be flooded but some mineral licks were reported in Phou Thin and Sam Liem area of the right bank will remain after inundation. It is believed that another

side of Phou Phanoy and Phou Phaheua around Nam Ma River may have some mineral licks. The mineral licks in these areas that are not flooded will be used by the animals.

6.2 Records of some vulnerable species

There are three vulnerable species were recorded by chance during the survey including Stump-tailed Macaque, Northern Pig-tailed Macaque and Sambar Deer. There are 2 records of Stump-tailed Macaque from feeding sites (UTM 2100721/0342698; 2069692/0337253), 2 records of Northern Pig-tailed Macaque from hand print in soft soil UMT 20941432/ 0339279; 2080048/0331580. One Northern Pig-tailed Monkey was shot dead during the survey by local hunter on 17 December, 2013. Sambar Deer was recorded 4 times (UTM 2101338/0342220; 2096591/0343145; 20941432/0339279; 2088511/0341116).

Figure 19. Pictures of vulnerable species

Figure 20. Evidence of Stumped-tailed Macaque and Northern Pig-tailed Macaque

6.3 Key wildlife habitats

The key wildlife habitats that the gibbons and Phayre's Leaf Monkey were reported are in Phou Thin, Phou Pha Noy, Phou Pha hua, Phou Sam Liem. These locations are mainly evergreen forest and some mixed deciduous forest. Also, important watershed for NNP1.

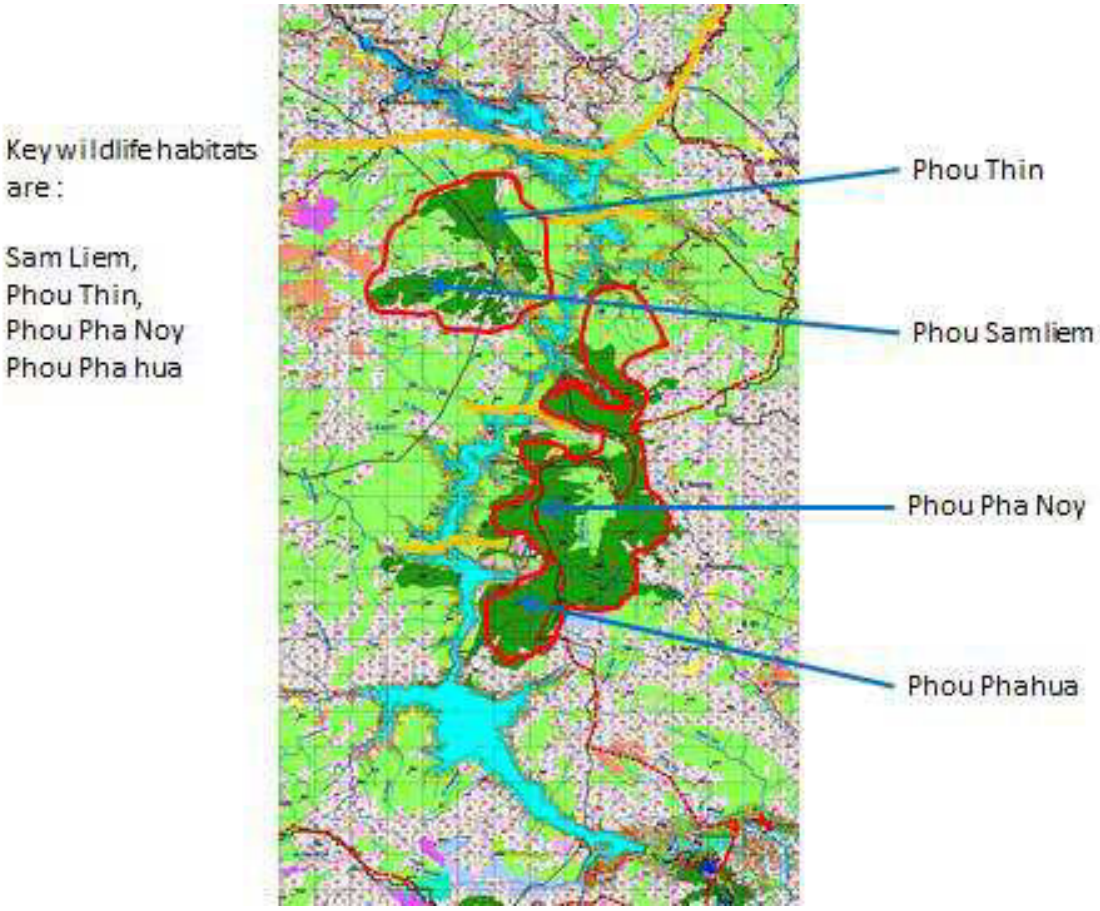


Figure 21. Map of the important wildlife habitat

6.4 Threats

Threat to wildlife and wildlife habitat is high in the area. Logging camps were found at Nam Chae, upstream of Ban Sop Phouan, downstream of Ban Sop Youak. According to the village interviews, Lao private firm receive quota for logging from the government but Vietnamese Loggers are hired to do log in the area. Hunting is common and that we found a number of gun man still holding a local gun. Hunting Phayre's Leaf Monkey is well reported in the area so the pressure from hunting is high in the area. Most hunters are local hunter, the Hmong people mainly in Sop Phouan, Sop Youak, and also Ban Pou and Ban Phiangta. Slash and

burn practice is an issue which made most forest habitat of upstream and downstream reservoir converted.

Figure 22. Logging camp of Vietnamese

7. Discussions

Nam Ngiep Project 1 hydropower project area has low biodiversity value. There has no particular critical habitats identified in the project area. Although gibbons are present in the project area their habitats are not be relevant to the inundation area. Population of this species remains very low in the area.

Phayre's Leaf Monkey has some minor impact due to their mineral licks will be flooded but mitigation measures are possible. The Phayre's Leaf Monkey population in Nam Ngiep project area is considered low. The global population of this species is large and distributed in many countries including India and Bangladesh. Therefore, the population of this monkey in the Nam Ngiep Project 1 is not significant. Apart from this in Lao PDR, the species is recorded in 7 National Protected Areas (NPAs) and some outside NPAs particularly the northern country. Once, the species will not impact by the development of Nam Ngiep 1 project. With availability of biodiversity offset plan by enhancing forest habitat and ban on wildlife hunting in the area will help better protect the species.

8. Recommendations

- Habitat rehabilitation as to make connectivity by leaving fallows to naturally grow and enrich where necessary.
- Artificial mineral licks to be established where possible especially in the area close to water body, mud flat etc. The potential location should be further identified and that the area is closed to the important habitats of Phayre's Leaf Monkey.
- Ban on wildlife hunting wildlife in the project area which regulation of wildlife and forest management should be developed.
- Develop a biodiversity offset plan for watershed protection, forest management and to support relevant local government departments for effective management of the Nam Ngiep watershed
- Ensure soil erosion protection in place (*Kok kkai*)

Figure 23. Mai Khai, as natural bank protection tree

Ensure maintaining flows of the main tributaries as to maintain fish breeding site when most part of Nam Ngiep is lost to the inundation.

Figure 24. Nam Hok, the small tributary of Nam Ngiep

9. Conclusion

NNP1 is a small and long reservoir thus is considered good dam according to the World Bank publication (Ledec & Quintero 2003) due to its small reservoir, narrow and length with minor impacts on natural habitats. Minor impacts would occur on only Phayre's Leaf Monkey and there would be no impact on the gibbons within the project area due to the low populations in the project area, and those populations being predominately located outside of the inundation area. Therefore, the development of Nam Ngiep 1 hydropower project will comply with international standard of IFC and safeguard policies of the World Bank as well as the ADB regarding *terrestrial biodiversity*.

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Annexes

Data forms

Listening post data form

Date	Location name	Coordinates		Time of song		Direction	Distance (km)	Type of song	Notes
		N	E	start	finish				

Observation data form for reconnaissance

Date	Time	Location name	Coordinates		Species (G, D, L)	Individual	Total estimate	Activity	Habitat type, distance from the river
			N	E					

Waypoints

❖ **Team 1**

- **Survey Camps**

ID	X	Y
1	342143	2100586
2	340230	2093334
3	335913	2086154
4	334263	2074329

- **Survey Pionts**

ID	X	Y
1	342199	2100662
2	342698	2100721
3	343043	2100941
4	342692	2101035
5	342620	2101192
10	340179	2091968
11	340203	2091846
12	340433	2091636
13	341206	2091923
14	335918	2086166
15	335851	2086250
16	335603	2086256
17	335498	2086186
18	335724	2085849
19	334377	2074072
20	334429	2074014
21	334513	2073988
22	334553	2074036

ID	X	Y
1	342035	2100568

2	342027		2100570
3	350018		2063605
4	340081		2092098
5	339869		2091904
6	335930		2086192
7	335931		2086192

ID	X	Y
1	342419	2100835
2	342419	2100686
3	342866	2100851
4	340286	2092934
5	340236	2092504
6	340484	2092057
7	340881	2091991
8	340137	2092470
9	334978	2086028
10	335342	2086028
11	334776	2074085
12	334958	2074003

- **Team 2**

- **Survey Camps**

ID	X	Y
1	342493	2099442
2	334300	2090263
3	333223	2080964
4	337719	2069000

- **Survey Points**

ID	X	Y
1	342027	2099954
2	334506	2090611
3	334400	2090839
4	333222	2080961

5	337252	2069692
6	337653	2069367
7	337653	2069367
8	337252	2069642
9	337252	2069642
10	342499	2099452
11	342496	2049476
12	342493	2099442
15	333550	2080614
16	334561	2090855
18	337252	2069692
19	337482	2069629
20	337555	2069429
21	337724	2068916
22	342457	2099878
23	341698	2099726
24	333915	2090983
25	332803	2081430
26	333207	2081835

❖ **Team 3**

- **Survey Camps**

ID	X	Y
1	340690	2094950
2	334041	2085549
3	334861	2081230
4	334584	2068418

- **Survey Points**

ID	X	Y
1	340413	2094950
2	340254	2095188

3	339817	2095268
4	335410	2080838
5	335749	2080792
6	335428	2081078
7	333486	2085436
8	333129	2085674
9	332851	2085992
10	332415	2085992
11	331780	2085436
12	335232	2081150
13	335590	2081309
14	335431	2081706
15	335153	2081706
16	334042	2068577
17	333685	2068498
28	333288	2068458
29	333010	2068140
20	332732	2067863

❖ **Team 4**

- **Survey Camps**

ID	X	Y
1	339863	2091303
2	339243	2089391
3	333317	2079725
4	333795	2067348

- **Survey Points**

ID	X	Y
1	339279	2094132
2	341116	2088511
3	331580	2080048
4	332476	2066630

5	339558	2089556
6	339916	2089357
7	340313	2089119
8	340828	2088961
9	341067	2088087
10	333685	2066910
11	333327	2066910
12	333010	2066831
13	332613	2067069
15	332692	2079991
16	332415	2079991
17	332137	2080110
18	331145	2080229
19	339360	2091191
20	339201	2091389
21	339201	2091667
22	339003	2091437
23	338804	2091794
24	339042	2091874

❖ **Team 5**

- **Survey Camps**

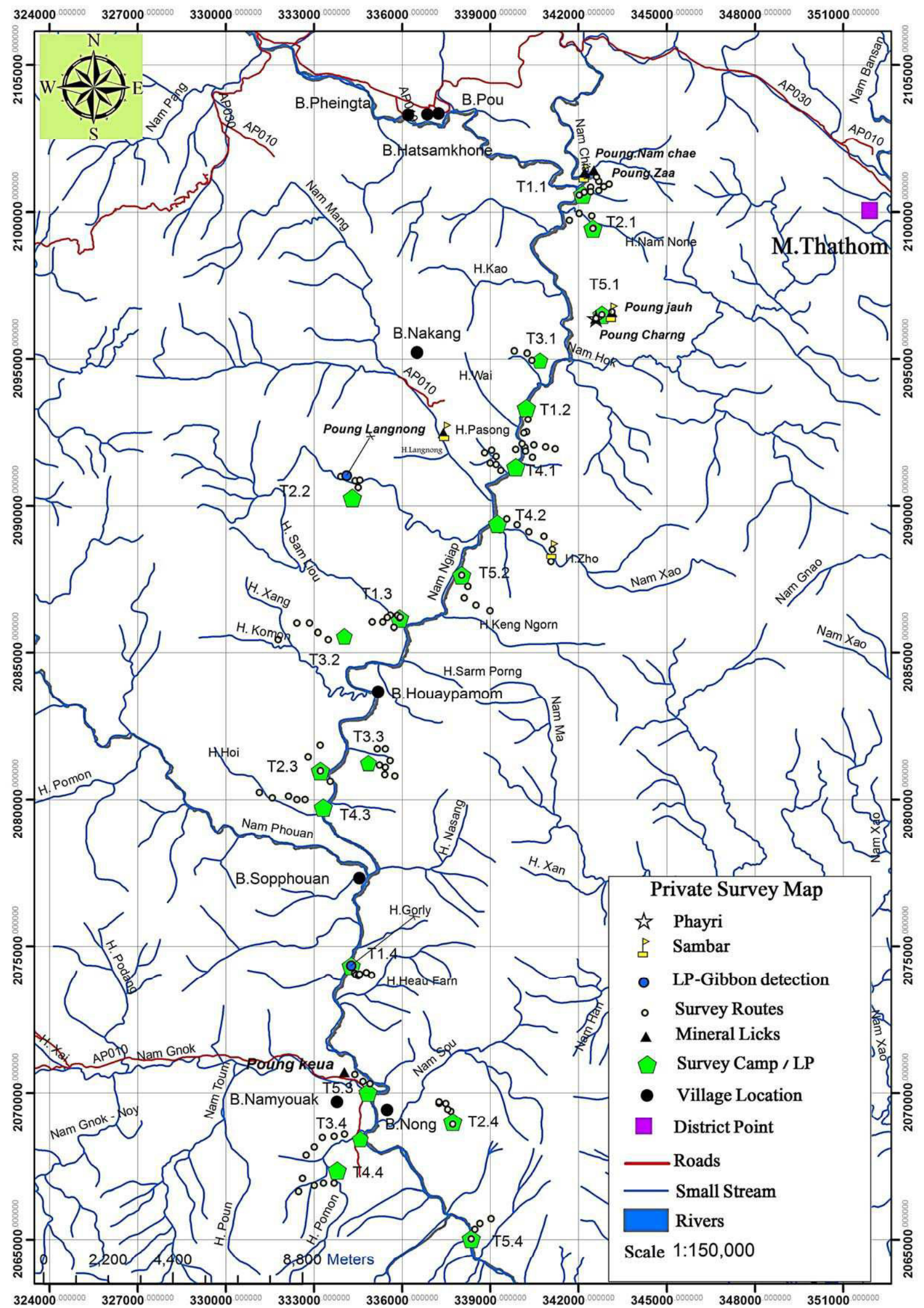
ID	X	Y
1	342800	2096490
2	338023	2087620
3	334840	2070018
4	338356	2065021

- **Survey Points**

ID	X	Y
1	342800	2096490
2	342601	2096370
3	343145	2096591

4	338023	2087620
5	338118	2086850
8	338356	2065021
9	338650	2065546
10	338475	2065348
11	339031	2065705
12	334903	2070309
13	334665	2070389
14	334387	2070627
15	338237	2087240
16	338515	2086605
17	338991	2086407

Data forms


N
W
E
S
B.Pheingta
B.Pou
B.Hatsamkhone
B.Nakang
B.Houaypamom
B.Sopphouan
B.Namyouak
B.Nong
M.Thathom
Poung.Nam chae
Poung Zaa
Poung jauh
Poung Charng
Poung Langnong
Poung keua
H.Nam None
H.Kao
H.Wai
H.Pasong
H.Langnong
H.Zho
H.Keng Ngorn
H.Sarm Porng
H.Hoi
H.Gorly
H.Heau Farn
T1.1
T1.2
T1.3
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T5.4
Nam Pang
Nam Mang
Nam Chia
Nam Hok
Nam Ngiap
Nam Xao
Nam Gnao
Nam Bansap
Nam Ma
Nam Phouan
Nam Gnok
Nam Gnok - Noy
Nam Toum
Nam Spu
Nam Han
H. Sam Kou
H. Xang
H. Komon
H. Pomon
H. Nasang
H. Xan
H. Podang
H. Xai
H. Poun
AP010
AP030
Private Survey Map
Phayri
Sambar
LP-Gibbon detection
Survey Routes
Mineral Licks
Survey Camp / LP
Village Location
District Point
Roads
Small Stream
Rivers
Scale 1:150,000
0
2,200
4,400
8,800 Meters
324000
327000
330000
333000
336000
339000
342000
345000
348000
351000
2105000
2100000
2095000
2090000
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2080000
2075000
2070000
2065000

Annex E

Specialists Fish Survey Reports (Kottelat, 2014; Warren 2014a; Warren 2014b)

Survey of fishes in fast water habitats in Nam Ngiep 1 project area

prepared by

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MARCH 2014

Table of contents

1 Summary

The fishes of fast water habitats of the Nam Ngiep inundation zone were surveyed in January–February 2014. Samples were also obtained in adjacent drainages (Nam Mang, Nam Xan and Nam Xao) to obtain information on the distribution of the endemic species.

The survey recorded 53 fish species in the NNP1 inundation zone. Two species were not observed, but reliably reported. The survey found 4 species new to science (unnamed), two of them in the inundation zone and 2 above FSL. An additional 4 species present difficulties of identification and are potentially new to science too..

Five species are known only from the Nam Ngiep drainage. The identity of four additional species is still not clear and they are potentially endemic to the Nam Ngiep drainage. For three of them, the same or a similar species (unnamed) is known from the Nam Ngum and/or Nam Mang drainages. None of the observed species is known only from the area to be inundated.

Four of the species of concern are known in the inundation zone and headwaters, or only in headwaters. The species are expected to survive the impacts of NNP1 project, provided that significant areas of their habitats (torrents, hill streams and small forest streams) remain intact. For species known only from the inundation zone or also until about FSL, they are expected to survive if stretches of several of the main tributaries remain intact at and above FSL for some distance.

Schistura crabro was earlier considered to be endemic to the Nam Ngiep. The survey did not observe it in the Nam Ngiep but was found at two sites in the Nam Xan.

The giant pike-carp *Luciocyprinus striolatus* is present in the inundation zone. It is assessed as EN (endangered) in IUCN's Red List. Work must now be undertaken to determine whether or not the Nam Ngiep is a Critical Habitat for the species; work should consider the number of populations globally, the number of 'discrete management units' and their environment quality and threats. Mitigation to the impact of NNP1 project on this species could include research to increase knowledge on the biology of the species and habitat requirements, develop methods for artificial reproduction, and possibly habitat modification to protect or create spawning sites.

2 Introduction

The diversity of inland fishes in Southeast Asia is very high, with more than 1000 species known from western Indonesia (Kottelat et al., 1993; Kottelat & Whitten, 1996a) and some 900 known from mainland Southeast Asia (Kottelat, 1989). Despite this high diversity and their importance for humans, our knowledge of fish biology over most of Asia is still very incomplete and often is restricted to mere lists (Kottelat & Whitten, 1996b). Large areas are still unsurveyed.

The information on Laotian fishes published in the scientific litterature is still limited. Scientific surveys of the fish diversity started in the mid 1990s in conjunction with hydropower development. Unfortunately most of this information is of limited quality and not openly available.

Hydropower projects are usually installed on rivers with a high gradient and the inundated stretches of rivers are mainly characterized by fast to very fast waters, with rapids and waterfalls. These fast water habitats (= rheophilic habitats) are inhabited by aquatic animals specialised for these strong current conditions; most of them are unable to adapt to slow flowing or standing water and will disappear with inundation of the reservoir and reduced flow downstream. However, EIAs often neglect this rheophilic fauna, mainly because the sites are difficult to access and to sample.

This report presents the observations on fish diversity made during surveys conducted in January and February 2014 in the Nam Ngiep 1 project area and discusses impacts of the project in the rheophilic fauna and possible mitigations.

3.1 Survey participants

Dr Maurice Kottelat, fish taxonomist
Mr Thavone Phommavong, Living Aquatic Resources Research Center, Vientiane
Mr Soukhsavan _____, NNP1PC

Mr Adam Greenhalgh, ERM
Mr _____, Division of Fisheries, Vientiane

3.2 Methods and terminology

Most fish samples were obtained with a Grassl IG200/2 battery-powered electric fish shocker and with ichthyocides. Additional material was obtained by push-net and seine, and by inspecting catches of villagers and kitchens of restaurants. Ichthyocides were used to obtain samples from habitats that could not be sampled by other means (crevices, rapids, etc.); they were used only where their effect could be entirely controlled and where the river topography allowed an immediate dilution below toxicity level immediately downstream of the sampled area.

The sites were accessed by boat or by car. The Nam Ngiep itself could not be sampled between the dam site and Ban Sopyouak as it cannot be travelled by boat and there is no access by car. Access to tributaries on the west side was not possible upstream of Ban Pouan for security reason.

Identifications and nomenclature follow mainly Kottelat (2001), updated with knowledge acquired posteriorly (compiled in Kottelat, 2012, 2013).

Species are recorded only under their scientific names; these are made of two words, written in italics, and follow the International Code of Zoological Nomenclature. For species that present identification problems, the term 'cf.' is added between the generic name (the 'first name' written with a capitalised initial) and the species name ('second name') to refer to populations which are likely to belong to the species referred to but whose identification is not yet certain because of unresolved taxonomic problems. For example, what is referred to as *Oreoglanis* cf. *delacouri* is possibly *Oreoglanis delacouri* but a soubt subsists and more work, or more material, or more populations are needed to be absolutely sure. The term 'aff.' (for 'affinis') denotes populations that cannot be identified with any species known to me, or which probably are new species (that is unnamed, without scientific name). The use of 'aff.' is to ally this possibly new taxon with what is possibly its closest species. For example, *Schistura* aff. *ephelis* indicates that the species is distinct but close to *Schistura ephelis*. 'sp. n.' is used for species new to science, that is, species that have not yet received a formal name. For example *Glyptothorax* aff. *zanaensis*.

The term "sp." means an unidentified species. For example *Schistura* sp. indicates a species of *Schistura*, which cannot be identified at the species level, for example very small juveniles or mutilated individuals.

Spelling of names of villages and streams follow the 1985 1:100,000 Lao P.D.R. topographic maps, when feasible. Co-ordinates were obtained with four different GPS (two of them mounted in camera) and, in a few cases, from the maps. Datum: WGS 84, UTM zone 48. *Altitudes listed below are only indicative*; they were measured with these two GPS; they often differed and they also differed from those indicated in other documents and maps, or those obtained from Google Earth. The amplitude of the differences varied between 1 to 20 meters. As a result, some samples obtained around FSL may be somewhat above or below.

In the discussion, the word *endemic*, used as either a noun or an adjective, means: whose distribution is restricted to a geographically limited area. For example, a species endemic to the Nam Ngiep is a species that has been observed only in the Nam Ngiep drainage.

3.3 Abbreviations

FSL	Full Supply Level
IUCN	International Union for Conservation of Nature
MOL	Minimum Operation Level
NNP1, NNP2	the 2 hydropower projects on the Nam Ngiep
NNP1PC	Nam Ngiep 1 Power Company

4 Results of survey

4.1 Collecting sites and observed species

Sampling sites are numbered in chronological sequence. The sites are organised in the following order: NNP1 inundation zone; Nam Ngiep drainage above FSL of NNP1; and sites outside NNP1 project area (Nam Mang, Nam Xan, Nam Xao). Species are listed in alphabetical order of families, genera and species.

4.1.1 Nam Ngiep in NNP1 inundation zone

14-001 Nam Chae, immediately upstream of confluence with Nam Ngiep, about 7.5 km downstream of Ban Pou; 18°59'39.5"N 103°30'00.0"E, 300 masl; 28 Jan 2014.

Balitoridae	*Homaloptera yunnanensis*
Cyprinidae	*Onychostoma* aff. *gerlachi*
Cyprinidae	*Scaphiodonichthys acanthopterus*
Nemacheilidae	*Schistura* aff. *ephelis*
Sisoridae	*Glyptothorax horai*
Sisoridae	*Glyptothorax laosensis*
Sisoridae	*Glyptothorax* aff. *zanaensis*
Sisoridae	*Pseudecheneis sympelvica*

14-002 Houay None, immediately upstream of confluence with Nam Ngiep, about 9 km downstream of Ban Pou; 18°59'06.9"N 103°29'39.8"E, 279 masl; 28 Jan 2014.

Channidae	*Channa gachua*
Cyprinidae	*Barbodes aurotaeniatus*
Cyprinidae	*Danio acrostomus*
Cyprinidae	*Esomus metallicus*
Cyprinidae	*Opsarius pulchellus*
Cyprinidae	*Osteochilus striatus*
Cyprinidae	*Poropuntius* aff. *carinatus*
Cyprinidae	*Puntius brevis*
Cyprinidae	*Rasbora atridorsalis*
Cyprinidae	*Rasbora rubrodorsalis*
Cyprinidae	*Scaphiodonichthys acanthopterus*
Cyprinidae	*Systomus jacobusboehlkei*
Cyprinidae	*Tor laterivittatus*
Nemacheilidae	*Nemacheilus platiceps*
Nemacheilidae	*Schistura defectiva*
Nemacheilidae	*Schistura dorsizona*

14-003 Houay Hok, about 300 m uspstream of confluence with Nam Ngiep, which is about 15 km downstream of Ban Pou; 18°56'25.7"N 103°29'58.2"E, 295 masl; 29 Jan 2014.

Balitoridae	*Hemimyzon confluens*
Cyprinidae	*Bangana lippa*
Cyprinidae	*Garra theunensis*
Cyprinidae	*Onychostoma* aff. *gerlachi*
Cyprinidae	*Opsarius pulchellus*
Cyprinidae	*Poropuntius* aff. *carinatus*
Cyprinidae	*Raiamas guttatus*
Cyprinidae	*Scaphiodonichthys acanthopterus*
Nemacheilidae	*Schistura coruscans*
Nemacheilidae	*Schistura defectiva*
Nemacheilidae	*Schistura dorsizona*
Sisoridae	*Glyptothorax horai*
Tetraodontidae	*Pao turgidus*

14-004 Nam Ngiep, rapids about 8.2 km downstream of Ban Pou; 18°59'20.9"N 103°29'41.6"E, 305 masl; 29 Jan 2014.

Balitoridae	*Homaloptera yunnanensis*
Cyprinidae	*Hampala macrolepidota*

Cyprinidae	*Mystacoleucus greenwayi*
Cyprinidae	*Mystacoleucus marginatus*
Cyprinidae	*Onychostoma* aff. *gerlachi*
Cyprinidae	*Opsarius pulchellus*
Cyprinidae	*Osteochilus striatus*
Cyprinidae	*Poropuntius* aff. *carinatus*
Cyprinidae	*Raiamas guttatus*
Cyprinidae	*Scaphiodonichthys acanthopterus*
Gobiidae	*Papuligobius ocellatus*
Nemacheilidae	*Schistura coruscans*
Nemacheilidae	*Schistura defectiva*
Nemacheilidae	*Schistura dorsizona*
Nemacheilidae	*Schistura* aff. *defectiva*
Nemacheilidae	*Schistura* aff. *ephelis*
Nemacheilidae	*Schistura* sp. 'compact'
Sisoridae	*Glyptothorax horai*
Sisoridae	*Glyptothorax laosensis*
Sisoridae	*Glyptothorax* aff. *zanaensis*

14-005 Houay Pa Ko, a small creek entering Nam Ngiep from the west as a small waterfall about 5 km downstream of Ban Pou; 19°00'00.4"N 103°28'50.0"E, 324 masl; 29 Jan 2014.

Cyprinidae	*Barbodes aurotaeniatus*
Cyprinidae	*Danio acrostomus*
Cyprinidae	*Esomus metallicus*
Cyprinidae	*Rasbora atridorsalis*
Nemacheilidae	*Nemacheilus platiceps*
Nemacheilidae	*Schistura defectiva*

14-006 Nam Khai, immediately upstream of confluence with Nam Ngiep, about 22 km downstream of Ban Pou and 19 upstream of Ban Soppouan; 18°53'48.8"N 103°28'21.9"E, 286 masl; 30 Jan 2014.

Balitoridae	*Hemimyzon confluens*
Cyprinidae	*Bangana lippa*
Cyprinidae	*Barbodes aurotaeniatus*
Cyprinidae	*Mystacoleucus marginatus*
Cyprinidae	*Onychostoma* aff. *gerlachi*
Cyprinidae	*Opsarius pulchellus*
Cyprinidae	*Raiamas guttatus*
Cyprinidae	*Scaphiodonichthys acanthopterus*
Cyprinidae	*Tor laterivittatus*
Nemacheilidae	*Schistura coruscans*
Nemacheilidae	*Schistura defectiva*
Nemacheilidae	*Schistura dorsizona*
Nemacheilidae	*Schistura* aff. ephelis
Nemacheilidae	*Schistura* sp. n. 'slender'
Sisoridae	*Glyptothorax horai*

14-007 Houay San, immediately upstream of confluence with Nam Ngiep, about 23 km downstream of Ban Pou and 18 km upstream of Ban Sopphouan; 18°53'10.8"N 103°28'06.6"E, 300 masl; 30 Jan 2014.

Cyprinidae	*Barbodes aurotaeniatus*
Cyprinidae	*Danio acrostomus*
Cyprinidae	*Opsarius pulchellus*
Cyprinidae	*Puntius brevis*
Cyprinidae	*Scaphiodonichthys acanthopterus*
Gobiidae	*Rhinogobius albimaculatus*
Mastacembelidae	*Mastacembelus armatus*
Nemacheilidae	*Schistura coruscans*
Nemacheilidae	*Schistura defectiva*
Nemacheilidae	*Schistura* aff. ephelis
Nemacheilidae	*Schistura* sp. 'compact'

Sisoridae	*Glyptothorax laosensis*
Sisoridae	*Oreoglanis delacouri*

14-008 Nam Pouan, upstream of Ban Soppouan, about 300 m upstream of confluence with Nam Ngiep; 18°46'57.4"N 103°25'57.7"E, 244 masl; 31 Jan 2014.

Balitoridae	*Hemimyzon confluens*
Balitoridae	*Homaloptera yunnanensis*
Cyprinidae	*Bangana lippa*
Cyprinidae	*Barbodes aurotaeniatus*
Cyprinidae	*Scaphiodonichthys acanthopterus*
Gobiidae	*Papuligobius ocellatus*
Nemacheilidae	*Nemacheilus platiceps*
Nemacheilidae	*Schistura coruscans*
Nemacheilidae	*Schistura defectiva*
Nemacheilidae	*Schistura* aff. *ephelis*
Nemacheilidae	*Schistura* sp. 'compact'
Nemacheilidae	*Schistura* sp. n. 'slender'
Sisoridae	*Glyptothorax laosensis*

14-009 Houay Hok, a small creek entering Nam Ngiep, about 3.5 km south of Ban Soppouan on road to Ban Sopyouak; 18°44'57.0"N 103°25'27.7"E, 261 masl; 31 Jan 2014.

Channidae	*Channa gachua*
Clariidae	*Clarias batrachus*
Cyprinidae	*Bangana lippa*
Cyprinidae	*Danio acrostomus*
Cyprinidae	*Garra theunensis*
Cyprinidae	*Neolissochilus blanci*
Cyprinidae	*Opsarius pulchellus*
Cyprinidae	*Puntius brevis*
Cyprinidae	*Scaphiodonichthys acanthopterus*
Cyprinidae	*Systomus jacobusboehlkei*
Gobiidae	*Papuligobius ocellatus*
Mastacembelidae	*Mastacembelus armatus*
Nemacheilidae	*Schistura defectiva*
Nemacheilidae	*Schistura* aff. *ephelis*
Nemacheilidae	*Schistura* sp. 'compact'
Nemacheilidae	*Schistura* sp. n. 'Nam Youak'
Sisoridae	*Glyptothorax laosensis*
Synbranchidae	*Monopterus albus*

14-010 Nam Ngiep at Keng Wong Kou [rapids], about 2 km upstream of Ban Sopyouak [measured from ferry on road to Ban Bo]; 18°43'35.2"N 103°25'29.2"E, 233 masl; 1 Feb 2014.

Cyprinidae	*Bangana lippa*
Cyprinidae	*Mystacoleucus greenwayi*
Cyprinidae	*Mystacoleucus marginatus*
Cyprinidae	*Onychostoma* aff. *gerlachi*
Cyprinidae	*Poropuntius* aff. *carinatus*
Cyprinidae	*Scaphiodonichthys acanthopterus*
Nemacheilidae	*Schistura defectiva*
Nemacheilidae	*Schistura* aff. *ephelis*
Sisoridae	*Glyptothorax horai*

14-011 Nam Ngiep at Keng Chong [rapids], about 4.5 km upstream of Ban Sopyouak [measured from ferry on road to Ban Bo]; 18°44'32.5"N 103°25'24.2"E, 239 masl; 1 Feb 2014.

Balitoridae	*Homaloptera yunnanensis*
Cyprinidae	*Bangana lippa*
Cyprinidae	*Garra cambodgiensis*
Cyprinidae	*Mystacoleucus marginatus*
Cyprinidae	*Opsarius pulchellus*
Cyprinidae	*Poropuntius* aff. *carinatus*

Cyprinidae	*Scaphiodonichthys acanthopterus*
Gobiidae	*Papuligobius ocellatus*
Gyrinocheilidae	*Gyrinocheilus aymonieri*
Sisoridae	*Glyptothorax horai*
Sisoridae	*Glyptothorax laosensis*
Sisoridae	*Glyptothorax* aff. *zanaensis*

14-012 Nam Youak at Ban Sopyouak, about 200 m upstream of confluence with Nam Ngiep; 18°42'56.5"N 103°25'55.1"E, 236 masl; 2 Feb 2014.

Balitoridae	*Hemimyzon confluens*
Balitoridae	*Homaloptera yunnanensis*
Cyprinidae	*Barbodes aurotaeniatus*
Cyprinidae	*Esomus metallicus*
Cyprinidae	*Onychostoma* aff. *gerlachi*
Cyprinidae	*Opsarius pulchellus*
Cyprinidae	*Poropuntius* aff. *carinatus*
Cyprinidae	*Puntius brevis*
Cyprinidae	*Rasbora atridorsalis*
Cyprinidae	*Scaphiodonichthys acanthopterus*
Cyprinidae	*Systomus jacobusboehlkei*
Cyprinidae	*Tor laterivittatus*
Gobiidae	*Papuligobius ocellatus*
Nemacheilidae	*Schistura coruscans*
Nemacheilidae	*Schistura defectiva*
Nemacheilidae	*Schistura dorsizona*
Nemacheilidae	*Schistura* aff. *ephelis*
Nemacheilidae	*Schistura* sp. 'compact'
Sisoridae	*Glyptothorax horai*
Sisoridae	*Glyptothorax laosensis*
Sisoridae	*Pseudecheneis sympelvica*

14-013 Restaurant in Ban Thaviang, from Nam Ngiep, 19°02'31.4"N 103°23'34.9"E; 30 Jan 2014; most of them identified from cut pieces or cooked fishes.

Bagridae	*Hemibagrus nemurus*
Bagridae	*Hemibagrus wyckioides*
Cyprinidae	*Cirrhinus prosemion*
Cyprinidae	*Hampala macrolepidota*
Cyprinidae	*Hypsibarbus vernayi* ?
Cyprinidae	*Poropuntius* aff. *carinatus*
Cyprinidae	*Tor laterivittatus*
Cyprinidae	*Tor tambra*
Sisoridae	*Bagarius yarrellii*

4.1.2 Nam Ngiep drainage above FSL of NNP1

14-015 Nam Youak between Ban Sopyouak and Ban Houaysey, 18°43'26.7"N 103°22'39.4"E, 304 masl; 14 Feb 2014.

Balitoridae	*Balitora lancangjiangensis*
Balitoridae	*Homaloptera yunnanensis*
Cyprinidae	*Danio acrostomus*
Cyprinidae	*Garra theunensis*
Cyprinidae	*Neolissochilus blanci*
Cyprinidae	*Onychostoma* aff. *gerlachi*
Cyprinidae	*Opsarius pulchellus*
Cyprinidae	*Poropuntius* aff. *carinatus*
Cyprinidae	*Scaphiodonichthys acanthopterus*
Cyprinidae	*Tor laterivittatus*
Gobiidae	*Rhinogobius albimaculatus*
Nemacheilidae	*Schistura coruscans*

Nemacheilidae	*Schistura defectiva*
Nemacheilidae	*Schistura* aff. *ephelis*
Nemacheilidae	*Schistura* sp. 'compact'
Nemacheilidae	*Schistura* sp. n. 'Nam Youak'
Sisoridae	*Glyptothorax horai*
Sisoridae	*Glyptothorax laosensis*
Sisoridae	*Oreoglanis delacouri*
Synbranchidae	*Monopterus albus*

14-016 Houay Kolong, first creek crossing road from Ban Houaysey to Ban Sopyouak, 18°43'31.9"N 103°21'20.3"E, 415 masl ; 14 Feb 2014.

Channidae	*Channa gachua*
Cyprinidae	*Danio acrostomus*
Cyprinidae	*Neolissochilus blanci*
Cyprinidae	*Poropuntius* aff. *carinatus*
Cyprinidae	*Scaphiodonichthys acanthopterus*
Nemacheilidae	*Schistura coruscans*
Nemacheilidae	*Schistura defectiva*
Nemacheilidae	*Schistura* sp. n. 'Nam Youak'
Sisoridae	*Glyptothorax horai*
Sisoridae	*Oreoglanis delacouri*

14-017 Nam Long, a tributary of Nam Chae [Nam Chian], about 5 km upstream from bridge on road from Ban Thathom to Ban Pou, 19°04'01.4"N 103°28'20.5"E, 435 masl; 16 Feb 2014.

Balitoridae	*Hemimyzon confluens*
Cyprinidae	*Danio acrostomus*
Cyprinidae	*Garra theunensis*
Cyprinidae	*Neolissochilus blanci*
Cyprinidae	*Opsarius pulchellus*
Cyprinidae	*Scaphiodonichthys acanthopterus*
Nemacheilidae	*Schistura coruscans*
Sisoridae	*Glyptothorax horai*
Sisoridae	*Oreoglanis delacouri*

14-019 Nam Ngiep north of Ban Naxong, 19°03'23.7"N 103°22'06.4"E, 337 masl; 17 Feb 2014.

Cyprinidae	*Barbodes aurotaeniatus*
Cyprinidae	*Mystacoleucus marginatus*
Cyprinidae	*Opsarius pulchellus*
Cyprinidae	*Poropuntius* aff. *carinatus*
Cyprinidae	*Puntius brevis*
Cyprinidae	*Tor laterivittatus*
Gobiidae	*Papuligobius ocellatus*
Nemacheilidae	*Nemacheilus platiceps*
Nemacheilidae	*Schistura coruscans*
Nemacheilidae	*Schistura defectiva*
Nemacheilidae	*Schistura dorsizona*
Nemacheilidae	*Schistura* aff. *ephelis*
Nemacheilidae	*Schistura* aff. *defectiva*
Nemacheilidae	*Schistura* sp. n. 'slender'
Sisoridae	*Glyptothorax horai*

14-020 Nam Chae about 200 m downstream of bridge on road from Ban Thathom to Ban Pou, 19°02'15.4"N 103°30'07.8"E, 368 masl; 17 Feb 2014.

Cyprinidae	*Barbodes aurotaeniatus*
Cyprinidae	*Danio acrostomus*
Cyprinidae	*Garra theunensis*
Cyprinidae	*Neolissochilus blanci*
Cyprinidae	*Onychostoma* aff. *gerlachi*
Cyprinidae	*Opsarius pulchellus*
Cyprinidae	*Poropuntius* aff. *carinatus*

Cyprinidae	*Rasbora atridorsalis*
Cyprinidae	*Scaphiodonichthys acanthopterus*
Cyprinidae	*Tor laterivittatus*
Nemacheilidae	*Nemacheilus platiceps*
Nemacheilidae	*Schistura coruscans*
Nemacheilidae	*Schistura defectiva*
Nemacheilidae	*Schistura dorsizona*
Sisoridae	*Glyptothorax horai*
Sisoridae	*Glyptothorax laosensis*
Sisoridae	*Oreoglanis delacouri*

14-021 Nam Xong, upstream of Ban Naxong; 19°03'19.2"N 103°22'27.1"E; 321 masl; 18 Feb 2014.

Channidae	*Channa gachua*
Cyprinidae	*Barbodes aurotaeniatus*
Cyprinidae	*Danio acrostomus*
Cyprinidae	*Opsarius pulchellus*
Cyprinidae	*Puntius brevis*
Cyprinidae	*Scaphiodonichthys acanthopterus*
Gobiidae	*Rhinogobius albimaculatus*
Nemacheilidae	*Nemacheilus platiceps*
Nemacheilidae	*Schistura coruscans*
Nemacheilidae	*Schistura defectiva*
Nemacheilidae	*Schistura dorsizona*
Sisoridae	*Oreoglanis delacouri*

14-030 Houay Xo, a hill stream entering Nam Ngiep at about 18°51'42"N 103°27'16"E; 18°51'12.2" N 103°29'39.3"E, 402 masl; 20 Feb 2014.

Channidae	*Channa gachua*
Clariidae	*Clarias batrachus*
Cyprinidae	*Danio* sp. n.
Cyprinidae	*Poropuntius* sp. n.
Nemacheilidae	*Schistura* sp.

14-032 Nam Sao, a tributary of Nam Ngiep, entering it about 1 km downstream of Ban Sopyouak; 18°43'38.3"N 103°28'14.0"E, 308 masl; 21 Feb 2014.

Channidae	*Channa gachua*
Cyprinidae	*Barbodes aurotaeniatus*
Cyprinidae	*Danio acrostomus*
Cyprinidae	*Neolissochilus blanci*
Cyprinidae	*Opsarius pulchellus*
Cyprinidae	*Poropuntius* aff. *carinatus*
Cyprinidae	*Puntius brevis*
Cyprinidae	*Rasbora atridorsalis*
Cyprinidae	*Scaphiodonichthys acanthopterus*
Cyprinidae	*Systomus jacobusboehlkei*
Gobiidae	*Papuligobius ocellatus*
Mastacembelidae	*Mastacembelus armatus*
Nemacheilidae	*Nemacheilus platiceps*
Nemacheilidae	*Schistura coruscans*
Nemacheilidae	*Schistura defectiva* ?
Nemacheilidae	*Schistura dorsizona*

4.1.3 Sites outside Nam Ngiep drainage upstream of NNP1 dam site

4.1.3.1 Nam Mang drainage

14-014 Nam Mang near Ban Pa La Veak [Nam Mang drainage], 18°40'00.0"N 103°12'05.5"E, 456 masl; 13 Feb 2014.

Amblycipitidae	*Amblyceps mucronatum*

Channidae	*Channa gachua*
Cyprinidae	*Esomus metallicus*
Cyprinidae	*Neolissochilus blanci*
Cyprinidae	*Opsarius pulchellus*
Cyprinidae	*Puntius rhombeus*
Cyprinidae	*Rasbora paviana*
Mastacembelidae	*Mastacembelus armatus*
Nemacheilidae	? *Schistura* aff. *defectiva*
Nemacheilidae	*Schistura ephelis*
Nemacheilidae	*Schistura leukensis*
Sisoridae	*Glyptothorax horai*
Sisoridae	*Glyptothorax laosensis*
Synbranchidae	*Monopterus albus*

4.1.3.2 Nam Xan drainage

14-018 Nam Pha, a tributary of Nam Tai, about 3 km northeast of Ban Thathom, 19°00'22.6"N 103°36'44.1"E, 317 masl; 16 Feb 2014.

Balitoridae	*Hemimyzon confluens*
Cyprinidae	*Danio acrostomus*
Cyprinidae	*Garra theunensis*
Cyprinidae	*Neolissochilus blanci*
Cyprinidae	*Opsarius pulchellus*
Cyprinidae	*Scaphiodonichthys acanthopterus*
Nemacheilidae	*Schistura coruscans*
Nemacheilidae	*Schistura ephelis*
Sisoridae	*Glyptothorax horai*
Sisoridae	*Oreoglanis* cf. *delacouri*

14-022 Nam Mang, about 800 m upstream of confluence with Nam Xan; 18°49'49.9"N 103°47'51.8"E, 224 masl, 18 Feb 2014.

Balitoridae	*Hemimyzon confluens*
Balitoridae	*Homaloptera smithi*
Balitoridae	*Homaloptera yunnanensis*
Cyprinidae	*Garra cambodgiensis*
Cyprinidae	*Onychostoma* aff. *gerlachi*
Nemacheilidae	*Schistura crabro*
Nemacheilidae	*Schistura dorsizona*
Nemacheilidae	*Schistura ephelis*
Nemacheilidae	*Schistura sombooni*
Nemacheilidae	*Schistura* cf. *nicholsi*
Sisoridae	*Glyptothorax horai*
Sisoridae	*Glyptothorax laosensis*

14-023 Nam Lard [Nam Lat], immediately uptream of confluence with Nam Xan, downstream of bridge; 18°46'38.6"N 103°49'16.3"E, 212 masl; 18 Feb 2014.

Balitoridae	*Homaloptera smithi*
Cyprinidae	*Garra cambodgiensis*
Cyprinidae	*Hampala macrolepidota*
Cyprinidae	*Mystacoleucus greenwayi*
Cyprinidae	*Onychostoma* aff. *gerlachi*
Cyprinidae	*Opsarius koratensis*
Cyprinidae	*Scaphiodonichthys acanthopterus*
Nemacheilidae	*Schistura dorsizona*
Nemacheilidae	*Schistura ephelis*
Nemacheilidae	*Schistura* cf. *nicholsi*
Sisoridae	*Glyptothorax horai*
Tetraodontidae	*Pao turgidus*

14-024 Nam Xan at Keng Yakhou, about 9 km upstream of Ban Pakhuang, about 3 km downstream of Ban Khanyong; 18°44'03.3"N 103°47'04.6"E; 19 Feb 2014.

Balitoridae	*Hemimyzon confluens*
Balitoridae	*Homaloptera smithi*
Balitoridae	*Homaloptera yunnanensis*
Belonidae	*Xenentodon canciloides*
Cyprinidae	*Garra cambodgiensis*
Cyprinidae	*Garra fuliginosa*
Cyprinidae	*Onychostoma* aff. *gerlachi*
Nemacheilidae	*Schistura crabro*
Nemacheilidae	*Schistura dorsizona*
Nemacheilidae	*Schistura ephelis*
Nemacheilidae	*Schistura* cf. *nicholsi*
Nemacheilidae	*Schistura sombooni*
Sisoridae	*Glyptothorax horai*
Tetraodontidae	*Pao turgidus*

14-025 Nam Xan at Keng Kokxan, about 7 km upstream of Ban Pakhuang; 18°43'35.0"N 103°48'13.5"E, 187 masl; 19 Feb 2014.

Bagridae	*Hemibagrus nemurus*
Bagridae	*Pseudomystus siamensis*
Balitoridae	*Homaloptera smithi*
Balitoridae	*Homaloptera yunnanensis*
Cyprinidae	*Crossocheilus atrilimes*
Cyprinidae	*Garra cambodgiensis*
Cyprinidae	*Mystacoleucus marginatus*
Cyprinidae	*Onychostoma* aff. *gerlachi*
Cyprinidae	*Opsarius pulchellus*
Cyprinidae	*Poropuntius normani*
Gobiidae	*Papuligobius ocellatus*
Mastacembelidae	*Mastacembelus armatus*
Nemacheilidae	*Schistura coruscans*
Nemacheilidae	*Schistura dorsizona*
Nemacheilidae	*Schistura ephelis*
Sisoridae	*Glyptothorax horai*

14-026 Nam Xa, a tributary of Nam Xan entering it about 2 km upstream of Ban Pakhuang; 18°42'00.4"N 103°47'40.3"E, 183 masl, 19 Feb 2014; fished with electricity about once a week.

Bagridae	*Hemibagrus nemurus*
Bagridae	*Pseudomystus siamensis*
Balitoridae	*Homaloptera smithi*
Cyprinidae	*Osteochilus hasselti*
Cyprinidae	*Poropuntius normani*
Gobiidae	*Papuligobius ocellatus*
Mastacembelidae	*Macrognathus siamensis*
Nemacheilidae	*Nemacheilus pallidus*
Nemacheilidae	*Nemacheilus platiceps*
Nemacheilidae	*Schistura coruscans*
Pristolepididae	*Pristolepis fasciata*
Tetraodontidae	*Pao turgidus*

14-027 Nam Xan at Keng Tong, about 1 km upstream of Ban Pakhuang; 18°41'37.5"N 103°47'17.1"E, 167 masl; 19 Feb 2014.

Balitoridae	*Balitora* sp.
Balitoridae	*Homaloptera smithi*
Balitoridae	*Homaloptera yunnanensis*
Cyprinidae	*Garra cambodgiensis*
Cyprinidae	*Opsarius pulchellus*
Cyprinidae	*Poropuntius normani*
Cyprinidae	*Scaphiodonichthys acanthopterus*

Gobiidae	*Papuligobius ocellatus*
Nemacheilidae	*Schistura dorsizona*
Nemacheilidae	*Schistura* aff. *ephelis*
Sisoridae	*Glyptothorax horai*

14-028 Nam Xan at Keng Pakhuang, immediately downstream of Ban Pakhuang; 18°40'57.8"N 103°47'08.7"E, 160 masl; 19 Feb 2014.

Balitoridae	*Hemimyzon confluens*
Balitoridae	*Homaloptera smithi*
Balitoridae	*Homaloptera yunnanensis*
Cyprinidae	*Garra cambodgiensis*
Cyprinidae	*Garra fuliginosa*
Cyprinidae	*Poropuntius normani*
Mastacembelidae	*Mastacembelus armatus*
Sisoridae	*Glyptothorax horai*
Nemacheilidae	*Schistura* cf. *nicholsi*
Nemacheilidae	*Schistura dorsizona*
Nemacheilidae	*Schistura ephelis*
Nemacheilidae	*Schistura sombooni*

4.1.3.3 Nam Xao drainage

Nam Xao is a tributary of Nam Ngiep, entering it downstream of NNP1 dam site.

14-029 Nam Xao downstream of Ban Phounxong; 18°49'20.2"N 103°32'20.6"E, 231 masl; 20 Feb 2014.

Channidae	*Channa gachua*
Clariidae	*Clarias batrachus*
Cyprinidae	*Barbodes aurotaeniatus*
Cyprinidae	*Esomus metallicus*
Cyprinidae	*Garra* sp. juv.
Cyprinidae	*Laocypris hispida*
Cyprinidae	*Opsarius pulchellus*
Cyprinidae	*Osteochilus lini*
Cyprinidae	*Poropuntius normani*
Cyprinidae	*Puntius rhombeus*
Cyprinidae	*Rasbora paviana*
Cyprinidae	*Systomus jacobusboehlkei*
Gobiidae	*Papuligobius ocellatus*
Gobiidae	*Rhinogobius* cf. *albimaculatus*
Nemacheilidae	*Nemacheilus platiceps*
Nemacheilidae	*Schistura sigillata*
Nemacheilidae	*Schistura sombooni*

14-031 Houay Ken, a small tributary of Nam Xao, upstream of Ban Phounxong; 18°50'09.2"N 103°32'05.4"E, 295 masl; 20 Feb 2014.

Channidae	*Channa gachua*
Cyprinidae	*Barbodes aurotaeniatus*
Cyprinidae	*Esomus metallicus*
Cyprinidae	*Osteochilus lini*
Cyprinidae	*Poropuntius normani*
Gobiidae	*Papuligobius ocellatus*
Nemacheilidae	*Nemacheilus platiceps*
Nemacheilidae	*Schistura nicholsi*

14-033 Nam Xao upstream of bridge on road from Ban Muanghuang to Ban Nahan; 18°45'33.3"N 103°32'57.1"E, 217 masl; 21 Feb 2014.

Amblycipitidae	*Amblyceps mucronatum*
Bagridae	*Pseudomystus siamensis*
Balitoridae	*Hemimyzon confluens*
Channidae	*Channa gachua*

Cyprinidae	*Barbodes aurotaeniatus*
Cyprinidae	*Esomus metallicus*
Cyprinidae	*Onychostoma* aff. *gerlachi*
Cyprinidae	*Osteochilus lini*
Cyprinidae	*Poropuntius normani*
Cyprinidae	*Puntius rhombeus*
Cyprinidae	*Rasbora paviana*
Cyprinidae	*Systomus jacobusboehlkei*
Gobiidae	*Papuligobius ocellatus*
Gobiidae	*Rhinogobius* cf. *albimaculatus*
Mastacembelidae	*Macrognathus siamensis*
Mastacembelidae	*Mastacembelus armatus*
Nemacheilidae	*Nemacheilus platiceps*
Nemacheilidae	*Schistura dorsizona*
Nemacheilidae	*Schistura nicholsi*
Nemacheilidae	*Schistura sigillata*
Tetraodontidae	*Pao turgidus*

14-034 Nam Xao, Hart [Keng] Teen Heen, about 2 km upstream of Ban Thahua; 18°39'56.4"N 103°37'24.9"E, 172 masl; 22 Feb 2014.

Bagridae	*Hemibagrus nemurus*
Bagridae	*Pseudomystus siamensis*
Balitoridae	*Hemimyzon confluens*
Balitoridae	*Homaloptera smithi*
Balitoridae	*Homaloptera yunnanensis*
Chandidae	*Parambassis siamensis*
Cyprinidae	*Crossocheilus atrilimes*
Cyprinidae	*Onychostoma* aff. *gerlachi*
Cyprinidae	*Osteochilus lini*
Cyprinidae	*Poropuntius normani*
Gobiidae	*Papuligobius ocellatus*
Gobiidae	*Rhinogobius* cf. *albimaculatus*
Nemacheilidae	*Nemacheilus platiceps*
Nemacheilidae	*Schistura dorsizona*
Nemacheilidae	*Schistura nicholsi*
Pristolepididae	*Pristolepis fasciata*

14-035 Nam Xao, Hart [Keng] Sarng Pa Fa, about 2.5 km upstream of Ban Thahua; 18°40'13.0"N 103°37'25.6"E, 171 masl [actually upstream of 14-034]; 22 Feb 2014.

Bagridae	*Pseudomystus siamensis*
Balitoridae	*Homaloptera smithi*
Balitoridae	*Homaloptera yunnanensis*
Belonidae	*Xenentodon canciloides*
Chandidae	*Parambassis siamensis*
Cyprinidae	*Poropuntius normani*
Gobiidae	*Papuligobius ocellatus*
Gobiidae	*Rhinogobius* cf. *albimaculatus*
Mastacembelidae	*Mastacembelus armatus*
Nemacheilidae	*Schistura nicholsi*

14-036 Nam Xao in Ban Thahua; 18°39'18.1"N 103°36'46.3"E, 168 masl; 22 Feb 2014.

Bagridae	*Pseudomystus siamensis*
Balitoridae	*Homaloptera smithi*
Cyprinidae	*Mystacoleucus marginatus*
Gobiidae	*Papuligobius ocellatus*
Nemacheilidae	*Schistura nicholsi*
Nemacheilidae	*Schistura sigillata*

4.2 Fish fauna

4.2.1 Diversity, endemism

Fish were sampled or observed at 21 sites in the Nam Ngiep drainage upstream of the dam site, 14 of them in fast water habitats in the inundation zone of NNP1 reservoir. A total of 56 species were recorded in the surveyed part of the drainage (Table 1), 53 of them present in the inundation zone, and 34 species were observed in the samples from outside the inundation zone.

Although not observed during the survey, interviews with villagers in Ban Pou, Ban Thaviang, Ban Viengta abd Ban Xomxeun indicate the presence of *Luciocyprinus striolatus* (see Annex 1). In 2013 I have seen in a restaurant in Ban Vanglouang (Hom District; Nam Ngum drainage) a specimen of *Labeo pierrei* that had been brought from Ban Sopyouak; the species has not been obtained by the survey but the origin of the observed specimen is reliable and conforms with what is known of the species in other drainages (Nam Ou, Nam Ngum, Xe Bangfai, Xe Kong). The two species are included in the fish fauna of the Nam Ngiep in Tables 1–2.

Among the 53 species in the inundation zone (Table 1), 2 are new to science (*Schistura* sp. n. 'Nam Youak', *Schistura* sp. n. 'slender'). A further 4 species are potentially also new to science but this cannot be established within the time available for this report (*Schistura* aff. *ephelis*, *Schistura* sp. 'compact', *Schistura* aff. *defectiva*, *Poropuntius* aff. *carinatus*). Awaiting clarification, I adopt a precautionary approach and treat them here as if they effectively are new species. These new species have been discovered by the survey in the Nam Ngiep drainage and therefore they must be treated as endemic to the Nam Ngiep. For 3 of these species there is, however, suspicion that some (or similar-looking species) also exist in adjacent drainages (*Poropuntius* aff. *carinatus*, *Schistura* aff. *ephelis*, *Schistura* aff. *defectiva*).

A further 2 new species were discovered in a small hill stream of the Nam Ngiep drainage (site 14-30), but far above FSL (*Danio* sp. n., *Poropuntius* sp. n.). *Glyptothorax* aff. *zanaensis* and *Onychostoma* aff. *gerlachi* are also unnamed species obtained by the survey but they were already known from surveys in other areas of Laos.

All the endemic species found in the inundation zone have also been found above FSL. Some have a wide distribution in the inundation zone (*Schistura* sp. n. 'slender', *Schistura* aff. *ephelis*, *Schistura* sp. 'compact', *Poropuntius* aff. *carinatus*) but others seem to have a restricted range, but this might result from a sampling bias because most of the tributaries of the reservoir are not accessible.

Eight sites were sampled in the Nam Xan drainage, one in the Nam Mang and six in the Nam Xao, a tributary ofv the Nam Ngiep entering it downstream of NNP1 dam site.

Schistura crabro was earlier known only from an unspecified locality in the Nam Ngiep drainage. The survey observed it at two sites in the Nam Xan and therefore the species is no longer to be treated as endemic of the Nam Ngiep. The habitat in which it was observed (riffles on a substrate of gravel to small stones) was rare in the surveyed stretch of the Nam Ngiep and the species possibly does no occur in the NNP1 inundation zone.

4.2.1.3 Other drainages

The sampling in the adjacent drainages yielded 55 species (Table 2). 30 of them are also present in the surveyed parts of the Nam Ngiep drainage. These species will not be further mentioned here unless relevant to the discussion of the NNP1 project area.

4.2.2 Migrations

Only two of the recorded species are known to be long distance migratory in other tributaries of the Mekong: *Labeo pierrei* and *Cirrhinus molitorella*. Both species were observed in restaurants and said to come from the Nam Ngiep.

Labeo pierrei is known to undertake long migrations. This has been documented in the Xekong River, where it moves between the middle Xekong (for spawning) and the Mekong. Such long migrations will not be possible in the Nam Ngiep after construction of the NNP1 dam. However, a survey of the Nam Ngum in 2013 observed that juveniles 1-2 years old were present upstream of Nam Ngum 1 and Nam

Ngum 2 reservoirs. They were at about FSL of Nam Ngum 2, in rapids exposed in the dry season. This shows that reproduction was possible without access to the Mekong, but this observation may not be informative for long term evolution since Nam Ngum 2 dam was commissioned in 2011.

4.2.3 Conservation status

The threat status of all the named freshwater fishes of mainland Southeast Asia has been assessed in the IUCN Red List of Endangered Species (www.iucnredlist.org) (Allen et al., 2012). 46 of the 56 species recorded in the Nam Ngiep drainage upstream of NNP1 dam site have already been assessed (see Table 3). The Red List rating indicates the risk of extinction based on precisely defined criteria. The threat categories are: Critically Endangered (CR), Endangered (EN) and Vulnerable (VU). All species, even those not threatened, have been rated. Least Concerned (LC) are species not threatened; Near Threatened (NT) are species not in any of the threatened category but for which small changes in the habitat or population would immediately move them in a threat category. Data Deficient (DD) are species for which the available data did not allow to objectively rate them. Most of the DD species are newly discovered or rare species. The fate of DD species is not to remain DD but to eventually be evaluated; experience shows that once evaluated a fair number of the DD species are rated as threatened. Note that the assesment is based on the global range of a species, which means that a wide-ranging species could be locally abundant in a given area but globally threatened, or the reverse.

Among the 46 species observed by the survey and that had already been evaluated, none is CR, 1 is EN (*Luciocyprinus striolatus*), 3 are VU, 2 are NT, 29 are LC, and 11 are DD.

5 Species of concern, threats and mitigation

5.1. Endemics

5.1.1 *Schistura* sp. n. 'Nam Youak'

This is a new species discovered by the survey. It was observed in a small fast flowing stream tributary of the Nam Ngiep near Ban Soppouan (site 14-009) in the inundation zone, in the Nam Youak at about FSL (site 14-015) and in a small tributary of the Nam Youak about 100 m above FSL (site 14-016). It was most abundant at the last site where most individuals were obtained in the stretches with the fastest current. It is expected to be present in adjacent headwaters and its presence in the inundation zone is expected to be restricted to small tributaries. Most of the habitat of the species is expected to be above FSL.

The species is not directly threatened by the project. Indirect impacts will be the construction of access roads that will damage the streams and attract human activity, logging activity (road, camps, etc.) that result in deforestation, siltation, pollution and overfishing. Site 14-016 was along the road, about 1 km from village, in secondary forest, with some impact but still had a good fish population.

Mitigations. The most efficient way to manage the species is to ensure that stretches of streams where the species is present retain intact aquatic habitats. Key factors are small stream with fast water on large stones (torrent-type), with riparian forest cover, clear water and absence of siltation. An important point should be the absence of cause of siltation in the upper part of the catchment. Conservation of habitats for the species can be achieved in conjuction with the establishment of protected areas for other animals and forest. It will require knowing better the distribution of the species to ensure that it will be present in some of the protected areas.

5.1.2 *Schistura* sp. n. 'slender'

This is a new species discovered by the survey. It was observed in two tributaries of the Nam Ngiep on the west side (Nam Khai, site 14-006; Nam Pouan, site 14-008), in the inundation zone, and in the Nam Ngiep upstream of FSL of NNP1 reservoir (site 14-019). It was found on and in a substrate of coarse sand, gravel and small stones. Its preferred habitat seems to be stretches with moderate flow (in the dry season), which is not frequent in the inundation zone but makes most of the observed stretch of the Nam Ngiep upstream of FSL until at least Ban Naxong (site 14-019); the extent of its range upstream is not known. The upstream of the Nam Khai and Nam Pouan could not be

researched because of access difficulties and security reasons.

The species has not been collected in the main stream of the Nam Ngiep in the inundation zone but it was present in two tributaries. Species of the genus *Schistura* have not been observed to adapt to reservoir conditions and it is expected *Schistura* sp. n. 'slender' will disappear from the inundation zone. It is expected to subsist in the Nam Ngiep between NNP1 reservoir and NNP2 dams, if the substrate of gravel and stones is not covered by sediment resulting from construction and human activity further upstream.

Mitigations. The most efficient way to manage the species is to ensure that stretches of streams where the species is present retain intact aquatic habitats. Key factors seems to be the presence of a substrate of coarse sand, gravel and small stones and that this remain free from sediments or siltation. It would be better if such habitat could be located in tributaries located in protected areas for other animals and forest.

5.1.3 *Danio* sp. n.

This is a species new to science. It was found only at site 14-030, which is a small stream draining to the Nam Ngiep, in the hills almost at the divide between Nam Ngiep and Nam Xao, about 100 m above FSL. It is probably present in other headwaters; site 14-030 is along one of the only two tracks on which it was possible to cross the divide between the Nam Ngiep and the Nam Xao (near Ban Muang Bo). The species was not observed in the inundation zone and probably occurs only in small headwaters.

The species is not directly threatened by the project. Indirect impacts will be the construction of access roads that will damage the streams and attract human activity, logging activity (road, camps, etc.) that result in deforestation, siltation, pollution and overfishing. It was found together with *Poropuntius* sp. n. (see below).

Mitigations. The most efficient way to manage the species is to ensure that stretches of streams where the species is present retain intact aquatic habitats. Key factors are riparian forest cover, clear water, absence of siltation and human disturbance. An important point should be the absence of cause of siltation in the upper part of the catchment. Conservation of habitats for the species can be achieved in conjuction with the establishment of protected areas for other animals and forest. It will require knowing better the distribution of the species to ensure that it will be present in some of the protected areas.

5.1.4 *Poropuntius* sp. n.

This is a species new to science. It was found only at site 14-030, which is a small stream draining to the Nam Ngiep, in the hills almost at the divide between Nam Ngiep and Nam Xao, about 100 m above FSL. It is probably present in other headwaters; site 14-030 is along one of the only two tracks on which it was possible to cross the divide between the Nam Ngiep and the Nam Xao (near Ban Muang Bo). The species was not observed in the inundation zone and probably occurs only in small headwaters.

The species is not directly threatened by the project. Indirect impacts will be the construction of access roads that will damage the streams and attract human activity, logging activity (road, camps, etc.) that result in deforestation, siltation, pollution and overfishing. It was found together with *Danio* sp. n. (see above).

Mitigations. The most efficient way to manage the species is to ensure that stretches of streams with where the species is presentretain intact aquatic habitats. Key factors are riparian forest cover, clear water, absence of siltation and human disturbance. An important point should be the absence of cause of siltation in the upper part of the catchment. Conservation of habitats for the species can be achieved in conjuction with the establishment of protected areas for other animals and forest. It will require knowing better the distribution of the species to ensure that it will be present in some of the protected areas.

5.1.5 *Oreoglanis delacouri*

This species is endemic to the Nam Ngiep drainage (Ng & Kottelat, 1999; Kottelat, 2001). It was earlier recorded only from the headwaters of the Nam Ngiep. It was found in the Nam Ngiep in the inundation zone and from several small tributaries, above FSL. It inhabits very fast flowing water, especially headwaters and torrents. One sample from the Nam Xan (site 14-018) looks similar to *Oreoglanis delacouri*; since it includes only juveniles, adults are needed to confirm the identification.

Most of the habitat of the species is above FSL. Outside of the inundation zone, it will not be directly threatened by the project. Indirect impacts will be the construction of access roads that will damage the streams and attract human activity, logging activity (road, camps, etc.) that result in deforestation, siltation, pollution and overfishing. It was found together and abundant with *Schistura* sp. n. 'Nam Youak' (see below).

Mitigations. The most efficient way to manage the species is to ensure that stretches of streams with where the species is presentretain intact aquatic habitats. Key factors are riparian forest cover, clear water, absence of siltation and human disturbance. An important point should be the absence of cause of siltation in the upper part of the catchment. Conservation of habitats for the species can be achieved in conjuction with the establishment of protected areas for other animals and forest. It will require knowing better the distribution of the species to ensure that it will be present in some of the protected areas.

5.1.6 *Schistura crabro*

Schistura crabro was earlier known only from an unspecified locality in the Nam Ngiep drainage. The survey observed tzhe species at two sites in the Nam Xan and therefore it is no longer to be treated as endemic to the Nam Ngiep. The habitat in which it was observed (riffles on a substrate of gravel to small stones) was rare in the surveyed stretch of the Nam Ngiep and the species possibly does no occur in the NNP1 inundation zone.

5.2 Potential endemics

5.2.1 *Poropuntius* aff. *carinatus*

This species has been observed at most sampling sites in the Nam Ngiep drainage, in the inundation zone as well as above FSL. It is possibly new to science. A similar or the same species is also present in the middle and upper Nam Ngum to the west; the time available for this report was not sufficient to confirm that hypothesis. The species has affinities with *Poropuntius carinatus*, a species known from the Mekong drainage in Laos and Xishuangbanna (Yunnan, China).

The species is apparently present everywhere in the main stream of the Nam Ngiep and its tributaries and headwaters. Species of the genus *Poropuntius* have not been observed to adapt to reservoir conditions and it is expected that *Poropuntius* aff. *carinatus* will disappear from the inundation zone. It will subsist in tributaries, will probably subsist in the Nam Ngiep between NNP1 reservoir and NNP2 dams, and may subsist in the stretches of streams immediately below FSL and emerged during most of the year.

Mitigations. The most efficient way to manage the species is to ensure that stretches of streams with where the species is presentretain intact aquatic habitats. Key factors are riparian forest cover, clear water, absence of siltation and human disturbance. An important point should be the presence of relatively deeper areas to provide shelter during the dry season and gravel and stones along the shores in some stretches for spawning. The presence of dams operating at peak hours upstream could have negative impact in daily exposing gravel beds and shore vegetation in which eggs are deposited. Conservation of habitats for the species can be achieved in conjuction with the establishment of protected areas for other animals and forest.

5.2.2 *Schistura* aff. *ephelis*

This species has been observed at most sampling sites in the Nam Ngiep mainstream in the inundation zone as well as above FSL. It was also observed in tributaries near their confluence with Nam Ngiep (but these tributaries could not be sampled away from the main river for access or security

reasons). In the Nam Youak it was observed at about FSL and similar habitat exist further upstream but could not be accessed. A similar or the same species is also present in the middle Nam Ngum drainage to the west; the time available for this report was not sufficient to confirm that hypothesis. The species has similarity with *Schistura ephelis*, a species present in the Nam Ngum and Nam Xan drainages, but still is very distinct.

The species apparently occupies stretches of the Nam Ngiep and its tributaries with fast current and stone substrate. Species of the genus *Schistura* require moving, clear and well oxygenated water and do not adapt to reservoir conditions and it is expected that *Schistura* aff. *ephelis* will disappear from the inundation zone. It will subsist in larger tributaries with sufficient discharge and stone, will probably subsist in the Nam Ngiep between NNP1 reservoir and NNP2 dams, and may subsist in the stretches of streams immediately below FSL but emerged during most of the year.

Mitigations. The most efficient way to manage the species is to ensure that stretches of streams where the species is present retain intact aquatic habitats. Key factors are clear water, absence of siltation and absence of dayly variation of discharge (as typical downstream of dams operating at peak hours) that would exposed part of the habitat everyday and kill fish trying to occupy that part of the river bed. Conservation of habitats for the species can be achieved in conjuction with the establishment of protected areas for other animals and forest. Lower parts of tributaries immediately above FSL should be primary target areas (as our sampling site on the Nam Youak).

5.2.3 *Schistura* aff. *defectiva*

This species has been observed at two sites, one in the Nam Ngiep mainstream in the inundation zone (site 14-004) and one in the Nam Ngiep above FSL (site 14-019). The identity of the species is not clear. Only few individuals were observed and it still cannot be excluded that these are aberrant specimens of *Schistura defectiva*, a species present at both sites and widely distributed in the Nam Ngiep and Nam Ngum. A similar or the same species is also present in the Nam Mang (site 14-014) and in the middle Nam Ngum drainage to the west; the small number of individuals collected by the survey is not sufficient to reach a definitive conclusion.

With the presence of this species in only two samples and its unclear identity, it is difficult to make hypotheses on the preferred habitat. The two sites have in common a long run on a substratum of stones about 10-20 cm diameter, about 50 cm deep. This may not be the preferred habitat but the habitat where it is most easily captured. Species of the genus *Schistura* require moving, clear and well oxygenated water and do not adapt to reservoir conditions and it is expected that *Schistura* aff. *defectiva* will disappear from the inundation zone. It is expected to subsist in tributaries, will probably subsist in the Nam Ngiep between NNP1 reservoir and NNP2 dams, and may subsist in the stretches of streams immediately below FSL and emerged during most of the year. It might also be possible that most of the habitat of the species is above FSL and that its presence in the inundation zone is only marginal.

Mitigations. No mitigation may be proposed until the identity of the samples can be clarified, especially its identity with the species of the Nam Mang and Nam Ngum drainages. Generally, the most efficient way to manage such small species is to ensure that stretches of streams where the species is present retain intact aquatic habitats. Considering the doubts about the identity of the species and its presence at only two sites, it is not possible to speculate on the key characteristics of the habitat. Conservation of habitats for the species can be achieved in conjuction with the establishment of protected areas for other animals and forest. At both sites it was collected with *Schistura* aff. *ephelis*.

5.2.4 *Schistura* sp. 'compact'

This species has been observed in the Nam Ngiep mainstream in the inundation zone (site 14-004). It was also observed in tributaries near their confluence with Nam Ngiep (but these tributaries could not be sampled away from the main river, because of access and security reasons) (sites 14-007, 14-008, 14-009, 14-012). In the Nam Youak it was observed at about FSL (site 14-015) and similar habitat exist further upstream but could not be accessed. The specific distincness is still not clear. Only few individuals were observed and it still cannot be excluded that these are aberrant specimens of *Schistura coruscans*, a species present at most sites and widely distributed in the Nam Ngiep and

Nam Ngum.

The species apparently occupies stretches of the Nam Ngiep and its tributaries with fast current and stone substrate. Species of the genus *Schistura* require moving, clear and well oxygenated water and do not adapt to reservoir conditions and it is expected that *Schistura* sp. 'compact' will disappear from the inundation zone. It will subsist in larger tributaries with sufficient discharge and stone, and it may subsist in the stretches of streams immediately below FSL but emerged during most of the year.

Mitigations. The most efficient way to manage the species is to ensure that stretches of streams where the species is present retain intact aquatic habitats. Key factors are clear water, absence of siltation and absence of cyclical variation of discharge (as typical downstream of dams operating at peak hours) that would exposed part of the habitat everyday and kill fish trying to occupy that part of the river bed. Conservation of habitats for the species can be achieved in conjuction with the establishment of protected areas for other animals and forest. Lower parts of tributaries immediately above FSL should be primary target areas (as our sampling site on the Nam Youak). At most sites it was collected with *Schistura* aff. *ephelis*.

5.3 *Luciocyprinus striolatus*

Luciocyprinus striolatus is recorded in the literature from Nam Tha, Nam Ou, Nam Ngum, Nam Kading (Nam Theun and Nam Gnouan), Xe Kong and Xishuangbanna (China) (Cui & Chu, 1986; Kottelat, 1998, 2001; Rainboth et al., 2013) The survey recorded for the first time its presence in the Nam Ngiep and obtained information suggesting it is also present in the Nam Xan. No specimen could be obtained but the identification seems reliable. The summaries of interviews are in Annex 1.

Luciocyprinus striolatus reaches a large size (at least 1.5 m, reportedly up to about 2 m) and lives in deep pools and adjacent rapids in fast flowing stretches of large rivers. It is absent in the Mekong floodplain and is only recorded from the middle and upper part of its main tributaries. It spawns downstream of rapids, along shores made of pebble and small stones. It is a predatory fish, feeding on aquatic animals and reported to also capture small mammal that enter the water (monkeys, dogs, etc.) although this is probably only exceptional behavior of very large individuals.

Most populations of the species are impacted or will be impacted by a variety of projects, mainly hydropower and/or mining. In theory, only the population in Nam Theun drainage upstream of the Nam Theun reservoir, in Nakay NBCA, is not threatened by impacts happening upstream.

Mitigations. The available information on the biology of the species is very limited and does not allow at this stage to propose concrete actions. The first steps to the management of the species is to confirm the identity, to establish its present distribution in the Nam Ngiep and outside and to obtain biological data.

Because of its size, spectacular appearance, and stories about its feeding habits, *Luciocyprinus striolatus* has a potential to attract attention from the general public and the visibility of the company's attention (or lack of) to conservation issues.

Main points to consider:

1) <u>Distribution</u>
Document the exact distribution of the species, identify exact river stretches, in the inundation zone and between NNP1 reservoir and NNP2 dams

Survey the inundation zone with villagers and identify sites where they have caught or observed the species, especially ripe females. To be done with villagers from Ban Pou, Ban Soppouan and Ban Sopyouak. Although these habitats will be lost at inundation, mapping and describing them may allow to identify geomorphological parameters that can be used later for identification of sites for potential stocking, or provide information for the creation of new, substitution habitats. This should include collection of data on wet-season parameters of these sites.

Survey upstream, of the inundation zone will document the exact distribution of the species. Villagers interviews indicate that very large individuals do not occur upstream of Ban Pou and but villagers are

not certain about the possible existence of spawning sites. Given that the species is not migratory, if large individuals and small juveniles are present, spawning sites may be expected. This needs confirmation from inhabitants of villages upstream.

In regard to ADB Critical Habitat policies, the size and quality of the Nam Ngiep population should be assessed relative to the global population. The 'discrete management units' of the species must be identified as their number, size and habitat quality and integrity may modify the classification.

2) Biological data
Obtain biological data on the species in the project area and outside. Sound management requires to know the basic requirements of the species and the characteristics of its life cycle: feeding, growth, habitat at different stages of life cycle, age and size at maturity, spawning sites and habits, ecology of eggs and fry, incubation, growth and feeding of fry, local movements, etc.

The project might join effort with other projects in which the species is also present in order to conduct or fund the research. Nam Theun 2 could be a potential partner; the drainage of their reservoir includes what is apparently the population in the safest conditions; the existence on site of an hydrobiology lab and researchers might ease the setting up of a research program.

As the species is not very abundant (as is the case for most large predatory animals), methods should be used that require to sacrifice only a limited number of individuals.

3) Fishing activity
Capture of the species should be managed in the Nam Ngiep. Fishing methods that specifically target the species should be banned. Individuals caught alive should be released; admittedly this is far from local customs. Some conservation pools should be established or, if there are already some, they should be extended where needed (this traditional management method is used at community level in the country).

Non-specific fishing methods can probaby not be controlled.

4) Captive breeding
In parallel to the collection of biological data in (2) above, a small captive or semi-captive stock should be established in a safe area. It could be used to study the artificial reproduction of the species. The aim should not be to maintain a permanent captive stock but to develop the knowledge and capacity to quickly produce a large number of juveniles if the need appears. This way, should the need arise the information will already exist and can be used immediately; it will not need to be develop in emergency.

The production of a large number of individuals could be, for example, for stocking in the river to stengthen the local population (at the beginning of flooding, or following a heavy pollution upstream) or to create a new population.

5) Identity
Confirm the identity of the species present in the Nam Ngiep. Considering the number of disjunct populations reported as *Luciocyprinus striolatus*, it cannot be totally ruled out that more than one species are confused under that name. Apparently, there has been no attempt to scientifically compare individuals of the different populations, because the material for comparison is not available. A DNA test could be useful; however, it should be kept in mind that while a great difference at DNA level usually indicate species distinctness, the absence of difference or a very small difference does not automatically mean that only one species is involved.

The conservation status of the Nam Ngiep population will be better if all the disjunct populations effectively belong to a single species. If more than one species is involved, the conservation actions must be drastically adapted.

Before possibly stocking individuals obtained by artificial reproduction (see (4) above), if the stocked material originates from another population/drainage, it may become necessary to check that this does not impact genetic integrity of the receiving population. However, there will always be some genetic

difference between isolated populations and in some situations the loss of genetic integrity is a minor concern compared to the loss of a population.

6) Habitat modifications

The survival of the species will depend of the presence of habitats were it can complete its life cycle. It also depends of the continued presence of the preys it feeds on. The habitat components identify during the interviews (Annex 1) and in earlier observations of the species in the Nam Theun drainage (Kottelat, 2002) indicate that adults live in deep pools, with a possible preference for the upper and lower parts, near rapids, riffles and runs. For spawning, it moves to shallow areas with stone and gravel banks along the shores; this is the wet season morphology of the sites since the species spawns in November, not in the dry season.

These habitats will disappear in most of the reservoir. Some will emerge for a few months in the drawdown zone of the Nam Ngiep and its main tributaries. In the stretches immediately below FSL rapids and deep pools may be functional (at least hydrologically) part of the year. However, the reported spawning season is in November (but some villagers gave dates as late as March, which seemed less reliable), which is in the period in which the reservoir is at FSL. Even the two most ustream spawning sites identified by villagers in Ban Pou and Ban Viengta will be submerged at that time (Wang Mon, Kaen Tao).

The status of this last-mentioned sites calls for some reservation. Maps indicate they will will be below FSL and the rapids would not be functional in November. This is the dry season situation. It is not known what the current morphology is during the wet season. The water is certainly some meters higher and what appears as rapids in the dry season are no longer rapids in the wet season, other rapids may appear, and the spawning sites described as in shallow water on pebble banks are not in the position of the dry-season pebble banks. It might well be that the current wet-season topography of these spawning sites remain after inundation, or that inundation of the reservoir might create wet-season situation further upstream comparable to the current wet-season situation in the inundation zone.

Observation of the spawning sites identified under (1) above is needed during the spawning season to observe the wet season topography and the position actually occupied by the fish.

Depending of these observations, it might be desirable or possible to modify some sites in the Nam Ngiep and main tributaries, above or close to FSL, to mimic the identified spawning sites and that could possibly be adopted by the fish. Without information, further speculations on the kind of modifications is premature.

7) Upstream impacts

The discharge from NNP2 project upstream of NNP1 may have impacts on the population of *Luciocyprinus striolatus* downstream. The main impacts will be caused by the increase of the dry-season discharge, the reduced discharge at the beginning of the wet season, and, if it operates at peak hours, the daily fluctuations of the discharge.

Daily fluctuations of the water level downstream of dams/powerhouses is a well-know cause of destruction of fish habitats, and especially of spawning sites. Eggs typically hatch in a few days. Those eggs attached to vegetation or deposited in the sand or in gravel in shallow water become exposed and die in a few minutes. Most fish species spawn this way and it has been observed that *Luciocyprinus striolatus* spawns in shallow water on stone or gravel banks. These stone and gravel banks will be impacted by the daily variation in water level. Here again, without data on the wet-season conditions of the spawning sites, and the planned discharge from NNP2, it is not possible to speculate on the real impact of NNP2.

Further, the impact of NNP2 on the aquatic fauna in the drawdown zone of NNP1 will be very different before and after inundation of the NNP1 reservoir. There will also be specific, short but intense impacts at the end of the construction and during the testing phase of NNP2. This potentially can be devastating for the aquatic fauna downstream.

Information on operation model and planned discharge of NNP2 is needed for management of the aquatic fauna in NNP1 inundation zone. NNP2 has a potential to annilitated mitigation measures taken by NNP1 to support *Luciocyprinus striolatus* and other fish species.

6 General recommendations

Four of the endemic species have been observed mainly or only in small streams and headwaters (*Schistura* sp. n. 'Nam Youak', *Danio* sp. n., *Poropuntius* sp. n., *Oreoglanis delacouri*). The most efficient way to manage these species is to ensure that stretches of streams remain intact, under forest cover, and especially to avoid disturbance of the stream morphology and to avoid siltation in these stretches and upstream. The main cause of siltation is road construction, logging, mining and agriculture. Conservation of habitats for these species can be achieved in conjunction with the establishment of protected areas for other animals and forest. This conservation areas should extend to the uppermost part of these streams to avoid any siltation originating upstream. *Schistura* sp. n. 'Nam Youak and *Oreoglanis delacouri* inhabit torrent habitats. *Danio* sp. n. and *Poropuntius* sp. n. were found in a slower flowing forest stream.

Four of the endemic species and potentially endemic species have been observed mainly in the inundation zone, including close to FSL (*Schistura* sp. n. 'slender', *Schistura* aff. *ephelis*, *Schistura* aff. *defectiva*, *Schistura* sp. 'compact'). They apparently do not occur in headwaters and seem to require larger stream and stone substrate, which is most common in the main river and the lower parts of the main tributaries. However, site 14-009 was a small torrent-type stream and both *Schistura* aff. *ephelis* and *Schistura* sp. 'compact' were present. The efficient way to manage these species is to ensure that stretches of the Nam Ngiep and main tributaries above FSL remain intact for some distance and especially to ensure that no sediment covers the bottom of the streams.

The most interesting streams would be the Nam Youak, Nam Pouan and Nam Chae, but of these last two streams, the Nam Chae is already impacted by the construction of the Nam Chae dam, and the Nam Pouan will be impacted by the construction of the Nam Pouan dam. Smaller tributaries in the project area might have suitable habitats. The species were found near their confluence but access or security reasons did not allow to sample them further away from the main river (Houay Hok, site14-003; Nam Khai, site 14-006; Houay San, site 14-007).

Judging from maps, these species should also occur further upstream on the Nam Ngiep and other tributaries upstream of the surveyed area, for example the Nam Siam upstream of the NNP2 power house. Again, security reasons do not allow to sample this area.

Poropuntius aff. *carinatus* occurs in both stream types.

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Table 1. Fish species observed or recorded in 2014 by the fast water habitat survey in the Nam Ngiep drainage upstream of NNP1 dam site. **DD,** documented distribution outside Nam Ngiep drainage; **EN,** endemic to Nam Ngiep drainage; **IZ,** inundation zone; **UP,** upstream of NNP1 reservoir FSL.

	IZ	UP	EN	DD
Bagridae				
Hemibagrus nemurus	x			Southeast Asia
Hemibagrus wyckioides	x			Mekong and Chao Phraya drainages
Balitoridae				
Balitora lancangjiangensis		x		Mekong and Red River drainages
Hemimyzon confluens	x	x		Nam Ngum and Nam Xan drainages
Homaloptera yunnanensis	x	x		Mekong drainage
Channidae				
Channa gachua	x	x		Southeast Asia
Clariidae				
Clarias batrachus	x	x		Southeast Asia
Cyprinidae				
Bangana lippa	x			Mekong basin from Nam Ngiep to Yunnan
Barbodes aurotaeniatus	x	x		Mekong basin
Cirrhinus prosemion	x			Mekong and Chao Phraya basins
Danio acrostomus	x	x		Nam Mang
Danio sp. n.		x	x	
Esomus metallicus	x			Mainland Southeast Asia
Garra cambodgiensis	x			Mainland Southeast Asia
Garra theunensis	x	x		Mekong basin from Nam Kading to Nam Tha
Hampala macrolepidota	x			Southeast Asia
Hypsibarbus vernayi ?	x			Mekong and Chao Phraya basins
Labeo pierrei	x			Mekong basin
Luciocyprinus striolatus	x			Makong basin from Xe Kong to Xishuanbanna
Mystacoleucus greenwayi	x			Mekong basin in Laos, Thailand and Yunnan
Mystacoleucus marginatus	x	x		Southeast Asia
Neolissochilus blanci	x	x		Mekong basin
Onychostoma aff. *gerlachi*	x	x		Mekong basin in Northern Laos and Yunnan
Opsarius pulchellus	x	x		Mekong and Chao Phraya basins
Osteochilus striatus	x			Mekong basin from Xe Bangfai to Nam Ngiep
Poropuntius aff. *carinatus*	x	x	?	? Nam Ngum
Poropuntius sp. n.		x	x	
Puntius brevis	x	x		Southeast Asia
Raiamas guttatus	x			Southeast Asia
Rasbora atridorsalis	x	x		Mekong basin in Laos and Thailand

Rasbora rubrodorsalis	x			Mekong basin in Laos and Thailand
Scaphiodonichthys acanthopterus	x	x		Mekong basin
Systomus jacobusboehlkei	x			Mekong and Chao Phraya basins
Tor laterivittatus	x	x		Mekong basin
Tor tambra	x			Southeast Asia
Gobiidae				
Papuligobius ocellatus	x	x		Mekong basin
Rhinogobius albimaculatus	x	x		Nam Ngum drainage
Gyrinocheilidae				
Gyrinocheilus aymonieri	x			Southeast Asia
Mastacembelidae				
Mastacembelus armatus	x			Southeast and South Asia
Nemacheilidae				
Nemacheilus platiceps	x	x		Mekong basin
Schistura coruscans	x	x		Nam Ngum drainage
Schistura defectiva	x	x		Nam Ngum drainage
Schistura dorsizona	x	x		Mekong basin in Laos
Schistura aff. *defectiva*	x	x	?	?`Nam Ngum drainage
Schistura aff. *ephelis*	x	x	?	? Nam Ngum drainage
Schistura sp. 'compact'	x	x	x	
Schistura sp. n. 'Nam Youak'	x	x	x	
Schistura sp. n. 'slender'	x	x	x	
Sisoridae				
Glyptothorax horai	x	x		Mekong basin from Nam Kading to Yunnan
Glyptothorax laosensis	x	x		Mekong and Chao Phraya basins
Glyptothorax aff. *zanaensis*	x			Mekong basin from Xe Kong to Yunnan
Oreoglanis delacouri	x	x	x	
Pseudecheneis sympelvica	x			Nam Kading and Nam Ngum drainages
Bagarius yarrellii	x			Southeast and South Asia
Synbranchidae				
Monopterus albus	x	x		Southeast and East Asia
Tetraodontidae				
Pao turgidus	x			Mekong basin
Total	53	34	9 ?	

Table 2. Fish species observed in the Nam Mang, Nam Xao and Nam Xan drainages. The Nam Xao is a tributary of the Nam Ngiep, entering it downstream of NNP1 dam site. **NM,** Nam Mang; **NXA,** Nam Xan; **NXO,** Nam Xao.

family	species	NXA	NM	NXO
Amblycipitidae	*Amblyceps mucronatum*		x	x
Bagridae	*Hemibagrus nemurus*	x		x
Bagridae	*Pseudomystus siamensis*	x		x
Balitoridae	*Balitora lancangjiangensis*.	x		
Balitoridae	*Hemimyzon confluens*	x		x
Balitoridae	*Homaloptera smithi*	x		x
Balitoridae	*Homaloptera yunnanensis*	x		x
Belonidae	*Xenentodon canciloides*	x		x
Chandidae	*Parambassis siamensis*			x
Channidae	*Channa gachua*		x	x
Clariidae	*Clarias batrachus*			x
Cyprinidae	*Barbodes aurotaeniatus*			x
Cyprinidae	*Crossocheilus atrilimes*	x		x
Cyprinidae	*Danio acrostomus*	x		
Cyprinidae	*Esomus metallicus*		x	x
Cyprinidae	*Garra cambodgiensis*	x		
Cyprinidae	*Garra fuliginosa*	x		
Cyprinidae	*Garra theunensis*	x		
Cyprinidae	*Hampala macrolepidota*	x		
Cyprinidae	*Laocypris hispida*			x
Cyprinidae	*Mystacoleucus greenwayi*	x		
Cyprinidae	*Mystacoleucus marginatus*	x		x
Cyprinidae	*Neolissochilus blanci*	x	x	
Cyprinidae	*Onychostoma* aff. *gerlachi*	x		x
Cyprinidae	*Opsarius koratensis*	x		
Cyprinidae	*Opsarius pulchellus*	x	x	x
Cyprinidae	*Osteochilus hasselti*	x		
Cyprinidae	*Osteochilus lini*			x
Cyprinidae	*Poropuntius normani*	x	x	x
Cyprinidae	*Rasbora paviana*		x	x
Cyprinidae	*Scaphiodonichthys acanthopterus*	x		
Cyprinidae	*Systomus jacobusboehlkei*			x
Gobiidae	*Papuligobius ocellatus*	x		x
Gobiidae	*Rhinogobius* cf. *albimaculatus*			x
Mastacembelidae	*Macrognathus siamensis*	x		x
Mastacembelidae	*Mastacembelus armatus*	x	x	x
Nemacheilidae	*Nemacheilus pallidus*	x		
Nemacheilidae	*Nemacheilus platiceps*	x		x
Nemacheilidae	*Schistura coruscans*	x		
Nemacheilidae	*Schistura crabro*	x		
Nemacheilidae	*Schistura* aff. *defectiva*		?	
Nemacheilidae	*Schistura dorsizona*	x		x
Nemacheilidae	*Schistura ephelis*	x	x	
Nemacheilidae	*Schistura* aff. *ephelis*	?		
Nemacheilidae	*Schistura leukensis*		x	
Nemacheilidae	*Schistura nicholsi*			x
Nemacheilidae	*Schistura* cf. *nicholsi*	x		
Nemacheilidae	*Schistura sigillata*			x
Nemacheilidae	*Schistura sombooni*	x		x
Pristolepididae	*Pristolepis fasciata*	x		x
Sisoridae	*Glyptothorax horai*	x	x	
Sisoridae	*Glyptothorax laosensis*	x	x	
Sisoridae	*Oreoglanis* cf. *delacouri*	x		
Synbranchidae	*Monopterus albus*		x	
Tetraodontidae	*Pao turgidus*	x		x

Table 3. Fish species observed, obtained or reliably recorded in the Nam Ngiep drainage upstream of NNP1 dam site and their extinction risk in IUCN's Red List. **EN,** endangered; **VU,** vulnerable; **NT,** near threatened; **LC,** least concerned; **DD,** data deficient.

	Red List status 2014
Bagridae	
Hemibagrus nemurus	LC
Hemibagrus wyckioides	LC
Balitoridae	
Balitora lancangjiangensis	LC
Hemimyzon confluens	VU
Homaloptera yunnanensis	LC
Channidae	
Channa gachua	LC
Clariidae	
Clarias batrachus	LC
Cyprinidae	
Bangana lippa	DD
Barbodes aurotaeniatus	LC
Cirrhinus prosemion	—
Danio acrostomus	DD
Danio sp. n.	—
Esomus metallicus	LC
Garra cambodgiensis	LC
Garra theunensis	DD
Hampala macrolepidota	LC
Hypsibarbus vernayi	LC
Labeo pierrei	VU
Luciocyprinus striolatus	EN
Mystacoleucus greenwayi	LC
Mystacoleucus marginatus	LC
Neolissochilus blanci	NT
Onychostoma aff. *gerlachi*	—
Opsarius pulchellus	LC
Osteochilus striatus	DD
Poropuntius aff. *carinatus*	—
Poropuntius sp. n.	—
Puntius brevis	LC
Raiamas guttatus	LC
Rasbora atridorsalis	LC
Rasbora rubrodorsalis	LC
Scaphiodonichthys acanthopterus	LC
Systomus jacobusboehlkei	LC
Tor laterivittatus	DD
Tor tambra	DD
Gobiidae	
Papuligobius ocellatus	LC
Rhinogobius albimaculatus	VU
Gyrinocheilidae	
Gyrinocheilus aymonieri	LC
Mastacembelidae	
Mastacembelus armatus	LC
Nemacheilidae	
Nemacheilus platiceps	DD
Schistura coruscans	DD
Schistura defectiva	DD
Schistura dorsizona	LC
Schistura aff. *defectiva*	—
Schistura aff. *ephelis*	—

Schistura sp. 'compact'	—
Schistura sp. n. 'Nam Youak'	—
Schistura sp. n. 'slender'	—
Sisoridae	
Glyptothorax horai	LC
Glyptothorax laosensis	LC
Glyptothorax aff. *zanaensis*	LC
Oreoglanis delacouri	DD
Pseudecheneis sympelvica	DD
Bagarius yarrellii	NT
Synbranchidae	
Monopterus albus	LC
Tetraodontidae	
Pao turgidus	LC

Annex 1. *Luciocyprinus striolatus*, data from interviews

Interviews were conducted upstream of FSL in Ban Thaviang, Ban Viengta and Ban Pou, and downstream of the dams site in Ban Xomxeun.

Luciocyprinus striolatus is called *Pa Kouan Say* upstream and *Pa Ern* downstream. The name Pa Kharm earlier reported in Ban Thathom is erroneous and resulted from confusion with *Raiamas guttatus*.

Ban Viengta
Information obtained from a fisherman usually working between Ban Viengta and Ban Soppouan.

Luciocyprinus striolatus (*L. s.*) extends upstream to Sop Syem [7 km upstream of Ban Thaviang, near NNP2 power house]. He has fished in Sop Syem and in the Nam Ngiap upstream but has not seen *L. s.* upstream. He thinks it is not present because the river is too steep and the water too cold.

According to him, *L. s.* is present in Nam Chae. He guesses that its distribution extends downstream to Mekong because he sees more individuals downstream near Sop Pouan but in fact he has never been further downstream). Maybe *L. s.* migrates because it is rare in dry season in Ban Viengta. At an usual fishing site about 8-10 km dowstream of Ban Pou, the fish is also rarer at the same time as in the village.

L. s. is usually caught in sectors about 2 m deep, between rapids and pools.

L. s. breeds in November. He knows it because he has seen a pair spawning, he caught one by net. The fish caught was a female that released eggs when brought out of the water. This is the only time he obsrved actual spawning. This spawning site was about 1 km downstream of village (not clear whether Ban Viengta or Ban Pou), at Wang Mon 'beach', on sand, in very shallow water, the back of the fishes was outside the water. Several pairs were observed at the same time on this 'beach'.

Ban Pou
Information obtained from three fishermen, fishing mainly between Nam Chae and Ban Pou.

L. s. lives in deep water, downstream of strong current but before deep pools. The depth is at least 2 m.

The distribution of *L. s.* extends upstream to Ban Sop Syem. They guess that *L. s.* is not present upstream because the river is too small and not deep enough. (But they do not go fishing upstream of Sop Syem; they have seen the river and think the fish cannot live there).

They guess that *L. s.* might go downstream to the Mekong, because the water is deeper downstream, but they do not go fishing downstream of Ban Sopppouan, because their boats cannot pass the rapids. They fish in the Nam Chae but they do not catch *L. s.* in that river. They know that villagers in Ban Soppouan go fishing in Nam Pouan, but they have never seen *L. s.* among the catches obtained from that river.

L. s. spawns only in December. They observed it at Kaen Tao 'beach', about 4 km downstrean of Ban Pou. Kaen Tao is about opposite sampling site 14-005. Only one of them has seen actual spawning and only once.The water was 40-50 cm deep and the back of the fish was out of the water. They have seen a small group spawning; they counted 4 but there were probably more. They killed one by gun. It was about 1.5 m long (when carried by two people on a pole, the tail was touching the ground). It was a female, 22 kg, of which 1 kg of eggs. Females grow larger than males.

Juveniles live in whirl pools downstream of rapids. At around 40 cm they are caught by gill nets, with 40-50 mm meshes. The fishermen guess that smaller juveniles also inhabit the same area.

L. s. moves downstream to big pools from November to May.

The fishermen think that there are also some large *L. s.* in Sop Syem, but they cannot be as big as downstream. Large individuals are not known from Ban Pou; they occur only from Kaen Tao downwards.

Ban Thaviang
Information obtained from villagers who catch between Sop Pouan and Ban Houay Pa Mom.

In the dry season, the river upstream of Ban Thaviang is too shallow for *L. s.*

L. s. spawns in shallow, flowing water. Mentioned supposed spawning sites are Keng Mai and Keng Mgoua near Sop San (site 14-007). *L. s.* spawns in January-March. It breeds in groups of about 10 individuals (they know because they hunt them with guns when they see groups of big fish). The fishes make a group in very close contact.

The maximum size is 1.5 m, up to 16 kg.

L. s. is also known from upstream until the upper part of Thaviang, but it only reaches a smaller size and there they are caught by net. The maximum known upstream extent is Sop Syem (Ban Sop Syem).

Ban Xomxeun.
Information obtained from 3 fishermen.

This village is located on the Nam Ngiep, it is the second village downstream of the dam site. *L. s.* is recognised on the photograph as Pa Ern. It is caught in October-November at Hat Nguen, below the confluence of Nam Ngiep and Nam Xao. They never catch *L. s.* at other times of the year.

L. s. is caught with 'drifting gill net'. The fish caught are about 60 cm. They never catch larger individuals, but this might be because the meshes they use (80 mm) would not allow to catch bigger fish. They have never see smaller individuals, although they also catch with smaller meshes. The fish they catch never have eggs or sperm.

Conclusions
Fish are observed downstream only at the end of the rainy season, when the discharge is highest; these are apparently vagrant individuals that came downstream with the current. This does not seem to be migrating individuals. This is very few km upstream of the confluence with the Mekong. If this species were migrating to the Mekong, it would certainly already have been noted by surveys and fisheries studies in Laos and Thailand.

The maximum extent of the species upstream is Sop Syem, about 15 km upstream of Ban Thaviang, near NNP2 power house. The species is reported not to grow as big as downstream, but there are still large individuals, and possibly spawning locally. Larger individuals and higher density are downstream of Ban Pou.

L. s. inhabits fast water between rapids and large pools. For spawning, it comes towards the shore, along beaches of pebbles, gravel or sand. These are shallow water habitats in the wet season, probably several meters above river level in the dry season.

Largest recorded individuals are females, about 1.5 m long. Males are smaller. On spawning sites, they form small groups and spawn (apparently as pairs) in shallow water, about 40-50 cm deep.

Spawning time is November-December. The mention of spawning in January-March seems less well informed. However, there might be local variation. For comparison, the information I obtained in the Nam Theun was that the species spawns in January-February in rapids (Kottelat, 1996); in 2002 I was told that in the Nam Kading drainage it spawns in October-December.

In the inundation zone, the two mentioned sites close to FSL are Kaen Tao 'beach', about 4 km downstrean of Ban Pou, opposite site 14-005 (19°00'00.4"N 103°28'50.0"E) and Wang Mon 1 km downstream of Ban Pou.

Annex 2. Fishes of Nam Ngiep drainage, upstream of damsite

Note: Not all species are figured. Material suitable for photography was not obtained for all species (small juveniles, individuals already cut in pieces for cooking, etc.).

Bagridae

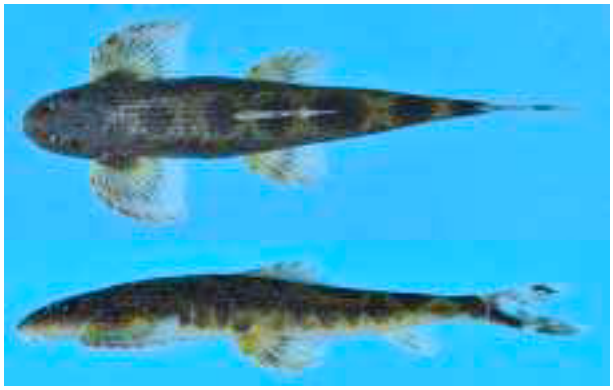
Hemibagrus nemurus, 98 mm SL

Hemibagrus wyckioides, about 400 mm SL

Balitoridae

Balitora lancangjiangensis, 62 mm SL

Hemimyzon confluens, 57 mm SL



Homaloptera yunnanensis, 58 mm SL

Channidae

Channa gachua, 89 mm SL

Clariidae

Clarias batrachus, 102 mm SL

Cyprinidae

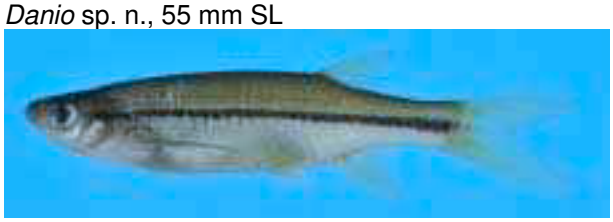
Bangana lippa, 110 mm SL

Barbodes aurotaeniatus, 62 mm SL

Cirrhinus prosemion, about 500 mm SL

Danio acrostomus, 40 mm SL

Danio sp. n., 55 mm SL



Esomus metallicus, 36 mm SL

Garra cambodgiensis, 77 mm SL

Garra theunensis, 121 mm SL

Hampala macrolepidota, 65 mm SL

Mystacoleucus greenwayi, 86 mm SL

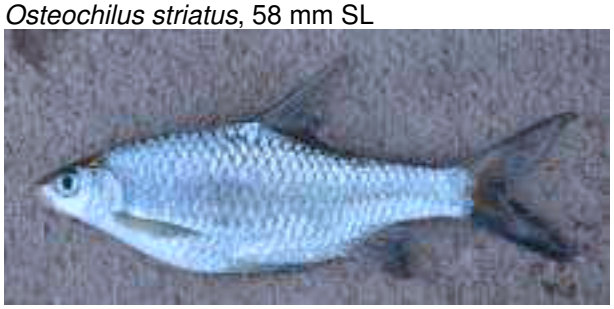
Mystacoleucus marginatus, 82 mm SL

Neolissochilus blanci, 80.0 mm SL

Onychostoma aff. *gerlachi*, 126 mm SL

Opsarius pulchellus, 88 mm SL

Osteochilus striatus, 58 mm SL



Poropuntius aff. *carinatus*, about 250 mm SL

Poropuntius normani, 88 mm SL

Poropuntius sp. n., 80 mm SL

Puntius brevis, 50 mm SL

Rasbora atridorsalis, 50 mm SL

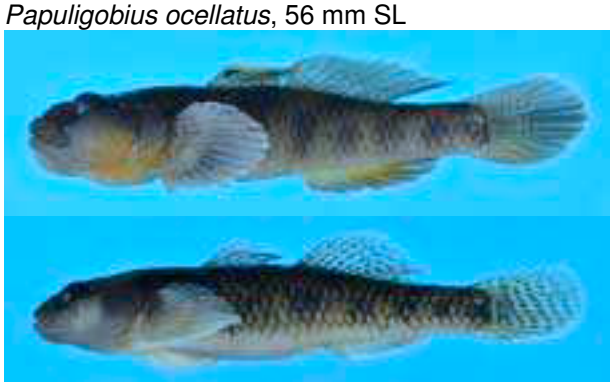
Rasbora rubrodorsalis, 15 mm SL

Scaphiodonichthys acanthopterus, 95 mm SL

Systomus jacobusboehlkei, 73 mm SL

Gobiidae

Papuligobius ocellatus, 56 mm SL



Rhinogobius albimaculatus, male, 56 mm SL (above) and female, 49 mm SL (below)

Mastacembelidae

Mastacembelus armatus, 270 mm SL

Nemacheilidae

Nemacheilus platiceps, 52 mm SL

Schistura coruscans, 68 mm SL

Schistura defectiva, 49 mm SL

Schistura dorsizona, 33 mm SL

Schistura aff. *defectiva*, 33 mm SL

Schistura aff. *ephelis*, 65 mm SL

Schistura sp. 'compact', 47 mm SL

Schistura sp. n. 'Nam Youak', 38 mm SL

Schistura sp. n. 'slender', 44 mm SL

Sisoridae

Glyptothorax horai, 90 mm SL

Glyptothorax laosensis, 57 mm SL

Glyptothorax aff. *zanaensis*, 74 mm SL

Oreoglanis delacouri, 104 mm SL

Pseudecheneis sympelvica, 40 mm SL

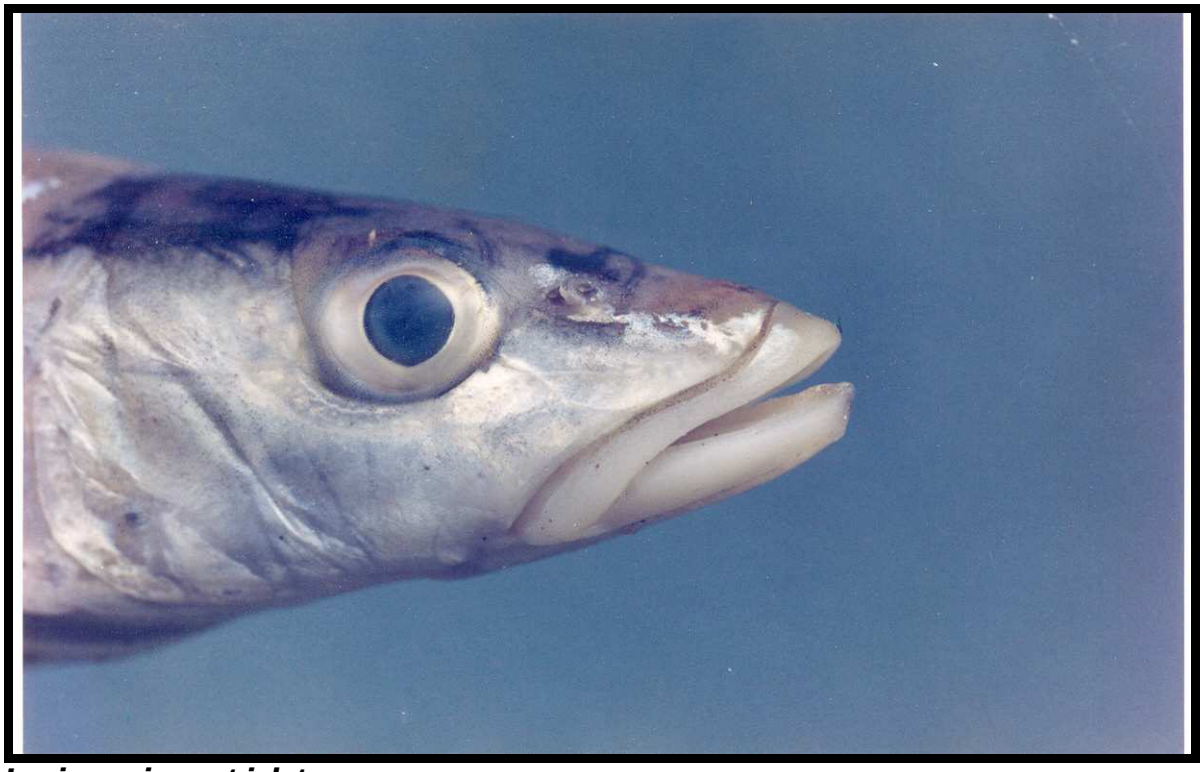
Synbranchidae

Monopterus albus, 295 mm SL

Tetraodontidae

Pao turgidus, 60 mm SL

Final Report on the status of ***Luciocyprinus striolatus*** (Ls) populations within the Nam Ngiep catchment and adjacent catchments (Phase 1 and Phase 2 studies - April and May 2014)



Luciocyprinus striolatus

Prepared by

Mr. Terry J. Warren

For

The Nam Ngiep Hydropower Company Ltd

May 2014

Table of Contents

1 Executive summary

Construction is shortly due to begin on the 290 megawatt (290MW) Nam Ngiep 1 Hydropower Project in Bolikhamxay and Xaysomboun Provinces of the Lao PDR and COD is planned for year 2019. The Project is a joint venture between Kansai Electric Power of Japan, the Electricity Generating Authority of Thailand (EGAT) and the Lao Holding State Enterprise (LHSE) of the Lao PDR.

An Environmental Impact Assessment (EIA) for the NN1 Power Company was prepared by the Environmental Research Institute of Chulalongkorn University (ERIC) in March 2012 and revised by Environmental Research Management (ERM) Siam in January 2014. It was during the course of carrying out extensive field surveys of aquatic biodiversity throughout the Nam Ngiep catchment that at least one species of fish was found to be present that the IUCN (2013) has placed under its endangered (EN) category in its Red List of species. A taxon is placed in the endangered category when the best available evidence indicates that it is facing a very high risk of becoming extinct in the wild.

This report highlights the findings of field surveys carried out in two separate phases during April and May 2014 directed at gaining a much broader understanding of the current pre-impoundment status of populations of ***Luciocyprinus striolatus*** (Ls) in the Nam Ngiep mainstream and its major tributaries within the Nam Ngiep catchment and adjacent catchments. Phase 1 part of the study was carried out over a large geographical area specifically to identify where Ls was found and identify and describe the critical habitats that allow it to carry out essential life-cycle events. Phase 2 part of the study focused on recording detailed information concerning critical habitats on all tributaries and mainstream reaches where populations of Ls were anecdotally reported to be present. These populations are considered to be beyond impacts created by all hydropower development throughout the Nam Ngiep catchment, and immediate adjacent catchments that are thus far unregulated.

This assessment marks the beginning of the process of providing important information in preparing a Critical Habitat Assessment (CHA) for which the developer and stakeholder will need to gain an understanding of the number and condition of other Discrete Management Unit (DMUs) sites throughout the country and the likely threats facing them. Understanding the status of Ls populations other than those inside the Nam Ngiep catchment is important in defining the potential for conservation measures as a biodiversity offset to ensure the persistence of viable populations of Ls in other river systems. Phase 3 studies are currently being planned and will commence shortly to address this issue.

Phase 1 surveys were able to establish that a population of Ls currently resides in the upper Nam Ngiep catchment and that highly defined spawning habitats are found over certain stretches of the mainstream. Although based on anecdotal reports only, the evidence provided by local people on spawning habitat was overwhelming. In almost all cases, the sites where Ls was reported to spawn have also been declared as Fishery Conservation Zones (FCZs) by nearby villages. Between the villages of Ban Pou and Ban Xiengthong, Thathom District a total of seven villages have established 11 FCZs. All the FCZs have been established over deep holes in the river bed at a depth of up to three or four meters during the dry season months. They vary in length from approximate 100 meters to 800 meters and are estimated to be anything from about 30 meters to 80 meters in width. In all cases where reports were provided by local people, spawning takes place between the months of January and April each year, and specifically takes place at the top end of gentle riffle and at the downstream end of deep pools. The actual spawning event itself follows a period of gathering of up to 30 individuals that can easily be observed at a respectful distance along

the river bank. After spawning takes place, masses of adhesive eggs can be observed sticking to rocks and boulders downstream of the deep pool.

A population of Ls is known to be resident in the upper Nam Ngiep catchment and is also found in certain large tributaries such as the Nam Chian and perhaps also the Nam Phouan. At certain times of the year the resident population becomes migratory and it appears that two distinct types of migration take place. The first appears to be a trophic migration involving smaller individuals weighing up to approximately one kilogram. These fish move up and into smaller tributaries such as the Nam Siam and the Nam Gnok at the beginning of the annual flood pulse. They presumably feed on the many other smaller fish species that also enter the tributaries for spawning and foraging, but then totally or almost totally exit the system during the early flood recession period and take up refuge in deep pools in the Nam Ngiep mainstream. When individual specimens have reached sexual maturity, a different type of migration takes place mainly in the Nam Ngiep mainstream. This involves an upstream or downstream movement to a spawning site. After spawning, presumably the fish disperse and assume a relatively solitary existence.

One major impact on Nam Ngiep mainstream Ls populations will be the likely inundation of some of the known spawning sites where Ls is known to breed at the current set NN1 FSL. An important issue that currently remains unknown is whether or not Ls can thrive within a reservoir environment; that is feeding and growth but not spawning. There are numerous examples of riverine Cyprinid fish species that can do this but that must also return to flowing-water habitats in order to breed. Most Cyprinid fish species are wet season spawners and not dry season spawners like Ls. Would it be possible for perhaps 50% of known Ls spawning sites to remain non-inundated and that would allow Ls to return to spawning sites after spending inter-spawning periods feeding in the newly created reservoir? This possible scenario needs to be explored.

As far as is currently known, Ls populations together with many other fish species in the Nam Ngiep and other Mekong tributaries are threatened by a wide range of indirect or background impacts not necessarily associated with dam construction. However, NN1 Project will inevitably impact on fish populations in the Nam Ngiep including populations of Ls. Further hydropower development upstream from the NN1 reservoir may also impact on Ls populations in what remains of the non-inundated sections of the Nam Ngiep through altered hydrology and possibly changes in water quality.

The Nam Ngiep 1 Hydropower Project has the potential to cause extirpation of Ls populations over certain stretches of the Nam Ngiep mainstream, but it will never cause the extinction of the species because it is already known from a number of other catchments throughout the Lao PDR. Further surveys are planned to study these catchments under a Phase 3 stage of this overall study of ***Luciocyprinus striolatus***.

2 Acknowledgements

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3 Introduction

3.1 General

In a first phase from April 3 to 8 (Phase 1), a survey of the upper Nam Ngiep catchment and upper adjacent catchments (Nam Xan) was made to better understand the likely extent of Ls populations and habitat ranges that might be affected by the Nam Ngiep 1, the NN2 and NN3 Projects. In a second phase, surveys were conducted from April 30 to May 4 that concentrated on the Nam Gnok (Youak), the Houayxay, the Nam Phouan, the Nam Thaen, and the Nam Chian (Jey) within the Nam Ngiep catchment (photos 3646, 3647, 3655 and 3651). The Nam Xan, just outside of the Nam Ngiep catchment was also surveyed during Phase 2 and so far remains unregulated in the middle and lower sections of the river system (photos 3799 and 3797). Both Phase 1 and Phase 2 surveys have been able to identify where Ls is found in the upper Nam Ngiep catchment and the types of habitat that it requires for dry season refuge and spawning (photos 3692, 3703, 3553, 3782, 3761, 3769 and 3757). Fishery Conservation Zones (FCZs) have been established at a number of different sites on the Nam Ngiep mainstream in the upper catchment area and also in the Nam Chian (photos 3553, 3730, 3663, 3782, 3761, 3769 and 3757). In many cases FCZs are designated as such because they represent dry season refuge and spawning habitat for many fish species including Ls. At least eleven FCZs have been visited, photographed and referenced using GPS from Ban Pou to Ban Xiengkhong on the Nam Ngiep mainstream.

3.2 Purpose of the Phase 1 and Phase 2 surveys

The overall purpose of these surveys was aimed at trying to assess the current status of Ls populations and their condition in relation to IFC Critical Habitat Threshold limits. In addition, these surveys aimed to identify how and to what extent the cumulative impacts of NN1, NN2 (photos 3361 and 3408) and NN3 (3461) will affect the population status of Ls throughout the Nam Ngiep catchment. The overall study also aims to apportion certain types of impact created by the three known Nam Ngiep Hydropower Projects currently under different stages of construction.

4 Methodology (Phase 1 and 2)

4.1 Literature search and survey planning

A literature search was carried out prior to beginning any field work. A short report was prepared based on the literature search (Warren 2014a). The field work was planned / based on 1) previous field surveys and studies, 2) the likely Project / inundation area footprint, 3) the unregulated parts of the upper Nam Ngiep catchment and 4) selecting areas where it was thought that Ls might be found based on the presence of specific habitat type in other rivers in the Lao PDR where it is known to exist (the Nam Theun / Kading, the Nam Mouan, the Nam Ngouang, the Nam Ou and the Xe Kong are examples).

4.2 Village interviews

At each of the villages where interviews took place the village chief was contacted and asked for assistance to carry out an interview with five or six people that had knowledge of fishing and fishery issues. This took place on each occasion (photos 3660 and 3793). A detailed description of Ls was provided to interviewees prior to showing any photographs of the fish. Ls is an easy fish to describe because of its size (adult fish weighing up to 30kg), shape and habits (spawning behavior and predatory nature). It was easy to gauge from interviewee reaction whether they knew the fish or not. Some were able to say that they knew it, but it was not found in the river / stream near their village. After the description was provided all

interviewees were shown photographs of the fish previously taken by the author from the Nam Theun and the Nam Ou and one taken by Dr. Maurice Kottelat. All information was recorded in notebooks and typed up each day. Each interview took anything up to 45 minutes to complete. A total of 19 interviews took place in villages during Phase 1 of this study (Warren 2014b) and 12 interviews took place in Phase 2.

5 Results (Phase 1 and 2)

5.1 Nam Ngiep mainstream and tributaries, deep pools and fish migration

The upper Nam Ngiep mainstream represents an aquatic environment where Ls can live and apparently carry out its entire life-cycle within the system. Juvenile Ls are reported present at many locations where surveys took place both in the mainstream Nam Ngiep and certain types of mainstream tributary. Apart from the mainstream Nam Ngiep, two other tributary habitats appear to support Ls populations. One is permanent in that Ls does not seem to leave major tributaries such as the Nam Chian (photos 3730 and 3722), whereas the second represents smaller tributaries that support temporary migratory populations of Ls during the wet season months only (the Nam Siam and Nam Gnok). These migrations mostly consist of smaller Ls individuals weighing up to about one kilogram. Occasionally much larger Ls are captured during these seasonal migrations weighing several kilograms. During the dry season months, all or almost all Ls exit the smaller tributaries and return to dry season refuge habitats (deep pools) in the Nam Ngiep mainstream. Very large Nam Ngiep tributaries such as the Nam Chian and perhaps the Nam Phouan (photo 3663) appear to provide some dry season refuge habitat for Ls and as such do not require that Ls returns to the Nam Ngiep mainstream. Anecdotal evidence strongly suggests that some of the deep pools / FCZs found in large tributaries also represent spawning sites for Ls observed within the last decade at least, and reports were provided to the study team of observed spawning events within the last two or three years at a few sites.

Based on all available evidence, Ls is not found in the Nam Xan from Ban Namphang in Thathom District downstream to Ban Simouangkhoun in Borikham District (photos 3799 and 3797). There is a very remote possibility that Ls is present in the Nam Xan river section upstream from the new access road to the Nam Xan 3B and 3A Hydropower Projects, but this section of river has no villages where interviews could be carried out and is characterized by series of strong rapids and small waterfalls.

5.2 Spawning habitat

Based on observations at other survey sites along the Nam Ngiep mainstream, it seems highly unlikely that the Nam Xan has suitable spawning habitat in the river section described above at 5.1 because there are few if any deep pool habitats with relatively gentle riffle leading away from them in the dry season. Ls is a dry season spawner and apparently breeds between January and April based on anecdotal evidence. Local people from a number of locations have provided evidence based on direct observation that Ls gathers in groups at the top of riffle / gentle rapids just below deep pool environments during both daylight and nighttime prior to spawning. After about one day of gathering, spawning takes place leaving adhesive eggs sticking to rocks scattered over a wide area below the deep pool environment. Female Ls were reported to be considerably larger that males during the period of gathering prior to the spawning event itself (Phase 1 and 2 interviews as part of this study). Based on anecdotal evidence juvenile Ls up to about ten or 15 centimeters in length are often observed or caught around the perimeters of large pools at almost any time of the year, but particularly during the dry season months. This may simply be a time when they are more easily observed and can be caught more easily.

5.3 Preliminary results from investigations into populations of ***L. striolatus*** in China and Vietnam

5.3.1 China

Initial investigations into the presence of Ls populations in China have been undertaken by ERM's Shanghai Offices. A number of people and organizations have contributed to the investigation (see Appendix 3).

Populations of Ls have been found in southern China. They are known from the middle to lower reaches of the Puwen River (a Langcang River tributary) and the Luosuo River (also a Langcang River tributary). Other reports strongly suggest that it is found in the lower reaches of the mainstream Langcang River and other non specified tributaries of it. No information or research has been carried out on the life-cycle of Ls and nothing much is known about it. No other research has been carried out on Ls in China so far. Research is generally quite difficult because Ls is caught so infrequently.

The main threats that Ls populations face in southern China are from overfishing, soil erosion and siltation of rivers, ecological and environmental degradation, pollution, hydropower development and climate change. In China, it is not recognized as a protected species but officials appreciate that it is endangered. It is assigned the category of vulnerable (VU) under China's Red List system. According to one source, fisheries have been banned along the Puwen River due to a local government established national protection zone for Fishery Genetic Resources (2012). However, there are reports that fishing still continues.

5.3.2 Vietnam

Evidence to date strongly suggests that Ls is not present in Vietnam. However, a species belonging to the same genus (***Luciocyprinus langsoni***) is found in Vietnam. As far as is known at present, there are only two species found within the ***Luciocyprinus*** genus. ***L. langsoni*** has been placed in Vietnam's Red List, but the exact category is not known. ***L. langsoni*** has been found in the Ky Cung River located in Lang Son Province in the northern mountainous region of China. According to Vietnamese scientists (Nguyen Van Hao and Ngo Si Van 2001), the difference between ***L. striolatus*** and ***L. langsoni*** is based on the number of stripes along the body, differences in dentition and the number of vertebrae present.

Some of the reasons why it is considered that Ls is not found in Vietnam are that: 1) Ls has specific requirements regarding habitat and is a large, vulnerable fish when fully mature. The terrain and aquatic habitat in southern Vietnam is not suitable for Ls. 2) The river networks in the central highlands are usually narrow, short and are high gradient and lack water in the dry season period. 3) The many hydropower dams built in the region prohibit the existence of large fish of this type. The river networks in the northern highlands represent suitable habitat for Ls, but so far only ***L. langsoni*** has been found. Generally speaking, very little research has been carried out on ***L. langsoni*** to date.

5.4 The physical barriers of the Nam Ngiep catchment population of ***Luciocyprinus striolatus*** and its restricted geographical range

The population of Ls in the upper Nam Ngiep catchment is restricted by the Tad-a-Tong waterfalls and rapids. Above these physical barriers the name of the river changes from the Nam Ngiep (below) to the Nam Ngiow (above). Ls is not present in the Nam Ngiow based on strong anecdotal evidence. This appears to be the limit of its upstream range because it represents a zoogeographical barrier (0325829 / 2133724) and other factors are not necessarily involved.

At present, the lower limits of the geographical range of Ls in the upper Ngam Ngiep mainstream can only be placed at the last reference point based on anecdotal information. This was at the Ban Pou FCZ – Wang Sop Pou - (0338585 / 2103326). Nothing is known about how far downstream Ls populations exist in the Nam Ngiep mainstream downstream of Ban Pou, but it has never been recorded from the Lower Mekong Countries (LMB) in the Mekong mainstream itself as far as the author is aware. It is however reported from the Langcang River (Mekong River) in southern China.

In the Nam Chian (Nam Jey) the known physical range of Ls is from the Nam Jey / Nam Ngiep confluence point to the last anecdotally reported capture of Ls at a "no name" deep pool some way up the rapids - ***Keng Pa Sang*** (0342720 / 2106788). It may persist above this deep pool habitat, but terrain was very difficult to access given the time and resource limitations of the study. The last anecdotally reported presence of Ls was at a deep pool ***Wang Mak*** (0341763 / 2101157) approximately one kilometer above the confluence of the Nam Chian (Nam Jey) and the Nam Ngiep mainstream. Nothing is known about Ls populations below this point in the Nam Ngiep mainstream.

Populations of Ls in the upper Nam Ngiep mainstream and tributaries may represent a single population and not necessarily sub-populations, although this is a possibility in certain large tributaries (Nam Chian and Nam Phouan). A hydropower project is now proposed for the Nam Phouan, but details are not clear at present and construction and operation will probably take place over the coming years.

The Nam Siam, a tributary of the Nam Ngiep mainstream and that had a seasonal migratory population of Ls (trophic migration) will be blocked by the NN2 Main Project Dam (0322177 / 2116873) and Ls will no longer be able to migrate in and out of this stream. Migrations have possibly been disrupted by the construction of the NN2 Main Project that is now well underway.

L. ***striolatus*** will still be able to enter the mainstream tributaries of Nam Phouan and Nam Gnok (Nam Youak) in the upper Nam Ngiep catchment, but only as far as the Nam Phouan Hydropower Project site, if this is to proceed as planned.

The stretch of river between Ban Pou (FCZ ***Wang Sop Pou*** - 0338585 / 2103326) and Ban Xiengkhong (0325632 / 2112784) remains critical in that this river stretch is host to important spawning sites for Ls. The current NN1 FSL will determine which ones will be inundated.

5.5 Conservation intervention

Table 1 Table 1 shows a rank score for various Nam Ngiep and major Nam Ngiep tributary river-sections where conservation intervention strategies may provide protection for populations of ***Luciocyprinus striolatus*** pre- and post NN1 impoundment.

Definition and rank of river stretch based on viable habitat	**Nam Ngiep mainstream locations**	**Tributary locations**	**Rank based on most viable habitat and least risk from threat**
1. This stretch of the Nam Ngiep mainstream consists of deep pool habitats (3 to 5 meters in depth) separated by sections of gentle rapids and riffle. Base substrates are either rocky in areas where rapids are found or sandy and muddy at some deep pool sites. There are seven main villages along this stretch of the river and FCZs have been established at 11 deep pool sites. A number of these deep pools / FCZs are locally recognized as, and confirmed as spawning sites for Ls.	1. The stretch of river between Ban Pou (coordinates available later) and Ban Xiengkhong (0325632 / 2112784).		RANK 1. 1. This river section is placed under Rank 1 because it represents critical spawning habitat and deep pool refuge habitat for Ls. BUT, approximately half of this habitat is under severe threat due to inundation from present NN1 FSL. The river sections that will remain non-inundated should remain under Rank 1. NN2 and NN3 HPP's can be expected to impact on this river stretch, but until more is known about how both project's will be operated, more detail on conservation intervention cannot be provided at present.

Table 1 …. continued

Definition and rank of river stretch based on viable habitat	Nam Ngiep mainstream locations	Tributary locations	Rank based on most viable habitat and least risk from threat
2. This stretch of major tributary river undoubtedly contains several deep pool habitats that act as vital dry season refuge sites for Ls. One deep pool (***Wang Mak***) is reported to be 13 meters deep in the dry season months. This may mean that Ls does not need to return to the Nam Ngiep mainstream deep pools as local knowledge suggests. However, Ls found there may still represent part of the Nam Ngiep Ls population. Of all six deep pools surveyed over this stretch of river, only one has been designated as an FCZ.		2. The stretch of the Nam Chian (Nam Jey) between the confluence point of the Chian / Ngiep (0342042 / 2100812) and the deep pool (0342720 / 2106788) at the ***Keng Pa Sang*** rapids (same coordinates as above).	RANK 1. 2. This river section is placed under Rank 1 because it contains several important deep pools that Ls uses for dry season refuge: 1. ***Wang Mak*** (0341763 / 2101157) is not an FCZ and may be inundated by NN1 FSL. 2. Two deep pools (no names) connected to each other (0342738 / 2104483) approximately 1.3 kilometers downstream of the road-bridge over the Nam Chian. Neither are FCZs. 3. ***Wang Kok Hai*** (0342776 / 2104706) approximately one kilometer downstream of the road-bridge over the Nam Chian and not an FCZ. 4. ***Wang Sangouan*** (0342182 / 2105901) and formerly known as ***Wang Tang Kham*** before it was made an FCZ in 2009 and is an FCZ. 5. ***Wang*** at the ***Keng Pa Sang*** rapids, not an FCZ (0342720 / 2106788). It is likely that ***Wang Mak*** will be inundated by NN1 FSL and if so, then important deep water habitat will be lost. Other deep pools upstream from ***Wang Mak*** may be above the NN1 FSL inundation limit.

Table 1 …. continued

Definition and rank of river stretch based on viable habitat	Nam Ngiep mainstream locations	Tributary locations	Rank based on most viable habitat and least risk from threat
3. The Nam Gnok (Nam Youak) is joined by the Houay Xay which is a small stream of approximately 10 to 15 meters wetted width in the dry season. It has several deep pools (< 1.5 meters deep) and long stretches of rapids and riffle. This stream is used by small Ls (≤ 1.0kg) during the wet season months for foraging, trophic type migrations. Ls does not stay in this stream during the dry season because habitat is not suitable (shallow and perhaps warm water).		3. The stretch of river between the Nam Gnok (Nam Youak) – Nam Ngiep confluence point (0334902 / 2069915) and Ban Houay Xay (0323385 / 2070823).	RANK 1. This stream is placed under Rank 1 because it is unregulated and there are no immediate plans for water-related development as far as known in year 2014. It is highly likely that the lower reaches of the Nam Gnok will be inundated by NN1 FSL, but it may still represent important foraging ground for Ls IF it is capable of living and feeding in the reservoir environment.

Table 1 …. continued

Definition and rank of river stretch based on viable habitat	Nam Ngiep mainstream locations	Tributary locations	Rank based on most viable habitat and least risk from threat
4. The Nam Phouan is a large Nam Ngiep tributary up to 30 or 40 meters wide and contains many deep pool habitats, and Ls has reportedly been caught in at least one of these close to Ban Sopphouan.		4. The stretch of river between the Nam Phouan – Nam Ngiep confluence point (0334762 / 2077310) and ***Wang Pba Deng*** (0334222 / 2077752) and beyond this point (not surveyed).	RANK 2. This stream is placed under Rank 2 because it is large deep pool / rapids and riffle stream. Ls are known to take up partial residence in the dry season months, but most fish probably return to the Nam Ngiep mainstream to dry season refuge habitats during the early to mid low water period. It has just been recently announced (late May 2014) that the Nam Phouan is being targeted for hydropower development. Conservation efforts may still be important for this major stream depending on where the hydropower plant will be located. ***Wang Pba Deng*** was designated as an FCZ in 2010 but was abandoned two years ago due to continued use of illegal fishing practices (bombs and electrical devices).
5. The Nam Ngiep mainstream between the NN2 Main Project discharge point and upstream to Ban Keokoang. Ls is known to be present between these two locations and exists as deep pools and sections of rapids and riffle.	5. The stretch of the Nam Ngiep mainstream between the NN2 discharge point (0322177 / 2116873) and Ban Keokoang (0328773 / 2129165).		RANK 3. This river stretch is placed under Rank 3 because it is threatened by upstream hydropower development, altered hydrology (de-watering) and possible changes to water quality. More detail on how the NN2 and NN3 companies intend to operate their dams is required.

Table 2 Table 2 provides a background summary of the main hydropower projects under construction or proposed in the Nam Ngiep catchment and the Nam Xan catchment.

Dam name	Catchment (map name)	Tributary name (local)	Coordinates
Nam Ngiep 3	Nam Ngiep	A tributary (s) of the Nam Ngiep	0326818 / 2134811 (at one end of the dam itself).
Nam Ngiep 2 Tributary Diversion Project.	Nam Ngiep.	Nam Sen	0319877 / 2128351 (looking at dam wall and into main reservoir.
Nam Ngiep 2 Main Project.	Nam Ngiep / Nam Siam.	Nam Siam	0322177 / 2116873 (looking straight at the dam construction).
Nam Ngiep 1 Project.	Nam Ngiep.	Mainstream Nam Ngiep	Coordinates not known at present but are available from NN1 Project offices.
Nam Chane Project (large bill board on route 1D). The Nam Chian (Nam Jey) HPP.	Nam Ngiep.	Nam Chian / Nam Chane (map and billboard names respectively) and my vernacular name for what I hear is Nam Jey.	0348126 / 2117801 (looking straight at the “V” walls of the dam under construction).
Nam Sane 3B Project (large billboard on route 1D). The Nam Xan 3B HPP.	Nam Xan.	Mainstream Nam Xan.	0354851 / 2110929 (looking directly at the dam under construction).
Nam Sane 3A Project (large billboard on route 1D). The Nam Xan 3A HPP.	Nam Xan	Mainstream Nam Xan.	0359249 / 2115479 (looking directly at the dam under construction).

Table 3 Table 3 presents a list of the eleven FCZs established by seven villages from Ban Xiengkhong downstream to Ban Pou on the Nam Ngiep mainstream.

Name of village closest to and responsible for the FCZ (descending order downstream from NN2 Main Project)	**Local name of FCZ**	**Coordinates**
Ban Xiengkhong	Xiengkhong FCZ (III) ***Wang***?	0325360 / 2113485
Ban Xiengkhong	Xiengkhong FCZ (II) ***Wang Hin Ngon***	0326019 / 2110950
Ban Xiengkhong	Xiengkhong FCZ (I) ***Wang Khouak***	0326443 / 2112467
Ban Viengthong	Viengthong FCZ (I) ***Wang Saphan***	0326723 / 2108798
Ban Naxong	Naxong FCZ (II) ***Wang Gua***	0328767 / 2106968
Ban Naxong	Naxong FCZ (I) ***Wang Ngiow***	0329194 / 2106856
Ban Thaviang Sai	Thaviang Sai FCZ (II) ***Wang Tham***	0330969 / 2106060
Ban Thaviang Sai	Thaviang Sai FCZ (I) ***Wang Sop Pang***	0331352 / 2105565
Ban Phiangta	Phiangta FCZ (I) ***Wang Som Lom***	0333814 / 2104624
Ban Hat Sam Khon	Hat Sam Khon FCZ (I) ***Wang Hat Sam Khon***	0335830 / 2103908
Ban Pou	Pou FCZ (I) ***Wang Sop Pou***	0338585 / 2103326

Table 4 Table 4 shows where Ls spawns in the Nam Ngiep tributaries and Nam Ngiep mainstream and where there is temporary dry season habitat and temporary wet season habitat.

a) Nam Gnok (Nam Youak) and Houay Xay – Nam Youak is a tributary of the Nam Ngiep and Houay Xay is a tributary of the Nam Gnok

Ls spawning habitat outside of hydropower development	**Temporary or permanent Ls dry season refuge habitat (deep pool) but not recognized as spawning habitat outside of hydropower development**	**Village / site reference. Temporary Ls wet season habitat outside of hydropower development**	**Stream name**	**Coordinates**
None reported during survey.	At least one deep pool between Ban Houayxay and confluence point with Nam Youak.	Ban Houayxay. Yes, Ls reported present here each year in wet season (mostly small around 1kg).	Houayxay (stream that joins the Nam Youak).	0323385 / 2070823 (Village). 0325059 / 2070772 (deep pool not FCZ)).
None reported during survey.	Two deep pools referenced between Ban Nam Youak and confluence point with the Houay Xay.	Ban Nam Youak. Yes, Ls reported present in this stream, but only during wet season. Ls moves back to Nam Ngiep by early to mid dry season.	Nam Youak (stream that flows into Nam Ngiep).	0331551 / 2071102 (Village). 0328434 / 2071085 (deep pool not FCZ). 0330260 / 2071127 (deep pool not FCZ).

b) Nam Phouan is a major tributary of the Nam Ngiep mainstream

Ls spawning habitat outside of hydropower development	**Ls dry season refuge habitat (deep pool) but not recognized as spawning habitat outside of hydropower development**	**Village / site reference. Temporary Ls wet season habitat outside of hydropower development**	**Stream name**	**Coordinates**
None reported during survey.	One deep pool (***Wang Pba Deng***) referenced approximately 1km upstream from Nam Phouan – Nam Ngiep confluence point. May represent a dry season refuge habitat.	Ban Sopphouan. Yes, Ls reported from this stream and caught in both dry and wet season. If deep pools are very large and deep, Ls stays throughout dry season.	Nam Phouan (stream that flows into Nam Ngiep).	0334373 / 2076996 (Village). 0334222 / 2077752 (***Wang Pba Deng*** no longer FCZ and abandoned two years ago).

b) Continued ….

Ls <u>spawning</u> habitat outside of hydropower development	**Ls dry season refuge habitat (deep pool) but not recognized as spawning habitat outside of hydropower development**	**Village / site reference. Temporary Ls wet season habitat outside of hydropower development**	**Stream name**	**Coordinates**
None reported during survey.	One deep pool (***Wang Hong Mor***) referenced 300 meters downstream from Ban Sopphouan on the Nam Ngiep mainstream. Definite Ls dry season refuge habitat.	Ban Sopphouan. Not defined as a wet season habitat but Ls probably pass through it.	Nam Ngiep mainstream.	0334373 / 2076996 (Village). 0334403 / 2076753 (***Wang Hong Mor*** no longer FCZ and abandoned two years ago).

c) Nam Chian (Nam Jey) is a major tributary of the Nam Ngiep, and Nam Long a right-bank tributary of the Nam Chian

Ls <u>spawning</u> habitat outside of hydropower development	**Ls dry season refuge habitat (deep pool) but not recognized as spawning habitat outside of hydropower development**	**Village / site reference. Temporary Ls wet season habitat outside of hydropower development**	**Stream name**	**Coordinates**
Not reported at this location.	Deep pool adjacent to road bridge (route 1D) over Nam Chian. Definite entire dry season habitat. Ls stays and does not go back to Nam Ngiep.	Road bridge (route 1D) over the Nam Chian.	Nam Chian (stream that flows into Nam Ngiep).	0342182 / 2105901 (FCZ / bridge). Formerly called ***Wang Tang Kham*** (now is FCZ and known as ***Wang Sangouan*** at the bridge).
Not reported at this location.	Deep pool approximately 2km upstream from road bridge / FCZ. Ls reported to stay in deep pool over entire dry season.	***Keng Pa Sang*** rapids just above deep pool in column 2. No name for deep pool.	Nam Chian (stream that flows into Nam Ngiep).	0342720 / 2106788 (Not an FCZ).

c) Continued …..

Ls <u>spawning</u> habitat outside of hydropower development	**Ls dry season refuge habitat (deep pool) but not recognized as spawning habitat outside of hydropower development**	**Village / site reference. Temporary Ls wet season habitat outside of hydropower development**	**Stream name**	**Coordinates**
None reported at this location.	Not a dry season refuge point.	Rapids just upstream from the Nam Chian road bridge and FCZ. Ls can pass rapids (bi-directional) only in wet season.	Nam Chian (stream that flows into Nam Ngiep).	0342199 / 2106137 (Rapids, no name).
None reported at this location.	Deep pool approximately 1.3km downstream below Nam Chian road bridge. No name for deep pool.	Deep pool on Nam Chian.	Nam Chian (stream that flows into Nam Ngiep).	0342738 / 2104483 (Deep pool).
None reported at this location.	Deep pool (***Wang Kok Hai***) approximately 100m above the deep pool mentioned above towards the Nam Chian road bridge. Very important entire dry season refuge habitat for Ls.	Deep pool on Nam Chian. Ls can pass (bi-directional) though it in wet season.	Nam Chian (stream that flows into Nam Ngiep).	0342776 / 2104706 (Deep pool, ***Wang Kok Hai***).
None reported at this location.	Ford crossing point through Nam Chian approximately 4km downstream from road bridge over the Nam Chian. Deep pool, but not important for Ls.	Deep pool on Nam Chian. Ls can pass (bi-directional) though it in wet season.	Nam Chian (stream that flows into Nam Ngiep).	0342147 / 2104072 (Ford crossing point through Nam Chian. Deep pool but not FCZ).
None reported at this location.	Right-hand bank tributary of the Nam Chian close to the road bridge over the Nam Chian. Ls does not enter this stream at any time of the year.	Right-hand bank tributary of Nam Chian.	Nam Long (stream that flows into Nam Chian	0342135 / 2105400 (Approximately 100m upstream from confluence with the Nam Chian).

c) Continued …..

Ls <u>spawning</u> habitat outside of hydropower development	**Ls dry season refuge habitat (deep pool) but not recognized as spawning habitat outside of hydropower development**	**Village / site reference. Temporary Ls wet season habitat outside of hydropower development**	**Stream name**	**Coordinates**
None reported at this location.	Not reported at this location.	The confluence point of the Nam Chian and the Nam Ngiep (about 7km downstream from Ban Pou). Ls can pass through this area in both the dry and wet season (bi-directional).	Nam Chian and Nam Ngiep.	0342042 / 2100812 (Confluence point of Nam Chian and Nam Ngiep.
None reported at this location.	Very important dry season refuge habitat and deep pool (***Wang Mak***) approximately 1km upstream from the confluence point on the Nam Chian. Ls can stay here throughout the dry season instead of going back to the Nam Ngiep.	Ls can pass through this area (bi-directional) in wet season.	Nam Chian.	0341763 / 2101157 (***Wang Mak*** deep pool and not an FCZ).

d) Nam Ngiep mainstream from Ban Xiengkhong to the Nam Chian – Nam Ngiep confluence point, and the Nam Thong (Nam Thaeng)

Ls <u>spawning</u> habitat outside of hydropower development	**Ls dry season refuge habitat (deep pool) but not recognized as spawning habitat outside of hydropower development**	**Village / site reference. Temporary Ls wet season habitat outside of hydropower development**	**Stream name**	**Coordinates**
None reported at this location.	Dry season refuge point (Xiengthong FCZ III)	Ls can pass through (bi-directional) during wet season months.	Nam Ngiep mainstream.	0325360 / 2113485 (FCZ)
None reported at this location.	Dry season refuge point (Xiengthong FCZ II – ***Wang Hin Ngon***).	Ls can pass through (bi-directional) during wet season months.	Nam Ngiep mainstream.	0326019 / 2110950 (FCZ)

d) Continued …..

Ls <u>spawning</u> habitat outside of hydropower development	**Ls dry season refuge habitat (deep pool) but not recognized as spawning habitat outside of hydropower development**	**Village / site reference. Temporary Ls wet season habitat outside of hydropower development**	**Stream name**	**Coordinates**
Dry season spawning site for Ls.	Dry season refuge point (Xiengkhong FCZ I – ***Wang Khouak***).	Ls can pass through (bi-directional) during wet season months.	Nam Ngiep mainstream	0326443 / 2112467 (FCZ)
None reported at this location.	Not a dry season refuge point (Nam Thong)	Ban Sanphouxai. Ls can pass through (bi-directional) during wet season months.	Nam Thong mainstream	0322554 / 2107531 (Village).
None reported at this location.	Not a dry season refuge point (Nam Thong).	Ls can pass through (bi-directional) during wet season months. Ls enters Nam Thong in wet season but only in the lower reaches.	Nam Thong flows into the Nam Ngiep at Ban Viengthong.	0327201 / 2108765 (Nam Thong – Nam Ngiep confluence point).
None reported at this location.	Dry season refuge point (Viengthong FCZ I – ***Wang***?	Ls can pass through (bi-directional) during wet season months.	Nam Ngiep mainstream.	0326723 / 2108798 (FCZ).
None reported at this location.	Dry season refuge point (Naxong FCZ II – ***Wang Gua***).	Ls can pass through (bi-directional) during wet season months.	Nam Ngiep mainstream.	0328767 / 2106968 (FCZ).
Dry season spawning site for Ls.	Dry season refuge point (Naxong FCZ I – ***Wang Ngiow***).	Ls can pass through (bi-directional) during wet season months.	Nam Ngiep mainstream.	0329194 / 2106856 (FCZ).
Dry season spawning site for Ls before road construction in 2003.	Dry season refuge point (Thaviang Sai FCZ II – ***Wang Tham***).	Ls can pass through (bi-directional) during wet season months.	Nam Ngiep mainstream.	0330969 / 2106060 (FCZ).

d) Continued ….

Ls <u>spawning</u> habitat outside of hydropower development	**Ls dry season refuge habitat (deep pool) but not recognized as spawning habitat outside of hydropower development**	**Village / site reference. Temporary Ls wet season habitat outside of hydropower development**	**Stream name**	**Coordinates**
None reported at this location.	Dry season refuge point (Thaviang Sai FCZ I – ***Wang Sop Pang***).	Ls can pass through (bi-directional) during wet season months.	Nam Ngiep mainstream.	0331352 / 2105565 (FCZ).
Dry season spawning site witnessed in 1988 / 89.	Dry season refuge point (Phiangta FCZ I – ***Wang Som Lom***).	Ls can pass through (bi-directional) during wet season months.	Nam Ngiep mainstream.	0333814 / 2104624 (FCZ).
Dry season spawning site for Ls.	Dry season refuge point (Hat Sam Khon FCZ I – ***Wang Hat Sam Khon***).	Ls can pass through (bi-directional) during wet season months.	Nam Ngiep mainstream.	0335830 / 2103908 (FCZ).
None reported at this location.	Dry season refuge point (Pou FCZ I – ***Wang Sop Pou***).	Ls can pass through (bi-directional) during wet season months.	Nam Ngiep mainstream.	0338585 / 2103326 (FCZ).
Dry season spawning site for Ls.	Dry season refuge point (***Wang Hat Ken Tow***). Point on Nam Ngiep mainstream between Ban Pou and the Nam Chian – Nam Ngiep confluence point.	Ls can pass through (bi-directional) during wet season months.	Nam Ngiep mainstream.	No direct reference because cannot be easily accessed.

6 Discussion

Luciocyprinus striolatus is a predatory Cyprinid fish species capable of reaching lengths of over one meter and weighing just in excess of 30 kilograms within the Nam Ngiep catchment. There were no reports of specimens weighing more than this after conducting interviews in 31 villages. Its preferred dry season habitat is deep pools up to about five meters in depth. Overwhelming anecdotal evidence gathered during surveys in April and May 2014 suggests that viable populations of Ls are still present in the Nam Ngiep mainstream and other tributaries of it. Juvenile Ls up to about one kilogram enter smaller tributaries (Nam Siam and Nam Gnok) on what appears to be a trophic migration during the early to late wet season period (May to about October). This is during a period when many other fish species (some of them small and weighing only two to three hundred grams each also enter tributaries for either spawning or for foraging. It may be the case that Ls juveniles find it easier to locate prey in certain types of tributary habitat rather than foraging in swiftly flowing currents during the wet season period in the Nam Ngiep mainstream. At the end of the wet season period Ls migrates back downstream again in most tributaries to dry season refuge habitats in the Nam Ngiep mainstream. However, some large Nam Ngiep tributaries such as the Nam Chian (Nam Jey) can also provide deep pool habitats during the dry season months and many fish species, including Ls, likely remain there and do not move back to the deep pools of the Nam Ngiep mainstream. When Ls reaches sexual maturity at about four or five kilograms in body weight for females, Ls probably then undertakes a spawning migration to a special habitat type and reproduces. It is not known if adult Ls return or 'home' to parental spawning sites.

The Nam Ngiep 1 Hydropower Project will block the Nam Ngiep mainstream close to Ban Hatsaykham with a 148 meter high dam. A re-regulation dam and reservoir will represent a year-round insurmountable barrier to almost all bi-directional fish movement in the downstream sections of the Nam Ngiep mainstream. This will have important implications for local fisheries in general and will involve a transition from a riverine fishery based on migratory and sedentary fish species to a static water fishery. This issue needs to be addressed under a separate study and anyway does not appear to affect Ls populations immediately apart from the inundation of known spawning habitats that will be lost through inundation due to NN1 FSL from about Ban Pou to about Ban Naxong (320 meters asl). One important question that remains unanswered from the Phase 1 and 2 surveys is; "can Ls survive in a reservoir environment and still gain seasonal access to historical spawning grounds that remain in free-flowing areas above NN1 FSL inundation? If so, could a population survive if all other factors remain equal?". Other riverine / rheophilic Cyprinid fish species **were** able to do this in the Nam Ngum 1 reservoir before access to the free-flowing feeder rivers were blocked by further upstream hydropower development. In theory, if at least half of the deep pools / FCZs / potential spawning grounds remain non-inundated between Ban Nam Pou and Ban Xiengkhong (photos 3782, 3761, 3769, 3757 and 3763) then perhaps there would be the possibility of a population of Ls surviving above the NN1 FSL. This of course will depend on what hydropower development takes place upstream of NN1 FSL and how it will be operated and managed (NN2 and NN3 Projects). Both the NN2 and NN3 Hydropower Projects have the **potential** to alter natural hydrological regimes and possibly produce changes in water quality in the Nam Ngiep mainstream where Ls is currently known to breed and carry out other essential life-cycle events.

Apart from the direct impacts that the NN1 Hydropower Project may have on populations of Ls throughout the Nam Ngiep catchment in the future, a number of indirect or background impacts have already taken place over the past two to three decades at least. Some of the most important ones involve catchment deforestation, indiscriminate use of illegal fishing methods (fishing using electrical devices, use of home-made bombs and use of fish toxins and anesthetics to catch fish), human population expansion linked to increased fishing

pressure (semi-commercial fish as opposed to subsistence fishing), pollution arising from a number of sources and general environmental degradation caused by widespread road and infrastructure development. Dam construction is having a major impact on fisheries and populations of Ls throughout the Nam Ngiep catchment and will continue to do so in the future, but it is not the only cause of a decline in fisheries in general that includes Ls populations. Reduced dry season flows, attributable to deforestation and perhaps changes in climate also represent major concerns for the viability of wilderness fish populations throughout the Lao PDR in general including the Nam Ngiep catchment.

This study is aimed specifically at populations of Ls throughout and within the Nam Ngiep catchment, but this is not the only geographical area where Ls populations are either known or thought to exist. Ls was first described from specimens caught in rivers in southern China (Yunnan Province) and is also reported to be present in upland river systems along the Annamite mountain range in neibouring Vietnam. Of even more importance to the Lao PDR, populations of Ls are found in at least the Nam Ou, the Nam Theun-Kading-Mouan-Ngouang system and the Xe Kong catchments. Its presence is also strongly suspected in the Nam Tha in Louang Nam Tha Province.

In a worst case scenario, the Nam Ngiep 1 Hydropower Project has the potential to bring about localized extirpation of this fish species over certain river stretches simply because it will inundate places where it spawns and lives during the annual dry season period. It will not cause, and could never cause the extinction of this species. Nothing is known about sub-species of this fish or even if they exist at all. Ls does appear to be resident in some other large Nam Ngiep tributaries that provide it with the types of habitat that it requires to carry out various critical life-cycle events (Nam Chian). The final decision, if not already made, on the height of NN1 FSL may prove very important to the continued existence of Ls populations in the Nam Ngiep mainstream. Of equal importance in maintaining a population of Ls in the Nam Ngiep mainstream will be to establish a close dialogue with the companies operating upstream hydropower projects (NN2 and NN3). Throughout the Nam Ngiep catchment, it may be possible to maintain a viable population of Ls even with the NN1 Hydropower Project in place, unless these populations become impacted by other events and activities not necessarily related to, or perhaps directly related to dams.

7 Conclusions

- ***Luciocyprinus striolatus*** populations are still present (May 2014) in the Nam Ngiep catchment and are found in certain types of large upper Nam Ngiep tributaries.
- The upper Nam Ngiep mainstream represents an aquatic environment where Ls can live and apparently carry out its entire life-cycle within the system.
- It is not yet known if it might be possible for Ls to thrive in a reservoir habitat outside of its known breeding period. If this could be demonstrated in some way, and linked presumably to its apparent absolute requirement to return to flowing water habitat in order to reproduce, this may have vital implications regarding its future existence within the Nam Ngiep catchment even if hydropower development continues as planned.
- The actual size of the population cannot be enumerated using known methods at present because it is caught infrequently and at some sites it is only encountered two or three times per year based on anecdotal reports.
- Because it is a large Cyprinid species, it is highly probable that it takes several years to reach sexual maturity (females at least). This, along with many other Mekong Basin giant fish species makes it highly vulnerable to the impact of over-fishing.
- Juvenile Ls (up to about one kilogram) appear to make a trophic migration into certain types of small tributary (Nam Siam and Nam Gnok) during the wet season months from May to October. However, there is sufficient anecdotal evidence to suggest that

Ls does not remain in these smaller tributaries and in fact moves back downstream again at the end of the wet season to take up residence in deep pools in the Nam Ngiep mainstream over the dry season period.

- There appear to be deep pool habitats in certain tributaries (Nam Chian and perhaps Nam Phouan) where Ls takes up residence during the dry season period and does not move back to the Nam Ngiep mainstream.
- Breeding almost certainly takes place during the dry season months of January to April each year at the top end of riffle sections at the downstream end of deep pools. Despite similarity of habitat to known places where Ls breeds, Ls does not appear to breed at **all** of the deep pool / riffle habitats surveyed in April and May 2014 based on information obtained during interviews.
- Ls populations throughout the Nam Ngiep catchment are threatened by a wide range of impacts including, but certainly not limited to hydropower development only.
- Upstream hydropower development (NN2 and NN3 Projects) have the potential to negatively impact on populations of Ls above NN1 FSL.
- Zoogeographical barriers to Ls movements are present in the Nam Ngiep and some of its tributaries in the form of powerful rapids and waterfalls (Nam Chian).
- Based on all available evidence to date, Ls does not appear to be resident in the Nam Xan from Ban Namphang to Ban Simouangkhoun that confluences with the Mekong at Pakxan. The reasons for this are unknown but may be related to elevation-temperature and shallow water during the dry season months.
- Upstream dam construction is producing high levels of siltation in the Nam Ngiep and the Nam Xan and has done so during the past three years at least. It is not known if this has impacted Ls populations or not.
- According to local sources, the establishment of eleven FCZs from Ban Pou to Ban Xiengkhong has been effective over the past decade in providing a measure of protection for fisheries resources. Some of the eleven FCZs will be inundated by the current NN1 FSL prediction.
- The artificial breeding of Ls remains an intriguing and challenging task, but it will be of very limited value or even useless unless the causes of the assumed decline in populations of Ls are addressed to begin with.

8. Recommendations

- Contact should be made with other hydropower companies in other river catchments within the Lao PDR or elsewhere that are running fisheries monitoring programs and that are known, or were known to have resident populations of Ls before impoundment took place. Every effort should be made to establish conclusive evidence if Ls is able to thrive in a reservoir environment outside of its normal spawning period.
- Efforts must be made to identify viable populations of Ls at as many other discrete river catchment areas as possible within the Lao PDR where Ls populations are thought to have a high probability of being resident (see Table 5 below). The objective of a Phase 3 part of this overall study will be to assess the persistence of Ls across its range in Lao PDR and define the potential for conservation measures as a biodiversity offset to ensure the persistence of viable populations of Ls in other discrete river catchments.
- As a recommendation (more of a suggestion) it must be stated that the lower the NN1 FSL can be set at, there will be more of a positive benefit regarding protection of Ls spawning and dry season refuge habitat. It is acknowledged that the NN1 FSL may need to be fixed based on optimum hydropower output and or economics.

- All efforts need to be directed towards establishing exactly what the NN1 FSL level will be and maps produced so that the impacts of inundation of Ls habitat can be best assessed.
- Effort and money spent on an artificial breeding program for Ls may be better directed towards protecting the known habitats where Ls spawns and lives. Also, it would be highly desirable to know if Ls can live within a static reservoir habitat.
- Direct dialogue must be established with the NN2 and NN3 Projects to understand exactly how these projects will be operated and managed.

Table 5 Table 5 shows a number of discrete river catchments (Discrete Management Units – DMUs) in various provinces placed in the rank of high probability of occurrence but adjusted for a priority rating based on selection criteria that will be surveyed in Phase 3 of the present study.

Name of province and name of discrete catchment	Priority rank and priority rating	Selected for by rank based on certain criteria
Luang Namtha Nam Tha catchment, the Nam Fa catchment and the Nam Ma catchment. ***Three possibilities, but Nam Tha is priority***.	High (1)	Province of Luang Nam Tha is bordered by Yunnan Province in China to the north where Ls was first described from in 1986. The Phou mountains range runs along the China / Lao border. Mountainous areas. December – February temperatures as low as 5 degrees Celsius. Northern Highlands zone elevations between 1,000-2,000 meters asl. Large tracts of dense forest on mountain slopes. Three large rivers drain westwards / southwards into the Mekong; Nam Tha, Nam Fa and Nam Long. Province known for its very wide range of wildlife. Easily accessed by air travel. Good communications / good roads.
Bokeo Nam Ngam (Nam Nga) catchment.	High (2)	Province of Bokeo borders Luang Namtha Province to the northeast, Oudomxai Province to the east and Xaignabouli Province to the south. The protected areas in Bokeo Province are characterized by mixed deciduous forest and mountainous terrain with elevation ranging from 500 to 1500 meters asl. Wildlife is in abundance throughout the province and the largest river that passes through the province is Nam Nga. Road access is reasonable and air connections with the capital needs to be checked (map).
Oudomxai Middle and upper Nam Beng catchment.	High (2)	Province Oudomxai borders China to the north, Phongsali Province to the northeast, Luang Prabang Province to the east and southeast, Xaignabouli Province to the south and southwest, Bokeo Province to the west, and Luang Namtha Province to the northwest. The topography of Oudomxai is mountainous, between 300 and 1,800 meters asl. Altogether approximately 60 rivers flow through Oudomxai Province. An air connection exists between Oudomxai and Vientiane and road connections and communications are generally good.
Houaphan Song Ma catchment and or Nam Sam catchment. ***Two possibilities, but Song Ma is priority***.	High (3)	Province of Houaphan is bordered by Vietnam to the north, east and southeast, Xiang Khouang Province to the south and southwest, and Luang Prabang to the west. The terrain is rugged, with dense mountainous forest forming much of the province especially on the western side. Main Route 6 runs through the center of the province. The Song Ma flows from and back into Vietnam. The province is characterized by hills and low mountains 300 to 1,800 meters asl. Wildlife is found in abundance. The province can be easily reached by air travel.

9 Mitigation and biodiversity offset

- As part of the recommendations section, mitigation primarily involves keeping the NN1 FSL as low as possible. This will help to protect important Ls spawning grounds and dry season habitat.
- As many “critical habitat” river sections should be preserved as possible and designated as FCZs to ensure protection for Ls populations in addition to those already present.
- Future studies should be aimed at identifying other populations of Ls both within the international borders of the Lao PDR and those in Yunnan Province in China and also in Vietnam.

10 Limitations and short comings of study

- Few limitations or shortcoming have been experienced during the field work part of this study apart from the obvious time restraints placed on all studies of this nature. However, it is difficult to imagine that much more information could have been gathered in the field from this remarkable and uncommon species of fish.

11 References

- Warren, T. J. (2014a) Preliminary report on the status of ***Luciocyprinus striolatus*** populations within the Lao PDR’s national boundaries within the Nam Ngiep catchment area.
- Warren, T. J. (2014b) Final Report Big Fish – ***Luciocyprinus striolatus*** (Pba Gooan Sai) Study April 3 to 8 2014.

12 Appendices

Appendix 1 – Photograph Captions

List of photo numbers and photo locations (April - May 2014)

3646 The Houay Xay close to Ban Houayxay.

3647 A deep pool (no name) on the Houayxay just before confluence with the Nam Youak.

3655 The Nam Gnok (Nam Youak is local name).

3651 The Nam Gnok approximately two to three kilometers above Ban Nam Youak.

3661 The Nam Phouan at the very end of ***Wang Pba Deng*** that was abandoned as an FCZ two years ago due to too much illegal fishing activity from people outside the village.

3667 The confluence point of the Nam Phouan and the Nam Ngiep.

3692 An FCZ on the Nam Chian (Nam Jey is local name) that is now referred to as Wang Sangouan after it was designated as an FCZ five years ago. Before that it was known as Wang Tang Kham. Ls was last seen and caught here five years ago. Now, nobody fishes here because it is an FCZ.

3693 This is a deep pool on the Nam Chian approximately 1.5 kilometers upstream from the FCZ at the road bridge (3692). This is the last place where Ls has been caught in recent years according to our guide and expert on Ls.

3697 This photograph is of a series of rapids (***Keng Pa Sang***) taken approximately 500 meters upstream from the Nam Chian road bridge.

3703 This is a photograph of ***Wang Kok Hai*** and is found approximately one kilometer downstream from the Nam Chian road bridge. This, according to our guide is a dry season hot spot for catching Ls. It is not an FCZ and Ls regard it as a dry season refuge habitat and up to 30 or 40 Ls are caught here each year.

3553 This is a photograph of Wang Khouak, an FCZ / deep pool close to Ban Xiengkhong and a known spawning site of Ls.

3361 The NN2 Main Project under construction.

3408 The NN2 Tributary Diversion Project under construction.

3461 The sluice gate for releasing water to the Nam Ngiep in the valley below at the NN3 project.

3660 Interview with villagers at Ban Sopphouan.

3793 Interview with villagers at Ban Wang Hai.

3730 ***Wang Mak*** on the lower Nam Chian approximately one kilometer upstream from the confluence with the Nam Ngiep.

3722 The confluence of the Nam Chian and the Nam Ngiep.

3663 The Nam Phouan close to Ban Sopphouan.

3799 The Nam Xan in Thathom District.

3797 The Nam Xan in Thathom District.

3761 ***Wang Gua*** close to Ban Naxong and FCZ.

3769 ***Wang Saphan*** close to Ban Viengthong and FCZ.

3757 ***Wang Tham*** close to Ban Thaviang Sai and FCZ.

3763 A village sign laying out the rules for the Wang Gua FCZ close to Ban Naxong.

Appendix 2 - Photographs

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Appendix 3 – Excel spreadsheets and a map of Ls distribution in southern China

1. Copy of L striolatus data form China (I).xlsx (Data from ERM Shanghai office, China)

2. Copy of L striolatus data form_China .xlsx (Data from ERM Shanghai office, China)

3. L striolatus data form - Mai Dinh Yen .xlsx (Data from ERM Ho Chi Minh office, Vietnam)

4. L striolatus data form - Nguyen Van Hao. xlsx (Data from ERM Ho Chi Minh office, Vietnam)

5. L striolatus data form - Nguyen Van Trong. xlsx (Data from ERM Ho Chi Minh office, Vietnam)

6. Location of Puwen River and Luosuo River 2.pptx (Data from ERM Shanghai office, China)

Final Report on the ***Luciocyprinus striolatus*** population impacts and conservation status in Lao PDR, Southern China and Vietnam (July 2014)

Prepared by

Mr. Terry J. Warren

For

The Nam Ngiep 1 Hydropower Company

July 2014

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Acknowledgements

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Executive Summary

Luciocyprinus striolatus (Ls) was placed under the IUCN red list Endangered (EN) category, and is a species likely to be impacted by the Nam Ngiep 1 HPP. The overall purpose of the study on *Ls* has been to ascertain population distribution and condition in relation to IFC Critical Habitat threshold limits.

A total of 69 separate interviews were undertaken in 10 major river systems of Lao PDR, which identified that the fish exists in at least six of these systems. In addition, a literature review revealed the Ls exists in another five rivers systems in Lao PDR, and three rivers in Southern China. In total, 14 Ls DMUs have been positively identified. Information on the distribution of the Ls is scant, and the fish is also likely to be present in rivers not yet surveyed.

As 14 DMUs have been positively identified, the threshold limits for the IFC Critical Habitat threshold Tier 1 sub-criterion (a) and (b) have been satisfied.

The studies found that Ls DMUs were clustered in Lao PDR, but this might only be a consequence of study constraints. It also determined that Ls appears to be a Mekong species, having only been found in Mekong tributaries where particular habitat types occur. In this context, the DMUs are of regional importance to the Mekong.

In addition to determining the distribution of the species it was necessary to understand the current condition and threats to the populations, as well as ascertain whether or not conservation mechanisms currently in place provide any form of protection toward its longer-term survival. This information was required to determine if limits for the IFC Critical Habitat threshold for Tier 2 sub-criterion (c), (d) and (e) are satisfied.

To help understand this, each of the 14 DMU was given an overall rank score to identifying its relative importance against the regional (Mekong) Ls population. The rank score (Regional Importance Ranking) was derived from a comparison assessment of DMU Condition, Threats and Conservation Status criteria. From this it was determined that the most important Ls population is the Nam Fa DMU, Luang Nam Tha Province, while the Nam Beng and Nam Ma DMUs in Oudomxai and Luang Nam Tha Provinces respectively were equally determined to be the least important. The Nam Ngiep DMU was ranked 6th overall.

Importantly, the study revealed that Ls species persists in tributaries were the major trunk stream of the rivers have been regulated by hydropower. This indicates that with appropriate mitigations the Nam Ngiep DMU can be sustained if tributary populations are managed accordingly. In any event, while the Nam Ngiep DMU is important (as currently only 14 DMUs are known) its possible extirpation is not likely to impact on the species regionally, given the low level of threats and high conservation status afforded to other DMUs and in particular the Nam Fa, Nam Theun / Kading and the Xe Bang Fai. As such the IFC Criteria for Tier 2 (c), (d) and (e) have been satisfied.

This assessment has been based on information gathered from a large of number of group interviews, field observations and literature research but it is recommended that further verification be undertaken in order to identify additional DMUs and build on current knowledge that was used to reach the current conclusions.

1 Introduction

The Nam Ngiep 1 Hydropower Project (NNP1) involves the construction of a 290MW hydropower dam on the lower Nam Ngiep, a left bank tributary of the Mekong River in Lao PDR. The project covers parts of the provinces of Bolikhamxay and Xaysomboun. The Nam Ngiep River flows in a south-southeast direction through a mountainous region. Part of the dam FSL location has been identified as potential habitat of the IUCN Red (EN) listed *Luciocyprinus striolatus* (Ls).

The study objective is to assess the persistence of Ls across its range in the Nam Ngiep, Lao PDR and beyond. It is also required to identify the current condition and threats on the population, and understanding the status conservation measures afforded to it.

The study provides important information for the preparation of a Critical Habitat Assessment (CHA), which was triggered by the positive identification of Ls in the NNP1 Project Area. This CHA is in accordance with Asian Development Bank Environmental Safeguard Policy Statement (2009).

This study compliments the *Comprehensive Species Profile,* which outlines taxonomy, biological characteristics, ecological role, life history, environmental requirements, and importance (economic or cultural) to Lao villagers.

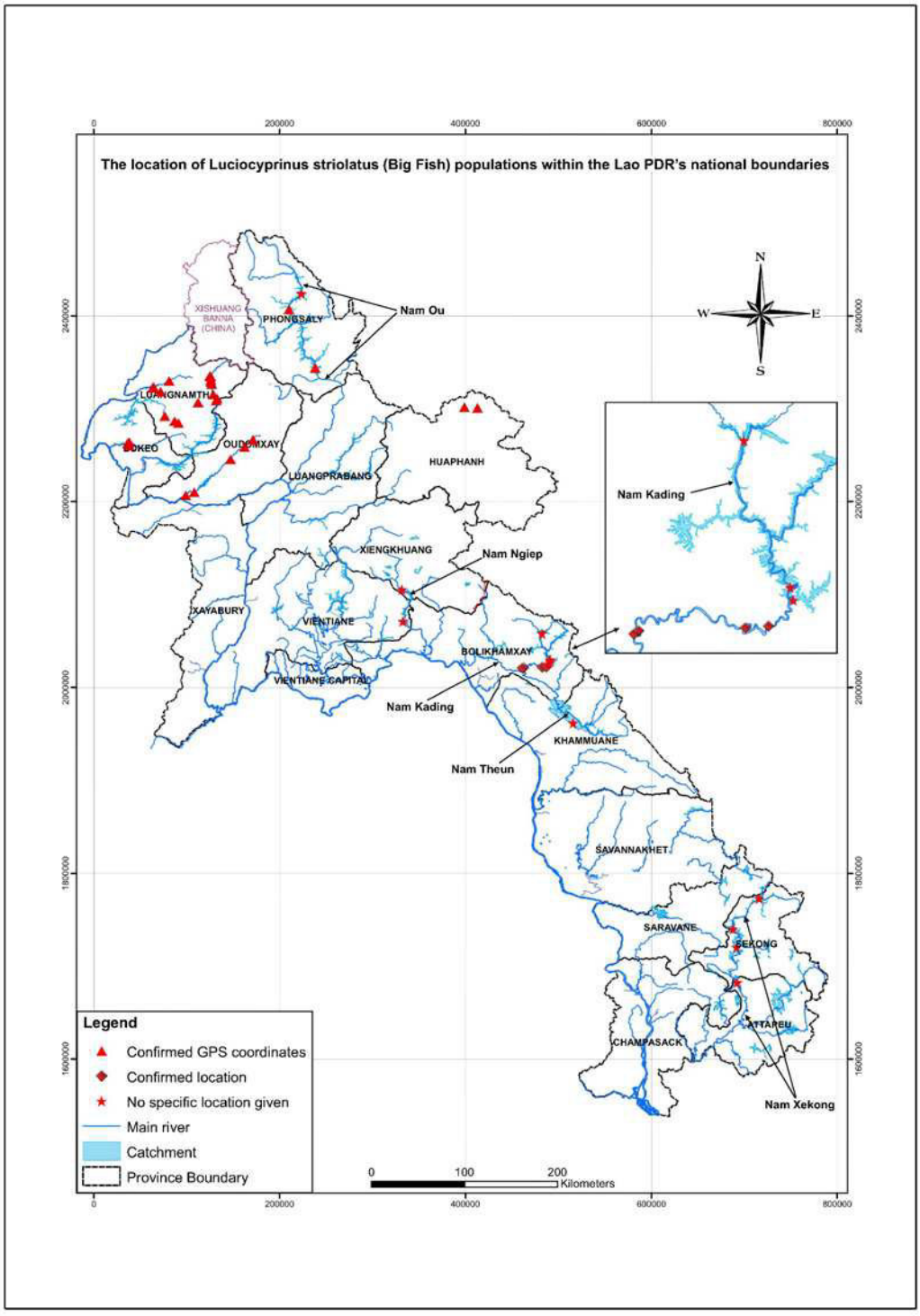

Figure 1. The location of ***Luciocyprinus striolatus*** populations identified during this study in the Lao PDR

2 Study Method

2.1 Field Investigation

Spatial data and maps were used to identify probable locations (catchments and unique habitat) of Ls populations. Semi structured interviews, 69 in total, were then conducted with villagers close by to these areas. The interviews were conducted with experienced fishers, generally six per village, chosen by the village chief, who also contributed. The interviews were used to obtain the following key information:

a) The presence of absence of Ls;
b) The location of Fishing Conservation Zones as they relate to Ls;
c) Known Ls spawning grounds;
d) Local fishing techniques;
e) Local land and water use;
f) Observed changes in river condition;
g) Trends in Ls fish populations including catch size, frequency, age and size class.

A literature review was also undertaken to identify all existing information of Ls populations in Lao PDR, Vietnam and Southern China.

2.2 Data Analysis

The study objective was to assess the persistence of Ls across its range in the Nam Ngiep, Lao PDR and beyond. It was also required to identify the current condition and threats on the population, and understanding of the status conservation measures afforded to it. For this approach refer to section on **3.1 Regional Ranking Procedure**.

The criteria for critical habitat reference is the *discrete management units* for the species. For the purposes of this assessment, the ADB has instructed that each catchment where the Ls has been reported from is considered to be a single management unit. In this context, the following analysis procedures have been applied.

3 Results

Eighteen major catchments were considered as part of the overall Ls study. Fourteen were found to contain Ls populations (Table 1 below).

Table 1 Major catchments assessed for Ls populations

River Number	Catchments considered in this assessment	Method of Assessment	L.s Identified
1	Nam Fa	Field Observations, Literature Review and Villager Interviews	Yes
2	Xe Bang Fai	Literature Review	Yes
3	Nam Ou	Literature Review	Yes
4	Nam Theun - Kading	Literature Review	Yes
5	Nam Ngum	Literature Review	Yes
6	Nam Ngiep	Field Observations, Literature Review and Villager Interviews	Yes
7	Nam Nga	Field Observations, Literature Review and Villager Interviews	Yes
8	Xekong	Literature Review	Yes
9	Nam Tha	Field Observations, Literature Review and Villager Interviews	Yes
10	Nam Beng	Field Observations, Literature Review and Villager Interviews	Yes
11	Nam Ma	Field Observations, Literature Review and Villager Interviews	Yes
12	Luosuo River (China)	Literature Review	Yes
13	Langcang Mainstream (China)	Literature Review	Yes
14	Puwen River (China)	Literature Review	Yes
15	Nam Xan (Vietnam)	Field Observations, Literature Review and Villager Interviews	No
16	Nam Xan (Laos)	Field Observations, Literature Review and Villager Interviews	No
17	Song Ma (Vietnam)	Field Observations, Literature Review and Villager Interviews	No
18	Nam Long	Field Observations, Literature Review and Villager Interviews	No

Table 2 Number of interviews at each location and the various categories of villager responses to fish catch questions.

DMU	Province	Number of interview villages / sites in total	Number of villages to report recent capture (last 2 years) but only small fish (≤ 3 - 400g) and not very many	Number of villages report to recent capture (last 2 years) but larger fish (≤ 1kg +) mixed with small fish but very few	Number of villages report to they used to catch it 3 to 10 years ago but very few now	Number of villages report they used to see it 10 + to 20 years ago but never see now	Number of villages reporting they do not know the fish and never caught it
Nam Tha (above NT3 dam)	Luang Namtha	4	3		1		
Nam Tha (below NT3 dam)	Luang Namtha	5		2	2	1	
Nam Ma	Luang Namtha	4		1	1	2	
Nam Fa	Luang Namtha	5	1	3		1	
Nam Nga	Bokeo	4	4				
Nam Beng(above Nam Beng 1 under construction)	Oudomxai	6	4			1	1
Nam Beng (below Nam Beng 1 under construction)	Oudomxai	3	1		1		1
Song Ma (Nam Ma)	Houaphan	4	1		1	1	1
Nam Sam	Houaphan	3					3
Nam Ngiep	Bolikhamxai and Xaysomboun	31	5	10	8		8
TOTAL		69					

Table 3 presents a summary of key information gathered during the field surveys, observations and literature review. (Comments made by the author are cited.)

Regional Priority Ranking	DMU Name	Key Comments and Observations
#1	Nam Fa	- Earlier this year (2014) two Ls caught, one 22 kg and one 19.5kg - Ls regularly appears (weekly) in the market at Muang Long from Nam Fa - At Muang Long, old people talk of the days (20 years ago) when Ls was "common" - Best fishing grounds are in deep pool areas towards Mekong confluence - There are many FCZs along lower reaches of the Nam Fa towards confluence with the Mekong - Largest population of Ls of all rivers surveyed during the entire study (author's observation) - No spawning sites were confirmed along Nam Fa (author's note)
#2	Xe Bang Fai	- Upper catchment remains well forested - Many deep pool habitats remain intact - River free from pollution - Many FCZs along various sections of the river - Relatively low numbers of people present - Illegal fishing methods employed because many remote areas - Protected area
#3	Nam Ou	- Low impact on fisheries resources due to low population numbers - Very productive fisheries observed in middle and upper reaches during surveys carried out in 2010 - Dam cascade now under construction - Phou Den Din NPA in place - Remote area and difficult to access road networks - Stable population of Ls observed in 2010
#4	Nam Theun - Kading	- -Comparatively pristine habitats above Nakai Plateau - Many deep pool habitats - Several reports of spawning behavior in Nam Mouan (Kading tributary) in 1990s - -River not affected greatly by reduced dry season flow - Clear water river and low levels of pollution - Large problem with illegal fishing according to interviews with fishers in 1990s - Impacts from dams - Low human population numbers - Large areas protected by NBCA

#5	Nam Ngum	- Low DMU population numbers - Dam cascade now in place involving at least four built - Remote area and difficult to access - No legally protected conservation or protected area in place
#6	Nam Ngiep	- Isolated reports of large (>10kg) Ls being caught - Small Ls still being caught in the NN1 FSL area - Many reports from villagers about negative impacts from road construction - Many deep water habitats being lost to sedimentation - Over-fishing becoming a serious problem - High levels of sedimentation - Eleven FCZs identified near to NN1 FSL tailwaters - Four spawning sites identified for Ls where fish have been seen to spawn within the last two or three years - No legally binding protected area - Some large deep pools now resemble static reservoirs (May 2014) where flow can barely be detected
#7	Nam Nga	- River mostly in a healthy condition in lower reaches, but human population numbers quite high (author's note) - Many bridges but no dams yet (author's note) - Contract farming of bananas cause great deal of surface run-off carrying high sediment load with it(extending over kilometers of riparian land) - Fish catch in general has declined considerably over past 10 years - Teenager in village said he caught Ls two years ago on rod and line - Many FCZs along Nam Nga and anyone can witness large numbers of small and large fish generally in the deep pools (author's note) - -Nam Nga runs through a protected area - Some large deep pools now resemble static reservoirs (May 2014) where flow can barely be detected - Many deep pools badly silted up - Villagers commented that many deep pools have silted up in recent years - Villagers said that some deep pools so badly silted now that they are more "like ponds" (May 2014)

#8	Xekong	- Large fish very vulnerable to attack with spears when spawning in very shallow water - Villagers report that fish very sensitive to waters with high sediment loadings in the dry season - Widespread impacts now from gold-dredging boats creating turbid conditions - Dams may threaten areas where Ls is known to live - Many FCZs throughout Xekong catchment and have proved to be very successful in protecting many fish species including Ls - Xe Sap NBCA may have helped to protect Ls - Xekong used to have a large population of Ls about 15 years ago as personally witnessed, but becoming more rare now.
#9	Nam Tha	- Villagers say that since the dam (Nam Tha 3) in 2005, they no longer see large Ls above the dam, only small ones (<12cm) - Villagers think that Ls still spawns somewhere above dam, because small fish appear at the high water period each year - Villagers said that road construction caused much damage to fisheries - One dam worker said that he caught one Ls fish below the dam on a rod and line in 2013 - Villagers just north of Luang Nam Tha reported that they knew Ls well and remember large Ls up to 20kg about 20 years ago - Many FCZs now being ignored along sections of the Nam Tha - Many villagers report that only very rarely is Ls caught around 1kg - - Old people from villages above the dam remember catching Ls over 15kg

#10	Nam Ma	- Now many deep water dry season habitats are filled with silt - Nam Ma waters damaged by contract farming causing sediment run-off - -Villagers said that now they only see small Ls during wet season - From 2009 villagers said they no longer see large individuals of Ls - Villagers said that they blamed contract farming for releasing pesticides and herbicides into water and causing a reduction in fisheries- - People often make the journey from Nam Long to Nam Fa to go fishing now because fishing is much better there (stay for several days) - Old villager said that now people no longer go fishing in the Nam Ma and instead they travel 50km to the Nam Fa to go fishing - Nam Ma runs outside of any protected areas - Many FCZs abandoned now along Nam Ma - Only see small Ls fish now - Used to be many large Ls in the Nam Ma over 10 years ago
#11	Luosuo River (China)	- System degraded by cascade of hydropower dams - Degraded ecological system - High human settlement level - Low, possibly unstable population of Ls
#12	Langcang Mainstream (China)	- System degraded by cascade of hydropower dams - Degraded ecological system - High human settlement level - Low, possibly unstable population of Ls
#13	Puwen River (China)	- System degraded by cascade of hydropower dams - Degraded ecological system - High human settlement level - Low, possibly unstable population of Ls
#14	Nam Beng	- "Small Ls still appear each year in upper reaches" - Old people interviewed in the upper Nam Beng area immediately knew the fish and placed the name of *Pba Gwan* on it and then positively identified it when shown photographs - In the middle reaches of the Nam Beng, many people said then knew it before devastating landslides four years ago - Fishers do not know the fish at Nam Beng / Mekong confluence - Villagers commented that landslides are commonly occur - One fisher said he had caught a small (<12cm) Ls the day before our interview with him, but had consumed it - For small Ls to be showing up each year, spawning must be taking place at an unknown location within system - Middle reaches are now silt-laden with many previously deep water habitats now contain shallow warm water

3.1 Regional Ranking Procedure

From village interviews it was identified that six common direct impacts were affecting the habitat quality of DMUs.

A. Habitat fragmentation and resource over extraction caused by human settlement.
B. Infrastructure expansion.
C. Population pressure on fisheries (exploitative processes).
D. Reduced dry season flows.
E. Increased sedimentation of habitat.
F. Pollutants in waterways.

These common six impacts were affecting all DMU to more or less degrees. These impacts were scored according to responses provided by villagers. **Table 4** provides the scoring systems for each of the Common Direct Impacts. The higher the score the poorer the quality of the DMU habitat, alternatively, the lower the score the better quality habitat. (Refer to Column 2 and 3, Results Section)

Table 4 Common Impact-Threat score criteria

Common Impact Type	Score	Score Criteria
A. Habitat fragmentation and resource over extraction caused by human settlement? B. Infrastructure expansion? C. Population pressure on fisheries (exploitative processes)? D. Reduced dry season flows? E. Increased sedimentation of habitat? F. Pollutants in waterways?	1	Stable: slow or indiscernible rate of change up to five years.
	2	Changing: can be observed in the DMU area over the medium term (4-5 years).
	3	Rapid: current and obvious changes in the short term 1-3 years.

To determine the degree of 'conservation status' for each DMU the following criteria were applied:

A. Is the DMU located inside a provincial or national protected area, or conservation zone?
B. Does the area of the DMU currently experience low human population occupation?
C. Is the locality of the DMU difficult to access due to terrain or some other limiting factor, such no roads, or just minor tracks?
D. Does the DMU have a large Ls population?
E. Is the DMU population stable?

Table 5 to **Table 9** present the relative score for each conservation status criteria (A – E). The lower the score for a given DMU the higher the conservation status. (Refer to Column 4 and 5, Results Section)

Table 5 Conservation Status score criteria for DMU area legal status

Conservation Status Criteria A	Score	Score Criteria
Is the DMU located inside a provincial or national protected area, or conservation zone?	1	The DMU is located almost entirely or is entirely inside a protected area.
	2	The DMU is within the buffer zone or adjacent to a protected area.
	3	The DMU is located outside a protected area.

Table 6 Conservation Status score criteria for the population size of a given DMU area.

Conservation Status Criteria B	Score	Score Criteria
Does the area of the DMU currently experience low human population occupation?	1	In the area of the DMU are non or very few villages.
	2	In the area of the DMU there are clusters of villages.
	3	In the area of the DMU there are a large number of villages or a large urban center.

Table 7 Conservation Status score criteria for the relative remoteness of a DMU area.

Conservation Status Criteria C	Score	Score Criteria
Is the locality of the DMU difficult to access due to terrain or some other limiting factor, such no roads, or just minor tracks?	1	The DMU is remote and access is difficult.
	2	The DMU is remote but access is not difficult
	3	The DMU is readily accessed.

Table 8 Conservation Status Score criteria for the relative productivity of Ls in DMU

Conservation Status Criteria D	Score	Score Criteria
Does the DMU have a large L.s population?	1	High degree of mixed sizes, regularly caught.
	2	Small to medium sizes caught irregularly.
	3	Small sizes, caught intermittently.

Table 9 Conservation Status Score criteria for the relative stability of DMU

Conservation Status Criteria E	Score	Score Criteria
Is the DMU population stable?	1	No obvious change in catch size over the past 10 years.
	2	Noticeable reduction of Ls catch over the past 10 years.
	3	Significant reduction in Ls catch over the past 10 years.

3.2 Overall Regional Ranking

The overall habitat priority ranking (Regional Priority Ranking) was determined by adding the scores for conservation status and those assigned for Common Direct Impacts. The best possible Regional Priority Ranking that can be achieved is 14, whilst the worst is 30. The 14 DMUs were the ranked according to this total score. (Refer to Column 1 and 6, Results Section).

Table 10 Regional DMU Ranking

Column 1	Column 2	Column 3	Column 4	Column 5	Column 6
DMU	**Common Direct Impacts Indicated at Villager Interviews**	**Cumulative Impacts Score for each DMU (as per list in Column 2 A-F)**	**Conservation Status**	**Current status of Ls populations**	**Regional Importance of the DMU – TOTAL**
Nam Fa RANK #1	A. Habitat fragmentation and resource over extraction caused by human settlement? B. Infrastructure expansion? C. Population pressure on fisheries (exploitative processes)? D. Reduced dry season flows? E. Increased sedimentation of habitat? F. Pollutants in waterways?	A 1 B 1 C 2 D 2 E 2 F 1 TOTAL 9	A. Is the DMU located in a provincial or national protected area, or conservation zone? B. Does the area of the DMU currently experience low human population occupation? C. Is the locality of the DMU difficult to access due to terrain or some other limiting factor, such no roads? D. Does the DMU have a large L.s population. E. Is that population stable?	A 1 B 1 C 1 D 1 E 1 TOTAL 5	14 (Column 1 + Column 2)

Xe Bang Fai RANK #2	A. Habitat fragmentation and resource over extraction caused by human settlement? B. Infrastructure expansion? C. Population pressure on fisheries (exploitative processes)? D. Reduced dry season flows? E. Increased sedimentation of habitat? F. Pollutants in waterways?	A 2 B 1 C 3 D 1 E 1 F 1 TOTAL 9	A. Is the DMU located in a provincial or national protected area, or conservation zone? B. Does the area of the DMU currently experience low human population occupation? C. Is the locality of the DMU difficult to access due to terrain or some other limiting factor, such no roads? D. Does the DMU have a large L.s population? E. Is that population stable?	A 1 B 1 C 1 D 1 E 1 TOTAL 5	14 (Column 1 + Column 2)
Nam Ou RANK #3	A. Habitat fragmentation and resource over extraction caused by human settlement? B. Infrastructure expansion? C. Population pressure on fisheries (exploitative processes)? D. Reduced dry season flows? E. Increased sedimentation of habitat? F. Pollutants in waterways?	A 1 B 3 C 1 D 1 E 2 F 1 TOTAL 9	A. Is the DMU located in a provincial or national protected area, or conservation zone? B. Does the area of the DMU currently experience low human population occupation? C. Is the locality of the DMU difficult to access due to terrain or some other limiting factor, such no roads? D. Does the DMU have a large Ls population? E. Is that population stable?	A 1 B 1 C 2 D 2 E 1 TOTAL 7	16 (Column 1 + Column 2)

Nam Theun-Kading RANK #4	A. Habitat fragmentation and resource over extraction caused by human settlement? B. Infrastructure expansion? C. Population pressure on fisheries (exploitative processes)? D. Reduced dry season flows? E. Increased sedimentation of habitat? F. Pollutants in waterways?	A 2 B 3 C 2 D 1 E 1 F 1 TOTAL 10	A. Is the DMU located in a provincial or national protected area, or conservation zone? B. Does the area of the DMU currently experience low human population occupation? C. Is the locality of the DMU difficult to access due to terrain or some other limiting factor, such no roads or tracks only? D. Does the DMU have a large Ls population? E. Is that population stable?	A 1 B 2 C 1 D 2 E 1 TOTAL	17 (Column 1 + Column 2)
Nam Ngum RANK #5	A. Habitat fragmentation and resource over extraction caused by human settlement? B. Infrastructure expansion? C. Population pressure on fisheries (exploitative processes)? D. Reduced dry season flows? E. Increased sedimentation of habitat? F. Pollutants in waterways?	A 2 B 3 C 2 D 1 E 1 F 1 TOTAL 10	A. Is the DMU located in a provincial or national protected area, or conservation zone? B. Does the area of the DMU currently experience low human population occupation? C. Is the locality of the DMU difficult to access due to terrain or some other limiting factor, such no roads or tracks only? D. Does the DMU have a large Ls population? E. Is that population stable?	A 3 B 2 C 2 D 3 E 3 TOTAL 13	23 (Column 1 + Column 2)
Nam Ngiep RANK #6	A. Habitat fragmentation and resource over extraction caused by human settlement? B. Infrastructure expansion? C. Population pressure on fisheries (exploitative	A 2 B 3 C 3 D 2	A. Is the DMU located in a provincial or national protected area, or conservation zone? B. Does the area of the DMU currently experience low human population occupation? C. Is the locality of the DMU	A 3 B 2 C 2 D 2	23 (Column 1 + Column 2)

	processes)? D. Reduced dry season flows? E. Increased sedimentation of habitat? F. Pollutants in waterways?	E 2 F 1 TOTAL 13	difficult to access due to terrain or some other limiting factor, such no roads or tracks only? D. Does the DMU have a large Ls population? E. Is that population stable?	E 2 TOTAL 11	
Nam Nga RANK #7	A. Habitat fragmentation and resource over extraction caused by human settlement? B. Infrastructure expansion? C. Population pressure on fisheries (exploitative processes)? D. Reduced dry season flows? E. Increased sedimentation of habitat? F. Pollutants in waterways?	A 2 B 2 C 3 D 2 E 2 F 1 TOTAL 12	A. Is the DMU located in a provincial or national protected area, or conservation zone? B. Does the area of the DMU currently experience low human population occupation? C. Is the locality of the DMU difficult to access due to terrain or some other limiting factor, such no roads? D. Does the DMU have a large Ls population? E. Is that population stable?	A 1 B 2 C 2 D 3 E 3 TOTAL 11	23 (Column 1 + Column 2)
Xekong RANK #8	A. Habitat fragmentation and resource over extraction caused by human settlement? B. Infrastructure expansion? C. Population pressure on fisheries (exploitative processes)? D. Reduced dry season flows? E. Increased sedimentation of habitat? F. Pollutants in waterways?	A 2 B 2 C 2 D 2 E 3 F 2 TOTAL 13	A. Is the DMU located in a provincial or national protected area, or conservation zone? B. Does the area of the DMU currently experience low human population occupation? C. Is the locality of the DMU difficult to access due to terrain or some other limiting factor, such no roads? D. Does the DMU have a large L.s population. E. Is that population stable?	A 1 B 3 C 3 D 2 E 2 TOTAL 11	24 (Column 1 + Column 2)

Nam Tha RANK #9	A. Habitat fragmentation and resource over extraction caused by human settlement? B. Infrastructure expansion? C. Population pressure on fisheries (exploitative processes)? D. Reduced dry season flows? E. Increased sedimentation of habitat? F. Pollutants in waterways?	A 3 B 2 C 3 D 2 E 2 F 2 TOTAL 14	A. Is the DMU located in a provincial or national protected area, or conservation zone? B. Does the area of the DMU currently experience low human population occupation? C. Is the locality of the DMU difficult to access due to terrain or some other limiting factor, such no roads or tracks only? D. Does the DMU have a large Ls population? E. Is that population stable?	A 1 B 2 C 3 D 3 E 3 TOTAL 12	26 (Column 1 + Column 2)
Luosuo River **(China)** RANK #10	A. Habitat fragmentation and resource over extraction caused by human settlement? B. Infrastructure expansion? C. Population pressure on fisheries (exploitative processes)? D. Reduced dry season flows? E. Increased sedimentation of habitat? F. Pollutants in waterways?	A 3 B 3 C 3 D 2 E 2 F 2 TOTAL 14	A. Is the DMU located in a provincial or national protected area, or conservation zone? B. Does the area of the DMU currently experience low human population occupation? C. Is the locality of the DMU difficult to access due to terrain or some other limiting factor, such no roads? D. Does the DMU have a large Ls population. E. Is that population stable?	A 3 B 2 C 3 D 3 E 3 TOTAL 14	28 (Column 1 + Column 2)

Langcang mainstream RANK #11	A. Habitat fragmentation and resource over extraction caused by human settlement? B. Infrastructure expansion? C. Population pressure on fisheries (exploitative processes)? D. Reduced dry season flows? E. Increased sedimentation of habitat? F. Pollutants in waterways?	A 2 B 3 C 3 D 2 E 2 F 2 TOTAL 14	A. Is the DMU located in a provincial or national protected area, or conservation zone? B. Does the area of the DMU currently experience low human population occupation? C. Is the locality of the DMU difficult to access due to terrain or some other limiting factor, such no roads or tracks only? D. Does the DMU have a large Ls population? E. Is that population stable?	A 3 B 3 C 3 D 2 E 3 TOTAL 14	28 (Column 1 + Column 2)
Puwen River (China) RANK #12	A. Habitat fragmentation and resource over extraction caused by human settlement? B. Infrastructure expansion? C. Population pressure on fisheries (exploitative processes)? D. Reduced dry season flows? E. Increased sedimentation of habitat? F. Pollutants in waterways?	A 3 B 3 C 3 D 2 E 2 F 2 TOTAL 15	A. Is the DMU located in a provincial or national protected area, or conservation zone? B. Does the area of the DMU currently experience low human population occupation? C. Is the locality of the DMU difficult to access due to terrain or some other limiting factor, such no roads? D. Does the DMU have a large Ls population? E. Is that population stable?	A 3 B 2 C 3 D 3 E 3 TOTAL 14	29 (Column 1 + Column 2)

Nam Ma RANK #13	A. Habitat fragmentation and resource over extraction caused by human settlement? B. Infrastructure expansion? C. Population pressure on fisheries (exploitative processes)? D. Reduced dry season flows? E. Increased sedimentation of habitat? F. Pollutants in waterways?	A 3 B 2 C 3 D 3 E 3 F 3 TOTAL 17	A. Is the DMU located in a provincial or national protected area, or conservation zone? B. Does the area of the DMU currently experience low human population occupation? C. Is the locality of the DMU difficult to access due to terrain or some other limiting factor, such no roads? D. Does the DMU have a large Ls population. E. Is that population stable?	A 2 B 2 C 3 D 3 E 3 TOTAL 13	30 (Column 1 + Column 2)
Nam Beng RANK #14	A. Habitat fragmentation and resource over extraction caused by human settlement? B. Infrastructure expansion? C. Population pressure on fisheries (exploitative processes)? D. Reduced dry season flows? E. Increased sedimentation of habitat? F. Pollutants in waterways?	A 3 B 2 C 3 D 3 E 3 F 2 TOTAL 16	A. Is the DMU located in a provincial or national protected area, or conservation zone? B. Does the area of the DMU currently experience low human population occupation? C. Is the locality of the DMU difficult to access due to terrain or some other limiting factor, such no roads? D. Does the DMU have a large Ls population. E. Is that population stable?	A 3 B 2 C 3 D 3 E 3 TOTAL 14	30 (Column 1 + Column 2)

3.3 Summary of the results in Table 10 above

1) Condition Status (Common Impacts)

A) Habitat fragmentation and resource over-extraction caused by human settlement

A total of two out of 14 (14%) of the DMUs identified in this study were experiencing stable conditions; slow or indiscernible rate of change up to the past five years: 1) Nam Fa and 2) Nam Ou. Seven out of 14 (50%) DMUs identified were undergoing changing conditions; observed in the medium term (4-5 years) and five out of 14 (36%) were undergoing rapid changes; current and obvious changes in the short term (1-3 years).

B) Infrastructure expansion

A total of two out of 14 (14%) of the DMUs identified in this study were experiencing stable conditions; slow or indiscernible rate of change up to the past five years: 1) Nam Fa and 2) Xe Bang Fai. Five out of 14 (36%) DMUs identified were undergoing changing conditions; observed in the medium term (4-5 years) and seven out of 14 (50%) were undergoing rapid changes; current and obvious changes in the short term (1-3 years).

C) Population pressure on fisheries (exploitative processes)

Only one out of 14 (7%) of the DMUs identified in this study were experiencing stable conditions; slow or indiscernible rate of change up to the past five years: 1) Nam Ou. Four out of 14 (29%) DMUs identified were undergoing changing conditions; observed in the medium term (4-5 years) and nine out of 14 (64%) were undergoing rapid changes; current and obvious changes in the short term (1-3 years).

D) Reduced dry season flows

A total of four out of 14 (29%) of the DMUs identified in this study were experiencing stable conditions; slow or indiscernible rate of change up to the past five years: 1) Xe Bang Fai; 2) Nam Ou; 3) Nam Theun / Kading and 4) Nam Ngum. Eight out of 14 (57%) DMUs identified were undergoing changing conditions; observed in the medium term (4-5 years) and two out of 14 (14%) were undergoing rapid changes; current and obvious changes in the short term (1-3 years).

E) Increased sedimentation of habitat

A total of three out of 14 (21%) of the DMUs identified in this study were experiencing stable conditions; slow or indiscernible rate of change up to the past five years: 1) Xe Bang Fai; 2)Nam Theun / Kading and 3) Nam Ngum. Eight out of 14 (57%) DMUs identified were undergoing changing conditions; observed in the medium term (4-5 years) and three out of 14 (21%) were undergoing rapid changes; current and obvious changes in the short term (1-3 years).

F) Pollutants in waterways

A total of seven out of 14 (50%) of the DMUs identified in this study were experiencing stable conditions; slow or indiscernible rate of change up to the past five years: 1) Nam Fa; 2) Xe Bang Fai; 3) Nam Ou; 4) Nam Theun / Kading; 5) Nam Ngum; 6) Nam Ngiep and 7) Nam Nga. Six out of 14 (43%) DMUs identified were undergoing changing conditions; observed in the medium term (4-5 years) and only one out of 14 (7%) was undergoing rapid changes; current and obvious changes in the short term (1-3 years).

2) Conservation Status

A) Is the DMU located in a provincial or national protected area or conservation zone?

A total of seven out of the 14 (50%) of all DMUs identified during this study were found to lie almost entirely or completely inside some type of legally protected area: 1) Nam Fa; 2) Upper Xe Bang Fai; 3) Nam Ou; 4) Nam Theun / Kading; 5) Nam Nga; 6) Xekong and 7) Nam Tha. Six out of the 14 (43%) of the DMUs identified during this study were found to lie outside of any protected area and just one of the DMUs identified during the study was found to lie within a protected area buffer zone or adjacent to it.

B) Does the area of the DMU currently experience low human population occupation?

A total of just three out of 14 (21%) of the DMUs identified during this study were found to lie within areas where no villages or very few villages were present: 1) Nam Fa; 2) Upper Xe Bang Fai and 3) Nam Ou. Nine out of 14 (64%) of DMUs identified were found to lie within areas where there were only clusters of villages present and two DMUs (14%) only were found to lie within areas where there were large numbers of villages or within large urban centers.

C) Is the locality of the DMU difficult to access due to terrain or some other limiting factor, such as no roads?

A total of three out of 14 (21%) of the DMUs identified during this study were found to be in areas that were remote and very difficult to access: 1) Nam Fa; 2) Upper Xe bang Fai and 3) The Nam Theun / Kading. Four out of 14 (29%) of DMUs identified in the study were found to be remote areas but could be accessed with reasonable ease and seven DMUs (50%) were found to lie within areas that could be accessed easily.

D) Does the DMU have a large Ls population?

Only two out of 14 (14%) of the DMUs identified in this study were found to have a high degree of mixed sizes of Ls and caught regularly: 1) Nam Fa and 2) Xe Bang Fai. Five out of 14 (36%) of the DMUs were identified as having a population of Ls of small (<0.3 to 0.4kg) to medium sized fish (1.0 to 3.0kg) that were caught regularly and seven out of 14 (50%) DMUs were identified as having a population of Ls that were small in size (0.3 to 0.4kg).

E) Is the population at (D) above stable?

A total of four out of 14 (29%) of the DMUs identified during this study found that there was no obvious change in catch size over the past ten years: 1) Nam Fa; 2) Xe Bang Fai; 3) Nam Ou and 4) Nam Theun / Kading. Two out of the 14 (14%) of the DMUs identified found that there was a noticeable reduction in Ls catch over the past 10 years and eight out of 14 (57%) of DMUs identified were found to have experienced a large reduction in catch size over the past 10 years.

4 Discussion

4.1 Condition Status (Common Impacts)

A) Habitat fragmentation and resource over-extraction caused by human settlement

Habitat fragmentation occurs when habitats that were once contiguous are divided up into smaller isolated units or areas. One of the most obvious examples of fragmentation is when the construction of a hydropower dam takes place such as in the Nam Tha, Nam Theun / Kading and the Xekong for example but fragmentation of riverine habitat can also be caused by modified riparian land use patterns. Perhaps the greatest source of allochthonous nutrient input to riverine systems comes from riparian forest cover. This not only supplies nutrients to the system in the form of decaying leaf matter but also protects from bank soil erosion and provides shade. The removal of forest cover for the purposes of developing cash crops and subsistence agriculture can cause aquatic habitat fragmentation. Examples of this type of fragmentation have taken place along the Nam Ma and the Nam Beng. Conversely, the Na Fa and the Xe Bang Fai have not yet suffered this type of habitat degradation to such a greater extent. The Nam Fa DMU was one of two that were experiencing *stable conditions* with respect to habitat fragmentation and resource over-extraction caused by human settlement (Tables 4 and 10 and section 3.3 above).

Human settlement inevitably brings with it a demand for water for washing, drinking, sanitation, watering livestock, irrigation and all types of industry. Human settlement also brings with it a demand for fisheries and aquatic resources (see section C below). Both the Nam Ma and the Nam Beng have suffered from *rapid current* and *obvious changes* in the short term period of one to three years. This is in contrast to the Nam Fa DMU which has experienced stable conditions with respect to human settlement (Tables 4 and 10 and section 3.3 above).

B) Infrastructure expansion

Infrastructure expansion includes construction of barriers, bridges, sluice gates, flood protection schemes, irrigation schemes, mining plants, roads, water diversion and channelization. These all impact on aquatic habitat, fisheries in general which includes populations of Ls. The negative impacts from dams for example might include disruptions to fish migratory pathways, reductions in sediment flow, impacts to downstream water quality and the submergence of important upstream habitats. Ls is a migratory species as a sub-adult (trophic migrations) and as an adult (spawning migration). In the northern provinces of the Lao PDR, so far only one dam has been built on the Nam Tha (Nam Tha 3) but already villagers have reported that since its construction large Ls are not seen in the stream above the dam. But since its construction some villagers report that they still regularly see small Ls at their villages above the dam which leads to the conclusion that Ls is still able to locate spawning habitat there and adult fish must be attaining sexual maturity there. Another dam is under construction on the Nam Beng just 16 kilometers above the Nam Beng / Mekong confluence. The population of Ls in the Nam Beng is mainly restricted to the upper reaches and so may not necessarily be affected by the Nam Beng 1 Project. The same situation may occur above the 320m NN1 FSL in

the Nam Ngiep because only one of the four spawning sites currently identified may be inundated in a normal hydrological year during the spawning period of Ls (ERM data).

Dams have been constructed in the Xekong catchment, including the mainstream but being such a large catchment it may still be possible for isolated populations of Ls to continue to exist in tributaries of the Xekong at least. Dams have been built on the mainstream Nam Theun / Kading and at least one of its major tributaries, but it is highly likely that populations of Ls are able to survive above the Nam Theun 2 Nakai Plateau. Construction of a seven dam cascade has begun on the Nam Ou and it seems highly likely that Ls will become extirpated over much of its present range, but likewise may be able to thrive in the free-flowing parts of the river that will remain above the highest dam upstream from the Mekong confluence.

Road constructions that follow waterways have undoubtedly caused major negative impacts to the fisheries in many streams throughout the length of the Lao PDR over the past 20 years or so. The negative impacts have mostly been caused by excavated soil being pushed sideways over the side of the road that is immediately above the river. Much of the road construction takes place during the dry season months and the removed soil stays where it is until the first rains begin arriving in late April and May. Soil is flushed into river systems causing silt build-up in deep pool habitats and causing the smothering of primary production areas such as algal beds growing on rocks. This impact has undoubtedly affected populations of Ls and the populations of fish species that are Ls prey items.

Two large dams on the Nam Theun; the Theun Hinboun Project and the Nam Theun 2 Project by design are inter-basin transfer projects and divert water from the Nam Theun to the Nam Hinboun and the Xe Bang Fai Projects respectively. This inevitably has a de-watering effect on sections of the Nam Theun that flow below both dams. This has undoubtedly had a negative impact on Ls populations that were found in the sections of the river before the dams were built, but Ls may still be able to exist above the Nam Theun 2 reservoir.

In terms of infrastructure expansion, the Nam Fa and the upper Xe Bang Fai DMUs have been awarded *stable condition* status where there has been slow or indiscernible change over the past five years. However, the Nam Beng, the Nam Ma and DMUs in Southern China have scored high ranks for infrastructure expansion whereby this process has been rapid change in the short term period over the past one to three years. Fifty percent of all 14 DMUs currently identified are experiencing this latter situation (Tables 4 and 10 and section 3.3 above).

C) Population pressure on fisheries (exploitative processes)

Exploitation of resource is one of the most common types of direct impact reported by villagers all over the Lao PDR and elsewhere in SE Asia and is usually associated with an increase in human population numbers. Over-fishing can be thought of as removing the resource at a greater rate than it can be replaced through reproduction and growth. It can also be viewed in terms of fishing effort. If fishing effort remains constant, but catch is declining then over-fishing is taking place, and in a similar way if fishing effort is increasing and catch is remaining constant or declining, then over-fishing is also occurring. However, the widely reported decline in Ls populations are unlikely to be caused only by over-fishing because it rarely represents a singular

target species except perhaps on its spawning grounds. It is often caught just by accident as in the case of many other IUCN Red-listed endangered fish species. However, the over-fishing of many other fish species that form the prey items of Ls may be contributing to its overall decline. This is probably the case in the Nam Ma, the Nam Tha and the Nam Beng. Where human population pressures are lower and aquatic habitats can be described as more stable (Nam Fa, upper Xe Bang Fai and Nam Ou) then over-fishing is less of a problem. This is not to state that over-fishing acts in isolation; it is part of a series of cumulative impacts (Tables 4 and 10 and section 3.3 above).

D) Reduced dry season flows

Almost without exception, this study and others completed in the Lao PDR villagers have noticed and reported that over the past 20 years or so dry-season water flows have become considerably reduced. There are probably multiple causes of this problem but many villagers believe that catchment deforestation is responsible for what has been observed. Some reports provided to us suggested that changing land use patterns linked to catchment deforestation was also a major factor. Some people thought that the abstraction of water for dry season agriculture was an important issue together with climate change. Many fish species have a requirement to return to deeper water habitats during the dry season months in order to escape the occasional harsh conditions during the low water period and this includes Ls populations. During this study, villagers made constant reference to the fact that because dry season flows were reduced and many deep water habitats had become silted up due to erosion and sedimentation that many fish no longer stayed where they used to seek refuge but instead moved much further downstream to deep water habitats closer to confluences with larger rivers. This may pose a significant negative issue for Ls populations because, as far as is understood, Ls prefers upland habitats where waters are cooler and more oxygenated.

Under the Regional Ranking Procedure (section 3.2) four DMUs identified during this study have been described as having *stable conditions* with respect to reduced dry-season flows whereby changes could be described slow or indiscernible over the past five years (Upper Xe Bang Fai; Nam Ou; Nam Theun / Kading and the Nam Ngum). The Nam Ma and the Nam Beng were placed in the category of undergoing rapid and obvious change with respect to a reduction in dry season flows (Tables 4 and 10 and section 3.3).

E) Increased sedimentation of habitat

Increase in sediment load carried by rivers close to almost all the villages visited made reference to increased sediment load in the dry-season, and in the wet-season also in some cases. Most people were clear in their views that two main factors were the causes: 1) catchment deforestation resulting in soil erosion; and 2) changes in land-use patterns resulting in increased sediment load carried by surface run-off. In some cases, the Nam Ma and the Nam Beng, villagers described rivers as carrying liquid soil in which fish could not survive although such conditions were described as extreme. Landslides along the Nam Beng valley were reported as serious over the last decade with human deaths occurring on occasion. Villagers reported that the increased sediment loading was responsible for “filling in” dry-season deep water refuge habitats in many of the river catchments visited and also causing the water to

become warmer in some case (Nam Beng). Shallow, warm and silty water are not conditions that Ls is known to tolerate.

Conversely, at least three DMUs have been assigned the status of *stable conditions* whereby changes in increased habitat sedimentation have been slow or imperceptible over the past five years (Tables 4 and 10 and section 3.3).

F) Pollutants in waterways

Large changes in riparian agricultural practices have brought about a necessity for the increase use of pesticides and herbicides in several of the DMUs visited (Nam Ma). This is in addition to the chemicals used to control pests and competitive plants associated with traditional rice farming practices for those farmers that still use them. Inevitably, some of these chemicals enter aquatic habitats via leeching or in surface run-off. It is difficult to generalize on what villagers said concerning the use of pesticides and herbicides because harmful effects on fish and humans vary widely on which chemicals were used and in what quantities and when they were applied. However, an expert on Ls based in Muang Long on the banks of the Nam Ma reported that Ls was especially sensitive to chemicals used in the contract banana farming businesses that have become established in the Nam Ma valley during the past seven years. He said that chemicals were in use and that since the plantations had been set up Ls population numbers dropped dramatically shortly afterwards. Human settlement inevitably means that all manner of house-hold chemicals come into use, perhaps some quite harmless but never-the-less enter local waterways.

Artisanal mining for gold was taking place along the Nam Ou in 2010 (70 back-hoes in operation) and ship-dredging for gold was taking place along the Xekong in 2012 (up to 30 ships counted). The chemicals used for the gold extraction process are usually either mercury or cyanide.

Fifty per cent of all DMUs visited during this survey came under the category of stable conditions and only one DMU was placed in the category of rapid and obvious change in the short term covering a period of one to three years (Tables 4 and 10 and section 3.3).

4.2 Conservation Status

A) Is the DMU located in a provincial or national protected area or conservation zone?

If a legal mechanism is in place for future protection of Ls populations in 50% of DMUs identified then realistic legislation can be applied if agreed to by all stakeholders involved. Under the IUCN Red List system Ls is placed in the category of Endangered (EN). A taxon is endangered when the best available evidence indicates that it meets any of the criteria A to E for Endangered, and it is therefore considered to be facing a very high risk of extinction in the wild.

Under Lao law (Forestry law 1996) aquatic animals and wildlife living naturally in the territory of Lao PDR are the property of the national community. It is the responsibility of the State, as

representative of the people, to determine the conditions of access, protection, propagation and use of these animals and wildlife (Article 39) (Cacaud and Latdavong 2009). The Wildlife and Aquatic Animals Act 2008 was adopted by the National Assembly in 2008. Under this Act exists the right to hunt wildlife and aquatic animals is provided to any individual or legal entity within the limits of the law (Article 9). Hunting certain species is prohibited or restricted. It is strictly prohibited to hunt species listed in Category I except for research or propagation purposes, whereas catching species of species under Category II is allowed with an authorization and during certain periods.

Species listed in Category III may be taken for customary purposes and to some extent for commercial purposes with an authorization from PAFO (Article 9). Species of wildlife and aquatic animals are classified into three categories a) Category I lists species that are considered to be rare, endangered or highly valuable in socio-economic terms. Ls therefore fits into Category I classification (Cacaud and Latdavong 2009). Realistically therefore this leads to the conclusion that Ls must be afforded protection at its spawning sites only and covering the period when it is known to spawn (January to April). Four known spawning sites along the Nam Ngiep above or close to NN1 FSL are already protected under village Fishery Conservation Zone (FCZ) initiatives, and only one may be inundated during the dry-season spawning period in a normal hydrological year (ERM data).

B) Does the area of the DMU currently experience low human population occupation?

Conservation and protection efforts might be best directed at the Nam Fa and upper Xe Bang Fai DMUs where few villages exist. These DMUs represent areas where fishing pressures are low and fish populations are most resilient including Ls. The Nam Ou has been targeted for a large-scale cascade hydropower scheme and the exact effects of this infrastructure development remain unclear at present (Tables 6 and 10 and section 3.3).

C) Is the locality of the DMU difficult to access due to terrain or some other limiting factor, such as no roads?

Part of the reason why the populations of Ls may be more robust and stable in the Nam Fa, the upper Xe Bang Fai and the Nam Theun / Kading is that it is difficult for people to access these areas (Tables 7 and 10 and section 3.3).

D) Does the DMU have a large Ls population?

Most of the populations of Ls in all 14 DMUs identified harbor small to medium sized fish only. This is consistent with an endangered species population that is under considerable stress (Tables 8 and 10 and section 3.3).

E) Is the population at (D) above stable?

The majority of the Ls populations within the 14 DMUs so far identified (about 70%) are experiencing various levels of instability and only about 30% might be described as stable. Populations that are faced with cumulative impacts and stress typically show an overall reduction in catch (landings) and a trend towards a reduction in the size of individuals of that population (Tables 9 and 10 and section 3.3).

5 Conclusions

1. There are numerous populations of Ls acting as Discrete Management Units throughout the Lao PDR and Southern China.

2. According to criteria (conservation status and common impacts) and related scoring results, the studies conclude that the Nam Fa is ranked regionally number one DMU because it contains a robust population resilient to current land use. The Nam Beng was identified as being the DMU worst affected by cumulative impacts.

3. Important information has been gathered on Ls spawning sites and spawning behavior in the upper Nam Ngiep mainstream. No information was forthcoming concerning spawning sites or spawning behavior in the three Northern provinces of the Lao PDR that were surveyed in 2014.

4. The Nam Ngiep DMU was ranked number six of regional significance. The studies identified Ls habitat above FSL 320m, namely the Nam Chian. In addition, of the four spawning sites identified only one will be inundated on an average hydrological year through the key spawning period. This suggests then that the habitat of the lower Nam Chian may in fact be less impacted than originally thought.

5. These studies have identified Ls populations that can persist in tributaries above reservoirs such as in the Nam Theun and also possibly in the Nam Tha above the Nam Tha 3 dam.

6. Of the 18 rivers assessed during these studies, fourteen were found to harbor populations of Ls. The fourteen rivers were all tributaries of the Mekong.

7. Given the above findings, it is reasonable to assume that other large Mekong tributaries with similar characteristics will also harbor populations of Ls in the Lao PDR (viz other DMUs). This might also be the case for right-banked Mekong tributaries in Northern Thailand and North-east Myanmar.

8. These studies have revealed that there has been a general decline in fish populations, including Ls, in all DMUs assessed in the field (a total of 10).

9. These studies have improved considerably the knowledge base of Ls. The studies have also highlighted the condition of the Nam Ngiep DMU and its relationship with known Ls range (rank #6 out of 14).

10. It is the view of the author that the possible extirpation of the Nam Ngiep population of Ls will not trigger species extinction. This position has been substantiated where the studies have identified Ls populations within areas of high conservation protection, low human occupation, slow rate of infrastructure development and existing robust populations such as Nam Theun, XBF and Nam Fa DMUs.

11. As the studies have shown that populations can persist in tributaries above reservoirs, it can be reasoned the Nam Ngiep tributary population can be sustained with appropriate intervention

12. It is acknowledged by the author that the conclusions in this report are based on material information collected through rapid survey and that additional biological quantitative investigation may support or challenge some of these conclusions.

13. It is highly possible that some of the other catchments that harbor Ls may be under far greater protection than the Nam Ngiep catchment and where populations of Ls will stand a much better chance of survival into the future.

6 Recommendations

1. It is recommended that biological investigations be undertaken in previously assessed DMUs to validate current knowledge and conclusions on Ls population dynamics. This is necessary to fill in major gaps still remaining concerning its life-cycle biology. It would involve the complete participation of local village fishers and should take place over one full calendar year.

2. It is recommended that a detailed profile of Ls habitat (water quality, geomorphology and hydrology) be developed to better inform life-cycle requirements within conservation strategies. This information can also be used to screen potential rivers with Ls populations.

3. Gaps still remain concerning precise details of conditions at spawning sites just before and after spawning has taken place. It is vital to gain a further understanding of the whole “spawning event” because this is the one main focus of any future protection and conservation measures. It is impossible to ask fishers to stop catching Ls because it, like many other IUCN Red-list endangered and critically endangered fish species are caught by accident. Protection at spawning sites would be a major step forward as a conservation strategy.

4. More detailed data and information is required on specific spawning habitats and bio-physical / chemical parameters of spawning sites pre- and post spawning event.

5. Undertake additional studies to conclude on full Ls population range. This would involve visiting three more DMUs where it is highly likely that Ls populations will be found. This

will help to bolster the case for the continued protection of Ls at other sites in the possible scenario that Ls becomes extirpated in the Nam Ngiep DMU as a result of all hydropower development over the coming years (NN1, NN2 and NN3 Projects). The three remaining DMUs where it is considered that Ls is present are the Xe Bang Hian in Savannakhet Province and the Nam Xuang and the Nam Khan in Luang Prabang Province. This survey work could be undertaken quite soon if required.

7 References

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Annex F

Flora Survey Results 2013

Lao Names	Families/Thai Names	Scientific Names		Main Dam site	Re- regulation Dam site	Resettlement	Transmission Line	Nam Ngiep		Nam Xan		Huay Ngua	IUCN Status	Remark
								Upper	Lower	Upper	Lower			
	DRYOPTERIDACEAE													
ຜັກກູດຂາວ	ผักกูดขาว	*Diplazium esculentum* (Retz.) Sw.	TerF			X	X	X		X			LC	
	MARSILEACEAE													
ຜັກແວ່ນ	ผักแว่น	*Marsilea crenata* C.Presl	AqF	X	X	X	X	X		X		X	LC	
	SCHIZAEACEAE													
ກະຈອດໜູ	ลิเภายุ่ง	*Lygodium microphyllum* (Car.) R.Br.	CF			X	X	X	X	X	X	X	LC	
	CYCADACEAE													
ຜ້າວໂຄກ	ปรง	*Cycas pectinata* Buch.-Ham.	S									X	VU	
ຜ້າວຕ່ຳ	มะพร้าวเต่า	*Cycas simplicipinna* (Smitinand) K.D.Hill	S	X				X		X			NT	
	GNETACEAE													
ໝ້ວຍ	เมื่อย	*Gnetum montanum* Markgr.	WC	X	X			X		X		X	LC	
	AMARANTHACEAE													
ຜົ້ງແພວ	ผักเป็ดไทย	*Alternanthera sessilis* (L.) DC.	H	X	X	X	X	X		X		X	LC	
ໝາກມ່ວງ	มะม่วง	*Mangifera indica* L.	T			X	X	X	X	X	X		DD	
	APOCYNACEAE													
ຕີນເປັດ	สัตบรรณ	*Alstonia scholaris* (L.) R.Br.	T	X	X	X	X	X	X	X	X	X	LC	
ມູກໃຫຍ່	โมกใหญ่	*Holarrhena pubescens* Wall. ex G.Don	T						X				LC	
	CELASTRACEAE													
ກະເມັ່ງ	กะเม็ง	*Eclipta angustata* Umemota & H.Koyama	H	X	X	X	X	X	X	X	X	X	LC	
	CONVOLVULACEAE													
ຈີ້ງຈ້ໍ	จิงจ้อ	*Aniseia martinicensis* (Jacq.) Choisy	HC	X	X	X	X	X		X		X	LC	

Lao Names	Families/Thai Names	Scientific Names		Main Dam site	Re- regulation Dam site	Resettlement	Transmission Line	Nam Ngiep		Nam Xan		Huay Ngua	IUCN Status	Remark
								Upper	Lower	Upper	Lower			
	DATISCACEAE													
ພຸງ	สะพุง	*Tetramelos nudiflora* R.Br.	T	X	X	X	X	X	X	X	X	X	LC	
	DIPTEROCARPACEAE													
ບາກເຫຼືອງ	กระบาก	*Anisoptera costata* Korth	T								X	X	EN	
ຍາງຂາວ	ยางนา	*Dipterocarpus alatus* Roxb. ex G.Don	T					X	X		X	X	EN	
ຍາງແດງ	ยางแดง	*Dipterocarpus turbinatus* Gaertn.f.	T	X	X			X		X		X	CR	
ແຄນຫີນ	ตะเคียนหิน	*Hopea ferrea* Laness.	T					X					EN	
ແຄນເຮືອ	ตะเคียนทอง	*Hopea odorata* Roxb.	T	X	X	X	X	X	X	X	X	X	VU	
ແຄນຄະຍອມ	พะยอม	*Shorea roxburghii* G.Don	T			X	X	X	X	X	X	X	EN	
	EBENACEAE													
ໝາກພັບໄຂ່ນົກ	มะพลับไข่นก	*Diospyros apiculata* Hiern	T	X	X	X	X	X		X		X	LC	
	EUPHORBIACEAE													
ໄຄ້ຜາດ	ไคร้น้ำ	*Homonoia riparia* Lour.	S	X	X	X	X	X	X	X	X	X	LC	
	GUTTIFERAE													
ອາຫວນ	กะทังหัน	*Calophyllum thorelii* Pierre	T	X	X	X	X	X		X		X		
ຕ໊ອເຫຼືອງ	ติ้วเกลี้ยง	*Cratoxylum cochinchinense* (Lour.) Blume	T	X	X	X	X	X	X	X	X	X	LC	
ຕ໊ອສົ້ມ	ติ้วขาว	*Cratoxylum formosum* (Jack) Dyer	T	X	X	X	X	X	X	X	X	X	LC	
	HYDROPHYLLACEAE													
ຜັກບີ້ອ່ຽນ	ปอผี	*Hydrolea zeylanica* (L.) Vahl	H	X	X	X	X	X		X		X	LC	
	LAURACEAE													
ໝາກດູກ	มะดูก	*Beilschmiedia roxburghiana* Nees	T	X	X	X	X	X	X	X	X	X	LC	

Lao Names	Families/Thai Names	Scientific Names		Main Dam site	Re- regulation Dam site	Resettlement	Transmission Line	Nam Ngiep		Nam Xan		Huay Ngua	IUCN Status	Remark
								Upper	Lower	Upper	Lower			
	LEGUMINOSAE-CAESALPINOIDEAE													
ແຕ້ຂ່າ	มะค่าโมง	*Afzelia xylocarpa* (Kurz) Craib	T	X	X	X	X	X	X	X	X	X	EN	
ແຕ້ຫນາມ	มะค่าลิง	*Sindora siamensis* Teijsm. & Miq.	T	X	X	X	X	X	X	X	X	X	LC	
	LEGUMINOSAE-PAPILIONOIDEAE													
ໂສນຫາງໄກ່	โสนหางไก่	*Aeschynomene indica* L.	H	X	X	X	X	X	X	X		X	LC	
ຂະຍຸງ	พะยูง	*Dalbergia cochinchinensis* Pierre	T					X				X	VU	
ຄໍາພີ້ຫຼືອງ	ชิงชัน	*Dalbergia oliveri* Gamble	T	X	X	X	X	X		X		X	EN	
	LENTIBULARIACEAE													
ຫຍ້າຮັງໄກ່	สาหร่ายข้าวเหนียว	*Utricularia aurea* Lour.	AqH	X	X	X	X	X		X		X	LC	
	MELIACEAE													
ສັງກະໂຕ້ງ	สังกะโต้ง	*Aglaia lawii* (Wight) C.J.Saldanha ex Ramamoorthy	T	X	X	X	X	X	X	X		X	LC	
ຕາເສືອ	ตาเสือ	*Aphanamixis polystachya* (Wall.) R.Parker	T	X	X	X	X	X		X	X	X	LC	
	MYRISTICACEAE													
ເລືອດຄວາຍໃບໃຫຍ່	เลือดควายใบใหญ่	*Knema furfuraceae* (Hook.f. & Thomson) Warb.	T					X			X			
ກົກທອມເລືອດ	เลือดแรด	*Knema globularia* (Lam.) Warb.	T	X	X	X	X	X	X	X	X	X	LC	
	MYRTACEAE													
ຫວ້າຂົນ	หว้าขน	*Syzygium vestitum* Merr. & L.M.Perry	ST						X			X	VU	
	POLYGONACEAE													
ຜົງພຸດ	ผักไผ่น้ำ	*Persicaria attenuata* (R.Br.) Soják subsp. *pulchera* (Blume) K.L.Wilson	H	X	X	X	X	X		X		X	LC	

Lao Names	Families/Thai Names	Scientific Names		Main Dam site	Re- regulation Dam site	Resettlement	Transmission Line	Nam Ngiep		Nam Xan		Huay Ngua	IUCN Status	Remark
								Upper	Lower	Upper	Lower			
	RUBIACEAE													
ໝາກດັນນ້ຳ	มะดันน้ำ	*Morinopsis capillaris* Kurz	S							X			VU	
	SAPINDACEAE													
ຂີ້ໜອນ	ขี้หนอน	*Zollingeria dongnaiensis* Pierre	T			X	X	X	X	X	X	X	DD	
	SCROPHULARIACEAE													
ໜອດປາດຸກ	หนวดปลาดุก	*Lindernia anagallis* (Burm.f.) Pennell	H	X	X	X	X	X		X		X	LC	
	THEACEAE													
ຕຳເສົາ	ตำเสา	*Ternstroemia wallichiana* (Griff.) Engl.	T					X		X		X	VU	
	THYMELAEACEAE													
ກາດສະໜາ	กฤษณา	*Aquilaria crassna* Pierre ex Lecomte	T							X			CR	Cultivated
	UMBELLIFERAE													
ຜັກໜອກ	บัวบก	*Centella asiatica* (L.) Urb.	H	X	X	X	X	X		X		X	LC	
	VERBENACEAE													
ຫຍ້າກ້ົດປາ	หญ้าเกล็ดปลา	*Phyla nodiflora* (L.) Greene	CrH	X	X	X	X	X	X	X	X	X	LC	
	ARACEAE													
ບອນ	บอน	*Colocasia esculenta* (L.) Schott	H	X	X	X	X	X	X	X	X	X	LC	
ຜັກກົບ	ผักกบ	*Cryptocoryne crispatula* Engl.	AqH					X		X			LC	
ຜັກໜາມ	ผักหนาม	*Lasia spinosa* Thwaites	H	X	X	X	X	X		X		X	LC	
	COMMELINACEAE													
ຫຍ້າກາບ	ผักปลาบ	*Commelina benghalensis* L.	H	X	X	X	X	X	X	X	X	X	LC	
ຄໍກີ໋ອ	ผักปลาบช้าง	*Floscopa scandens* Lour.	H	X	X	X	X	X		X	X	X	LC	
	CYPERACEAE													
ຜືອ	กกสามเหลี่ยม	*Actinoscirpus grossus* (L.f.) Goetgh. & D.A.Simpson	H	X	X	X	X	X		X		X	LC	

Lao Names	Families/Thai Names	Scientific Names		Main Dam site	Re- regulation Dam site	Resettlement	Transmission Line	Nam Ngiep		Nam Xan		Huay Ngua	IUCN Status	Remark
								Upper	Lower	Upper	Lower			
ຜືກະບາກ	กกขนาก	*Cyperus difformis* L.	H	X	X	X	X	X		X		X	LC	
ຜືຈຸ່ດອກຂົ່ນ	กกช่อดอกขน	*Cyperus digitatus* Roxb.	H	X	X	X	X	X		X		X	LC	
ຫຍ້າດແຫ້ວໝູ	หญ้าแห้วหมู	*Cyperus rotundus* L.	H	X	X	X	X	X		X		X	LC	
ຫຍ້າຄົມບາງກົມ	หญ้าคมบางกลม	*Fuirena ciliaris* (L.) Roxb.	H	X	X	X	X	X		X		X	LC	
	GRAMINEAE													
ຫຍ້າພົ້	เลา	*Saccharum spontaneum* L.	G	X	X	X	X	X	X	X	X	X	LC	
	XYRIDACEAE													
ຕານ	ตาน	*Xyris complanata* R.Br.	H				X						LC	
	ZINGIBERACEAE													
ໜາກແຫນ	เร่ว	*Amomum uliginosum* K.D.König	H	X	X	X	X	X		X		X	LC	
Total				**397**	**390**	**410**	**408**	**513**	**278**	**462**	**317**	**446**		

Remarks

X = occurrence

[1] Habit

2 Status refers to IUCN 2012. IUCN Red List of Threatened Species. Version 2012.2. <www.iucnredlist.org>

AqH	=	Aquatic Herb	ScanS	=	Scandent Shrub
B	=	Bamboo	ST	=	Shrubby Tree
C	=	Climber	T	=	Tree
CrH	=	Creeping Herb	US	=	Undershrub
Ex	=	Exotic	Vu		Vulnerable
G	=	Grass	WC	=	Woody Climber
H	=	Herb	S	=	Shrub
HC	=	Herbaceous Climber	S/ST	=	Shrub/Shrubby Tree
EN	=	Endangered			
VU	=	Vulnerable			
NT	=	Near Threaten			
LR/NT	=	Lower Risk/least concern ver. 2.3			

Annex G

TISTR Fauna Survey Results 2013

Table G.1 Species diversity, abundance, conservation status, and IUCN status of mammals in the study areas

Family/Common Name	Scientific Name	Abundance[1]	Distribution of wildlife						Conservation Status[2]		IUCN Red List Status[3]				
			Nam Ngiep		Huay Ngua	Resettlement Site	Nam Xan		Restricted (List I)	Protected (List II)	CR	EN	VU	NT	LC
			Upper	Lower			Upper	Lower							
Family Tupaiidae (Treeshrews)															
Northern Treeshrew*	*Tupaia belangeri*	LC	X	X			X	X							X
Family Sciuridae (Squirrels and Flying Squirrels)															
Black Giant Squirrel*	*Ratufa bicolor*	LC	X				X	X		X				X	
Gray-bellied Squirrel	*Callosciurus caniceps*	C	X	X			X	X							X
Pallas's Squirrel	*Callosciurus erythraeus*	LC	X	X			X	X							X
Indochinese Flying Squirrel*	*Hylopetes phayrei*	LC	X	X			X	X							X
Large Brown Flying Squirrel*	*Petaurista philippensis*	LC	X												X
Maritime Striped Squirrel*	*Tamiops maritimus*	LC	X	X			X	X							X
Family Muridae (Mice and Rats)															
House Mouse*	*Mus musculus*	C		X											X
Oriental House Rat *	*Rattus tanezumi*	C				X									X
Long-tailed Giant Rat*	*Leopoldamys sabanus*	C	X			X	X	X							X
Large Bamboo Rat	*Rhizomys sumatrensis*	C	X	X			X			X					X
Lesser Bamboo Rat*	*Cannomys badius*	LC	X	X			X	X							X
Family Manidae (Pangolins)															
Sunda Pangolin*	*Manis javanica*	LC	X			X	X	X				X			

Family/Common Name	Scientific Name	Abundance[1]	Distribution of wildlife						Conservation Status[2]		IUCN Red List Status[3]				
			Nam Ngiep		Huay Ngua	Resettlement Site	Nam Xan		Restricted (List I)	Protected (List II)	CR	EN	VU	NT	LC
			Upper	Lower			Upper	Lower							
Family Felidae (Cats and Tigers)															
Asiatic Golden Cat*	*Pardofelis temminckii*	LC	X				X	X	X					X	
Leopard Cat*	*Prionailurus bengalensis*	LC	X				X	X	X						X
Leopard*	*Panthera pardus*	LC	X						X					X	
Tiger*	*Panthera tigris*	LC	X						X			X			
Family Ursidae (Bears)															
Himalayan Black Bear*	*Ursus thibetanus*	LC	X						X				X		
Sun Bear*	*Helarctos malayanus*	LC	X				X	X	X				X		
Family Hystricidae (Porcupines)															
Asiatic Brush-tailed Porcupine	*Atherurus macrourus*	LC	X			X	X	X		X					X
Malayan Porcupine*	*Hystrix brachyura*	LC	X			X	X	X		X					X
Family Viveridae (Civets and Linsang)															
Small Indian Civet*	*Viverricula indica*	LC	X	X			X	X							X
Large Indian Civet*	*Viverra zibetha*	LC	X				X							X	
Common Palm Civet*	*Paradoxurus hermaphroditus*	LC	X	X			X	X		X					X
Masked Palm Civet*	*Paguma larvata*	LC	X				X			X					X
Small-toothed Palm Civet*	*Arctogalidia trivirgata*	LC	X				X	X							X
Spotted Linsang*	*Prionodon pardicolor*	LC	X												X

Family/Common Name	Scientific Name	Abundance[1]	Distribution of wildlife						Conservation Status[2]		IUCN Red List Status[3]				
			Nam Ngiep		Huay Ngua	Resettlement Site	Nam Xan		Restricted (List I)	Protected (List II)	CR	EN	VU	NT	LC
			Upper	Lower			Upper	Lower							
Binturong*	*Arctictis binturong*	LC	X				X	X		X			X		
Family Herpestidae (Mongooses)															
Small Asian Mongoose*	*Herpestes javanica*	LC	X	X		X	X	X		X					X
Family Canidae (Wild Dogs)															
Dhole*	*Cuon alpinus*	LC	X				X		X			X			
Golden Jackal*	*Canis aureus*	LC	X				X	X	X						X
Family Mustelidae (Weasels, Otters, Badgers)															
Smooth-coated Otter*	*Lutrogale perspicillata*	LC	X				X	X	X				X		
Asian Small-clawed Otter*	*Aonyx cinerea*	LC	X				X	X	X				X		
Large-toothed Ferret Badger*	*Melogale personata*	LC	X							X					DD
Hog Badger*	*Arctonyx collaris*	LC	X				X	X		X				X	
Family Vespertilionidae (Vesper Bats)															
Lesser Bamboo Bat	*Tylonycteris pachypus*	C	X		X		X	X		X					X
Family Loridae (Lorises)															
Pygmy Slow Loris*	*Nycticebus pygmaeus*	LC	X				X	X	X				X		
Bengal Slow Loris*	*Nycticebus bengalensis*	LC	X				X	X	X				X		
Family Cercopithecidae (Old World monkeys)															
Phayre's Leaf Monkey*	*Trachypithecus phayrei*	LC	X				X	X		X		X			

Family/Common Name	Scientific Name	Abundance[1]	Distribution of wildlife						Conservation Status[2]		IUCN Red List Status[3]				
			Nam Ngiep		Huay Ngua	Resettlement Site	Nam Xan								
			Upper	Lower			Upper	Lower	Restricted (List I)	Protected (List II)	CR	EN	VU	NT	LC
Northern Pig-tailed Macaque*	*Macaca leonina*	LC	X				X	X		X			X		
Assam Macaque*	*Macaca assamensis*	LC	X							X				X	
Stump-tailed Macaque*	*Macaca arctoides*	LC	X				X	X		X			X		
Family HOMINIDAE (Great Apes and Humans)															
Northern White-cheeked Gibbon	*Nomascus leucogenys*	LC	X				X	X	X		X				
Family Suidae (Pigs)															
Wild Boar	*Sus scrofa*	C	X			X	X	X							X
Family Tragulidae (Chevrotains)															
Lesser Oriental Chevrotain*	*Tragulus kanchil*	LC	X	X		X	X	X		X					X
Family Cervidae (Deer)															
Barking Deer	*Muntiacus vaginalis*	LC	X			X	X	X		X					X
Sambar	*Rusa unicolor*	LC	X				X	X	X				X		
Family Bovidae (Cattle, Antelopes, and Goats)															
Southwest China Serow*	*Capricornis milneedwardsii*	LC	X				X	X	X					X	
Total		**-**	**46**	**12**	**1**	**9**	**39**	**35**	**15**	**17**	**1**	**4**	**10**	**7**	**24**

Remarks:	* = inquiry data	X = occurrence	
	[1]Abundance:	[2]Conservation Status: refers to the Regulation of the Ministry of Agriculture and Forestry No. 0360/MAF, dated 8th Dec. 2003	[3]IUCN Red List Status: IUCN (2012)
	VC = very common		CR = critically endangered
	C = common		EN = endangered
	LC = Less common	Reserved species (Category 1)	VU = vulnerable
		Protected species (Category 2)	NT = near threaten
			LC = least concern
			DD = Data Deficient

Table G.2 Species diversity, abundance, conservation status, and IUCN status of birds in the study areas.

Family/Common Name	Scientific Name	Migratory Status[1]	Abundance[2]	Distribution of wildlife						Conservation Status[3]		IUCN Red List Status[4]				
				Nam Ngiep		Huay Ngua	Resettlement Site	Nam Xan		Restricted (List I)	(Protected (List II)	CR	EN	VU	NT	LC
				Upper	Lower			Upper	Lower							
Family Anhingidae)Darters(																
Oriental Darter	*Anhinga melanogaster*	R						X							X	
Family Ardeidae (Herons, Bitterns, and Egrets)																
Chinese Pond Heron	*Ardeola bacchus*	M	C	X												X
Cattle Egret	*Bubulcus ibis*	R	C	X				X	X							X
Black Bittern	*Ixobrychus flavicollis*	M	VC	X												X
Family Acciptridae (Hawks, Kites, Eagles, and Vultures)																
Crested Serpent-eagle	*Spilornis cheela*	R	LC	X		X										X
Shikra	*Accipiter badius*	R	C			X	X									X
Rufous-winged Buzzard	*Butastur liventer*	R	LC					X	X							X
Family Phasianidae (Pheasants)																
Scaly-breasted Partridge	*Arborophila chloropus*	R	LC	X				X	X							X
Red Junglefowl	*Gallus gallus*	R	LC	X			X									X
Siamese Fireback *	*Lophura diardi*	R	LC					X	X	X						X
Silver Pheasant *	*Lophura nycthemera*	R	LC					X	X	X						X
Grey Peacock-pheasant*	*Polyplectron bicalcaratum*	R	LC					X	X	X						X
Family Scolopacidae (Sandpipers, Snipes)																

Family/Common Name	Scientific Name	Migratory Status[1]	Abundance[2]	Distribution of wildlife						Conservation Status[3]		IUCN Red List Status[4]				
				Nam Ngiep		Huay Ngua	Resettlement Site	Nam Xan		Restricted (List I)	(Protected (List II)	CR	EN	VU	NT	LC
				Upper	Lower			Upper	Lower							
Common Sandpiper	*Actitis hypoleucos*	M	LC	X												X
Family Columbidae (Doves and Pigeons)																
Orange-breasted Green-pigeon	*Treron bicinctus*	R	LC			X					X					X
Spotted Dove	*Stigmatopelia chinensis*	R	C	X	X	X					X					X
Emerald Dove	*Chalcophaps indica*	R	C			X		X								X
Family Psittacidae (Parrots)																
Vernal Hanging-parrot	*Loriculus vernalis*	R	LC	X												X
Blossom-headed Parakeet	*Psittacula roseata*	R	C			X					X					X
Red-breasted Parakee	*Psittacula alexandri*	R	C			X				X						X
Family Cuculidae (Cuckoos)																
Plaintive Cuckoo	*Cacomantis merulinus*	R	LC	X	X	X	X	X	X							X
Greater Coucal	*Centropus sinensis*	R	C	X	X	X	X	X	X	X						X
Lesser Coucal	*Centropus bengalensis*	R	LC	X	X			X								X
Green-billed Malkoha	*Phaenicophaeus tristis*	R	LC	X				X	X							X
Family Strigidae (Owls)																
Collared Scops-Owl	*Otus bakkamoena*	R	LC	X	X	X	X	X	X		X					X
Family Caprimulgidae (Nightjars)																
Great Eared-nightjar	*Eurostopodus macrotis*	R	LC	X				X	X							X

Family/Common Name	Scientific Name	Migratory Status[1]	Abundance[2]	Distribution of wildlife						Conservation Status[3]		IUCN Red List Status[4]				
				Nam Ngiep		Huay Ngua	Resettlement Site	Nam Xan								
				Upper	Lower			Upper	Lower	Restricted (List I)	(Protected (List II)	CR	EN	VU	NT	LC
Large-tailed Nightjar	*Caprimulgus macrurus*	R	LC	X	X											X
Family Apodidae (Swifts)																
Brown-backed Needletail	*Hirundapus giganteus*	R	C	X	X	X		X	X							X
Fork-tailed Swift	*Apus pacificus*	R	C	X	X											X
Asian Palm-swift	*Cypsiurus balasiensis*	R	C					X	X							X
Family Alcedinidae (Kingfishers)																
Common Kingfisher	*Alcedo atthis*	M	LC	X				X	X		X					X
Blue-eared Kingfisher	*Alcedo meninting*	R	LC	X												X
White-throated Kingfisher	*Halcyon smyrnensis*	R	LC	X	X											X
Family Coraciidae (Rollers)																
Asian Dollarbird	*Eurystomus orientalis*	R	LC	X												X
Indian Roller	*Coracias benghalensis*	R	LC	X	X		X	X	X							X
Family Bucerotidae (Hornbills)																
Oriental Pied Hornbill	*Anthracoceros albirostris*	R	LC	X				X	X		X					X
Great Hornbill*	*Buceros bicornis*	R	LC					X	X	X					X	
Wreathed Hornbill*	*Aceros undulatus*	R	LC					X	X	X						X
Family Megalaimidae (Barbets)																
Lineated Barbet	*Megalaima lineata*	R	LC		X	X	X	X	X							X

Family/Common Name	Scientific Name	Migratory Status[1]	Abundance[2]	Distribution of wildlife						Conservation Status[3]		IUCN Red List Status[4]				
				Nam Ngiep		Huay Ngua	Resettlement Site	Nam Xan								
				Upper	Lower			Upper	Lower	Restricted (List I)	(Protected (List II)	CR	EN	VU	NT	LC
Green-eared Barbet	*Megalaima faiostricta*	R	LC	X		X		X	X							X
Coppersmith Barbet	*Megalaima haemacephala*	R	LC			X	X									X
Family Eurylaimidae (Broadbills)																
Long-tailed Broadbill	*Psarisomus dalhousiae*	R	LC	X												X
Family Hirundinidae (Swallows)																
Barn Swallow	*Hirundo rustica*	M	C	X												X
Red-rumped Swallow	*Hirundo daurica*	M	C	X	X		X									X
Family Motacillidae (Pipits and Wagtails)																
Grey Wagtail	*Motacilla cinerea*	M	C	X	X			X	X							X
Family IRENIDAE (Fairy-Bluebirds)																
Asian Fairy-bluebird	*Irena puella*	R	LC	X				X	X							X
Family Pycnonotidae (Bulbuls)																
Black-headed Bulbul	*Pycnonotus atriceps*	R	LC	X	X	X		X	X							X
Sooty-headed Bulbul	*Pycnonotus aurigaster*	R	C													X
Black-crested Bulbul	*Pycnonotus melanicterus*	R	C	X	X	X	X	X	X							X
Stripe-throated Bulbul	*Pycnonotus finlaysoni*	R	C					X	X							X
Streak-eared Bulbul	*Pycnonotus blanfordi*	R	C	X	X	X	X	X	X							X
Grey-eyed Bulbul	*Iole propinqua*	R	LC	X		X		X	X							X
Family Dicruridae (Drongos)																

Family/Common Name	Scientific Name	Migratory Status[1]	Abundance[2]	Distribution of wildlife						Conservation Status[3]		IUCN Red List Status[4]				
				Nam Ngiep		Huay Ngua	Resettlement Site	Nam Xan		Restricted (List I)	(Protected (List II)	CR	EN	VU	NT	LC
				Upper	Lower			Upper	Lower							
Black Drongo	*Dicrurus macrocercus*	R	C	X	X											X
Bronze Drongo	*Dicrurus aeneus*	R	LC	X												X
Greater Racket-tailed Drongo	*Dicrurus paradiseus*	R	LC	X	X	X		X	X							X
Family Corvidae (Crows, Jays, and Magpies)																
Large-billed Crow	*Corvus macrorhynchos*	R	LC					X	X							X
Family Timaliidae (Babblers)																
White-browed Scimitar-babbler	*Pomatorhinus schisticeps*	R	LC			X	X									X
Puff-throated Babbler	*Pellorneum ruficeps*	R	LC	X	X	X	X	X	X							X
Pin-striped Tit-babbler	*Macronous gularis*	R	C	X	X	X	X	X	X							X
Family Sylviidae (Old World Warblers)																
Thick-billed Warbler	*Acrocephalus aedon*	M	C					X	X							X
Common Tailorbird	*Orthotomus sutorius*	R	LC	X	X	X	X	X	X							X
Family Turdidae (Thrushes)																
Blue Whistling-thrush	*Myophonus caeruleus*	R	C	X												X
Oriental Magpie-robin	*Copsychus saularis*	R	C	X	X		X	X	X							X
White-rumped Shama	*Copsychus malabaricus*	R	LC	X			X	X	X							X
Stonechat	*Saxicola torquatus*	M	C	X												X
Family Muscicapidae (Flycatchers)																

Family/Common Name	Scientific Name	Migratory Status[1]	Abundance[2]	Distribution of wildlife						Conservation Status[3]		IUCN Red List Status[4]				
				Nam Ngiep		Huay Ngua	Resettlement Site	Nam Xan								
				Upper	Lower			Upper	Lower	Restricted (List I)	(Protected (List II)	CR	EN	VU	NT	LC
Asian Brown Flycatcher	*Muscicapa dauurica*	M	LC	X		X	X	X	X							X
Tickell's Blue-flycatcher	*Cyornis tickelliae*	R	LC			X										X
Family Monarchidae (Monarchs)																
Black-naped Monarch	*Hypothymis azurea*	R	LC	X	X	X		X	X							X
Family Laniidae (Shrikes)																
Brown Shrike	*Lanius cristatus*	M	LC				X	X	X							X
Family Strurnidae (Starlings and Mynas)																
Common Myna	*Acridotheres tristis*	R	C				X				X					X
White-vented Myna	*Acridotheres grandis*	R	C					X	X							X
Hill Myna	*Gracula religiosa*	R	LC	X	X	X	X				X					X
Family Nectaniidae (Sunbirds and Spiderhunters)																
Olive-backed Sunbird	*Nectarinia jugularis*	R	C	X	X		X	X	X							X
Streaked Spiderhunter	*Arachnothera magna*	R	LC	X	X											X
Family Dicaeidae (Flowerpeckers)																
Scarlet-backed Flowerpecker	*Dicaeum cruentatum*	R	LC			X	X									X
Family Passeridae (Sparrows)																
Eurasian Tree Sparrow	*Passer montanus*	R	LC				X									X
Family Estrildidae (Munias)																
Scaly-breasted Munia	*Lonchura punctulata*	R	C	X	X	X										X

Family/Common Name	Scientific Name	Migratory Status[1]	Abundance[2]	Distribution of wildlife						Conservation Status[3]		IUCN Red List Status[4]				
				Nam Ngiep		Huay Ngua	Resettlement Site	Nam Xan		Restricted (List I)	(Protected (List II)	CR	EN	VU	NT	LC
				Upper	Lower			Upper	Lower							
Total		**-**	**-**	**50**	**27**	**29**	**24**	**43**	**40**	**7**	**8**	**0**	**0**	**0**	**2**	**73**

Remarks are overleaf

Remarks: * = inquiry data X = occurrence [4]IUCN Red List Status: IUCN (2012)

[1]Migratory Status
- M = migratory species
- R = resident species

[2]Abundance:
- VC = very common
- C = common
- LC = Less common

[3]Conservation Status: refers to the Regulation of the Ministry of Agriculture and Forestry No. 0360/MAF, dated 8th Dec. 2003
- Reserved species (Category 1)
- Protected species (Category 2)

- CR = critically endangered
- EN = endangered
- VU = vulnerable
- NT = near threaten
- LC = least concern

Table G.3 Species diversity, abundance, conservation status, and IUCN status of reptiles in the study areas.

Family/Common Name	Scientific Name	Abundance[1]	Distribution of wildlife						Conservation Status[2]		IUCN Red List Status[3]				
			Nam Ngiep		Huay Ngua	Resettlement Site	Nam Xan		Restricted (List I)	Protected (List II)	CR	EN	VU	NT	LC
			Upper	Lower			Upper	Lower							
Family Testudinidae (Land Tortoises)															
Elongated Tortoise*	*Indotestudo elongata*	LC					X	X		X		X			
Family Trionychidae (Softshell Turtles)															
Southeast Asian Softshell Turtle *	*Amyda cartilaginea*	LC	X	X		X	X	X		X			X		
Family Platysternidae (Big-headed Turtle)															
Big-headed Turtle*	*Platysternon megacephalum*	LC	X				X		X			X			
Family Bataguridae (Asian Pond Turtles)															
Southeast Asian Box Turtle*	*Cuora amboinensis*	LC					X	X		X			X		
Snail-eating Turtle*	*Malayemys subtrijuga*	LC	X			X				X			X		
Siamese Temple Turtle*	*Siebenrockiella crassicollis*	LC	X				X	X					X		
Family Gekkonidae (Geckos)															
Tokay Gecko	*Gekko gecko*	LC	X	X	X	X	X	X				Not Listed			
Common House Gecko	*Hemidactylus frenatus*	C	X	X	X	X	X	X							X
Flat-tailed House Gecko	*Hemidactylus platyurus*	C					X					Not Listed			
Family Agamidae (Agamid Lizards)															
Forest Garden Lizard	*Calotes emma*	C	X				X					Not Listed			

Family/Common Name	Scientific Name	Abundance[1]	Distribution of wildlife						Conservation Status[2]		IUCN Red List Status[3]				
			Nam Ngiep		Huay Ngua	Resettlement Site	Nam Xan		Restricted (List I)	Protected (List II)	CR	EN	VU	NT	LC
			Upper	Lower			Upper	Lower							
Blue crested lizard*	*Calotes mystaceus*	LC	X	X									Not Listed		
Common Garden Lizard	*Calotes versicolor*	LC	X	X	X		X	X					Not Listed		
Scale-bellied Tree Lizard*	*Acanthosaura lepidogaster*	C					X	X							X
Asian Water Dragon	*Physignathus cocincinus*	LC	X			X	X	X		X			Not Listed		
Spotted Flying Dragon	*Draco maculatus*	LC					X	X							X
Family Uromastycidae (Spinytail Lizards)															
Butterfly Lizard*	*Leiolepis belliana ocellata*	LC				X							Not Listed		
Family Scincidae (Skinks)															
Long-tailed Sun Skink	*Eutropis longicaudata*	LC	X	X									Not Listed		
Common Sun Skink*	*Eutropis multifasciata*	LC	X	X		X							Not Listed		
Spotted Forest Skink	*Spenomorphus maculatus*	LC					X	X					Not Listed		
Family Varanidae (Monitor Lizards)															
Clouded Monitor*	*Varanus bengalensis*	LC	X			X	X	X		X					X
Common Water Monitor*	*Varanus salvator*	C	X	X		X	X	X		X					X
Family Pythonidae (Pythons)															
Reticulated Python*	*Broghammerus reticulatus*	LC	X	X		X	X	X	X				Not Listed		
Family Colubridae (Colubrid Snakes)															
Common Mock Viper	*Psammodynastes pulverulentus*	LC		X			X	X					Not Listed		

Family/Common Name	Scientific Name	Abundance[1]	Distribution of wildlife						Conservation Status[2]		IUCN Red List Status[3]				
			Nam Ngiep		Huay Ngua	Resettlement Site	Nam Xan								
			Upper	Lower			Upper	Lower	Restricted (List I)	Protected (List II)	CR	EN	VU	NT	LC
Red-necked Keelback*	*Rhabdophis subminiatus*	LC					X	X							X
Green Cat Snake	*Boiga cyanea*	LC		X			X	X				Not Listed			
Red-tailed Green Ratsnake*	*Gonyosoma oxycephalum*	LC	X				X	X							X
Radiated Ratsnakes*	*Coelognathus radiatus*	LC	X			X	X	X				Not Listed			
Indo-Chinese Rat Snake*	*Ptyas korros*	LC	X	X		X	X	X				Not Listed			
Oriental Ratsnake*	*Ptyas mucosa*	LC	X	X		X	X	X				Not Listed			
Common Bronze-back*	*Dendrelaphis pictus*	LC	X	X		X						Not Listed			
Deuve's Water Snake	*Homalopsis nigroventralis*	LC						X							X
Checkered Keelback*	*Xenochrophis piscator*	LC					X	X							X
Plumbeous Water Snake*	*Enhydris plumbea*	LC	X	X		X	X	X							X
Family Elapidae (Elapid Snakes)															
King Cobra*	*Ophiophagus hannah*	LC	X	X			X		X				X		
Indo-Chinese Spitting Cobra *	*Naja siamensis*	LC	X	X		X				X			X		
Malayan Krait*	*Bungarus candidus*	LC	X	X											X
Banded Krait	*Bungarus fasciatus*	LC	X	X		X	X					Not Listed			
Family Viperidae (Vipers)															
Malayan Pit Viper*	*Calloselasma rhodostoma*	LC	X	X		X									X
Pope's Tree Viper*	*Trimeresurus popeiorum*	LC	X	X		X									X
Total		**-**	**27**	**21**	**3**	**19**	**28**	**24**	**3**	**8**	**0**	**2**	**6**	**0**	**13**

Remarks:	* = inquiry data	X = occurrence	
	[1]Abundance:	[2]Conservation Status: refers to the Regulation of the Ministry of Agriculture and Forestry No. 0360/MAF, dated 8th Dec. 2003	[3]IUCN Red List Status: IUCN (2012)
	VC = very common		CR = critically endangered
	C = common		EN = endangered
	LC = Less common	Reserved species (Category 1)	VU = vulnerable
		Protected species (Category 2)	NT = near threaten
			LC = least concern
			NA = not listed

Table G.4 Species diversity, abundance, conservation status, and IUCN status of amphibians in the study areas.

Family/Common Name	Scientific Name	Abundance[1]	Distribution of wildlife						Conservation Status[2]		IUCN Red List Status[3]				
			Nam Ngiep		Huay Ngua	Resettlement Site	Nam Xan		Restricted (List I)	Protected (List II)	CR	EN	VU	NT	LC
			Upper	Lower			Upper	Lower							
Family Bufonidae (Typical Toads)															
Black-spectacled Toad	*Duttaphrynus melanostictus*	C	X	X			X	X							X
Bony-headed Toad	*Ingerophrynus galeatus*				X										X
Family Dicroglossidae (True Frogs)															
East Asian Bullfrog	*Hoplobatrachus rugulosus*	LC	X	X		X	X	X							X
Asian Grass Frog	*Fejervarya limnocharis*	C	X	X	X	X	X								X
Large-headed Frog*	*Limnonectes kuhlii*	C	X		X	X	X	X							X
Family Ranidae (Typical Frogs)															
Pointed-tongued Floating Frog	*Occidozyga lima*	C	X	X		X	X	X							X
Dark-sided Frog	*Hylarana nigrovittata*	C	X		X		X								X
Unidentified	*Hylarana cf. nigrovittata*							X				Not Listed			
Giant Asian River Frog*	*Limnonectes blythii*	LC	X				X	X						X	
Unidentified	*Odorrana cf. livida*	C					X	X				Not Listed			
Unidentified	*Rana* sp.	LC			X							Not Listed			
Family Rhacophylidae (Old World Tree Frogs)															
White-lipped Tree Frog	*Polypedates leucomystax*	C	X	X		X									X

Family/Common Name	Scientific Name	Abundance[1]	Distribution of wildlife						Conservation Status[2]		IUCN Red List Status[3]				
			Nam Ngiep		Huay Ngua	Resettlement Site	Nam Xan		Restricted (List I)	Protected (List II)	CR	EN	VU	NT	LC
			Upper	Lower			Upper	Lower							
Family Microhylidae (Microhylid Frogs, Froglets)															
Malaysian Narrowmouth Toad	*Kaloula pulchra*	C				X	X	X							X
Arcuate-spotted Pygmy Frog	*Microhyla heymonsi*	C					X								X
Ornamented Pygmy Frog	*Microhyla ornata*	C	X	X											X
Beautiful Pygmy Frog	*Microhyla pulchra*	C	X	X		X	X	X							X
Ornate Chorus Frog	*Microhyla fissipes*	C				X	X	X							X
Berdmore's Narrow-mouthed Frog	*Microhyla berdmorei*	C			X		X	X							X
Total		**-**	**10**	**7**	**6**	**8**	**13**	**11**	**0**	**0**	**0**	**0**	**0**	**1**	**14**

Remarks: * = inquiry data

X = occurrence

[1]Abundance:

A = very common

C = common

LC = Less common

[2]Conservation Status: refers to the Regulation of the Ministry of Agriculture and Forestry No. 0360/MAF, dated 8th Dec. 2003

Reserved species (Category 1)

Protected species (Category 2)

[3]IUCN Red List Status: IUCN (2012)

CR = critically endangered

EN = endangered

VU = vulnerable

NT = near threaten

LC = least concern

NA = not listed

Annex H

Aquatic Biota Survey Results 2013

Family/Common Name	Scientific Name	Abundance[1]	Distribution						Conservation Status[2]		IUCN Red List Status[3]				
			Nam Ngiep		Huai Ngua	Resettlement Site	Nam Xan		Restricted (List I)	Protected (List II)	CR	EN	VU	NT	LC
			Upper	Lower			Upper	Lower							
Family Notopteridae															
1. Bronze featherback	***Notopterus notopterus***	C		1			1								X
Family Sundasalangidae															
2. Mekong noodlefish	***Sundasalanx mekongensis***	LC		7											X
Family Clupeidae															
3. Thai river sprat	***Clupeichthys aesarnensis***	VC	2												X
Family Cyprinidae															
4. Asiatic minnow	***Paralaubuca typus***	C		15											X
5. Glass barb	***Parachela oxygastroides***	C		2											X
6. Salmon carp	***Raiamas guttatus***	VC	4				2	2							X
7. -	***Opsarius koratensis***	VC	92	24	1		4	18							X
8. Mackerel barb	***Opsarius pulchellus***	C	5												X
9. Leaping barb	***Laubuca caeruleostigmata***	C	13					16				X			
10. Laos danio	***Devario laoensis***	LC			1										X
11. Queen danio	***Devario regina***	LC	1												X
12. Flying minnow	***Esomus metallicus***	C	3												X
13. Apollo shark minnow	***Luciosoma bleekeri***	VC	15	20			5	6		X					X
14. -	***Rasbora atridorsalis***	C				1									
15. Pale rasbora	***Rasbora aurotaenia***	LC						3							X

Family/Common Name		Scientific Name	Abundance[1]	Distribution						Conservation Status[2]		IUCN Red List Status[3]				
				Nam Ngiep		Huai Ngua	Resettlement Site	Nam Xan		Restricted (List I)	Protected (List II)	CR	EN	VU	NT	LC
				Upper	Lower			Upper	Lower							
16.	Slender rasbora	***Rasbora daniconius***	C	7					7							X
17.	Rosefin rasbora	***Rasbora dusonensis***	C	6					2							
18.	Sidestripe rasbora	***Rasbora paviana***	VC	1	8	1	25		56							X
19.	Scissor-tail rasbora	***Rasbora trilineata***	C						2							X
20.	Common carp*	***Cyprinus carpio***	LC						1					X		
21.	White eye barb	***Cyclocheilichthys repasson***	LC	5												X
22.	-	***Labiobarbus leptocheila***	LC		1											X
23.	-	***Mystacoleucus atridorsalis***	VC	5	10	2			37							X
24.	Spiny barb	***Mystacoleucus marginatus***	VC	336	750	34	1	7	41							X
25.	Sikuk barb	***Sikukia gudgeri***	VC	6	106	32	1	14	66							
26.	Java barb	***Barbonymus gonionotus***	VC	20	6	2		4								X
27.	Goldfin tinfoil barb	***Hypsibarbus malcomi***	LC		1											X
28.	Golden belly barb	***Hypsibarbus vernayi***	C	2	1											X
29.	Golden barb	***Hypsibarbus wetmorei***	VC	5	21		1		14							X
30.	Mekong shoveljaw carp	***Onychostoma gerlachi***	LC						1							
31.	Golden Poropuntius	***Poropuntius normani***	C	141	22	13	21	3	191							X
32.	-	***Poropuntius laoensis***	VC	92	10			3								X
33.	-	***Scaphiodonichthys acanthopterus***	LC	210												X
34.	Bandan sharp-mouth Barb	***Scaphognathops bandanensis***	C			3			1					X		

Family/Common Name		Scientific Name	Abundance[1]	Distribution						Conservation Status[2]		IUCN Red List Status[3]				
				Nam Ngiep		Huai Ngua	Resettlement Site	Nam Xan		Restricted (List I)	Protected (List II)	CR	EN	VU	NT	LC
				Upper	Lower			Upper	Lower							
35.	Spotted hampala barb	***Hampala dispar***	LC		1											X
36.	Tranverse-bar barb	***Hampala macrolepidota***	VC	27	4		1	7	1							X
37.	Golden swap barb	***Puntius aurotaeniatus***	LC	1												X
38.	Swamp barb	***Puntius brevis***	VC	61			4		79							X
39.	Red cheek barb	***Systomus orphoides***	C	1				1								X
40.	Tiger barb	***Systomus partipentazona***	LC						1							X
41.	-	***Puntius rhombeus***	VC	96		1			26							X
42.	-	***Pethia stoliczkana***	LC	5												X
43.	-	***Bangana lippus***	LC	9												
44.	Sucker barb	***Barbichthys laevis***	LC		1											X
45.	Mrigal carp*	***Cirrhinus cirrhosus***	LC		2									**X**		
46.	Mud carp	***Cirrhinus molitorella***	C	8				2							**X**	
47.	-	***Hemiculterella macrolepis***	LC	8												
48.	Lineated silver mud carp	***Henicorhynchus lineatus***	C	4	1											X
49.	Lesser silver mud carp	***Henicorhynchus lobatus***	VC	3	32			2	1							**X**
50.	-	***Henicorhynchus ornatipinnis***	LC	13												X
51.	Siamese mud carp	***Henicorhynchus siamensis***	VC						3							
52.	Siver mudminnow	***Osteochilus hasselti***	VC	3	1			1	2							X
53.	Dusky face carp	***Osteochilus lini***	LC		2											X

Family/Common Name		Scientific Name	Abundance[1]	Distribution						Conservation Status[2]		IUCN Red List Status[3]				
				Nam Ngiep		Huai Ngua	Resettlement Site	Nam Xan		Restricted (List I)	Protected (List II)	CR	EN	VU	NT	LC
				Upper	Lower			Upper	Lower							
54.	Striped bony-lip carp	***Osteochilus microcephalus***	LC	1												X
55.	Mekong algae eater	***Crossocheilus atrilimes***	LC	2												X
56.	Siamese flying fox	***Crossocheilus oblongus***	LC	1												X
57.	Silver Flying fox	***Crossocheilus reticulatus***	VC	2	7		4									X
58.	Stonelapping minnow	***Garra cambodgiensis***	LC		1											X
59.	-	***Garra fasciacauda***	LC		1											X
60.	-	***Mekongina erythrospila***	VC	1	2										X	
Family Nemacheilidae																
61.	-	***Nemacheilus pallidus***	VC	31	27	3			10							X
62.	-	***Nemacheilus platiceps***	VC			1	1									
63.	-	***Schistura kengtungensis***	VC	17	1				2							X
64.	-	***Schistura magnifluvis***	C	1												X
65.	Nichol's Brook Loach	***Schistura nicholsi***	VC	4	4		1									X
Family Cobitidae																
66.	Jaguar loach	***Yasuhikotakia splendida***	C		1	4								X		
67.	Horseface loach	***Acantopsis choirorhynchos***	VC	1	7	38			21							X
68.		***Lepidocephalichthys furcatus***	VC	2		3			8							
69.	Dwarf horseface loach	***Lepidocephalichthys hasselti***	C	1					14							
Family Gyrinocheilidae																

Family/Common Name	Scientific Name	Abundance[1]	Distribution						Conservation Status[2]		IUCN Red List Status[3]				
			Nam Ngiep		Huai Ngua	Resettlement Site	Nam Xan		Restricted (List I)	Protected (List II)	CR	EN	VU	NT	LC
			Upper	Lower			Upper	Lower							
70. Honeysucker	***Gyrinocheilus aymonieri***	LC		1											X
Family Bagridae															
71. Yellow catfish	***Hemibagrus nemurus***	VC	2		22	1	3	3							X
72. Redtail catfish	***Hemibagrus wyckioides***	VC	2				8			X					X
73. Striped catfish	***Mystus mysticetus***	LC						4							X
74. Long finn mystus	***Mystus singaringan***	LC			44										X
75. Bubblebee catfish	***Pseudomystus siamensis***	VC		3	11	2									X
Family Siluridae															
76. Butter Catfish	***Ompok bimaculatus***	LC						1							
Family Schilbeidae															
77. Mekong bachcha	***Clupisoma sinensis***	LC	1												X
Family Sisoridae															
78. Goonch	***Bagarius bagarius***	C	1	7										X	
79. Giant goonch	***Bagarius yarrelli***	C		1										X	
80. -	***Glyptothorax laosensis***	C	2												X
Family Clariidae															
81. Walking catfish	***Clarias batrachus***	C			2			7							X
Family Belonidae															
82. Freshwater garfish	***Xenentodon cancila***	VC		8	2	6	17	37							

Family/Common Name	Scientific Name	Abundance[1]	Distribution						Conservation Status[2]		IUCN Red List Status[3]				
			Nam Ngiep		Huai Ngua	Resettlement Site	Nam Xan		Restricted (List I)	Protected (List II)	CR	EN	VU	NT	LC
			Upper	Lower			Upper	Lower							
Family Syngnathidae															
83. Giant pipefish	***Doryichthys boaja***	LC				3									X
Family Synbranchidae															
84. Asian swamp eel	***Monopterus albus***	VC	5			10		4							X
Family Mastacembelidae															
85. Peacock eel	***Macrognathus siamensis***	C						4							X
86. Tiretrack spiny eel	***Mastacembelus armatus***	VC	16	5	1		1	15							X
87. Flower spiny eel	***Mastacembelus favus***	C			1										X
Family Ambassidae															
88. Iridescent glassy perchlet	***Parambassis apogonoides***	C				1		5							X
Family Pristolepididae															
89. Malayan leaffish	***Pristolepis fasciata***	C					1	7							X
Family Eleotridae															
90. Marble goby	***Oxyeleotris marmorata***	C		5											X
Family Gobiidae															
91. Mekong Bumblebee goby	***Brachygobius mekongensis***	C		2		3									X
92. Mekong Rock goby	***Papuligobius ocellatus***	C	1			1									X
Family Osphronemidae															
93. Threestripe gourami	***Trichopsis schalleri***	C						1							X

Family/Common Name	Scientific Name	Abundance[1]	Distribution						Conservation Status[2]		IUCN Red List Status[3]				
			Nam Ngiep		Huai Ngua	Resettlement Site	Nam Xan		Restricted (List I)	Protected (List II)	CR	EN	VU	NT	LC
			Upper	Lower			Upper	Lower							
94. Croaking gourami	***Trichopsis vittata***	C				1									X
Family Channidae															
95. Dwarf snakehead	***Channa gachua***	VC	58	17	12	3	1	76							X
96. Great snakehead	***Channa marulius***	VC	2				1								X
97. Striped snakehead	***Channa striata***	C	3					1							X
Family Tetraodontidae															
98. Greenbottle pufferfish	***Auriglobus nefastus***	C						3							X
99. Target puffer	***Monotrete leiurus***	VC	1	9	1	1	1	19							X
100. Arrowhead puffer	***Tetraodon suvattii***	LC						1							X
Total no. of fishes			**1,368**	**1,158**	**235**	**93**	**89**	**820**							
Total no. of species			**58**	**43**	**23**	**21**	**21**	**44**		**2**	**0**	**1**	**4**	**4**	**79**

Remarks:

* = Introduced species

[1]Abundance:
X = occurrence
VC = very common
C = common
LC = Less common

[2]Conservation Status: refers to the Regulation of the Ministry of Agriculture and Forestry No. 0360/MAF, dated 8th Dec. 2003

[3]IUCN Red List Status: IUCN (2013)
CR = critically endangered
EN = endangered
VU = vulnerable
NT = near threaten
LC = least concern

Annex I

Critical Habitat Candidate Species Profiles

Species	*Afzelia xylocarpa*
Candidate Criteria	Criterion 1 – The species is listed as Endangered on the IUCN Red List
Record	*Direct* TISTR 2013 survey recorded the species at the main dam inundation, re-regulation dam inundation, resettlement area, transmission line, Huay Ngua and upper and lower Nam Ngiep sampling plots. NUL ground-truthing of the access road did not detect the species within the search areas.
	Indirect -
Distribution	The species is native to Cambodia, India, Lao PDR, Myanmar, Thailand and Viet Nam. TISTR survey detected the species at a number of locations throughout the Nam Ngiep catchment and it was also detected in upper and lower Nam Xan sampling plots. Specialists advice from Dr Pheng Phengsintham indicates that the distribution in Lao PDR includes Vientiane capital, Phouhin Namno National Biodiversity Conservation Area (pers. comm. 7/12/2013).
Population	Limited information is available regarding the population size of the species locally and globally however the direct data indicates a number of records locally.
Habitat	This tree is reported to grow in dense forest habitats and in transitional areas between evergreen and dry open dipterocarp forest. Altitude range of 100-650m in areas with uniform rainfall range, 1000-1500mm/year, a dry season of 5-6 months, mean annual temperature of 20-32°C is listed. Flowers March-April, fruiting September-December.
Threats	In Viet Nam the timber is values for carpentry. Other reports suggest the tree is harvested for medicinal purposes, pulp for cigarettes as well as wood turning
Summary	This species has been noted within a number of sampling plots during survey of the Nam Ngiep and Nam Xan catchment hence it appears that the species is disturbed across the region. The species is also known from Vientiane and a protected area in the south of Lao PDR. Given the distribution of known records it is considered **unlikely that the Project area sustains >10 per cent of the global population (Tier 1), or, habitat of significant important or containing nationally important concentrations (Tier 2).** Measures such as planting and management of harvesting threats locally will assist in managing the local population of the species.
References	Nghia, N.H. 1998. *Afzelia xylocarpa*. In: IUCN Red List of Threatened Species. Version 2013.1. www.iucnredlist.org Downloaded on 26 August 2013. Danida Forest Seed Centre Seed Leaflet No. 6 September 2000 *Afzelia xylocarpa* (Kurz) Craib

Species	*Anisoptera costata*
Candidate Criteria	Criterion 1 – The species is listed as Endangered on the IUCN Red List
Record	*Direct* TISTR 2013 survey recorded the species in a sampling plot within the Huay Ngua PPA survey in lower mixed deciduous forest habitat. The species was also detected in the lower Nam Xan survey location. DFRM road corridor survey identified 254 stems of the species. NUL ground-truthing survey identified the species within and outside of the proposed access road corridor.
	Indirect -
Distribution	The species is native to Brunei, Cambodia, Indonesia, Malaysia, Myanmar, Philippines, Singapore, Thailand and Viet Nam (Ashton, 1998c). It is not reported to be native to Lao PDR. TISTR survey detected the species at a number of locations throughout the Nam Ngiep catchment.
Population	Limited information is available regarding the population size of the species locally and globally however the recent survey noted the species as a dominant tree species within the proposed access road and in the adjacent area.
Habitat	It is reported to grow in semi-evergreen dipterocarp, evergreen and humid lowland forest.
Threats	The species is an economic tree and used for house construction.
Summary	This species was detected in the Huay Ngua PPA survey locations (by TISTR 2013) and more recently during ground-truthing of the disturbance corridor (by NUL 2013). The species is not native to Lao PDR and as such is not considered a priority biodiversity value. **The species is not a candidate for critical habitat within the Project area.**
References	Ashton, P. 1998. *Anisoptera costata*. In IUCN 2013. IUCN Red List of Threatened Species Version 2013.1. www.iucnredlist.org. Downloaded on 12 September 2013.

Species	*Dalbergia oliveri*
Candidate Criteria	Criterion 1 – The species is listed as Endangered on the IUCN Red List
Record	*Direct* TISTR 2013 survey recorded the species within the main dam, re-regulation dam, resettlement area, transmission line, upper Nam Ngiep, Huay Ngua amd upper Nam Xan survey areas. NUL ground-truthing of the access road did not detect the species within the search areas.
	Indirect -
Distribution	This species is not native to Lao PDR. It is native to Myanmar, Thailand and Viet Nam. TISTR survey detected the species at a number of locations throughout the Nam Ngiep catchment.
Population	Limited information is available regarding the population size of the species locally and globally.
Habitat	It is reported to be scattered among dense evergreen and semi-deciduous forest of up to 1200 m elevation.
Threats	
Summary	The species is not native to Lao PDR and as such is not considered a priority biodiversity value. **The species is not a candidate for critical habitat within the Project area.**
References	Nghia, N.H. 1998. *Dalbergia oliveri*. In: IUCN Red List of Threatened Species. Version 2013.1. www.iucnredlist.org Downloaded on 26 August 2013.

Species	*Dipterocarpus alatus*
Candidate Criteria	Criterion 1 – The species is listed as Endangered on the IUCN Red List
Record	*Direct* TISTR 2013 survey recorded the species in upper and lower Nam Ngiep survey locations as well as Huay Ngua and lower Nam Xan survey locations. NUL ground-truthing survey identified the species along the JICA Road and outside of the access road corridor.
	Indirect -
Distribution	This species is not native to Lao PDR. It is native to Bangladesh, Cambodia, India, Myanmar, Philippines, Thailand and Viet Nam. The species is common in Southeast Asian countries. Phengsintham (2013) notes recording the species in several Lao PDR provinces including Vientiane capital, Bolikhamxay, Khammouane, Savannekhet, Saravane, Champasak and Attapeu.
Population	Limited information is available regarding the population size of the species locally and globally however the NUL survey noted the species both within the proposed access road and in the adjacent area.
Habitat	In Indo-China and Thailand the species occurs gregariously along river banks, and in the Philippines it is found in mixed dipterocarp forest. It is a tropical tree of dense evergreen and mixed dense forest.
Threats	The major threat to the species is habitat loss. In Cambodia it is a valued construction timber and resin used for proofing and traditional medicine.
Summary	This species was detected in the Project area at a number of survey locations. The species is not native to Lao PDR and as such is not considered a priority biodiversity value. **The species is not a candidate for critical habitat within the Project area.**
References	Ashton, P. 1998. *Dipterocarpus alatus*. In IUCN 2013. IUCN Red List of Threatened Species Version 2013.1. www.iucnredlist.org. Downloaded on 21 August 2013.

Species	*Dipterocarpus turbinatus*
Candidate Criteria	Criterion 1 – The species is listed as Critically Endangered on the IUCN Red List
Record	*Direct* TISTR 2013 survey recorded the species at main dam, re-regulation dam, upper Nam Ngiep and the Huay Ngua PPA as well as lower Nam Xan survey locations. NUL ground-truthing of the proposed assess road did not detect the species within the search areas. ERI 2007 survey recorded the species in dry evergreen forest, mixed deciduous forest and unstocked forest in the main dam survey area.
	Indirect -
Distribution	The species is native to Bangladesh, Cambodia, India, Lao PDR, Myanmar, Thailand and Viet Nam. TISTR survey detected the species at a number of locations throughout the Nam Ngiep catchment. Hossain and Nath note that in Bangladesh the species scattered in the tropical ever-green forests and tropical semi-evergreen forests of Chittagong, Chittagong Hill Tracts, Cox's Bazar and Sylhet while in Myanmar the species has a comparatively wide distribution in tropical semi-evergreen forests and tropical moist deciduous forest. Dr Pheng Phengsintham indicated that the distribution in Lao PDR includes Vientiane province (pers. comm. 7/12/2013).
Population	Limited information is available regarding the population size of the species locally and globally.
Habitat	The species is found in mixed deciduous, evergreen and semi-evergreen forests. It is reported to often occur in wet dense forest.
Threats	In some countries the resin of the tree is used to prepare torches.
Summary	This species has been noted within a number of the Project area survey locations and affords a distribution across a number of countries outside Lao PDR. Given the distribution of known records it is considered **unlikely that the Project area sustains >10 per cent of the global population (Tier 1), or, habitat of significant important or containing nationally important concentrations (Tier 2).** Measures such as planting and management of harvesting threats locally will assist in managing the local population of the species.
References	Ashton, P. 1998. *Dipterocarpus turbinatus*. In IUCN 2013. IUCN Red List of Threatened Species Version 2013.1. www.iucnredlist.org. Downloaded on 21 August 2013. Hossain, M. K. and Nath, P.K. Part II Species Descriptions: *Dipterocarpus turbinatus* Gaertn. Institute of Forestry and Environmental Sciences, Chittagong University, Bangladesh

Species	*Hopea ferrea*
Candidate Criteria	Criterion 1 – The species is listed as Endangered on the IUCN Red List
Record	*Direct* TISTR 2013 survey recorded the species in upper Nam Ngiep survey locations however the species was not detected in other survey areas. ERI 2007 survey recorded the species in mixed deciduous forest and unstocked forest in the main dam survey area.
	Indirect -
Distribution	The species is native to Cambodia, Malaysia, Myanmar, Thailand and Viet Nam. This species is not native to Lao PDR.
Population	Limited information is available regarding the population size of the species locally and globally.
Habitat	
Threats	The species is commercially traded as an important timber tree.
Summary	This species was detected in the Project area at a number of survey locations. The species is not native to Lao PDR and as such is not considered a priority biodiversity value. **The species is not a candidate for critical habitat within the Project area.**
References	Ashton, P. 1998. *Hopea ferrea*. In IUCN 2013. IUCN Red List of Threatened Species Version 2013.2. www.iucnredlist.org. Downloaded on 16 December 2013.

Species	*Shorea roxburghii*, White Meranti
Candidate Criteria	Criterion 1 – The species is listed as Endangered on the IUCN Red List
Record	*Direct* TISTR 2013 survey recorded the species in resettlement, transmission line, upper and lower Nam Ngiep and Huay Ngua PPA as well as upper and lower Nam Xan survey locations. The NUL ground-truthing survey (2013) of the proposed access road did not detect the species within the search areas.
	Indirect -
Distribution	The species is native to Cambodia, India, Lao PDR, Malaysia, Myanmar, Thailand and Viet Nam. TISTR survey detected the species at a number of locations throughout the Nam Ngiep catchment. Phengsintham (2013) notes recording the species in several Lao PDR provinces including Vientiane capital, Savannekhet and Road no 13.
Population	Limited information is available regarding the population of the species, though healthy regenerating subpopulations are reported in the south of India.
Habitat	The species is considered unusual for its adaptation to withstand adverse climatic conditions and soil types. It occurs in dry evergreen or deciduous forest and bamboo forest, often on sandy soils.
Threats	
Summary	This species has been noted within a number of the Project area survey locations and affords a distribution across a number of countries outside Lao PDR. Given the distribution of known records it is considered **unlikely that the Project area sustains >10 per cent of the global population (Tier 1), or, habitat of significant important or containing nationally important concentrations (Tier 2).** Measures such as planting and management of harvesting threats locally will assist in managing the local population of the species.
References	Ashton, P. 1998. *Shorea roxburghii*. In IUCN 2013. IUCN Red List of Threatened Species Version 2013.1. www.iucnredlist.org. Downloaded on 12 September 2013.

Species	*Vatica cinerea*
Candidate Criteria	Criterion 1 – The species is listed as Endangered on the IUCN Red List
Record	*Direct* TISTR 2013 survey did not record the species. A survey undertaken by the Department of Forestry Resource Management along a section of the proposed access road detected one individual. NUL ground-truthing did not detect the species within the search area.
	Indirect -
Distribution	This species is not native to Lao PDR. Is native to Cambodia, Malaysia, Myanmar, Thailand and Viet Nam.
Population	Limited information is available regarding the size of the population of the species and habitat preferences.
Habitat	This small species is reported to flourish in exposed areas, occurring on rocky, dry land and in bamboo forest.
Threats	
Summary	The species is not native to Lao PDR and as such is not considered a priority biodiversity value. **The species is not a candidate for critical habitat within the Project area.**
References	Ashton, P. 1998. *Vatica cinerea*. In IUCN 2013. IUCN Red List of Threatened Species Version 2013.1. www.iucnredlist.org. Downloaded on 12 September 2013.

Species	*Aonyx cinerea*, Asian small-clawed otter
Candidate Criteria	Criterion 1 – The species is listed as Restricted in the Regulation of the Ministry of Agriculture and Forestry No. 0360/MAF.
Record	*Direct* TISTR 2013 biodiversity survey did not record the species. ERI 2007 biodiversity survey did not record the species.
	Indirect Biodiversity village surveys in 2013 apparently recognised the species in the upper Nam Ngiep area. Note: Verbal village information on otters is close to impossible to assign to species despite the often overconfident presentation in interview reports. These reports are thus no more than weakly indicative of Small-clawed otter presence in the Project area. However, otters as a group are readily recognised and because no otter species remains widespread or common in Lao PDR, the information at group level remains of value. Reports of otters may also include Eurasian otter *Lutra lutra* as well as the two species treated here.
Distribution	The species has a large distribution range, extending from India, eastward through south-east Asia to the Philippines, and north to Taiwan and southern China.
Population	A reliable population estimate of the Asian Small-clawed otter is lacking. Duckworth et al (1999) noted that the species was then probably widespread in Lao PDR with populations considered to be of moderate global significance. In northern Lao PDR, records have been noted in Nam Kading and Nam Theun, with other records in central and southern Lao PDR (Duckworth et al 1999). Since then, massive declines in otters across northern southeast Asia render it likely that the species has disappeared from, or been reduced to non-viably low populations within, some or many of the Lao PDR catchments it formerly inhabited.
Habitat	Habitat use apparently varies across its wide range. In Indonesia, the typical habitats of the species in are wetland systems having pools and stagnant water, including shallow stretches, with depths less than one metre. In the Western Ghats of India, it seems tied to streams through forest and tree plantations in evergreen and semi-evergreen areas, with no records from the sort of agricultural and urban landscapes it typically uses in Java. Original habitat use in Lao PDR is unknown; recent hunting is likely to have removed it from accessible and even some remote areas. Asian small-clawed otters have a high climatic and trophic adaptability in south and south-east Asian tropics, occurring from coastal wetlands up to mountain streams.
Threats	Throughout Asia the main threat to the species is trade-driven hunting. The drivers and dynamics of this are poorly understood, particularly in southeast Asia. Habitat destruction due to development activities may be a local threat, but the species remains widespread in Java in, for example, towns and paddy-dominated landscapes. Other threats might include degradation of water quality due to the use of agrochemicals in catchments, and reduction in prey due to over-exploitation. In Lao PDR over the last 15 years these have all been, if relevant at all, dwarfed by the effects of hunting.
Summary	The general patterns in northern southeast Asia suggest it is unlikely that hunting will not have reduced this species to very low numbers in the Project area. There is no situational reason to expect an anomalously high survival in the Project area (which could potentially now qualify as critical habitat) and the record is a weak indication of the species, but this cannot be excluded. The key threats relate to hunting and degradation of aquatic environments and although current information does not confirm critical habitat, the precautionary approach should be considered and the threats to the species should be managed throughout the Project construction and operation and

Species	*Aonyx cinerea*, **Asian small-clawed otter**
	within any Biodiversity Offset Design.
References	Hussain, S.A. & de Silva, P.K. 2008a. Aonyx cinerea. In: IUCN 2013. IUCN Red List of Threatened Species. Version 2013.1. <www.iucnredlist.org>. Downloaded on 07 November 2013. Duckworth, J.W., Salter, R.E. and Khounboline, K. 1999. Wildlife in Lao PDR 1999 Status Report. Vientiane: IUCN-The World Conservation Union/Wildlife Conservation Society/Centre for Protected Areas and Watershed Management.

Species	*Canis aureus*, Golden jackal
Candidate Criteria	Criterion 1 – The species is listed as Restricted in the Regulation of the Ministry of Agriculture and Forestry No. 0360/MAF.
Record	*Direct* TISTR 2013 biodiversity survey did not record the species.
	Indirect Biodiversity village surveys in 2013 apparently recognised the species in the upper Nam Ngiep area. Stakeholder village surveys in 2013 apparently recognised the species reporting it as very common at Ban Xomxuen, Ban Kanyong and Ban Pakheuang thugh never encountered at Ban Pou, Ban Pakyong or Ban Don. The Project EIA (2007) notes the species occurrence within and outside the Project area based on a secondary data source though no location is specified.
Distribution	The species is widespread in north and north-east Africa, occurs in the Arabian Peninsula, parts of Europe, Turkey, Syria, Iraq, Iran, Central Asia, the entire Indian subcontinent, and east and south to Sri Lanka, Myanmar, Thailand and parts of Indo-China. The species is fairly common throughout its range. Duckworth et al. 1999 noted the species to occur in southern Lao PDR (Xe Pian and Dong Khanthung) though there are provisional records in northern and central Lao PDR. It has since been found on the Nakai plateau (before inundation) and Phou Phanang NPA northwest of Vientiane.
Population	
Habitat	All records in Lao PDR and surrounding areas come from deciduous dipterocarp forest and other open, deciduous forests, and also, in areas where hunting is relatively low, cleared evergreen areas. There are no records from interior evergreen forest. As such, the species is highly restricted in Lao PDR, because most suitable habitats are too heavily hunted for it to survive. It seems, for example, to be on the brink of extinction on the Nam Ngum plain.
Threats	Hunting, apparently primarily as by-catch or in retaliation for livestock-killing is the main threat in Lao PDR; there is no evidence of any trade demand. Given its tolerance of habitat degradation (and, in fact, it is likely to have benefitted in southeast Asia from encroachment into evergreen forest areas, where hunting is relatively low, as indicated by the recent colonisation of Khao Yai NP and environs, Thailand), the Lao PDR population could be much higher than it presently is.
Summary	The species has a large global range; Lao PDR is on the edge of this. Numbers in the Project area are likely insignificant given the much larger, and growing populations in Thailand and probably Cambodia. Although numbers in Lao PDR are now probably small, there is no reason to indicate the Project area has any particular role for conserving the species compared with the many other landscapes of similar habitat in the country. **As such the Project area is considered unlikely to be critical habitat for the species.**
References	Jhala, Y.V. & Moehlman, P.D. 2008. Canis aureus. In: IUCN 2013. IUCN Red List of Threatened Species. Version 2013.1. <www.iucnredlist.org>. Downloaded on 06 November 2013. Duckworth, J.W., Salter, R.E. and Khounboline, K. 1999. Wildlife in Lao PDR 1999 Status Report. Vientiane: IUCN-The World Conservation Union/Wildlife Conservation Society/Centre for Protected Areas and Watershed Management.

Species	*Capricornis milneedwardsii*, **Southwest China serow**
Candidate Criteria	Criterion 1 – The species is listed as Restricted in the Regulation of the Ministry of Agriculture and Forestry No. 0360/MAF.
Record	*Direct* TISTR 2013 biodiversity survey did not record the species. ERI 2007 biodiversity survey did not record the species.
	Indirect Biodiversity village surveys in 2013 apparently recognised the species in the upper Nam Ngiep area. Stakeholder village surveys in 2013 apparently recognised the species reporting it as very common at Ban Xomxuen, common at Ban Pakyong though never encountered at Ban Pou, Ban Kanyong, Ban Pakheuang or Ban Don.
Distribution	This species occurs in much of Myanmar, Cambodia, south and central China, Lao PDR, Thailand, and Viet Nam.
Population	No total estimates of population size have been made, however in Lao PDR, this species is still widespread, and despite heavy hunting, it is consistently present in areas of suitable habitat.
Habitat	Accounts from throughout the species range report the species inhabits rugged steep hills and rocky places, especially limestone regions up to 4,500 m. However, the species is also routinely recorded (by camera-trapping) in hill and mountain forest areas with gentler terrain.
Threats	Threats to the species include hunting, to which it seems remarkably resilient. Habitat loss for agricultural expansion, and habitat degradation from clearance for firewood and timber, are also negatively affecting the population somewhat, in large parts through fragmenting and increasing accessibility to areas of remaining unconverted habitat.
Summary	Serows plausibly remain widespread and locally common in the Project area, but this is equally true of much of hilly north and central Lao PDR. **The Project area is only a small proportion of the nation's total such habitat and as such would not be expected to constitute critical habitat.**
References	Duckworth, J.W., Steinmetz, R. & Pattanavibool, A. 2008. Capricornis milneedwardsii. In: IUCN 2013. IUCN Red List of Threatened Species. Version 2013.1. <www.iucnredlist.org>. Downloaded on 07 November 2013.

Species	*Cuon alpinus*, Dhole/Asian wild dog
Candidate Criteria	Criterion 1 – The species is listed as Endangered on the IUCN Red List and is listed as Restricted in the Regulation of the Ministry of Agriculture and Forestry No. 0360/MAF.
Record	*Direct* TISTR 2013 biodiversity survey did not record the species. ERI 2007 biodiversity survey did not record the species.
	Indirect Biodiversity village surveys in 2013 apparently recognised the species in the upper Nam Ngiep area. Stakeholder village surveys in 2013 apparently recognised the species reporting that it is very commonly encountered in Ban Pou, Ban Xomxuen, Ban Pakyong and Ban Don though never encountered in Ban Kanyong and Ban Pakheuang villages. The Project EIA (2007) notes the species occurrence within and outside the Project area based on a secondary data source though no location is specified.
Distribution	The species is native to Bangladesh, Bhutan, Cambodia, China, India, Indonesia, Kazakhstan, Kyrgyzstan, Lao PDR, Malaysia, Mongolia, Myanmar, Nepal, Russian Federation, Tajikistan, Thailand and Viet Nam. The species is thought to have ranged over most of Lao PDR, Cambodia, Viet Nam and Thailand although reliable site-specific information is scarce. Duckworth et al 1999 note the species to occur in north Lao (Phou Khaokhoay) and in southern Lao (Dong Hua Sao, Xe Pian and Dong Khanthung) and there are more recent records from various other survey areas such as the Nakai plateau and Nam Et Phou Louey NPA.
Population	It is estimated that fewer than 2,500 mature individuals remain in the wild with a declining population trend. The Lao PDR population is not known, although the species evidently remains considerable more widespread in Lao PDR than do the big cats.
Habitat	The species is found in a wide variety of vegetation types including primary, secondary and degraded tropical dry and moist deciduous forest, evergreen and semi-evergreen forests, dry thorn forests, grassland scrub forest mosaics and alpine steppe. Habitat selection factors include the availability of medium to large ungulate prey, water, presence of other large carnivores, suitability of breeding sites and human population levels.
Threats	The most important threat in Lao PDR is likely to be hunting, although this is usually as by catch in retaliation for livestock killing; as yet there is no evidence of significant trade demand. Secondary threats include habitat loss, depletion of prey population, interspecific competition, persecution and possibly disease.
Summary	Dholes plausibly remain widespread and perhaps even locally common in the Project area; but this is equally true of much of hilly north and central Lao PDR. **The Project area is only a small proportion of the nation's total such habitat and as such would not be expected to constitute critical habitat.**
References	Durbin, L.S., Hedges, S., Duckworth, J.W., yson, M., Lyenga, A. and Venkataraman, A. (IUCN SSC Canid Specialist Group – Dhole Working Group) 2008. Cuon alpinus. In: IUCN 2013. IUCN Red List of Threatened Species. Version 2013.2 www.iucnredlist.org. Downloaded 16 December 2013. Duckworth, J.W., Salter, R.E. and Khounboline, K. 1999. Wildlife in Lao PDR 1999 Status Report. Vientiane: IUCN-The World Conservation Union/Wildlife Conservation Society/Centre for Protected Areas and Watershed Management.

Species	*Elephas maximus*, Asian elephant
Candidate Criteria	Criterion 1 – The species is listed as Endangered on the IUCN Red List and is listed as Restricted in the Regulation of the Ministry of Agriculture and Forestry No. 0360/MAF.
Record	*Direct* TISTR 2013 biodiversity survey did not record the species.
	Indirect The Huay Ngua MP (2010) notes presence of the species within the provincial preserved area. Stakeholder village surveys in 2013 recognised the species reporting it is not commonly encountered in Ban Pakyong and never seen in Ban Pou, Ban Xomxuen and Nam Xan villages. The Project EIA (2007) notes the species occurrence within and outside the Project area based on a secondary data source though no location is specified.
Distribution	The species is native to Bangladesh, Bhutan, Cambodia, China, India, Indonesia, Lao PDR, Malaysia, Myanmar, Nepal, Sri Lanka, Thailand and Viet Nam (Choudhury et al. 2008). Populations in Lao PDR are now numerically insignificant compared with those of south Asia, but in the context of even steeper declines in Vietnam and China and similar ones in Cambodia, they are highly significant in the maintenance of ancestral range. The species in Lao PDR is reported to be widely, but very patchily distributed in forested areas (highlands and lowlands) with potentially important populations Nam Phouy west of the Mekong and in northern Lao PDR; in Phou Phanang and Phou Khao Khoay in Vientiane Province; Nakai Nam Theun NPA and surrounding in Khammouane Province; Phou Xang He NPA in Savannakhet Province; Dong Ampham, Dong Khanthung, Xe Pian, close to Cambodian border; and Nam Et, Nam Xam, Phou Dendin, and Nam Ha in the north, close to the Vietnamese and Chinese borders. However recent information on most of these areas is sparse. Near the Project area, potentially important elephant populations have been reported at Phou Phanang and Phou Khao Khoay to the west (approximately 20 km) and Nam Xan. An area to the east (approximately 20 km) of Huay Ngua PPA is considered important for a population of elephants that links to Nam Kading National Protected Area (pers comm. Kham khoun Khounboline 19/11/2013).
Population	It was estimated in 2003 that the global population of the species is between 41,410 and 52,345 (however this has been contested) which includes between 500 and 1000 in Lao PDR. Estimate of national population is expected to be larger than the 200-500 estimated in Lair (1997) and the Lao PDR population has been considered to be the most important national population for conservation in Indochina. However, ongoing declines in Lao PDR and recent discoveries in Cambodia suggest this statement may require modification.
Habitat	The species is found in many habitat types up to at least 1200 m, remaining widely distributed in forested, hilly areas. The species is a generalist occurring in grassland, evergreen forest, semi-evergreen forest, moist deciduous forest, dry deciduous forest, dry thorn forest, scrublands and cultivated and secondary forests. The Asian elephant is an herbivore requiring large amounts of food per day. Their dung contributes to germinating seed dispersal. The home range varies but is considered to be large with ranges in excess of 60,000 ha recorded in India and only 16,000 ha range in Sri Lanka.
Threats	The overwhelming threat to the species in Lao PDR and surroundings is hunting, both for trade and resulting from crop destruction. Subsidiary threats

Species	*Elephas maximus*, Asian elephant
	include habitat loss, degradation and fragmentation, chiefly because these increase the likelihood of human-elephant conflict and enhance the ease of poaching. Large areas of prime elephant habitat in Lao PDR have already lost the species.
Summary	The location of the indirect records is mainly to the east of the Project area and to the north, outside the Project area. Similarly there are a number of locations noted for the species other countries. As such, the **Project area is not considered likely to be part of one of 10 or fewer habitat areas or required to sustain greater than 10 per cent of the global population (C1 Tier 1).** The Project area is not a known important area in Lao PDR for the species however suitable habitat exists.
References	Choudhury, A., Lahiri Choudhurym D.K., Desai, A., Duckworth, J.W., Easa, P.S., Johnsingh, A.J.T., Fernando, P., Hedges, S., Gunawardena, M., Kurt, F., Karanth, U., Lister, A., Menon, V., Riddle, H., Rubel, A. and Wikramanayake, E. (IUCN SSC Asian Elephant Specialist Group) 2008. *Elephas maximus*. In: IUCN 2012. IUCN Red List of Threatened Species. Version 2013.1. <www.iucnredlist.org>. Downloaded on 03 September 2013. Duckworth, J.W., Salter, R.E. and Khounboline, K. 1999. Wildlife in Lao PDR 1999 Status Report. Vientiane: IUCN-The World Conservation Union/Wildlife Conservation Society/Centre for Protected Areas and Watershed Management.

Species	*Helarctos malayanus*, Sun bear
Candidate Criteria	Criterion 1 – The species is listed as Restricted in the Regulation of the Ministry of Agriculture and Forestry No. 0360/MAF.
Record	*Direct* TISTR 2013 biodiversity survey did not record the species.
	Indirect The Huay Ngua MP (2010) notes presence of the species within the preserved area. Biodiversity village surveys in 2013 apparently recognised the species to occur in the upper Nam Ngiep area. Stakeholder village surveys in 2013 apparently recognised the species, reporting that it is not commonly encountered in Ban Pakyong and is never seen in Ban Pou, Ban Xomxuen and Nam Xan villages. The Project EIA (2007) notes the species occurrence outside the Project area based on a secondary data source though no location is specified. Note: Verbal village information on bears is difficult to assign to species despite the often overconfident presentation in interview reports. These reports are thus no more than weakly indicative of Sun bear presence in the Project area. However, the species' wide distribution in Lao PDR, its known use of habitats similar to those in the Project area, and its level resilience to human activities all suggest it could well inhabit the Project area.
Distribution	The species is native to numerous countries (Bangladesh; Brunei Darussalam; Cambodia; China; India; Indonesia; Lao People's Democratic Republic; Malaysia; Myanmar; Thailand; Viet Nam). Sun bears occur in mainland south-east Asia as far west as Bangladesh and north-eastern India, as far north as southern Yunnan Province in China, and south and east to Sumatra and Borneo, respectively. The species now occurs very patchily through much of its former range. Duckworth et al 1999 note the species to occur in central Lao PDR (Nakai-Nam Theun) and in southern Lao (Phou Ahyon, Dong Ampham, Nam Ghong Provincial PA, Dong Hua Sao and Xe Pian); at this stage there had been few relevant surveys in northern highlands of Lao PDR. Subsequent records from, e.g., Nam Et-Phou Louey NPA; suggest a former wide occurrence in that part of the country.
Population	Reliable estimates of sun bear populations are lacking.
Habitat	Sun bears rely on tropical forest habitat and in mainland south-east Asia inhabit seasonal ecosystems with a long dry season (3–7 months), during which rainfall is 1,000m.
Threats	The major threat to sun bears in Lao PDR is commercial hunting.
Summary	Sun bears plausibly occur in the Project area; but this is equally true of much of Lao PDR. **The Project area is only a small proportion of the nation's total such habitat and as such would not be expected to constitute critical habitat.**
References	Fredriksson, G., Steinmetz, R., Wong, S. & Garshelis, D.L. (IUCN SSC Bear Specialist Group) 2008. Helarctos malayanus. In: IUCN 2013. IUCN Red List of Threatened Species. Version 2013.1. <www.iucnredlist.org>. Downloaded on 06 November 2013. Duckworth, J.W., Salter, R.E. and Khounboline, K. 1999. Wildlife in Lao PDR 1999 Status Report. Vientiane: IUCN-The World Conservation Union/Wildlife Conservation Society/Centre for Protected Areas and Watershed Management.

Species	*Lutrogale perspicillata*, Smooth-coated otter
Candidate Criteria	Criterion 1 – The species is listed as Restricted in the Regulation of the Ministry of Agriculture and Forestry No. 0360/MAF.
Record	*Direct* TISTR 2013 biodiversity survey did not record the species. ERI 2007 biodiversity survey did not record the species.
	Indirect Biodiversity village surveys in 2013 apparently identified the species to occur in the upper Nam Ngiep area. Note: Verbal village information on otters is close to impossible to assign to species despite the often overconfident presentation in interview reports. These reports are thus no more than weakly indicative of Smooth-coated otter presence in the Project area. However, otters as a group are readily recognised and because no otter species remains widespread or common in Lao PDR, the information at group level remains of value. Reports of otters may also include Eurasian Otter (*Lutra lutra*) as well as the two species treated here.
Distribution	The species is distributed through much of south Asia and south-east Asia. Its distribution is largely continuous from Indonesia, through south-east Asia, and westwards from southern China to India and Pakistan, with an isolated population in Iraq.
Population	Reliable estimates of its population are not available (Hussain 2008b). Duckworth et al (1999) notes records from Xe Pian and Nam Ghong PPA as well as many signs of large otters in various localities. Duckworth et al (1999) noted that the species was probably widespread in Lao PDR with populations considered to be of moderate global significance. Since then massive declines in otters across northern southeast Asia render it likely that the species has disappeared from, or been reduced to non-viably low populations within, some or many of the Lao PDR catchments it formerly inhabited.
Habitat	Habitat use may vary across its wide range, but in general it seems mostly to occur in areas of gentle terrain, in both flowing and standing wetlands.
Threats	Throughout Asia the main threat to the species is trade-driven hunting The drivers and dynamics of this are poorly understood, particularly in SE Asia. Habitat destruction due to development activities may be a local threat but the species occurs in significant numbers in south India and – where not yet hunted out – north and central India in reservoirs and on major rivers flowing amid purely agricultural landscapes. Other threats might include degradation of water quality due to the use of pesticides in catchments, and reduction in prey due to over-exploitation. In Lao PDR over the last 15 years these have all been if relevant at all, dwarfed by the effects of hunting.
Summary	The general patterns in northern southeast Asia suggest it is likely that hunting will have reduced this species to very low numbers in the Project area. There is no situational reason to expect an anomalously high survival in the Project area (which could potentially now qualify as critical habitat), and the record is a weak indication of the species, but this cannot be excluded. The key threats relate to hunting and degradation of aquatic environments and although current information does not confirm critical habitat, the precautionary approach should be considered and the threats to the species should be managed throughout the Project construction and operation and within any Biodiversity Offset Design.
References	Hussain, S.A., de Silva, P.K. & Mostafa Feeroz, M. 2008b. *Lutrogale perspicillata.* In: IUCN 2013. IUCN Red List of Threatened Species. Version 2013.1. <www.iucnredlist.org>. Downloaded on 06 November 2013. Duckworth, J.W., Salter, R.E. and Khounboline, K. 1999. Wildlife in Lao PDR 1999 Status Report. Vientiane: IUCN-The World Conservation Union/Wildlife Conservation Society/Centre for Protected Areas and Watershed Management.

Species	*Manis javanica*, Sunda pangolin
Candidate Criteria	Criterion 1 – The species is listed as Endangered on the IUCN Red List and is listed as Restricted in the Regulation of the Ministry of Agriculture and Forestry No. 0360/MAF.
Record	*Direct* TISTR 2013 biodiversity survey did not directly record the species. One was photographed in the lower Nam Ngiep area in early 1999 that had reportedly been collected 30 minutes' walk in a village from the village of Ban Sopyouk; two more unidentified pangolins were seen then in Ban Houaypamom, reportedly collected a few hours' walk away. Specific location information is unavailable.
	Indirect The Huay Ngua MP (2010) notes presence of pangolins, assumed to be the species within the preserved area. Stakeholder village surveys in 2013 recognised pangolins, assumed to be the species is commonly encountered in Ban Pou (of Nam Ngiep) and Ban Pakheuang (of Nam Xan) and less common in Ban Xomxuen, Ban Pakyong and Ban Kanyong. He species is noted as very common at Ban Don village. The Project EIA (2007) notes the species occurrence within and outside the Project area based on a secondary data source though no location is specified. Note: There is some uncertainty associated with these indirect data sources for the species as there can be confusion between *Manis javanica* and the other pangolin species of Lao PDR, Chinese pangolin *M. pentadactyla*. However, pangolins as a group are readily recognised and because no pangolin species remains widespread or common in Lao PDR, the information at group level remains of value.
Distribution	The species ranges of much of mainland Southeast Asia, including southern Myanmar through central and southern Lao PDR, Thailand, central and southern Viet Nam, Cambodia, Peninsular Malaysia, Sumatra, Java and Borneo. In Lao PDR it is expected that the species is restricted to the Mekong plain and adjacent foothills to around 900 m, with potential occurrence in the Bolaven Plateau. Duckworth et al 1999 noted records from many survey areas in the 1990s. However very high levels of trade-driven hunting since hen suggest that pangolins are likely now to be very rare and plausibly widely extirpated from suitable habitat in Lao PDR.
Population	The species is rarely observed and as such population size information is unavailable. The species is noted as common in parts of Singapore and relatively common Sabah though reports of substantial declines are noted in areas of Viet Nam and Lao PDR.
Habitat	Found in primary and secondary forest as well as cultivated areas, gardens and plantations. The species inhabits hollows for sleeping and den sites and as such primary forest might occupy more individuals because they contain higher numbers of older, larger trees with suitable hollows. The species is largely nocturnal and solitary, feeding on ants and termites. Home range size has been estimated at 6.97 ha.
Threats	The overwhelming threat to the species is hunting for (formerly) local use and (now, almost entirely) international trade (skins, scales, meat). Pangolins are highly adaptable to some modified habitats (those with sufficient food), where not hunted.
Summary	There is some uncertainty associated with the indirect data sources for the species as there can be confusion between *Manis javanica* and other pangolin species. The key threat to the species is hunting and although current information does not confirm critical habitat, the precautionary approach should be considered and the threats to the species should be managed throughout the Project construction and operation and within any Biodiversity Offset Design.

Species	*Manis javanica*, **Sunda pangolin**
References	Duckworth, J.W., Pattanavibool, A., Newton, P. and Nguyen Van Nhuan. 2008. *Manis javanica*. In: IUCN 2013. IUCN Red List of Threatened Species. Version 2013.2. www.iucnredlist.org. Downloaded on 17 December 2013. Duckworth, J.W., Satler, R.E. and Khounboline, K. 1999. Wildlife in Lao PDR 1999 Status Report. Vientiane: IUCN The World Conservation Union/Wildlife Conservation Society/Centre for Protected Areas and Watershed Management.

Species	*Nomascus leucogenys*, Northern white-cheeked gibbon
Candidate Criteria	Criterion 1 – The species is listed as Critically Endangered on the IUCN Red List. It also has an elevated protection status nationally and is listed as Restricted in the Regulation of the Ministry of Agriculture and Forestry No. 0360/MAF.
Record	*Direct* TISTR 2013 biodiversity survey recorded a vocalisation of a gibbon assumed to be the species in the upper Nam Ngiep survey area in the main dam inundation area. Targeted primate survey was undertaken in November 2013 by Dr Phaivanh Phiapalath of the IUCN SSC/Primate Specialist Group which reported two records (vocalisation) of gibbons in uphill mountain area outside the inundation area.` *Indirect* -
Distribution	The species is native to Lao PDR and Viet Nam and (now very much reduced) in China. In Lao gibbons probably of this species have been recorded widely in the northern highlands, potentially south into the northern Annamites in Nakai-Nam Theun and Nam Kading NPAs. However, ongoing challenges in identifying gibbons to species render many claims provisional. The gibbons of the Nam Ngiep catchment may include this species, but may also include, or even be entirely comprised of Southern white-cheeked gibbon *N. siki*.
Population	Population numbers are highest in Lao PDR due to larger tracts of natural habitat remaining in comparison to Viet Nam and China where forest habitat is much more fragmented and hunting has been in general, at higher levels for longer.
Habitat	The species is strictly arboreal though there is very little behavioural ecology information, including home range extent. Habitat includes tall primary and heavily degraded evergreen and semi-evergreen forest. The diet is dominated by fruits and some small amounts of leaves and insects. Anecdotal reports suggest group sizes of 3-4 individuals. Targeted primate survey identified a number of key habitat areas for the species, though located outside the inundation area.
Threats	Hunting has been so heavy in much of Lao PDR that many forest blocks have now lost gibbons entirely or support only tiny numbers. However, in some areas local traditional beliefs have resulted in the survival of potentially viable numbers in areas where almost all other wildlife species of similar, or even much lower, sensitivity to offtake have been seriously reduced. These areas are particularly important in retaining gibbons in the northern half of Lao PDR, but general erosion of these beliefs is high threat to these remnant populations.
Summary	Key habitat areas for the species are reported by Dr Phaivanh Phiapalath at Phou Thin, Phouru Pha Noy, Phou Pha hua and Phou Sam Liem. These locations are outside the Project area though must be considered for indirect impact. **As such the Project area is not considered to be critical habitat** however threat management should be considered.
References	Bleisch, B., Geissmann, T., Manh Ha., Rawson, B. and Timmins, R.J. 2008a. *Nomascus leucogenys*. In IUCN 2013. IUCN Red List of Threatened Species. Version 2013.1. www.iucnredlist.org. Downloaded on 21 August 2013.

Species	*Nycticebus bengalensis*, **Bengal slow loris**
Candidate Criteria	Criterion 1 – The species is listed as Restricted in the Regulation of the Ministry of Agriculture and Forestry No. 0360/MAF.
Record	*Direct* TISTR 2013 biodiversity survey did not record the species.
	Indirect Biodiversity village surveys in 2013 apparently recognised the species to occur in the upper Nam Ngiep area. Stakeholder village surveys in 2013 apparently recognised lorises, reporting to be as very common at all the villages surveyed: Ban Pou, Ban Xomxuen, Ban Pakyong, Ban Kanyong, Ban Pekheuang and Ban Don. The Project EIA (2007) notes the species occurrence within and outside the Project area based on a secondary data source though no location is specified.
Distribution	The species has a broad distribution in south-east Asia and occurs in: Bangladesh, Cambodia, southern China, north-eastern India, Lao PDR, Myanmar, Thailand, and Viet Nam (except the south).
Population	In Lao PDR, the population seems to be large and occurs in both large forest tracts and in degraded and fragmented areas. In the 1990s large lorises were among the most common species seen during spotlight surveys in much of central and southern Lao PDR (the north had no comparable surveys), and – in the absence of repeat survey – the limited credible village information gathered since then suggests no major declines within remaining suitable habitat.
Habitat	The species is arboreal and nocturnal, and inhabits tropical evergreen rainforest, semi-evergreen forest, and moist deciduous forest (Streicher 2008b).
Threats	The species is hunted and traded for food, traditional medicine, sport and as pets. Presently, in Lao PDR, this seems to be at lower levels than in countries such as Cambodia, although an escalation of hunting pressure may occur. The species' habitat is being reduced by farming, human settlement, infrastructure development (roads, dams and transmission lines) and fires, but very large areas remain in Lao PDR and the species is not yet anywhere close to being threatened by habitat factors.
Summary	This loris plausibly remains widespread and common in the Project area, but this is equally true of much of Lao PDR. **The Project area is only a small proportion of the nation's total such habitat and as such would not be expected to constitute critical habitat.**
References	Streicher, U., Singh, M., Timmins, R.J. & Brockelman, W. 2008b. *Nycticebus bengalensis*. In: IUCN 2013. IUCN Red List of Threatened Species. Version 2013.1. <www.iucnredlist.org>. Downloaded on **07 November 2013**.

Species	*Nycticebus pygmaeus*, Pygmy slow loris
Candidate Criteria	Criterion 1 – The species is listed as Restricted in the Regulation of the Ministry of Agriculture and Forestry No. 0360/MAF.
Record	*Direct* TISTR 2013 biodiversity survey did not record the species.
	Indirect Biodiversity village surveys in 2013 apparently recognised the species to occur in the upper Nam Ngiep area. Stakeholder village surveys in 2013 recognised lorises, apparently this species, as very common at all the villages surveyed: Ban Pou, Ban Xomxuen, Ban Pakyong, Ban Kanyong, Ban Pekheuang and Ban Don. The Project EIA (2007) notes the species occurrence within and outside the Project area based on a secondary data source though no location is specified.
Distribution	This species is found east of the Mekong River in eastern Cambodia, southernmost China (south-eastern Yunnan), Lao PDR, and Viet Nam. In China it is not clear if individuals recorded are wild animals or captured animals brought into China from Viet Nam.
Population	In Lao PDR, the population seems to be large and occurs both in large forest tracts and in degraded and fragmented areas. In the 1990s small lorises were among the most common species seen during spotlight surveys in some parts of central and southern Lao PDR (the north had no comparable surveys), and – in the absence of repeat surveys – the limited credible village information gathered since then suggests no major declines within remaining suitable habitat.
Habitat	This species has been sighted in a wide variety of habitats, including primary evergreen and semi-evergreen forest, forest on limestone, secondary and highly degraded habitats, and bamboo thickets. It seems to be more common below 600 m.
Threats	In Viet Nam and Cambodia the species is threated by exploitation for medicinal purposes. Levels of exploitation in Lao PDR are significantly lower so far, but escalation may occur. Habitat loss, due to agriculture (woody plantations, annual crops and so forth), and human settlement, may be resulting in localized declines.
Summary	This loris plausibly remains widespread and common in the Project area, but this is equally true of much of Lao PDR. **The Project area is only a small proportion of the nation's total such habitat and as such would not be expected to constitute critical habitat.**
References	Streicher, U., Ngoc Thanh,V., Nadler,T., Timmins, R.J. & Nekaris, A. 2008a. Nycticebus pygmaeus. In: IUCN 2013. IUCN Red List of Threatened Species. Version 2013.1. <www.iucnredlist.org>. Downloaded on 07 November 2013. Duckworth, J.W., Satler, R.E. and Khounboline, K. 1999. Wildlife in Lao PDR 1999 Status Report. Vientiane: IUCN The World Conservation Union/Wildlife Conservation Society/Centre for Protected Areas and Watershed Management.

Species	*Panthera pardus*, **Leopard**
Candidate Criteria	Criterion 1 – The species has an elevated protection status nationally and is listed as Restricted in the Regulation of the Ministry of Agriculture and Forestry No. 0360/MAF.
Record	*Direct* TISTR 2013 biodiversity survey did not directly record the species.
	Indirect The Huay Ngua MP (2010) notes presence of the species within the protected area. Biodiversity village interviews in 2013 apparently recognised the species has been seen in the upper Nam Ngiep area. The Project EIA (2007) does not note the species. Note: Verbal village information on cats is close to impossible to assign to species despite the often overconfident presentation in interview reports. These reports are thus no more than weakly indicative of Leopard presence in the Project area.
Distribution	The species also occurs across most of sub-Saharan Africa, as remnant populations in north Africa, and in the Arabian peninsula and Sinai/Judean Desert (Egypt/Israel/Jordan), south-western and eastern Turkey and through southwest Asia and the Caucasus into the Himalayan foothills, India, China and the Russian Far East as well as Java and Sri Lanka. The species distribution includes Lao PDR. In the 1990s there were rather few confirmed records during extensive surveys (Duckworth et al. 1999) but methods were not very suitable for finding the species. There have been few records since (again in part reflecting the limited application of suitable methods). However, the extreme rarity with which big cat signs are now found in most of Lao PDR means that the species's distribution in the country is probably now highly fragmented.
Population	There is no reliable global population estimate, and population estimates for India and Africa are considered unreliable. Many populations west of southeast Asia are believed to be increasing, and there are high levels of human-leopard conflict. In Lao PDR the identification of the species by local reports and signs is challenging and many claims are over-confident (as proven almost whenever skins or other relicts are available to be examined). The species might still be widespread in the Bolikhamxay province though at very low density (IEWMP 2006).
Habitat	In south-east Asia, the species is found in all forest types, from tropical rainforest to the temperate deciduous and alpine coniferous (up to 5,200 m in the Himalaya), and also in dry scrub and grasslands.
Threats	The massive declines in Indochina have been driven at least almost entirely by hunting. Suitable habitat remains widespread in Lao PDR but mostly no longer supports the species, at least at potentially viable levels.
Summary	Given the large range of the species, certainty of records and secondary information from local village representatives it is **unlikely that the Project area and immediate surrounds supports greater than 10 per cent of the global population or habitat of significant importance.** The key threat to the species is hunting and although current information does not confirm critical habitat and there is uncertainty of the relevance of the village interview data, the precautionary approach should be considered and the threats to the species should be managed throughout the Project construction and operation and within any Biodiversity Offset Design.

Species	*Panthera pardus*, Leopard
References	Henschel, P., Hunter, L., Breitenmoser, U., Purchase, C., Khorozyan, I., Bauer, H., Marker, L., Sogbohossou, E. and Breitenmoser-Wursten, C. 2008. *Panthera pardus*. In: IUCN 2013. IUCN Red List of Threatened Species. Version 2013.2. www.iucnredlist.org Downloaded 3 November 2013 Duckworth, J.W., Salter, R.E. and Khounboline, K. 1999. Wildlife in Lao PDR 1999 Status Report. Vientiane: IUCN-The World Conservation Union/Wildlife Conservation Society/Centre for Protected Areas and Watershed Management.

Species	*Panthera tigris*, Tiger
Candidate Criteria	Criterion 1 – The species is listed as Endangered on the IUCN Red List. It also has an elevated protection status nationally and is listed as Restricted in the Regulation of the Ministry of Agriculture and Forestry No. 0360/MAF.
Record	*Direct* TISTR 2013 biodiversity survey did not directly record the species. *Indirect* Biodiversity village interviews in 2013 apparently recognised the species has been seen in the upper Nam Ngiep area and stakeholder village surveys in 2013 noted the species is less common in Ban Pou (upper Nam Ngiep area) and never seen in Ban Xomxuen, Ban Pakyong, Ban Kanyong, Ban Pakheuang and Ban Don. The Project EIA (2007) notes the species occurrence within and outside the Project area based on a secondary data source though no location is specified. Note: Verbal village information on cats is close to impossible to assign to species despite the often overconfident presentation in interview reports. These reports are thus no more than weakly indicative of Tiger presence in the Project area.
Distribution	There are thirteen range countries for the tiger including Bangladesh, Bhutan, Cambodia, China, India, Indonesia, Lao PDR, Malaysia, Myanmar, Nepal, Russia, Thailand and Viet Nam. Duckworth et al. (1999) presented confirmed or plausible records from many areas of Lao PDR in the 1990s, but very heavy hunting in the interim cautions against assuming that Tigers persist in these sites (mostly not subsequently surveyed). It is possible that only one population remains in Lao PDR, in Nam Et-Phou Louey NPA, and those other recent Tiger indications, where not based on misidentification, are wandering animals.
Population	Population size estimates in 42 protected source sites are 2154 individuals and estimates outside protected areas is poorly known. Global Tiger Recovery program estimates the population as 3948 across range countries. The Lao PDR population is likely to be a few dozen at most and possible already much smaller than that.
Habitat	The availability of sufficient prey base or large ungulates is a major habitat requirement for the species. It is estimated a tiger needs to kill 50 large prey animals per year. The species is generally solitary. Home range is dependent on prey availability but can be up to 10,000 ha.
Threats	Main threats to the species include illegal trade and habitat loss.
Summary	Given the large range of the species, certainty of records and secondary information from local village representatives it is **unlikely that the Project area and immediate surrounds supports greater than 10 per cent of the global population or habitat of significant importance.** The key threat to the species is hunting and although current information does not confirm critical habitat and there is uncertainty of the relevance of the village interview data, the precautionary approach should be considered and the threats to the species should be managed throughout the Project construction and operation and within any Biodiversity Offset Design.
References	Chundawat, R.R., Habib, B., Karanth, U., Kawanishi, K., Ahmad Khan, J., Lyman, T., Miquelle, D., Nyhus, P., Sunarto, S., Tilson, R. and Sonam Wang 2011. Panthera tigris. In IUCN 2013. IUCN Red List of Threatened Species Version 2013.1. www.iucnredlist.org. Downloaded 21 August 2013. Duckworth, J.W., Salter, R.E. and Khounboline, K. 1999. Wildlife in Lao PDR 1999 Status Report. Vientiane: IUCN-The World Conservation Union/Wildlife Conservation Society/Centre for Protected Areas and Watershed Management.

Species	*Pardofelis temminckii*, Asiatic golden cat
Candidate Criteria	Criterion 1 – The species has an elevated protection status nationally and is listed as Restricted in the Regulation of the Ministry of Agriculture and Forestry No. 0360/MAF.
Record	*Direct* TISTR 2013 biodiversity survey did not record the species. A shot individual was photographed in the lower Nam Ngiep in early 1999 that had reportedly been killed in a village near chickens, though specific location details are unavailable.
	Indirect The Huay Ngua MP (2010) notes presence of the species within the protected area. Biodiversity village interviews in 2013 apparently recognised the species in the upper Nam Ngiep area. Stakeholder village surveys in 2013 apparently recognised the species, reporting it is common at Ban Kanyong however never encountered at all other villages surveyed: Ban Pou, Ban Xomxuen, Ban Pakyong, Ban Pekheuang and Ban Don. The Project EIA (2007) notes the species occurrence outside the Project area based on a secondary data source though no location is specified. Note: Verbal village information on cats is close to impossible to assign to species despite the often overconfident presentation in interview reports. These reports are thus no more than weakly indicative of Asian golden cat presence in the Project area. However, the 1999 record from in/near the area, the species' known use of such habitats and its somewhat higher resilience to human activities than of the big cats all suggest it should be in the Project area, and may perhaps be widespread.
Distribution	The species occurs from the Himalayan foothills into China and south-east Asia, and is native to: Bangladesh; Bhutan; Cambodia; China; India; Indonesia (Sumatera); Lao PDR; Malaysia; Myanmar; Nepal; Thailand; Viet Nam.
Population	In 1990s surveys in Lao PDR Golden Cat was the second-most widely recorded cat species, with several records from outside the protected area system, suggesting a high population. However, recent camera-trapping in Nakai-Nam Theun NPA suggests that a decade of heavy snaring has now greatly depleted populations in the surveyed parts of that protected area. While Golden Cat evidently remained common in Nam Et-Phou Loeuy until at least few years ago, this exceptional area retained even Tigers. Nakai-Nam Theun NPA is likely to be a better predictor for the typical situation in Lao PDR, and it may be that numbers across Lao PR are typically now much lower than in the 1990s.
Habitat	The species is primarily found in forest habitats ranging from tropical and subtropical evergreen to mixed and dry deciduous forest; it is evidently very tolerant of degradation and perhaps, where not hunted, of fragmentation.
Threats	The species is threatened in Lao PDR by indiscriminate snaring and other forms of hunting, driven largely by illegal trade in the species' pelt and bones.
Summary	This cat plausibly persists, perhaps widely, in the Project area, but this is equally true of much of Lao PDR. **The Project area is only a small proportion of the nation's total such habitat and as such would not be expected to constitute critical habitat.**
References	Sanderson, J., Mukherjee, S. Wilting, A., Sunarto, S., Hearn, A., Ross, J. and Khan, J.A. 2008. *Pardofelis temminckii*. In: IUCN 2013. IUCN Red List of Threatened Species. Version 2013.2. www.iucnredlist.org Downloaded 3 November 2013 Duckworth, J.W., Salter, R.E. and Khounboline, K. 1999. Wildlife in Lao PDR 1999 Status Report. Vientiane: IUCN-The World Conservation Union/WCS/Centre for Protected Areas and Watershed Management.

Species	*Prionailurus bengalensis*, Leopard cat
Candidate Criteria	Included at request
Record	*Direct* TISTR 2013 biodiversity survey did not record the species.
	Indirect Biodiversity village interviews in 2013 apparently recognised the species has in the upper Nam Ngiep area. Stakeholder village surveys in 2013 apparently recognised the species, reporting it as very common at Ban Pakheuang and Ban Don, common at Ban Xomxuen and Ban Kanyong however never encountered at Ban Pou or Ban Pakyong. The Project EIA (2007) notes the species occurrence within and outside the Project area based on a secondary data source though no location is specified. Note: Verbal village information on cats is close to impossible to assign to species despite the often overconfident presentation in interview reports. These reports are thus no more than weakly indicative of Leopard Cat presence in the Project area. However, the species' wide distribution in Lao PDR, its known use of habitats similar to those in the Project area, and its high resilience to human activities all suggest it should be in the Project area, and is plausibly widespread and common.
Distribution	The species occurs from the India into northeast and south-east Asia.
Population	Generally distributed and common across its south-east Asian range, and typically the most commonly encountered small cat on recent surveys. Its current status in Lao PDR is unclear, but all indications are that it remains widespread and common.
Habitat	The species is found widely in forest habitats (ranging from tropical and subtropical evergreen to mixed and dry deciduous forest) and is highly tolerant of deforestation provided some dense low-level cover remains, being common, for example, in various plantations, and even persisting in peri urban Bangkok and Hanoi, far from any forest..
Threats	The species is apparently not threatened, at least in southeast Asia. In areas of very heavy hunting, such as much of Lao PDR, numbers are doubtless much reduced, but there is no evidence yet for significant extirpation.
Summary	Leopard cat plausibly remains widespread and perhaps locally common in the Project area; but this is equally true of much of Lao PDR. **The Project area is only a small proportion of the nation's total such habitat and as such would not be expected to constitute critical habitat.**
References	Sanderson, J., Mukherjee, S. Wilting, A., Sunarto, S., Hearn, A., Ross, J. and Khan, J.A. 2008. *Pardofelis temminckii*. In: IUCN 2013. IUCN Red List of Threatened Species. Version 2013.2. www.iucnredlist.org Downloaded 3 November 2013 Duckworth, J.W., Salter, R.E. and Khounboline, K. 1999. Wildlife in Lao PDR 1999 Status Report. Vientiane: IUCN-The World Conservation Union/Wildlife Conservation Society/Centre for Protected Areas and Watershed Management.

Species	*Prionailurus viverrinus*, Fishing cat
Candidate Criteria	Criterion 1 – The species is listed as Endangered on the IUCN Red List and is listed as Restricted in the Regulation of the Ministry of Agriculture and Forestry No. 0360/MAF.
Record	*Direct* TISTR 2013 biodiversity survey did not record the species. *Indirect* The Huay Ngua MP (2010) notes presence of the species within the provincial preserved area. Stakeholder village surveys in 2013 apparently recognised the species, reporting it is common in Ban Kanyong and Ban Don of Nam Xan while noted the species as less common Ban Pou and Ban Pakyong of Nam Ngiep River. The Project EIA (2007) notes the species occurrence within and outside the Project area based on a secondary data source though no location is specified. Note: Verbal village information on cats is close to impossible to assign to species despite the often overconfident presentation in interview reports. Fishing cat is so widely misidentified in South-east Asia (e.g. Duckworth *et al*. 2010) yet so universally reported in verbal village information that these reports should not be taken as even weakly indicative of Fishing cat presence in the Project area. In fact, there is no confirmation that the species occurs in Lao PDR at all. Most of the valid recent records from southeast Asia are from coastal areas, and while there are historical specimens from a few inland areas, there are too few inland records to make a habitat-based prediction of Fishing cat's likely status in the Project area.
Distribution	The species is native to Bangladesh, Bhutan, Cambodia, India, perhaps Indonesia, perhaps Lao PDR, Myanmar, Nepal, Sri Lanka, Thailand and Viet Nam. The species is primarily found in wetland habitats, which are increasingly being settled, degraded and converted; its occurrence may now be highly localised in southeast Asia, and is almost certainly so, away from the coast. The species has not been seen captive or in trade in Lao PDR suggesting that it is extremely rare or not likely to occur (pers comm. Will Duckworth 15/11/2013).
Population	Population estimates are not well understood. There are very few reports from Lao, all either certain or plausible errors. It is possible that the species is extinct or never occurred in Lao PDR; it is inconceivable that, if present, it is other than extremely rare. This is also true of Cambodia even though a sizeable number of captive animals have been reported in this latter country. In southeast Asia recent records are infrequent suggesting a decline in populations.
Habitat	Past statements on habitat use in SE Asia are confounded by incorporation of information from misidentified animals. Almost all recent SE Asian records are from the coast, although a few historical specimens prove inland occurrence. All such latter records seem to have been from the level lowlands, in areas with many standing waterbodies. The species is thought to feed mainly on fish but also small rodents, reptiles and amphibians. Home ranges reported in Nepal ranged between 400 and 1600 ha.
Threats	Main threats to the species include wetland destruction and degradation.
Summary	There is no reason to think that Fishing cat inhabits the Project area, but equally it cannot be excluded that it does so. However, the Project area's habitat is not distinct in any way from typical Lao hill-country, and **so there is no reason to conclude that the Project area could be considered critical habitat for the species.** This assessment remains particularly provisional given the uncertainty surrounding the species' distribution and habitat use in inland SE Asia.

Species	*Prionailurus viverrinus*, Fishing cat
References	Mukherjee, S., Sanderson, J., Duckworth, W., Melisch, R., Khan, J., Wilting, A., Sunarto, S. and Howard, J.G. 2010. *Prionailurus viverrinus*. In: IUCN 2013. IUCN Red List of Threatened Species. Version 2013.1. <www.iucnredlist.org>. Downloaded on 03 September 2013. Duckworth, J.W., Salter, R.E. and Khounboline, K. 1999. Wildlife in Lao PDR 1999 Status Report. Vientiane: IUCN-The World Conservation Union/Wildlife Conservation Society/Centre for Protected Areas and Watershed Management.

Species	*Pygathrix nemaeus*, Red shanked douc langur
Candidate Criteria	Criterion 1 – The species is listed as Endangered on the IUCN Red List
Record	*Direct* TISTR 2013 biodiversity survey did not record the species. Targeted primate survey was undertaken in November 2013 by Dr Phaivanh Phiapalath of the IUCN SSC/Primate Specialist Group which detected no douc langur.
	Indirect Stakeholder village surveys in 2013 identified that the villagers indicated to never encounter this species at any of the villages surveyed. The Project EIA (2007) notes the species occurrence outside the Project area based on a secondary data source though no location is specified.
Distribution	The species is native to Lao PDR and Viet Nam, and perhaps Cambodia. The IUCN mapped distribution does not include the Study area. Timmins and Duckworth (1999) and Coudrat et al. (2012) traced no records northwest of Nam Kading NPA (where the species is rare and localised) so it is quite plausible the Project area lies outside the species's range. There are a few verbal reported from Pho Khao Khoay NPA (west of the Project area) but these may reflect mistaken interpretation, e.g. from people who saw them elsewhere. However, the area between Nam Kading NPA and Phou Khao Khoay NPA (and even the latter protected area itself) remains poorly surveyed and the true status of the doucs in it is open to question.
Population	IUCN reports the population of the species in Lao is likely to be larger than in other areas. In Lao the largest and most important global population occurs in Nam Theun basin and surrounds which includes a number of protected areas and is to the south of the Project area.
Habitat	The species is found in primary and secondary evergreen and semi-evergreen broadleaf forest. It is mainly folivorous.
Threats	Main threats to the species include hunting for subsistence use and traditional medicine as well as, probably now only to a low extent, the pet trade.
Summary	The Project area is outside the range of the species and targeted primate survey in 2013 did not detect the species.
References	Ngoc Thanh, V., Lippold, L., Timmins, R.J., and Manh Ha, N. 2008. *Pygathrix nemaeus*. In: IUCN 2013. IUCN Red List of Threatened Species. Version 2013.1. <www.iucnredlist.org>. Downloaded on 03 September 2013.

Species	*Rusa unicolor*, Sambar
Candidate Criteria	Criterion 1 – The species has an elevated protection status nationally and is listed as Restricted in the Regulation of the Ministry of Agriculture and Forestry No. 0360/MAF.
Record	*Direct* TISTR 2013 biodiversity survey did not record the species.
	Indirect The Huay Ngua MP (2010) notes presence of the species within the protected area. Biodiversity village interviews in 2013 apparently recognised the species in the upper Nam Ngiep area. Stakeholder village surveys in 2013 apparently recognised the species reporting it as very common at Ban Pou, Ban Kanyong and Ban Pakheuang, common at Ban Pakyong and Ban Don, however less commonly encountered at Ban Xomxuen. Note: There is some uncertainty associated with these indirect data sources for the species, in particular with respect to the frequency of encounters. The Project EIA (2007) notes the species occurrence within and outside the Project area based on a secondary data source though no location is specified.
Distribution	The species occurs from India and Sri Lanka in the west, along the southern Himalayas and through south China to Taiwan. Further south it occurs in Bangladesh, throughout mainland south-east Asia and many of the main islands of the Greater Sundas (Timmins et al. 2008). Duckworth et al 1999 noted that the species occurred in numerous survey areas in north Lao, central and southern Lao. However with ongoing very heavy hunting since then in the country, many local extirpations may have occurred.
Population	In Lao PDR, Sambar was described as very common in 1940 and widespread at low numbers in the 1990s. Sites surveyed between 2004 and 2007 have shown major declines. The remaining Lao populations are centred around areas with extensive open, or at least broken, habitat amid forest (Timmins et al. 2008).
Habitat	Habitat is reported as wooded areas, more commonly in broken areas amid semi-evergreen forest but also open deciduous forest and unbroken evergreen forest.
Threats	There are major, ongoing, declines in Viet Nam, Lao PDR, Cambodia and Thailand which can plausibly only be driven by hunting, because suitable habitat for Sambar is abundant in these countries but is almost or actually bereft of the species (Timmins et al. 2008).
Summary	If the reports that Sambar is locally common in the Project area are accurate, the area may be important habitat on a national scale rather than a global scale. There are large remaining populations in some other countries. **As such the Project area is not considered to be critical habitat for the species** however measures should be employed to understand the importance of the population on a national level.
References	Timmins, R.J., Steinmetz, R., Sagar Baral, H., Samba Kumar, N., Duckworth, J.W., Anwarul Islam, Md., Giman, B., Hedges, S., Lynam, A.J., Fellowes, J., Chan, B.P.L. & Evans, T. 2008. Rusa unicolor. In: IUCN 2013. IUCN Red List of Threatened Species. Version 2013.1. <www.iucnredlist.org>. Downloaded on 07 November 2013. Duckworth, J.W., Salter, R.E. and Khounboline, K. 1999. Wildlife in Lao PDR 1999 Status Report. Vientiane: IUCN-The World Conservation Union/Wildlife Conservation Society/Centre for Protected Areas and Watershed Management.

Species	*Trachypithecus phayrei*, Phayre's leaf monkey
Candidate Criteria	Criterion 1 – The species is listed as Endangered on the IUCN Red List. Its treatment in the Regulation of the Ministry of Agriculture and Forestry No. 0360/MAF is ambiguous; it is not mentioned by English or scientific name, but is best seen as listed as Restricted, taking the entity translated as Silvered Langur to in fact refer to all grey langurs (=leaf monkeys).
Record	*Direct* TISTR 2013 biodiversity survey did not record the species. Targeted primate survey was undertaken in November 2013 by Dr Phaivanh Phiapalath of the IUCN SSC/Primate Specialist Group which reported one record (vocalisation) and three mineral licks were found within the area. A shot individual was photographs in the lower Nam Ngiep in early 1999 however specific location information is unavailable. *Indirect* Biodiversity village surveys in 2013 suggested the species in the main dam inundation area. Stakeholder village surveys in 2013 apparently recognised the species, reporting that it is very common in Ban Pou, common at Ban Xomxuen and Ban Kanyong however is never encountered at Ban Pakyong, Ban Pakheuang or Ban Don. The Project EIA (2007) notes the species occurrence within and outside the Project area based on a secondary data source though no location is specified. Note: Although interviews cannot reliably distinguish the various taxa of *Trachypithecus* inhabiting Lao PDR, on geographical grounds Indochinese Silvered Leaf Monkey *T. germaini* can be eliminated, and the Project area seems to support little if any habitat rugged enough for François's Leaf Monkey (sensu lato) *T. fancoisi*.
Distribution	The species is native to Bangladesh, China, India, Lao PDR, Myanmar, Thailand and Viet Nam (Bleisch et al., 2008b). In Lao PDR the species has been confirmed only in the northern parts (including the Project area), perhaps extending marginally into central Lao PDR. Viet Nam records are from less than five areas. In Thailand there are good populations in Nam Nao National Park and Phukhio Wildlife Sanctuary and Western Forest complex. In Lao PDR, Timmins et al. (2013) note the species to occur from the Mekong Valley up to at least 800m, with one record (at a mineral lick) at 1125m.
Population	Populations are generally small and isolated. China has reported healthy populations in a number of reserves though overall the species population is reported on serious decline globally. Timmins et al. (2013) noted recent Lao records only from ten survey areas (in some, merely objectively identified as grey leaf monkeys, but which on range can be assumed to be this species), with little evidence for large numbers in any survey area.
Habitat	The species inhabits primary and secondary evergreen and semi-evergreen forest, mixed moist deciduous forest as well as bamboo areas, light woodlands and near tea plantations. In Lao it seems to be particularly occurring in edge and degraded areas, which suggest high tolerance to habitat perturbation, but, because such areas are often on the margins of wilderness areas, elevated rick from hunting. It is a predominantly arboreal species that is folivorous. Home range extent not reported.

Species	*Trachypithecus phayrei*, Phayre's leaf monkey
Threats	The main threat to the species In Lao PDR is hunting, its effects may be exacerbated by the species' habitat use. Most of the areas within the species' geographic range large enough to have remotes cores with relatively lower hunting have such areas above 800m, and thus probably support few if any of this species. However, the numbers of records from outside the protected area system and fairly close to heavy human activity suggest higher resilience to hunting than shown by, for example, Red-shanked douc langur.
Summary	This species is probably among the mammal species for which the Project area provides a significant contribution to national conservation prospects. However, even at the national level it is implausible that the Project area supports close to 10 per cent of the population, given that it comprises far less than 10% of the species' presumed present area of occupancy in today's Lao PDR. **As such the Project area is not considered to be critical habitat for the species.** Key habitat areas for the species are reported by Dr Phaivanh Phiapalath at Phou Thin, Phouru Pha Noy, Phou Pha hua and Phou Sam Liem. These locations are outside the Project area though must be considered for indirect impact.
References	Bleisch, B., Brockelman, W., Timmins, R.J., Nadler, T., Thun, S., Das, J. and Yongcheng, L. 2008b. Trachypithecus phayrei. In IUCN 2013. IUCN Red List of Threatened Species. Version 2013.1. www.iucnredlist.org. Downloaded on 21 August 2013. Duckworth, J.W., Salter, R.E. and Khounboline, K. 1999. Wildlife in Lao PDR 1999 Status Report. Vientiane: IUCN-The World Conservation Union/Wildlife Conservation Society/Centre for Protected Areas and Watershed Management.

Species	*Ursus thibetanus*, Himalayan black bear
Candidate Criteria	Criterion 1 – The species has an elevated protection status nationally and is listed as Restricted in the Regulation of the Ministry of Agriculture and Forestry No. 0360/MAF.
Record	*Direct* TISTR 2013 biodiversity survey did not record the species.
	Indirect The Huay Ngua MP (2010) notes presence of the species within the protected area. Biodiversity village interviews in 2013 recognised bears apparently this species as been seen in the upper Nam Ngiep area. Stakeholder village surveys in 2013 apparently recognised the species, reporting it is common in Ban Kanyong and Ban Pakheuang however less common in Ban Pou, Ban Xomxuen and Ban Pakyong and never encountered at Ban Don. The Project EIA (2007) notes the species occurrence outside the Project area based on a secondary data source though no location is specified. Note: Verbal village information on bears is close to impossible to assign to species despite the often overconfident presentation in interview reports. These reports are thus no more than weakly indicative of Sun bear presence in the Project area. However, the species' wide distribution in Lao PDR, its known use of habitats similar to those in the Project area, and its level resilience to human activities all suggest it could well inhabit the Project area.
Distribution	The species is native to numerous countries (Afghanistan; Bangladesh; Bhutan; Cambodia; China; India; Iran, Islamic Republic of; Japan; Korea, Democratic People's Republic of; Korea, Republic of; Lao People's Democratic Republic; Myanmar; Nepal; Pakistan; Russian Federation; Taiwan, Province of China; Thailand; Viet Nam). The species occupies a narrow band from south-eastern Iran eastward through Afghanistan and Pakistan, across the foothills of the Himalayas, to Myanmar. It occupies all countries in mainland south-east Asia except Malaysia. Duckworth et al. (1999) traced few certain records from 1990s surveys which, however, used methods unsuitable to generate records confirmed to species level (as distinct from as unidentified bears). More recent information (suggested by a number of captive cubs_ suggests a surprising wide occurrence in Lao PDR's northern highlands, including outside the protected area system.
Population	No rigorous population estimates exist for this species in Lao PDR, but it can safely be assumed to be much reduced even if not yet very widely extirpated. . Estimates available include 8-1400 bears in Japan (though perhaps no longer valid), 5-6000 in Russia, 7-9000 in India, 1000 in Pakistan and 15-46000 in China, however here are concerns regarding the reliability of these estimates.
Habitat	The species occupies a variety of forested habitats in Lao PDR, including highly degraded landscapes.
Threats	The overriding threat to the species in Lao PDR is commercially driven hunting for skins, paws and gall bladders.
Summary	The Project area's habitat is not distinct in any way from typical Lao hill-country, and **so there is no reason to conclude that the Project area could be considered critical habitat for the species.**
References	Garshelis, D.L. & Steinmetz, R. (IUCN SSC Bear Specialist Group) 2008. Ursus thibetanus. In: IUCN 2013. IUCN Red List of Threatened Species. Version 2013.1. <www.iucnredlist.org>. Downloaded on 06 November 2013. Duckworth, J.W., Salter, R.E. and Khounboline, K. 1999. Wildlife in Lao PDR 1999 Status Report. Vientiane: IUCN-The World Conservation Union/WCS/Centre for Protected Areas and Watershed Management.

Species	*Aceros undulatus*, Wreathed hornbill
Candidate Criteria	Criterion 1 – The species has an elevated protection status nationally and is listed as Restricted in the Regulation of the Ministry of Agriculture and Forestry No. 0360/MAF.
Record	*Direct* TISTR 2013 biodiversity survey did not record the species.
	Indirect Biodiversity village survey indicated that hornbills apparently identified as this species, reporting it as less commonly encountered in the upper and lower Nam Xan only.
Distribution	The global extent of occurrence for the species is extremely large. Surveys in the 1990s recorded the species widely across Lao PDR, although only in small numbers in many areas Duckworth et al. (1999); there is recent information only from few areas, reflecting patchy survey but some local extirpations are likely to have occurred in the intervening period.
Population	The species is reported to be locally common in several areas across its range. The global population has not been quantified. In Lao PDR populations were already extremely low in some areas by the 1990s and based on general hunting patterns declines are assumed to have continued.
Habitat	The species is report to occur in evergreen forest from lowlands to at least 1300m. Range extends into deciduous forest to visit fruit trees
Threats	The primary threat to the species in Lao PDR is hunting; many large tracts of prime habitat support only small numbers, or none, because of this threat.
Summary	Wreathed hornbill plausibly still occurs in the Project area but probably only in low numbers. Its status is similar across large parts of Lao PDR. **The Project area is small in proportion to the nation's total suitable habitat and as such is most unlikely to constitute critical habitat.**
References	Birdlife International 2012. Aceros undulates. In: IUCN 2013. IUCN Red List of Threatened Species. Version 2013.2. www.iucnredlist.org. Downloaded 18 December 2013. Duckworth, J.W., Salter, R.E. and Khounboline, K. 1999. Wildlife in Lao PDR 1999 Status Report. Vientiane: IUCN-The World Conservation Union/Wildlife Conservation Society/Centre for Protected Areas and Watershed Management.

Species	*Buceros bircornis*, Great hornbill
Candidate Criteria	Criterion 1 – The species has an elevated protection status nationally and is listed as Restricted in the Regulation of the Ministry of Agriculture and Forestry No. 0360/MAF.
Record	*Direct* TISTR 2013 biodiversity survey did not record the species.
	Indirect The Huay Ngua MP (2010) notes presence of the species within the provincial preserved area. Biodiversity village survey apparently recognised the species, reporting it as less commonly encountered in the upper and lower Nam Xan only. Note: Verbal village information on hornbills is difficult to assign to species despite the often overconfident presentation in interview reports. These reports are thus no more than weakly indicative of Great Hornbill presence in the Project area. In most of Lao PDR Great Hornbill is much more declined than Wreathed Hornbill, and most village reports of 'great hornbills' and taken by the interviewers to mean Great Hornbill in fact probably refer to Wreathed Hornbill.
Distribution	The species has a wide distribution, occurring in China, India, Nepal, Bhutan, Bangladesh, Myanmar, Thailand, Lao PDR, Vietnam, Cambodia, Malaysia and Indonesia. Surveys in the 1990s recorded the species in a fair number in areas across Lao PDR, although almost invariably in small numbers (Duckworth et al. 1999); there is recent information only from few areas, reflecting patchy survey but some local extirpations are likely to have occurred in the intervening period.
Population	Although the species has a large range it occurs at low densities and is patchily distributed. In Lao PDR, the species was formerly common but now (although still widespread) is scarce. Based on population estimates in India, the species global population is estimated at 10,000 to 70,000 individuals. It is probably best placed in the band 20,000-49,999 individuals.
Habitat	This species frequents evergreen, semi-evergreen and mixed deciduous forests, ranging out into open deciduous areas to visit fruit trees and ascending slopes to at least 1,560 m. The species is perhaps most common in unlogged forest.
Threats	The primary threat to the species in Lao PDR is hunting; many large tracts of prime habitat support only small numbers, or none, because of this threat.
Summary	Great hornbill plausibly still occurs in the Project area but probably only in low numbers. Its status is similar across large parts of Lao PDR. **The Project area is small in proportion to the nation's total suitable habitat and as such is most unlikely to constitute critical habitat.**
References	BirdLife International. 2013. *Buceros bircornis*. In: IUCN 2013. IUCN Red List of Threatened Species. Version 2013.1. <www.iucnredlist.org>. Downloaded on 04 September 2013. Duckworth, J.W., Salter, R.E. and Khounboline, K. 1999. Wildlife in Lao PDR 1999 Status Report. Vientiane: IUCN-The World Conservation Union/Wildlife Conservation Society/Centre for Protected Areas and Watershed Management.

Species	*Cairina scutulata*, White winged duck
Candidate Criteria	Criterion 1 – The species is listed as Endangered on the IUCN Red List
Record	*Direct* TISTR 2013 biodiversity survey did not record the species. *Indirect* The Huay Ngua MP (2010) notes presence of the species within the provincial preserved area. Stakeholder village surveys in 2013 apparently recognised the species, reporting it as common in Ban Xomxuen and Ban Pakyong of the Nam Ngiep River though never seen in Ban Pou. In Nam Xan River villagers responded that the species is common in Ban Kanyong and Ban Don and very common in Ban Pakheuang. The Project EIA (2007) notes the species occurrence outside the Project area based on a secondary data source though no location is specified. Note: Verbal village information on ducks and other swimming birds is impossible reliably to assign to species despite the often overconfident presentation in interview reports. In particular, inept interview teams almost invariably record White-winged Duck almost anywhere in Lao PDR that villagers report ducks of any species. Given that the considerable specific search effort for White-winged Duck in the 1990s and to a lesser extent in the 2000s found only few areas to support the species, and that competently executed interview surveys very rarely find reports that conform in morphological and behavioural aspects with White-winged Duck, it is obvious that most purported White-winged Duck interview claims are in error. The same is assumed to hold here. However, the habitat is suitable for the species, and would surely have held it previously, and it cannot be excluded that small numbers remain.
Distribution	The species is native to Bangladesh, Cambodia, India, Indonesia, Lao PDR, Myanmar, Thailand and Viet Nam. Duckworth et al (1999) note 2 – 3 population centres for the species in Lao PDR. There are no recent (post-1950) records or convincing reports of the species in Lao PDR from north of the Nakai plateau, there are also no historical reports, but in the light of highly limited survey efforts, the species is assumed to have been overlooks in the many Mekong tributary systems upstream of the Nam Kading to at least the Nam Sang. Recent intensive activity in the Nam Theun catchment suggests that very small numbers may survive for some years in areas where conventional survey under practical levels of effort cannot guarantee to find then, even by sign. Therefore, the actual status (extirpated vs reduced to very small numbers) in north Lao PDR in and since the 1990s cannot be determined.
Population	Estimates of global population report 450 individuals in India, low hundreds in Myanmar, 100 in Cambodia and 150 in Indonesia. Precautionary estimates places the global population between 350 and 1500 individuals. Total numbers in Lao PDR are likely to be no more than a few dozen, and probably now are many fewer.
Habitat	The species occur in stagnant or slow-flowing wetlands (natural and artificial) within or adjacent to evergreen, deciduous or swamp forest. Individuals roost and nest in the tree hollows. The species is secretive and forages at night on seeds, aquatic plants, grain, rise, small fish and invertebrates. Duckworth et al (1999) note records from slower moving stretches of forested streams and rivers, and pools in forests, up to 600 m.
Threats	The primary threat to the species in Lao PDR is hunting, apparently mainly for local use; many large tracts of prime habitat support only small numbers, or none, because of this threat. The threat from hunting is exacerbated by the

Species	*Cairina scutulata*, White winged duck
	species' habitat use: riverine and riparian forest habitats, and are among those most heavily used and degraded by human activity. Thus, although there seems to be no trade demand for the species in Lao PDR, incidental/opportunistic hunting occurs throughout its Lao PDR range at levels sufficient for widespread local extirpation.
Summary	White winged duck might possibly still occur in the Project area but at best only in very low numbers. Despite major loss of habitat in the last half century, tracts similar in extent and condition to the Project area remain in many parts of Lao PDR. The Project area is only a small proportion of the national's total suitable habitat and as such it is **unlikely to constitute critical habitat.**
References	BirdLife International. 2012c. *Cairina scutulata*. In: IUCN 2013. IUCN Red List of Threatened Species. Version 2013.1. <www.iucnredlist.org>. Downloaded on 04 September 2013. Duckworth, J.W., Salter, R.E. and Khounboline, K. 1999. Wildlife in Lao PDR 1999 Status Report. Vientiane: IUCN-The World Conservation Union/Wildlife Conservation Society/Centre for Protected Areas and Watershed Management.

Species	*Centropus sinensis*, Greater coucal
Candidate Criteria	Criterion 1 – The species has an elevated protection status nationally and is listed as Restricted in the Regulation of the Ministry of Agriculture and Forestry No. 0360/MAF.
Record	*Direct* TISTR 2013 biodiversity survey recorded the species in Huay Ngua PPA the upper and lower Nam Ngiep, resettlement site, and upper and lower Nam Xan.
	Indirect The Huay Ngua MP (2010) notes presence of the species within the provincial preserved area. The Project EIA (2007) notes the species occurrence within and outside the Project area based on a secondary data source though no location is specified.
Distribution	This species has an extremely large distribution and is native to: Bangladesh, Bhutan, Brunei Darussalam, Cambodia, China, India, Indonesia, Lao PDR, Malaysia, Myanmar, Nepal, Pakistan, Philippines, Singapore, Sri Lanka, Thailand, and Viet Nam.
Population	The global population size has not been quantified, but the species is reported to be common almost everywhere throughout its range. National population sizes have been estimated at c.100-10,000 breeding pairs and c.50-1,000 individuals on migration in China; and c.100-10,000 breeding pairs in Taiwan. It is widespread and generally abundant, including in areas with very heavy human use and bird hunting pressure, across Lao PDR.
Habitat	Habitat is noted to be forest edge, scrub, tall secondary growth and grassland including ponds and villages.
Threats	There are no threats to Greater coucal populations in Lao PDR. Although it is often hunted, it seems resilient to current levels, and while populations may by below carrying capacity in heavily settled areas, there has been no significant contraction of range. The species has doubtless benefitted hugely from the major conversion and degradation of Lao PDR's forests over the last century.
Summary	Greater coucal is probably abundant over the deforested and degraded parts of the Project area. **This is so across Lao PDR however the Project area constitutes an insignificant proportion of the nation's total suitable habitat and as such does not constitute critical habitat.**
References	BirdLife International. 2012. *Centropus sinensis*. In: IUCN 2013. IUCN Red List of Threatened Species. Version 2013.1. <www.iucnredlist.org>. Downloaded on 04 September 2013. Duckworth, J.W., Salter, R.E. and Khounboline, K. 1999. Wildlife in Lao PDR 1999 Status Report. Vientiane: IUCN-The World Conservation Union/Wildlife Conservation Society/Centre for Protected Areas and Watershed Management.

Species	*Gyps bengalensis*, White backed vulture
Candidate Criteria	Criterion 1 – The species is listed as Critically Endangered on the IUCN Red List Criterion 3 – The species may be considered congregatory
Record	*Direct* TISTR 2013 biodiversity survey did not record the species.
	Indirect The Project EIA (2007) notes the species occurrence outside the Project area based on a secondary data source though no location is specified. Note: Despite their distinctive physical appearance and habits, and unique Lao name, vultures are surprisingly widely reported by incompetent interviews across parts of Lao PDR from where they have been extirpated for many decades. Extensive field observation and careful interview shows that resident vultures are extirpated from all but the southernmost two provinces of Lao PDR. Himalayan griffon *G. himalayensis* and Cinereous vulture *Aegypius monachus* are erratic vagrants from the north which presumably could occur anywhere in Lao PDR, although so far there have been no record of either.
Distribution	The species is native to Afghanistan, Bhutan, Cambodia, India, Iran, Lao PDR, Myanmar, Nepal, Pakistan, Thailand and Viet Nam (BirdLife International 2012a). In Lao PDR Duckworth et al 1999 note that historically the species was widespread and common however recent records come only from Champasak and Attapu provinces. There have been no records or credible reports since 1999 from any other province in Lao PDR.
Population	The global population of the species is estimated between 2500 and 9999 mature individuals which equates to between 3,500-15,000 individuals. Viable populations in South-east Asia are known in Myanmar and Cambodia. The IUCN mapped distribution identifies the species is 'possibly extinct' in Lao PDR and much of Thailand and Cambodia.
Habitat	The species occurs mainly in plains and less commonly in hilly regions. It is known to utilise light woodland, villages, cities and open areas. The species is thought to forage over a vast range, primarily on carrion. Vultures play a role in the wider landscape as providers of ecosystems services, relied upon to dispose of animal and human remains in India. The species is reported to form considerable aggregations when feeding, and use communal roosting sites, breeding in colonies and as such may be considered a congregatory species.
Threats	Major decline in the south Asian population has been attributed to veterinary drugs used to treat domestic livestock poisoning individuals. However, the southeast Asian population has declined hugely before the introduction of these drugs, apparently through declines in food supply: hunting driven collapse of wild large mammal populations and changes in livestock carcase disposal practices. Remaining use of Lao PDR by this species may depend entirely on ranging from Cambodia, where birds are maintained by specific feeding ('vulture restaurants').
Summary	Given the ease of finding this species when present and the high levels of survey in the general region of Lao PDR within which lies the Project area, there is no chance that the interview reports collected in fact refer to a resident population of this or any other vulture. **This the Project area does not constitute critical habitat**
References	Birdlife International 2013. *Gyps bengalensis*. In: IUCN 2013. IUCN Red List of Threatened Species. Version 2013.2. www.iucnredlist.org. Downloaded 18 December 2013. Duckworth, J.W., Salter, R.E. and Khounboline, K. 1999. Wildlife in Lao PDR 1999 Status Report. Vientiane: IUCN-The World Conservation Union/Wildlife Conservation Society/Centre for Protected Areas and Watershed Management.

Species	*Lophura diardi*, Siamese fireback
Candidate Criteria	Criterion 1 – The species has an elevated protection status nationally and is listed as Restricted in the Regulation of the Ministry of Agriculture and Forestry No. 0360/MAF.
Record	*Direct* TISTR 2013 biodiversity survey did not record the species. *Indirect* The Huay Ngua MP (2010) notes presence of the species within the protected area. Biodiversity village surveys in 2013 apparently recognised the species, reporting it is less common in upper and lower Nam Xan however did not recognise its presence in Nam Ngiep and Huay Ngua visited areas. Stakeholder village surveys in 2013 recognised the species as very common in Ban Pou and Ban Xomxuen of the Nam Ngiep River though common in Ban Pakyong. In Nam Xan River villagers responded that the species is very common in Ban Kanyong, Ban Pakheuang and Ban Don. The Project EIA (2007) notes the species occurrence within and outside the Project area based on a secondary data source though no location is specified. Note: Verbal village information on pheasants in Lao PDR is difficult to assign to species despite the often overconfident presentation in interview reports. These reports are thus no more than weakly indicative of Siamese fireback presence in the Project area. However, the area contains suitable habitat in its lower-lying parts, and the species is extremely resilient to hunting and forest degradation (it may even benefit from some level of the latter). Thus, it is highly likely that Siamese fireback inhabits the area.
Distribution	The species occurs in Thailand, Lao PDR, Cambodia and Vietnam. 1990s surveys recorded the species widely across lower-lying parts of Lao PDR.
Population	The species is locally common in much of its range. The total population is suspected to number 20,000-49,999 individuals based on a conservative estimate of c.2,000 individuals in Cambodia and an estimate of c.5,000 individuals in Thailand; the Lao PDR population is likely to dwarf both of these.
Habitat	The species occurs in evergreen, semi-evergreen and bamboo forest, secondary growth and scrub, often near roads and tracks through the forest, chiefly in the plains and foothills to 500 m, but occasionally much higher.
Threats	This species is declining in Lao PDR in proportion to wholesale conversion of lowland and lower-hill forest to plantations and other uses. However, very large areas of suitable habitat persist, and there are a sufficient number of records in the last decade to be sure that the species is not threatened in Lao PDR. Despite earlier concerns, it is now clear the species is highly resilient to hunting, perhaps including large-scale snaring, although this largely takes place in forests above it main altitudinal range.
Summary	Siamese fireback is very likely to occur, perhaps widely, in the Project area. Nonetheless, the **Project area constitutes an insignificant proportion of suitable habitat across Lao PDR, so does not constitute critical habitat**.
References	BirdLife International. 2013. *Lophura diardi*. In: IUCN 2013. IUCN Red List of Threatened Species. Version 2013.1. <www.iucnredlist.org>. Downloaded on 04 September 2013. Duckworth, J.W., Salter, R.E. and Khounboline, K. 1999. Wildlife in Lao PDR 1999 Status Report. Vientiane: IUCN-The World Conservation Union/WCS/Centre for Protected Areas and Watershed Management.

Species	*Lophura nycthemera*, Silver pheasant
Candidate Criteria	Criterion 1 – The species has an elevated protection status nationally and is listed as Restricted in the Regulation of the Ministry of Agriculture and Forestry No. 0360/MAF.
Record	*Direct* TISTR 2013 biodiversity survey did not record the species.
	Indirect The Huay Ngua MP (2010) notes presence of the species within the protected area. Biodiversity village surveys in 2013 apparently recognised the species, reporting it is less common in upper and lower Nam Xan however did not recognise its presence in Nam Ngiep and Huay Ngua visited areas. The Project EIA (2007) notes the species occurrence within and outside the Project area based on a secondary data source though no location is specified. Note: Verbal village information on pheasants in Lao PDR is difficult to assign to species despite the often overconfident presentation in interview reports. These reports are thus no more than weakly indicative of Silver pheasant presence in the Project area. However, the area contains suitable habitat in its higher-lying parts, and the species is extremely resilient to hunting and forest degradation in Lao PDR. Thus, it is highly likely that Silver pheasant inhabits the area.
Distribution	The species occurs broadly across south-east Asia. The species is native to Thailand, Myanmar, Lao PDR, Vietnam, Cambodia and southern China.
Population	The global population size of the Silver Pheasant has not been quantified, but the species is reported to be widespread and seemingly common in suitable habitat. The population size in China has been estimated at c.10,000-100,000 breeding pairs (BirdLife International 2013). Lao PDR supports large populations as the species is widespread and locally common.
Habitat	Occurs in hill and montane forest (mainly evergreen) and tall secondary growth. Generally found between 500m and 2020m although occasionally down to 200m.
Threats	Silver pheasant is declining in Lao in proportion to wholesale conversion of occupied hill forest to plantations and other uses. However, very large areas of suitable habitat persist, and there are a sufficient number of records in the last decade to be sure that the species is not threatened in Lao PDR. Despite earlier concerns, it is now clear the species is highly resilient to hunting, perhaps including large-scale snaring (most of which occurs in this species' main altitudinal range), although this is so far not well assessed.
Summary	Silver Pheasant is very likely to occur, perhaps widely and commonly, in the Project area. Nonetheless, the Project area constitutes an insignificant proportion of suitable habitat across Lao PDR, so does **not constitute critical habitat**. This remains so even if one treats the various morphologically distinctive races as separate conservation units.
References	BirdLife International. 2013. *Lophura nycthemera*. In: IUCN 2013. IUCN Red List of Threatened Species. Version 2013.1. <www.iucnredlist.org>. Downloaded on 04 September 2013. Duckworth, J.W., Salter, R.E. and Khounboline, K. 1999. Wildlife in Lao PDR 1999 Status Report. Vientiane: IUCN-The World Conservation Union/Wildlife Conservation Society/Centre for Protected Areas and Watershed Management.

Species	*Pavo muticus*, Green peafowl
Candidate Criteria	Criterion 1 – The species is listed as Endangered on the IUCN Red List
Record	*Direct* TISTR 2013 biodiversity survey did not record the species.
	Indirect The Huay Ngua MP (2010) notes presence of the species within the provincial preserved area. Note: Verbal village information on pheasants in Lao PDR is difficult to assign to species despite the often overconfident presentation in interview reports. This is so even for the morphologically distinctive Green peafowl, which is often confused/amalgamated with Crested argus (*Rheinardia ocellata*) but also often is 'reported' from outside the plausible present-day range of either. In the context of huge range contraction of Green peafowl in Lao PDR in the last 60 years and the great rarity of surviving remnant populations outside of Savannakhet, these interview reports are most sensible taken as in error.
Distribution	The IUCN mapped distribution across the Project area is mapped as 'possibly extinct'. Birdlife International recognises almost 2,500 ha on the south-western periphery of PKK as an Important Bird Area (IBA) where individuals have been heard at a roosting site in 1994, 1995 and 2002, and were credibly reported as still present in 2009. All other remnant populations of Green peafowl confirmed in Lao PDR since 1990 are al far to the south of the Project area.
Population	The estimates of global population size are 15,000-30,000 individuals. Birdlife International (2003) notes while the population is of moderate to high national significance, it is of low global significance given the larger populations in parts of Cambodia. Duckworth et al 1999 report five areas that are likely to retain populations large enough to be viable in Lao PDR, including PKK.
Habitat	The species has been reported to occupy a variety of habitats including primary and secondary, tropical and subtropical, evergreen and deciduous forest types, mixed coniferous forest, swamp forest, open woodland, forest edge, bamboo, grasslands, savannah, scrub and farmland edge.
Threats	The main threat to the species in Lao PDR is hunting, including egg collection. Habitat modification and fragmentation may locally compound the problem. These threats have led to widespread extirpation across Lao PDR and adjacent countries.
Summary	Assuming that the interview reports are in error, there is **no reason to consider that the Project area constitutes critical habitat**. However, the rather anomalous survival of the small population around Ban Nakhaty, Phou Khao Khoay NPA, emphasises the possibility that other remnants may also survive, and it cannot be excluded that the Project area might support one. Such a population could be significant at the national level.
References	BirdLife International. 2012. *Pavo muticus*. In: IUCN 2013. IUCN Red List of Threatened Species. Version 2013.1. <www.iucnredlist.org>. Downloaded on 12 September 2013 Duckworth, J.W., Salter, R.E. and Khounboline, K. 1999. Wildlife in Lao PDR 1999 Status Report. Vientiane: IUCN-The World Conservation Union/Wildlife Conservation Society/Centre for Protected Areas and Watershed Management.

Species	*Polyplectron bicalcaratum*, Grey peacock-pheasant
Candidate Criteria	Criterion 1 – The species has an elevated protection status nationally and is listed as Restricted in the Regulation of the Ministry of Agriculture and Forestry No. 0360/MAF.
Record	*Direct* TISTR 2013 biodiversity survey did not record the species.
	Indirect The Huay Ngua MP (2010) notes presence of the species within the provincial preserved area. Biodiversity village surveys in 2013 apparently recognised the species, reporting it is less common in upper and lower Nam Xan however did not recognise its presence in Nam Ngiep and Huay Ngua visited areas. Note: Verbal village information on pheasants in Lao PDR is difficult to assign to species despite the often overconfident presentation in interview reports. These reports are thus no more than weakly indicative of Grey peacock-pheasant presence in the Project area. However, the area contains extensive suitable habitat, and the species is extremely resilient to hunting and forest degradation. Thus, it is highly likely that Grey peacock-pheasant inhabits the area, and it is quite probably common.
Distribution	The species is native to Bangladesh, Bhutan, Cambodia, China, India, Lao PDR, Myanmar, Thailand and Viet Nam.
Population	The population size has not been quantified however it is not believed to be <10,000 mature individuals. The species is reported to be locally common to fairly common and rare. The population is suspected to be declining owing to habitat loss and degradation and, locally, overexploitation. It remains widespread and common almost across the Lao PDR.
Habitat	Occurs in evergreen forest from lowlands to 1850 m. The species is reported to be tolerant to degradation of forest.
Threats	As with other evergreen forest pheasants in Lao PDR, although hunting is very high within this species' habitats, it seems highly resilient to offtake. There are thus no serious threats to the species in Lao PDR presently, although its population is presumably declining in proportion to the conversion of forest to plantations and other non-forest habitats.
Summary	Grey Peacock Pheasant is very likely to occur, perhaps widely and commonly, in the Project area. Nonetheless, the Project area constitutes an insignificant proportion of suitable habitat across Lao PDR, so **does not constitute critical habitat**.
References	BirdLife International. 2012. *Polyplectron bicalcaratum*. In: IUCN 2013. IUCN Red List of Threatened Species. Version 2013.1. <www.iucnredlist.org>. Downloaded on 04 September 2013. Duckworth, J.W., Salter, R.E. and Khounboline, K. 1999. Wildlife in Lao PDR 1999 Status Report. Vientiane: IUCN-The World Conservation Union/Wildlife Conservation Society/Centre for Protected Areas and Watershed Management.

Species	*Psittacula alexandri*, **Red-breasted parakeet**
Candidate Criteria	Criterion 1 – The species has an elevated protection status nationally and is listed as Restricted in the Regulation of the Ministry of Agriculture and Forestry No. 0360/MAF.
Record	*Direct* TISTR 2013 biodiversity survey recorded the species in Huay Ngua PPA. The survey did not detect the species the Nam Ngiep, Nam Xan or resettlement site areas.
	Indirect Biodiversity village surveys in 2013 apparently recognised the species, reporting it is common in Huay Ngua. The Project EIA (2007) notes the species occurrence within and outside the Project area based on a secondary data source though no location is specified. Note: Verbal village information on parakeets in Lao PDR is difficult to assign to species despite the often overconfident presentation in interview reports. These reports are thus no more than weakly indicative of Red-breasted parakeet presence in the Project area. However, the area contains some suitable habitat and there are recent records from relatively nearby (lower Nam Kading plain; Pakxan wetlands) so it is quite plausible that Red-breasted parakeet inhabits the area, although, given general recent trends in its population in Lao PDR, it is unlikely to be common.
Distribution	The species has a broad distribution and is native to Bangladesh; Bhutan; Cambodia; China; India; Indonesia; Lao PDR; Myanmar; Nepal; Thailand; and Viet Nam.
Population	The global population size has not been quantified; however the species is reported to be generally common. The species has been heavily traded, and 125,695 wild-caught individuals have been recorded in international trade since 1981. In Lao, Duckworth et al 1999 report flocks exceeding 1000 to occur (recorded in southern Lao PDR) but in most areas rarely number more than 20-30. The species has particularly declined in the northern half of the country, and has been widely extirpated.
Habitat	In Lao the species occurs in deciduous forests and adjacent secondary growth, mostly below 400m.
Threats	Four species of parakeets occur in Lao PDR the populations of all of them have probably declined hugely although this is based on status documented in neighbouring countries (where flocks are typically much larger than in Lao PDR, especially in Cambodia, China and, locally, in Vietnam) rather than on direct evidence of decline: historical Lao information is insufficiently precise. Declines have been particularly severe in the northern half of the country, where suitable habitat is naturally more fragmented and in smaller patches. The decline is assumed to have been driven by the cagebird trade, because there is no evidence of other trade in significant volumes, and ample suitable habitat remains widespread but supporting only very small numbers.
Summary	Accepting the likelihood of this species' occurrence in the Project area, it is however **unlikely, that in the context of the much larger numbers remaining in parts of Central and South Lao PDR, that the Project area could comprise critical habitat.**
References	BirdLife International. 2012. *Psittacula alexandri*. In: IUCN 2013. IUCN Red List of Threatened Species. Version 2013.1. <www.iucnredlist.org>. Downloaded on 04 September 2013. Duckworth, J.W., Salter, R.E. and Khounboline, K. 1999. Wildlife in Lao PDR 1999 Status Report. Vientiane: IUCN-The World Conservation Union/Wildlife Conservation Society/Centre for Protected Areas and Watershed Management.

Species	*Anhinga melanogaster*, Darter
Candidate Criteria	Criterion 1 – The species has an elevated protection status nationally and is listed as Restricted in the Regulation of the Ministry of Agriculture and Forestry No. 0360/MAF.
Record	*Direct* TISTR 2013 biodiversity survey recorded the species in the upper Nam Xan: at least two birds.
	Indirect Verbal village information on large waterbirds in Lao PDR is difficult to assign to species despite the often overconfident presentation in interview reports. These are particular problems with Darter in that name assigned to it (on what basis is apparently undocumented), *nok kho ngou* (snake-necked bird) is widely assigned by rural lowland Lao to Purple Heron *Ardea purpurea*.
Distribution	The species occur widely in South and South-east Asia. In Lao it was historically widespread and common, but suffered a massive decline during the latter 20th century, so that during the 1990s it was recorded in few survey areas, and only in small numbers. Effective protection of major breeding colonies in Cambodia has resulted in a rapidly rising number of visitors to Lao PDR usually in the late dry season and wet season; however, some birds can apparently now be seen all year. There seems to be no evidence of re-establishment of breeding in Lao PDR, but this may not be far away (if indeed it has not already happened, undocumented).
Population	In Lao PDR and surrounding countries, numbers are low except for Cambodia, which supports large breeding numbers. These disperse widely during non-breeding season. Numbers now using Lao PDR are unclear; in the 1990s there were probably no more than a few dozen per year, but now there are likely to be in the hundreds or perhaps even the low thousands.
Habitat	In Lao PDR a wide variety of waterbodies, from forest streams to large ope reservoirs, is used. This is typical of the species elsewhere in its range. The species is probably independent of forests.
Threats	Overharvest evidently drove the major declines in mainland SE Asia and when the large numbers breeding around the Great Lake of Tonle Sap were given effective protection in the early 2000s, the decline rapidly reversed. Pot-hotting of visitors to Lao PDR is likely to be widespread, but presently an insignificant proportion of the Cambodian population visits the country. Breeding re-establishment in Lao PDR may well be severely restrained by this factor: almost all waterbodies and –course used by the species are navigable.
Summary	Darters in Lao PDR's forest rivers are presently widely scattered in small numbers. The Project area would support only a small proportion of the number visiting Lao PDR presently, which are moreover, mobile (much suitable habitat remains unoccupied); and in any case the reservoir might actually improve Darter habitat in the Project area. **Thus, the Project area does not comprise critical habitat.**
References	Duckworth, J.W., Salter, R.E. and Khounboline, K. 1999. Wildlife in Lao PDR 1999 Status Report. Vientiane: IUCN-The World Conservation Union/Wildlife Conservation Society/Centre for Protected Areas and Watershed Management.

Species	*Ichthyophaga humilis*, **Lesser Fish Eagle**
Candidate Criteria	Criterion 1 – The species has an elevated protection status nationally and is listed as Restricted in the Regulation of the Ministry of Agriculture and Forestry No. 0360/MAF.
Record	*Direct* None: but the species is easily overlooked unless specifically searched for.
	Indirect None: but the species cannot be detected by village reports. The Project area holds some potentially suitable habitat (see below), but it is probably fairly localised in the Project area, if it occurs at all.
Distribution	Widespread in tropical Asia. In Lao PDR, formerly widespread but now reduced to a few centres of population; still occurs from the far north (Nam Ou) to the far south.
Population	Now much reduced in Lao PDR to a few centres of population, each probably with only about a dozen pairs at maximum.
Habitat	Rivers with good fringing forest. Photographs of the Nam Gniang look similar to some of the other streams inhabited by the species in Lao PDR, other streams of similar width, flow an flanking habitat seem to lack the species (e.g. the Nam Kading). Although in some areas this doubles because of persecution, this explanation is implausible for the Nam Kading within Nam Kading NPA. Without clearer understanding of the species' habitat use in Lao PDR it is not possible to predict the suitability of the Project area for the species.
Threats	Loss of riverine forest and persecution; the relative importance of the two is unclear. All remaining populations in Lao PDR are in relatively remote areas (really remote areas lack streams of sufficient width) in landscapes retaining a high proportion of forest.
Summary	With no information on the status in the Project area no firm decision can be made. Numbers, if any, in the Project area are probably too few for the area to constitute critical habitat; but if there are surprisingly large numbers there, then it possible would be critical habitat.
References	Duckworth, J.W., Salter, R.E. and Khounboline, K. 1999. Wildlife in Lao PDR 1999 Status Report. Vientiane: IUCN-The World Conservation Union/Wildlife Conservation Society/Centre for Protected Areas and Watershed Management.

Species	Other possible species: *Aceros nipalensis*, **Rufous-necked hornbill** *Rheinardia ocellata*, **Crested argus** *Bubo nipalensis*, **Spot-bellied eagle owl** *Picus rabieri*, **Red-collared woodpecker** *Upupa epops*, **Hoopoe**
Candidate Criteria	Criterion 1 – These species have an elevated protection status nationally and are listed as Restricted in the Regulation of the Ministry of Agriculture and Forestry No. 0360/MAF.
Record	*Direct* None
	Indirect Based on habitat and geographical location, these bird species surely (Hoopoe), may well (Red-collared woodpecker, Spot-bellied eagle owl) or might (Crested argus) occur in the Project area, or might have done so (Rufous-necked hornbill).
Distribution	Various. None is endemic to Lao PDR. In Lao PDR, Crested argus is naturally restricted to eastern parts, but the others are or (Rufous-necked hornbill) were widespread.
Population	Various. Rufous-necked hornbill is now localised and rare; the breeding Hoopoe population is now localised and scarce; the others remain common within suitable habitat.
Habitat	Various. Rufous-necked hornbill - occupies hill forest Red-collared woodpecker - occupies lowland forest Crested argus – occupies wet evergreen forest with marginal extension into adjacent areas. Suitable habitat for these three species is naturally restricted or possibly absent in the Project area. Spot-bellied eagle owl and hoopoe occupy a range of habitats.
Threats	Various. Hunting has severely reduced Lao PDR populations of Rufous-necked hornbill, the breeding Hoopoe population and, probably to some extent, Spot-bellied eagle owl. Crested argus may also have been locally affected, especially where suitable habitat is naturally or anthropogenically fragmented. Suitable habitat remains extensive for all species, although ongoing conversion of lowland forest to plantations is probably much reducing suitable habitat for Red-collared woodpecker. Migrant populations of Hoopoe are probably not threatened in Lao PDR, although many individuals are probably killed.
Summary	Although some, perhaps all of these species are likely to inhabit the Project area, it forms only an insignificant part of the habitat in Lao PDR for all of them and it is **implausible it could be critical habitat** for any of them.
References	Duckworth, J.W., Salter, R.E. and Khounboline, K. 1999. Wildlife in Lao PDR 1999 Status Report. Vientiane: IUCN-The World Conservation Union/Wildlife Conservation Society/Centre for Protected Areas and Watershed Management.

Species	*Broghammerus reticulatus*, Reticulated python
Candidate Criteria	Criterion 1 – The species has an elevated protection status nationally and is listed as Restricted in the Regulation of the Ministry of Agriculture and Forestry No. 0360/MAF.
Record	*Direct* TISTR 2013 biodiversity survey did not record the species.
	Indirect The Huay Ngua MP (2010) notes presence of the species within the protected area. Biodiversity village surveys in 2013 apparently recognised the species, reporting it is less common in upper and lower Nam Ngiep, resettlement site and upper and lower Nam Xan however did not recognise its presence in Huay Ngua. Stakeholder village surveys in 2013 recognised the species as very common in Ban Pou, Ban Xomxuen and Ban Pakyong of the Nam Ngiep River as well as Ban Pakheuang and Ban Don of the Nam Xan River. Ban Kanyong of the Nam Xan River noted the species as common.
Distribution	The species occurs in Indonesia, Timor-Leste, Bangladesh, Brunei Darussalam, Cambodia, India, Lao PDR, Malaysia, Myanmar, Philippines, Singapore, Thailand and Vietnam.
Population	The species is considered to be widespread in Lao PDR, and populations are considered to be of low global significance.
Habitat	Duckworth et al (1999) noted the species is expected to occur in most forest types though it is also documented to inhabit humid forests and is typically found in riparian areas (Raffles Museum of Biodiversity Research 2013). It also occurs in agricultural areas, scrubland, mangroves and urban areas (Raffles Museum of Biodiversity Research 2013).
Threats	It is threatened by commercial exploitations for the skin trade.
Summary	Given that the Lao PDR population is not considered to be of global significance and that is it widespread it is **unlikely that the Project area sustains greater than 10 per cent of the global population or is one of 10 discrete management sites globally for the species (C1 Tier 1).** The baseline information **does not provide an indication that the habitat is of significant importance, or that records are part of an important concentration (C1 Tier 2).**
References	Duckworth, J.W., Salter, R.E. and Khounboline, K. 1999. Wildlife in Lao PDR 1999 Status Report. Vientiane: IUCN-The World Conservation Union/Wildlife Conservation Society/Centre for Protected Areas and Watershed Management. Raffles Museum of Biodiversity Research. 2013. *Broghammerus reticulatus* (Schneider, 1801). In: The DNA of Singapore. < http://rmbr.nus.edu.sg/dna/> Downloaded on 08 November 2013. Uetz, P & Hallerman, J. 2013. *Broghammerus reticulatus* (Schneider, 1801). In: The Reptile Database. Zoological Museum Hamburg. < http://reptile-database.reptarium.cz/>. Downloaded on 08 November 2013.

Species	*Indotestudo elongate*, Elongate tortoise
Candidate Criteria	Criterion 1 – The species is listed as Endangered on the IUCN Red List Included at request
Record	*Direct* TISTR 2013 biodiversity survey did not record the species.
	Indirect -
Distribution	The species is found in Asia from Nepal to Malaysia.
Population	Limited population information available. Duckworth et al. reported in 1999 that the species is widespread in Lao PDR and that the population is of low global significance. In 2006 the IEWMP reported that the species is found widely in Lao PDR and although has not been recorded in Bolikhamxay Province should occur.
Habitat	A damp forest species although is also found in dry habitats. The species dietconsist of fruits, leafy greens, worms, slugs and carrion.
Threats	The species is commonly encountered in Asian food markets and the most common tortoise shipped to the Chinese food markets from Vietnam.
Summary	Given that the Lao PDR population is not considered to be of global significance and that is it widespread it is **unlikely that the Project area sustains greater than 10 per cent of the global population or is one of 10 discrete management sites globally for the species (C1 Tier 1).** The baseline information **does not provide an indication that the habitat is of significant importance, or that records are part of an important concentration (C1 Tier 2).**
References	Duckworth, J.W., Salter, R.E. and Khounboline, K. 1999. Wildlife in Lao PDR 1999 Status Report. Vientiane: IUCN-The World Conservation Union/Wildlife Conservation Society/Centre for Protected Areas and Watershed Management. Senneke, D. 2003. *Indotestudo elongaae* The Elongated Tortoise. World Chelodian Trust. http://www.chelonia.org/articles/elongatacare.htm Accessed 14 January 2014. IEWMP. 2006. Significant Wildlife and Wildlife Habitats of Bolikhamxay Province. Bolikhamxay Provincial Agriculture and Forestry Office and Wildlife Conservation Society. Vientiane Lao PDR.

Species	*Ophiophagus hannah*, King cobra
Candidate Criteria	Criteria 1 – The species is listed as Vulnerable on the IUCN Red List
Record	*Direct* TISTR 2013 biodiversity survey did not record the species.
	Indirect -
Distribution	Widely distributed in south and southeast Asia from Nepal and India, across southern China, southward to the Philippines and Indonesia east to Bali, as well as parts of Malaysia.
Population	The species is common in good habitat in Thailand however is not frequently encountered in other areas of the wide range. Duckworth et al. reported in 1999 that the species is widespread in Lao PDR and that the population is of low global significance. In 2006 the IEWMP reported that the species probably occurs throughout Bolikhamxay Province.
Habitat	Found in most forest types, including bamboo.
Threats	The species is sought for wildlife trade to Vietnam and China where it is believed to have medicinal value.
Summary	Given that the Lao PDR population is not considered to be of global significance and that its habitat is widespread it is **unlikely that the Project area sustains greater than 10 per cent of the global population or is one of 10 discrete management sites globally for the species (C1 Tier 1).** The baseline information **does not provide an indication that the habitat is of significant importance, or that records are part of an important concentration (C1 Tier 2).**
References	Duckworth, J.W., Salter, R.E. and Khounboline, K. 1999. Wildlife in Lao PDR 1999 Status Report. Vientiane: IUCN-The World Conservation Union/Wildlife Conservation Society/Centre for Protected Areas and Watershed Management. IEWMP. 2006. Significant Wildlife and Wildlife Habitats of Bolikhamxay Province. Bolikhamxay Provincial Agriculture and Forestry Office and Wildlife Conservation Society. Vientiane Lao PDR.

Species	*Platysternon megacephalum*, **Big-headed turtle**
Candidate Criteria	Criterion 1 – The species is listed as Endangered on the IUCN Red List
Record	*Direct* TISTR 2013 biodiversity survey did not record the species. *Indirect* The Huay Ngua MP (2010) notes presence of the species within the provincial preserved area. Biodiversity village surveys in 2013 apparently recognised the species, reporting it is less common in upper Nam Ngiep and upper Nam Xan.
Distribution	The species is native to China, Lao PDR, Myanmar, Thailand and Viet Nam. The species has been reported to occur in PKK to the west of the Project area as well as other records in Annamite mountains and southern Lao PDR in 1999 (Duckworth et al 1999).
Population	There is limited information regarding the size of the population of the species. In 1999 Duckworth et al. reported that Lao PDR populations are considered to be of moderate global significance with the species being widespread. In 2006 IEWMP reported the species probably occurs widely in the Bolikhamxay Province with known records from the Ban Nape area, Nam Nouang and NNT.
Habitat	The species inhabits fast flowing, cool, rocky mountain brooks and streams, usually narrower than 1 m and less than 10 cm deep. There are a number of low order streams that the Project area intersects. The species is thought to be nocturnal when it forages along the stream bottom and stream edge. It is a carnivorous species.
Threats	A key threat to the species will be improved access to the area for illegal wildlife collectors, either via the reservoir itself, or via project access roads
Summary	The key threat to the species is hunting and although current information does not confirm critical habitat, the precautionary approach should be considered and the threats to the species should be managed throughout the Project construction and operation and within any Biodiversity Offset Design.
References	Asian Turtle Trade Working Group. 2000. *Platysternon megacephalum*. In: IUCN 2012. IUCN Red List of Threatened Species. Version 2012.2. <www.iucnredlist.org>. Downloaded on 12 June 2013. Kirkpatrick, D.T. 1995. The Big-headed Turtle, *Platysternon megacephalum*. Originally published in Reptile and Amphibian Magazine, November/December 1995, pages 40-47. Duckworth, J.W., Salter, R.E. and Khounboline, K. 1999. Wildlife in Lao PDR 1999 Status Report. Vientiane: IUCN-The World Conservation Union/Wildlife Conservation Society/Centre for Protected Areas and Watershed Management. IEWMP. 2006. Significant Wildlife and Wildlife Habitats of Bolikhamxay Province. Bolikhamxay Provincial Agriculture and Forestry Office and Wildlife Conservation Society. Vientiane Lao PDR.

Species	*Catlocarpio siamensis*, Giant barb
Candidate Criteria	Criterion 1 – The species is listed as Endangered on the IUCN Red List Criterion 3 – The species is migratory
Record	*Direct* TISTR 2013 biodiversity survey did not record the species. Fast water habitat fish survey 2014 did not record the species. *Indirect* The Huay Ngua MP (2010) notes presence of the species within the provincial preserved area.
Distribution	The species is native to Cambodia, Lao PDR, Thailand and Viet Nam.
Population	The size of the population is reported to have declined rapidly since 1990. The species is very rare in Thai and Lao Mekong and associated tributaries.
Habitat	The species inhabits floodplain and main river habitats feeding on algae, phytoplankton, vegetation and small fish. Spawning areas are unknown and little is known about spawning behaviour. The Mekong River Commission notes juveniles are mainly seen in floodplain habitats and small tributaries, and that mature fish are only found in large streams. Large mature fish have not been observed in floodplain habitats and it is more likely the species spawns in certain habitats within the main river channel where juveniles can reach rearing habitats on the floodplain. The species is reported to undertake short-distance migrations however further research is needed on the migratory patterns of the species.
Threats	Main threats to the species include over-harvest and habitat fragmentation.
Summary	Specialist input identified that there is very little survey data from the Nam Ngiep catchment (pers. comm. Dr Maurice Kottelat 7/11/2013). The species is threatened throughout its range and any area where the species reproduces would be considered critical habitat (pers. comm. Dr Maurice Kottelat 7/11/2013). Species profile information suggests that the species spawning occurs in main or larger river channels and identifies the importance of floodplain areas. If the species is present downstream of the reservoir, the modification of the topography of its habitat and alteration of the flow pattern (especially disruption of daily and annual cycle) are expected to have an impact of the spawning sites and the reproduction of the species. Given the declining global population and the fragmentation of its distribution range, any spawning site would be a critical habitat. Environmental Flows Assessment identifies flow release regime to manage downstream flows for maintaining normal river functions to manage this threat to potential habitat.
References	Hogan, Z. 2011. *Catlocarpio siamensis*. In: IUCN 2013. IUCN Red List of Threatened Species. Version 2013.1. <www.iucnredlist.org>. Downloaded on 12 September 2013. MRC. 2005a. Key Mekong fish species – migration paths. *Catlocarpio siamensis*. http://ns1.mrcmekong.org/programmes/fisheries/mig_catlocarpio.htm. Accessed 20 November 2013.

Species	*Laubuca caeruleostigmata,* **Flying minnow**
Candidate Criteria	Criteria 1 – The species is listed as Endangered on the IUCN Red List
Record	*Direct* TISTR 2013 biodiversity survey recorded this species in surveyed of the upper Nam Ngiep and lower Nam Xan sites. *Indirect*
Distribution	The species has been recorded from Thailand in the Mae Khlong and Chao Phraya basins, and from the Mekong in Cambodia, Lao PDR and Thailand.
Population	There is limited information on the population size of the species. In Thailand 60% of populations extirpated in 10 years due to loss of habitat. It is likely that the species is rare in Lao PDR.
Habitat	Found in large rivers and flooded forest.
Threats	
Summary	Species profile information identifies the importance of flood areas and large river environments. If the species is present downstream of the reservoir, the alteration of the flow pattern (especially disruption of daily and annual cycle) may have an indirect impact. Environmental Flows Assessment identifies flow release regime to manage downstream flows for maintaining normal river functions.
References	Vidthayanon, C. 2011. *Laubuca caeruleostigmata*. In IUCN 2013. IUCN Red List of Threatened Species. Version 2013.2. www.iucnredlist.org Downloaded on 16 January 2014.

Species	*Pangasianodon hypophthalmus*, Striped catfish
Candidate Criteria	Criterion 1 – The species is listed as Endangered on the IUCN Red List Criterion 3 – The species is migratory
Record	*Direct* TISTR 2013 biodiversity survey did not record the species.
	Indirect The Huay Ngua MP (2010) notes presence of the species within the provincial preserved area.
Distribution	There is limited information regarding the size of the population of the species however the species remains common and popular aquaculture species. It is used in aquaculture.
Population	The species is native to Cambodia, Lao PDR, Thailand and Viet Nam.
Habitat	It inhabits main channels and floodplains, moving off-channel for feeding and nursing. The species feeds mainly on algae, plants, zooplankton, insects, fruits, crustaceans and fish. The species is reported to move seasonally from main channels floodplains of large rivers to floodplains and marshland for feeding and nursing. The species is capable of migration in excess of 300 km.
Threats	Major threats to the species globally include overexploitation, habitat degradation, and changes in water quality and flow. Plans to dam the Mekong may disrupt the species life cycle as the migratory requirements appear to rely on flow or water quality to facilitate migration, cue spawning, and aid dispersal of young.
Summary	Species profile information suggests that the species utilises main or larger river channels and floodplain areas and undertakes long distance migrations and as such more confirmation of presence of the species is required. In the event there is spawning area downstream of the dam, the area may be considered critical habitat. Environmental Flows Assessment identifies flow release regime to manage downstream flows for maintaining normal river functions to manage this threat to potential habitat.
References	Vidthayanon, C. and Hogan, Z. 2011. *Pangasianodon hypophthalmus*. In IUCN 2012. IUCN Red Lost of Threatened Species. Version 2013.1. www.iucnredlist.org Downloaded on 12 September 2013.

Species	*Probarbus labeamajor,* **Thicklipped barb**
Candidate Criteria	Criterion 1 – The species is listed as Endangered on the IUCN Red List Criterion 2 – The species is endemic to the Mekong Criterion 3 – The species is migratory
Record	*Direct* TISTR 2013 biodiversity survey did not record the species.
	Indirect The Huay Ngua MP (2010) notes presence of the species within the provincial preserved area.
Distribution	The species is endemic to the Mekong and reported only from the Mekong mainstream from Nakorn Phanom Province (Thailand) and Sambor District, Kratie District (Cambodia). It has also been found in Sesan, Sekong and Srepok tributaries of the Mekong.
Population	Population size is not well understood though it is noted to be decreasing and a population decline of at least 50% is inferred across the global population.
Habitat	The species inhabits the deep, slow reaches of the main channel of large rivers with a sand or gravel substrate and abundant mollusc population. It is known to undertake short distance migrations for spawning in November and January. The species feeds on aquatic plants, insects and shelled molluscs. The species is reported to undertake short distance migrations for spawning in November and January.
Threats	Threats to the species include overfishing, habitat destruction and large dams.
Summary	Specialist input (Dr Maurice Kottelat pers comm 11/11/2013) indicated that the species is not known to occur in the Project area part of the catchment and the record would require verification. The species is very distinctive and identification is generally unproblematic, as such the record is likely valid. Species profile information suggests that the species utilises main or larger river channels. Should the record be correct, the habitat in the lower reaches of the Nam Ngiep River may be susceptible to indirect impacts from the propose dam, however the area is unlikely to represent >10% of the habitat within the Mekong. **The Project area is not considered to be critical habitat for the species.**
References	Baird, I. 2011a. *Probarbus labeamajor*. In IUCN 2013. IUCN Red List of Threatened Species. Version 2013.1. www.iucnredlist.org Downloaded on 12 September 2013.

Species	*Wallago leeri*
Candidate Criteria	Criterion 1 – The species has an elevated protection status nationally and is listed as Restricted in the Regulation of the Ministry of Agriculture and Forestry No. 0360/MAF.
Record	*Direct* TISTR 2013 biodiversity survey did not record the species. *Indirect* The Huay Ngua MP (2010) notes presence of the species within the provincial preserved area.
Distribution	The distribution of the species reaches from the Mekong delta to northern Lao PDR and Thailand. Other sources note that reports of the species from the Mekong River basin are mis-identifications of *Wallago micropogon*. *W. leeri* is restricted to western Indonesia and Malay Peninsula where in the Mekong River *W. micropogon* occurs.
Population	No information available
Habitat	*W. micropogon* is found in rivers and smaller streams. It moves to flooded forests during high water levels and migrates from rivers to smaller steams to spawn.
Threats	Threats to *W. micropogon* are likely related to loss of riverine forest and possibly changes to flow regimes.
Summary	*Wallago micropogon* is listed as data deficient on the IUCN Red list, it has been previously misidentified as *W. leeri* in the Mekong. **As such the species is not a candidate for critical habitat.**
References	Allen, D. 2011. *Wallago micropogon*. In: IUCN 2013. IUCN Red List of Threatened Species. Version 2013.1. www.iucnredlist.ord. Downloaded on 20 November 2013.

Species	Migratory Fish Species
Candidate Criteria	Criterion 3 – These species are migratory
Record	
General	• *Acantopsis choirorhynchos* (Horseface loach) – potamodromous, occurs in swift, clear streams with sand or gravelly substrate, also large rivers. IUCN distribution does not include Lao PDR (Ng 2012a). • *Barbonymus gonionotus* (Java barb) – potamodromous, occurs in rivers, streams, floodplains and occasionally reservoirs. Prefers standing water habitats. Local migrant from the Mekong to small streams and flooded areas (Thinh et al 2012). The species is widely distributed and cultivated. • *Henicorhynchus lineatus* – occurs mainly in medium to large-sized rivers and enters flooded fields (Allen 2011). • *Henicorhynchus ornatipinnis* • *Hypsibarbus venayi* • *Luciosoma bleekeri* (Shark minnow) – occurs in rivers and tributaries, moving to floodplains in the rainy season (Vidthayanon 2012a). • *Mystacoleucus atridorsalis* – occurs in lowland rivers and submontane streams and tributaries (Vidthayanon 2012c). • *Oxyeleotris marmorata* (Marbled goby) – occurs in wetlands, rivers, ponds, reservoirs, canals, swamps and flooded forest. Prefers little to no water movement (Allen 2011b). Conflicting evidence regarding the migratory nature of this species. • *Scaphognathops bandanensis* • *Sikukia gudgeri* (Sikuk barb) – common throughout its range, potamodromous, migrates from Cambodia to southern Lao PDR and north-eastern Cambodia between November and February (Baird 2012).
Summary	For species where the aquatic habitats up and downstream of the access road crossings may play a role in migration pathways, the area may be considered critical habitat. Further investigation into the migratory species relevant to the Project area is scheduled. Environmental flows release from the proposed dam will be required to consider the requirements of migratory species.
References	Ng, H.H. 2012a. *Acantopsis choirorhynchos*. In IUCN 2013. IUCN Red List of Threatened Species. Version 2013.2. www.iucnredlist.org. Downloaded on 26 November 2013. Thinh, D.V., Van, N.S. and Nguyen, T.H.T. 2012. *Barbonymus gonionotus*. In IUCN 2013. IUCN Red List of Threatened Species. Version 2013.2. www.iucnredlist.org. Downloaded on 26 November 2013. Allen, D. 2011a. *Clarias batrachus*. In IUCN 2013. IUCN Red List of Threatened Species. Version 2013.2. www.iucnredlist.org. Downloaded on 26 November 2013. Allen, D. 2011. *Gymnostomus lineatus*. In IUCN 2013. IUCN Red List of Threatened Species. Version 2013.2. www.iucnredlist.org. Downloaded on 16 January 2014. Vidthayanon, C. 2012. *Luciosoma bleekeri*. In IUCN 2013. IUCN Red List of Threatened Species. Version 2013.2. www.iucnredlist.org. Downloaded on 26 November 2013. Rayamajhi, A., Jha, B.R. and Sharma, C. 2010. *Mastacembelus armatus*. In IUCN

Species	Migratory Fish Species
	2013. IUCN Red List of Threatened Species. Version 2013.2. www.iucnredlist.org. Downloaded on 26 November 2013.
	Vidthayanon, C. 2012b. *Mastacembelus favus*. In IUCN 2013. IUCN Red List of Threatened Species. Version 2013.2. www.iucnredlist.org. Downloaded on 26 November 2013.
	Vidthayanon, C. 2012c. *Mystacoleucus atridorsalis*. In IUCN 2013. IUCN Red List of Threatened Species. Version 2013.2. www.iucnredlist.org. Downloaded on 26 November 2013.
	Ng, H.H. 2012b. *Mystus singaringan*. In IUCN 2013. IUCN Red List of Threatened Species. Version 2013.2. www.iucnredlist.org. Downloaded on 26 November 2013.
	Allen, D. 2011b. *Oxyeleotris marmorata*. In IUCN 2013. IUCN Red List of Threatened Species. Version 2013.2. www.iucnredlist.org. Downloaded on 26 November 2013.
	Ng, H.H. 2012c. *Pseudomystus siamensis*. In IUCN 2013. IUCN Red List of Threatened Species. Version 2013.2. www.iucnredlist.org. Downloaded on 26 November 2013.
	Baird, I. 2012. *Sikukia gudgeri*. In IUCN 2013. IUCN Red List of Threatened Species. Version 2013.2. www.iucnredlist.org. Downloaded on 26 November 2013.
	Dey, S.C. 2010. *Xenentodon cancila*. In IUCN 2013. IUCN Red List of Threatened Species. Version 2013.2. www.iucnredlist.org. Downloaded on 26 November 2013.

Nam Ngiep 1 Hydropower Project

Species Profile—Luciocyprinus Striolatus

Nam Ngiep 1 Power Company Limited

July 2014

0229866

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FINAL REPORT

Nam Ngiep 1 Power Company Limited

Nam Ngiep 1 Hydropower Project

Species Profile – Luciocyprinus Striolatus

July 2014

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Acronym	
ADB	Asian Development Bank
CIRAD	French Agricultural Research Centre for International Development
CR	Critically endangered
EIA	Environmental Impact Assessment
EN	Endangered
FSL	Full supply level
GoL	Government of Lao PDR
IFC	International Finance Corporation
IUCN	International Union for Conservation of Nature
JIRCAS	Japan International Research Center for Agriculture
LaRREC	Living Aquatic Resources Research Centre
MoNRE	Ministry of Natural Resources and Environment
NBCA	National Biodiversity Conservation Area
NN2	Nam Ngum 2 (Hydroelectric Power Project)
NN3	Nam Ngiep 3 (Hydroelectric Power Project)
NNP1	Nam Ngiep 1 Power (Company Ltd)
NT2	Nam Theun 2 Hydropower Company
PDR	People's Democratic Republic
USD	United States Dollar

EXECUTIVE SUMMARY

CURRENT STATUS

ERM, Nam Ngiep 1 Power Company and contractors have undertaken detailed assessment of the distribution, threats and current status of Luciocyprinus striolatus within Lao PDR and Southern China. The purpose of this assessment has been to provide context to the assessment of the species against the Asian Development Bank Safeguard Policy Statement (ADB SPS), guided by the International Finance Corporation Performance Standards to determine the significance of impacts from the Nam Ngiep 1 Hydropower Scheme in Lao PDR.

To enhance the current knowledge of the current status of populations for the L. striolatus across its range, an in-field survey of river basins was undertaken in Lao PDR to confirm by villager interview where the species was yet to be confirmed but likely present (Warren 2014). Direct contact with academics and government officials also occurred in China and Vietnam to determine the presence of the species in those countries. The information collected indicates that the number of Discrete Management Units (DMU) for the species has now been confirmed as 14; 11 in Lao PDR; 3 in Southern China and none in Vietnam, where it was confirmed that the species is not present.

An analysis of threats across the species' range (including the newly identified DMUs) has confirmed that significant threats to the species' persistence exist in the majority of DMUs. In Lao PDR, most populations are threatened by: over-fishing; water quality and quantity changes from development pressures; disruptions to the spawning cycle from impacts on habitats (deep pools); and impacts to intra-migratory patterns. However, conservation activities exist within at least five DMUs: one DMU has been confirmed to contain a population that is currently within a protected area; and a further four DMUs contain Fisheries Management Zones (FMZ) that limit fishing activities. Populations in China are less well described, however it was noted that populations are under threat from developments and over-fishing.

CRITICAL HABITAT STATUS

The information collated regarding the species has been used to assess the habitat of the Project area in accordance with the ABD SPS definition of critical habitat. L. striolatus is an Endangered species on the IUCN Red List and as such "critical habitat" would be present if the habitat is considered critical to the survival of the species. To determine this, the assessment has been guided by the critical habitat criteria and thresholds described in the International Finance Corporation Performance Standard 6 Guidance Note.

Based on the information collected, and an understanding of the importance of the Nam Ngiep River concentration in the context of the remaining DMUs, the Nam Ngiep River concentration is not considered to meet the criteria for critical habitat. The Nam Ngiep River concentration is not considered to be regionally-important given the challenges associated with existing threat conditions and the presence of

other DMU concentrations more likely to support the recovery of the species, as such the habitat associated with the Project area is not considered to be critical to the survival of the species.

PROJECT IMPACTS

While the habitat associated with the Project location does not meet the criteria for critical habitat (and not critical to the survival of the L. striolatus), an impact assessment has been undertaken to understand the impact on the population of the Nam Ngiep River basin. Threats specifically posed by the Nam Ngiep 1 Hydropower Project (NNP1 Project) relate to the potential reduction in the availability of spawning habitats in the upper inundation area of the reservoir. Other threats that are not directly related to the NNP1 Project include: changed hydrology from upstream hydropower schemes; changes in land use impacting on water quality and quantity; and pressures from fishing. However, Fisheries Conservation Zones are present in the Nam Ngiep River, as are at least 2 spawning habitat locations that are located within tributaries not subject to proposed hydropower developments.

PROPOSED MITIGATION MEASURES

It is considered that there is a high probability that the species can persist in the Nam Ngiep River if appropriate mitigation measures are applied. There is sufficient habitat available within the Nam Ngiep River above Full Supply Level (FSL) level of the NNP1 Project and also within tributaries to enable spawning to occur and for the species to persist. Mitigations are proposed to protect habitats within the watershed through managing FMZs; coordinating management with other hydro schemes and working with the community to reduce fishing pressure on the population. As a last resort, captive breeding may occur to ensure that the genetic resource is preserved. These actions will mitigate impacts so that the functioning of the habitat remains sufficient for the species to persist.

The mitigation measures proposed aim to preserve habitats necessary for the species' persistence, especially spawning habitats not currently threatened by hydro power schemes within the watershed. Operation of the dam indicates that spawning habitat will be exposed in the upper reaches of the reservoir during the breeding period (January to March). Monitoring of the population also is recommended to occur to determine the population persistence and its viability over the long term. Co-management of the Nam Theun 2 population will also assist in gathering important information on the biology of the species. These measures are likely to protect and enhance habitat within the Nam Ngiep watershed so that the ecosystem remains viable.

In summary, to mitigate against impacts and threats from the NNP1 Project, the following mitigation measures have been proposed:

1) *Watershed management above the Full Supply Level (FSL) to coordinate the management and monitoring of the species' habitat; manage threats*

(such as overfishing); enhance management of FMZs; and manage water quality and quantity with other hydropower schemes;

2) *Management of dam operations to expose spawning habitat below FSL during the breeding period (January – March);*
3) *Potential captive breeding to provide a genetic resource to supplement the wild population if monitoring indicates that the population is reducing.*

To mitigate against further loss of the species across its range, the following additional conservation actions are proposed:

1) *Species recovery coordination across Lao PDR is proposed to establish a framework to coordinate conservation efforts, facilitate research and conservation for the species*
2) *Potential co-management of the Nam Theun population of the species in conjunction with the Nam Theun 2 Hydropower Company*

While Nam Ngiep River is not considered to meet the critical habitat criteria, management of the species as outlined in the mitigation measures is recommended to support persistence of the species within the Nam Ngiep River Basin. To manage the species across its range, a species recovery planning framework for Lao PDR is required to assist in the reduction of further loss of populations. This framework, when undertaken in conjunction with mitigations in the Nam Ngiep River Basin, will coordinate management of habitat and improve the long-term survivability of the species both in the Nam Ngiep River Basin and across the species range.

The following recommendations are made regarding L. striolatus in relation to the NNP1 Project:

1) *Contact should be made with NN2 Hydro power Scheme regarding opportunities for co-management of the species within the Nam Ngiep watershed;*
2) *Contact with MoNRE and the Lao PDR Fisheries Department should be made regarding the preparation for a Species Recovery Plan for L. striolatus within Lao PDR; and*
3) *Monitoring of the upper inundation area during the spawning period of L. striolatus should be undertaken to determine the use of the deep pools and FCZs during this period;*
4) *Monitoring of the fish population should be undertaken, including assessment of population and abundance from year to year. This should include monitoring of all spawning areas within the catchment (through villager interviews) to determine the persistence of the species;*
5) *Monitoring of habitat quality should considered to determine the long term viability of the habitat and the success or otherwise of management actions; and*
6) *Management of the species should be incorporated into the Watershed Management Planning Framework and the Biodiversity Offset Management Plans being prepared for the NNP1 Project.*

1 INTRODUCTION

The Nam Ngiep 1 Hydropower Project (the Project) involves construction and operation of a hydroelectric power generation facility on the Nam Ngiep River, Lao PDR. The Project site is located in the provinces of Vientiane, Xieng Khouang and Bolikhamxay, approximately 145 kilometres (km) northeast from the city of Vientiane or 50 km north from Pakxan District. Project details are reported in the Nam Ngiep 1 Hydropower Project Environmental Impact Assessment (EIA) along with the assessment of other terrestrial and aquatic biodiversity values.

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

This report focusses on collating available information from specialist reports and literature sources for *Luciocyprinus striolatus* such that it can be determined if the area is critical habitat for the species. It describes the biological aspects, distribution and threats to the species to support the conclusions and where necessary identifies mitigation and offsetting options. The species is not previously known for the Nam Ngiep catchment however during biodiversity studies undertaken to inform the EIA, anecdotal evidence of the species was collected and sub sequential studies have in turn been undertaken the population and its distribution. The species is listed as Endangered on the IUCN Red List of threatened species.

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

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

This report is informed by expert advice documented and provided in *Annex A - D* provided by Mr Terry Warren (Annex *A* and *B*), Dr Maurice Kottelat (*Annex C*), and Mr Sinthavong Viravong and Mr Thavone Phommavong (*Annex D*). The information collated combines known records and anecdotal reports where appropriate.

1.1 INFORMATION LIMITATIONS

This report collates information derived from literature, field sampling, habitat surveys, village interviews and other observations. As such some information presented is based on anecdotal evidence provided by local people during interview.

Anecdotal evidence has been used in the absence of more detailed survey data in sections of this report. Warren (2014b) notes that, over the limited survey period, capturing an individual or witnessing spawning behaviour would be challenging, as the species lives in low abundance. During Warren's village interview, measures were employed to maximise confidence in valid species identification and the anecdotal nature of the data has been considered when drawing conclusions.

Through collection of data for this report, it is also noted that a substantial amount of the information for the species has been collected to inform hydropower Project assessments and as such there is survey bias. The distribution of the species shown in the literature is likely to be biased toward these targeted locations, i.e. fewer surveys are likely to have been undertaken in areas not being considered for hydropower infrastructure and the presence of the species in such areas is less well known.

Phase 3 of Warren's investigations were designed to overcome this data gap by undertaking a more comprehensive assessment of the likelihood of presence of the species across its range and investigations into candidate river basins to confirm presence.

2 BIOLOGICAL PROFILE

Luciocyprinus striolatus is a large predatory fish of the family Cyprinidae (Kottelat 2011). The species is differentiated from the other species of the genus by the presence of five to eight longitudinal black stripes on the body of adults, 78 to 89 lateral line scales, and 40 to 46 predorsal scales.

The species is reported to reach up to 70-100 kg in weight, however there are almost no recent reports of large specimens (greater than 60 kg) (Warren 2014a). Females have been recorded growing to about 1.5 m (reportedly up to 2 m) long, and males are reported to be smaller. A fisherman from Ban Pou described one female fish caught as about 1.5 m long and weighing 22 kg, 1 kg of which was eggs (Kottelat 2014). According to a local expert on the species, two specimens weighing 19.5 and 22kg were caught in the Nam Fa River during the 2014 dry season.

The species lives in upland areas (Warren 2014a). Interviews with local fishermen and observations of the species in the Nam Theun drainage indicate that adults live in deep pools, with a possible preference for the upper and lower parts of the pool, near rapids, riffles and runs (Kottelat 2014). Interviews by Baird *et al*. (1999, cited in Warren 2014a) indicate that the species occupies middle to surface water strata and prefers rivers with small stones substrate or large slabs of rock. Deep pools of between two and six metre depth during dry season conditions are expected to be preferred (Warren 2014b).

The species is reported to spawn in shallow, flowing water (approximately 40 – 50 cm deep) along beaches of pebbles, gravel or sand (Kottelat 2014). One fisherman reported that water was no more than approximately 20 cm deep at a spawning site (Warren 2014a), and others noted that fish dorsal fins were out of the water (Kottelat 2014). These shallow habitats are likely several meters above the dry season water level (Kottelat 2014). Based on anecdotal observations, the species forms small groups (reportedly around ten individuals) and apparently spawn in pairs (Kottelat 2014).

Spawning is believed to occur in January to April, however there may be local variation. Fishermen interviewed have reported spawning in January-March. Information obtained by Kottelat in Nam Theun in 1996 indicated spawning in January-February, and information obtained by Kottelat in Nam Kading in 2002 indicated spawning in October-December (Kottelat 2014). Baird has reported the fish breeds in May and June (Warren 2014a).

The species is not known to migrate (Kottelat 2011), although fishermen provided anecdotal evidence of local seasonal movements (Kottelat 2014). This has been confirmed by investigations by Warren who has confirmed intra-migratory patterns of the species between dry season refugia in deep pools and wet season migration up river. This supports evidence provided by fishermen in Ban Pou who reported that the species moves downstream to large pools from November to May (Kottelat 2014).

The species is predatory and feeds on aquatic animals (mainly fish and perhaps some amphibians) (Kottelat 2014; Warren 2014). The species has also been reported to capture small mammals that enter the water, such as dogs and monkeys, however this is likely to be exceptional behaviour of very large individuals (Kottelat 2014). The species is not very abundant and this is typical of large predatory animals (Kottelat 2014).

3 DISTRIBUTION

3.1 GLOBAL AND NATIONAL

L. striolatus has been recorded in Lao PDR and China, although it is not known if the species persists in China currently (Kottelat 2014).

In Lao PDR, the species is reported to been found in upper Xe Kong, upper Nam Kading (Nam Theun and Nam Ngouang), upper Nam Ou, the upper Xekaman, Nam Ngum and upper Nam Tha rivers (Kottelat 2014). Work by Warren in May 2014 (Warren 2014a) (*Annex C*) confirmed additional populations in the Nam Tha, Nam Fa, Nam Ma, Nam Nga and Nam Beng Rivers. ERM interviews with officials in China provided evidence that the species is still present in the Puwen River and the Luosuo River in Southern China. The species was confirmed as not present in Vietnam. The species is also absent from the Mekong floodplain.

Figure 3.1 indicates the catchments where the species has been found in Lao PDR according to Warren (2014).

A recent survey of fast water habitats by Kottelat (2014) (*Annex D*) identified the first anecdotal evidence of the species in the Nam Ngiep catchment, and the first information suggesting its presence in the neighbouring Nam Xan catchment. Although no specimens were obtained during the survey, the identifications appear reliable. Subsequent target survey by Warren (2014b) also recorded anecdotal evidence of the species in the Nam Ngiep and Nam Xan catchments during village interviews. Further detail specific to the distribution in the Nam Ngiep and surrounding catchments is provided in *Section 3.2*.

Table 3.1 summarises the available information on the occurrence of *L. striolatus* in each catchment in which it is known to occur in Lao PDR.

The species is listed as Endangered on the IUCN list due to suspected and inferred population declines of 50% or more over the past 30 years (Kottelat 2011). The listing is due to a decline in the quality and availability of habitat resulting from hydro-power development throughout the species' range, as well as the removal of individuals through recreational and illegal fishing and poaching. Other reported impacts to the species' habitat include soil erosion, sedimentation and chemical pollution associated with logging, deforestation and agriculture within the species' distribution (Kottelat 2011).

Table 3.1 Description of occurrence in each known catchment as of June 2014

Catchment	Description of occurrence
Nam Ou (Lao PDR)	• Warren (2010, cited in Warren 2014a) identified an individual at a market that was caught in Nam Ou, upstream of Ban Hat Sa, and another juvenile specimen caught in Huay En, a tributary of Nam Ou (Phongsaly Province).
Nam Theun/ Kading (Lao PDR)	• Individuals identified by Warren (1995, cited in Warren 2014a) were identified as being sourced from Nam Theun, near Ban Thabac. • Local fishers at Ban Thabac on the Nam Theun considered the species was found more frequently in Nam Gnounang (a tributary of Nam Kading) than Nam Theun (Warren 2014a). • There is anecdotal evidence of much larger *L. striolatus* being found between Ban Thabac and Ban Huay Gan Ya in 1995 (now the Theun-Hinboun head-pond) (Warren 2014a). • In theory, the population in Nam Theun drainage, upstream of the Nam Theun reservoirs, in Nakay NBCA, is the only population not threatened by impacts happening upstream and is possibly the population in the safest condition (Kottelat 2014).
Xe Kong (Lao PDR)	• Juvenile *L. striolatus* were identified from the upper Xe Kaman in Saysettha District in Attapeu Province in 1996 (Baird et al. 1999, cited in Warren 2014). • Juveniles are rarely seen in the lower parts of Xe Kong in Kaleum District, although juveniles are rarely seen (Baird et al. 1999, cited in Warren 2014). • It is not common in the lower part of Xe Kong in Lamam District, Xe Kong Province and is not found at all in the lower part of the Xe Kong in Attapeu Province (Baird et al. 1999, cited in Warren 2014a).
Nam Ngiep (Lao PDR)	• Further description of the species' presence in this catchment is provided in *Section 3.2*.
Nam Xan (Lao PDR)	• Anecdotal evidence identifies a population of the species near Muang Thathom (Warren 2014b) • Anecdotal evidence during Kottelat (2014) survey, though no specimen collected.
Nam Ngum (Lao PDR)	• Photograph listed from Nam Ngum reservoir (Rainboth et al. 2012)
Nam Ngao/Nam Ngam Bokeo Province, Lao PDR)	• Survey by Warren in 2014 confirmed that populations of Ls were reported to exist in Nam Ngao / Nam Ngam (local name is Nam Nga catchment), but numbers caught are quite low.
Nam Beng (Oudomxai Province, Lao PDR)	• Survey by Warren in 2014 confirmed presence in the Nam Beng River.
Nam Tha, Nam Ma and Nam Fa (Luang Nam Tha Province, Lao PDR)	• Surveys by Warren in 2014 confirmed populations of Ls are found in three major river catchments (The Nam Tha, The Nam Ma and The Nam Fa). The largest and most healthy populations are found in the Nam Fa, followed by The Nam Tha and then the Nam Ma. According to a local expert on Ls, two specimens weighing 19.5 and 22kg were caught during the 2014 dry season.
Puwen River (China)	• Investigations by ERM confirmed that the species is found in the Puwen River in Southern China as of May 2014
Luosuo River (China)	• Investigations by ERM confirmed that the species is found in the Luosuo River in Southern China as of May 2014.

The location of Luciocyprinus striolatus (Big Fish) populations within the Lao PDR's national boundaries

0 200000 400000 600000 800000

2400000 2200000 2000000 1800000 1600000

N W E S

XISHUANG BANNA (CHINA)

PHONGSALY

Nam Ou

LUANGNAMTHA

BOKEO

OUDOMXAY

LUANGPRABANG

HUAPHANH

XIENGKHUANG

Nam Ngiep

XAYABURY

VIENTIANE

VIENTIANE CAPITAL

BOLIKHAMXAY

Nam Kading

KHAMMUANE

Nam Theun

SAVANNAKHET

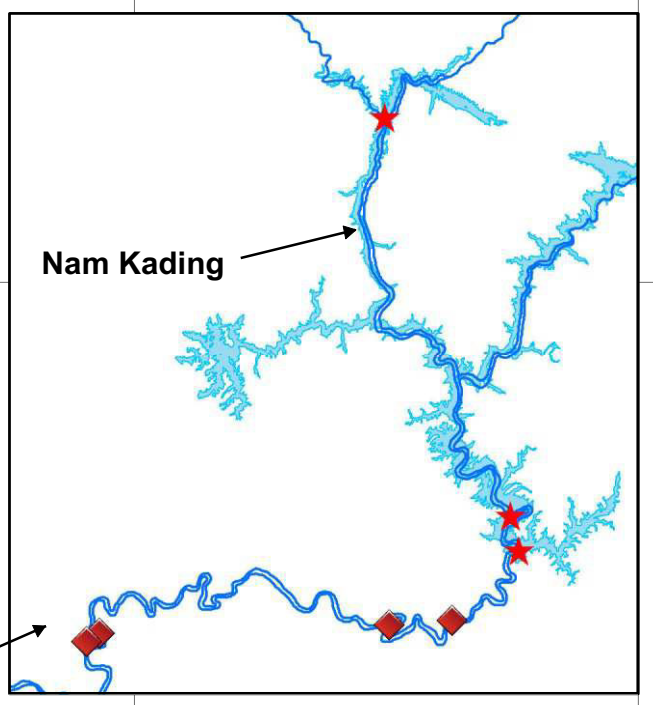
SARAVANE

SEKONG

ATTAPEU

CHAMPASACK

Nam Xekong



Legend

- Confirmed GPS coordinates
- Confirmed location
- No specific location given
- Main river
- Catchment
- Province Boundary

0 100 200 Kilometers

3.2 NAM NGIEP POPULATION

3.2.1 Current presence within the Nam Ngiep

The survey undertaken by Kottelat (2014) (*Annex D*) revealed the first evidence of the species in the Nam Ngiep catchment. Given the evidence is the first from the catchment, the habitat must be considered for its importance to the species.

The full distribution of the species is not well understood hence to obtain an understanding of the distribution within Nam Ngiep, five consultation events were undertaken as part of the additional targeted studies for the *L. striolatus*.

- Viravong and Phommavong (2014) held interviews between the upper Project full supply level (FSL) and near NN2 (incorporated Nasong, Viengthong, Nasay and Xiengkhong villages) (Annex *D*);
- Kottelat (2014) reported interviews upstream of the FSL in Ban Thaviang, Ban Viengta and Ban Pou (Annex *C*); and
- Warren (2014a) undertook interview in the upper Nam Ngiep catchment and various adjacent sub-catchments (Annex *B*).
- Warren (2014b) undertook a survey and villager interviews across river basins in Lao PDR where the species was likely to be found but not confirmed.
- ERM undertook a stakeholder engagement exercise with Government and Academics in Vietnam and China to determine the likelihood of the species being present in those countries.

Figure 3.2 shows the location of the villages interviewed, location of spawning sites reported, current and proposed hydroelectric schemes, fish conservation zones (FCZ) identified and key landmarks in the Nam Ngiep catchment.

Kottelat (2014) reported fishermen working in the Nam Ngiep noted that the species occurs as far upstream as Sop Syem (approximately 7 km upstream of Ban Thaviang, near the NN2 Powerhouse). It was reported that this stretch of the river, upstream of Ban Thaviang, is too shallow for the species to occur during the dry season. The individuals in the upstream section of the river are said to be smaller, with large fish believed to occur downstream of Kaen Tao (Kottelat 2014). Interviews by Warren (2014b) also reported the species in this region with anecdotal evidence from the Nam Siam and between Xiengkhong and Nasong. The results of the survey suggested the species occupies habitats between 325m and 800m elevation with the Nam Siam the smallest river where the species was reported to migrate for spawning or feeding (Warren 2014b).

Warren (2014b) also reported evidence of the species in lower Nam Chian (or Nam Jey) and the neighbouring Nam Xan catchment; however presence in the Nam Xan catchment was discounted following investigations in May 2014.

Fishermen suggested that the species may occur as far downstream as the Mekong, but have not fished that far downstream. Fishermen from Ban

Xomxuen report catching the species at Hat Nguen, below the confluence of Nam Ngiep and Nam Xao in October-November, but not at any other time of the year (Kottelat 2014).

A fisherman working between Ban Viengta and Ban Soppouan reported that the species is present in Nam Chae although other fishermen indicated they had not caught the species in Nam Chae (Kottelat 2014).

Two spawning sites were reported within the inundation zone: Kaen Tao 'beach', about 4 km downstream of Ban Pou, and Wang Mon 1 km downstream of Ban Pou (Kottelat 2014). Warren (2014b) reported three additional spawning locations between Xiengkhong and Nasong, and Viravong and Phommavong (2014) noted it is highly likely that more spawning habitats occur in the river. It is difficult to determine whether there are more spawning locations unless direct observation occurs during spawning events. For this reason, the spawning habitats outlined in *Table 3.3* are likely to be conservative.

Fisheries Conservation Zones (FCZ) have been identified within the Nam Ngiep River that coincides with the deep pools. These FCZs are outlined in *Table 3.2* below.

Table 3.2 Fisheries Conservation Zones in the Nam Ngiep River

Name of village closest to and responsible for the FCZ (descending order downstream from NN2 Main Project)	**Local name of FCZ**
Ban Xiengkhong	Xiengkhong FCZ (III) *Wang*?
Ban Xiengkhong	Xiengkhong FCZ (II) *Wang Hin Ngon*
Ban Xiengkhong	Xiengkhong FCZ (I) *Wang Khouak*
Ban Viengthong	Viengthong FCZ (I) *Wang Saphan*
Ban Naxong	Naxong FCZ (II) *Wang Gua*
Ban Naxong	Naxong FCZ (I) *Wang Ngiow*
Ban Thaviang Sai	Thaviang Sai FCZ (II) *Wang Tham*
Ban Thaviang Sai	Thaviang Sai FCZ (I) *Wang Sop Pang*
Ban Phiangta	Phiangta FCZ (I) *Wang Som Lom*
Ban Hat Sam Khon	Hat Sam Khon FCZ (I) *Wang Hat Sam Khon*
Ban Pou	Pou FCZ (I) *Wang Sop Pou*

Table 3.3 provides an analysis of the current status of the population within the Nam Ngiep River as undertaken by Terry Warren in May 2014.

Table 3.2 Current status of Habitat for L. striolatus within the Nam Ngiep River (Adapted from Warren 2014a)

Known Ls spawning habitat	Temporary or permanent Ls dry season refuge habitat (deep pool)	Village / site reference. Temporary Ls wet season habitat	Stream name
Nam Gnok (Nam Youak) and Houay Xay			
None reported during survey.	At least one deep pool between Ban Houayxay and confluence point with Nam Youak.	Ban Houayxay. Yes, Ls reported present here each year in wet season (mostly small around 1kg).	Houayxay (stream that joins the Nam Youak).
None reported during survey.	Two deep pools referenced between Ban Nam Youak and confluence point with the Houay Xay.	Ban Nam Youak. Yes, Ls reported present in this stream, but only during wet season. Ls moves back to Nam Ngiep by early to mid-dry season.	Nam Youak (stream that flows into Nam Ngiep).
Nam Phouan			
None reported during survey.	One deep pool (*Wang Pba Deng*) referenced approximately 1km upstream from Nam Phouan – Nam Ngiep confluence point. May represent a dry season refuge habitat.	Ban Sopphouan. Yes, Ls reported from this stream and caught in both dry and wet season. If deep pools are very large and deep, Ls stays throughout dry season.	Nam Phouan (stream that flows into Nam Ngiep).
None reported during survey.	One deep pool (*Wang Hong Mor*) referenced 300 meters downstream from Ban Sopphouan on the Nam Ngiep mainstream. Definite Ls dry season refuge habitat.	Ban Sopphouan. Not defined as a wet season habitat but Ls probably pass through it.	Nam Ngiep mainstream.
Nam Chian (Nam Jey)			
Not reported at this location.	Deep pool adjacent to road bridge (route 1D) over Nam Chian. Definite entire dry season habitat. Ls stays and does not go back to Nam Ngiep.	Road bridge (route 1D) over the Nam Chian.	Nam Chian (stream that flows into Nam Ngiep).
Not reported at this location.	Deep pool approximately 2km upstream from road bridge / FCZ. Ls reported to stay in deep pool over entire dry season.	*Keng Pa Sang* rapids just above deep pool in column 2. No name for deep pool.	Nam Chian (stream that flows into Nam Ngiep).
None reported at this location.	Not a dry season refuge point.	Rapids just upstream from the Nam Chian road bridge and FCZ. Ls can pass rapids (bi-directional) only in wet season.	Nam Chian (stream that flows into Nam Ngiep).
None reported at this location.	Deep pool approximately 1.3km downstream below Nam Chian road bridge. No name for deep pool.	Deep pool on Nam Chian.	Nam Chian (stream that flows into Nam Ngiep).
None reported at this location.	Deep pool (*Wang Kok Hai*) approximately 100m above the deep pool mentioned above towards the Nam Chian road bridge. Very important entire dry season refuge habitat for Ls.	Deep pool on Nam Chian. Ls can pass (bi-directional) though it in wet season.	Nam Chian (stream that flows into Nam Ngiep).
None reported at this location.	Ford crossing point through Nam Chian approximately 4km downstream from road bridge over the Nam Chian. Deep pool, but	Deep pool on Nam Chian. Ls can pass (bi-directional) though it in wet season.	Nam Chian (stream that flows

Known Ls spawning habitat	Temporary or permanent Ls dry season refuge habitat (deep pool)	Village / site reference. Temporary Ls wet season habitat	Stream name
	not important for Ls.		into Nam Ngiep).
None reported at this location.	Right-hand bank tributary of the Nam Chian close to the road bridge over the Nam Chian. Ls does not enter this stream at any time of the year.	Right-hand bank tributary of Nam Chian.	Nam Long (stream that flows into Nam Chian
None reported at this location.	Not reported at this location.	The confluence point of the Nam Chian and the Nam Ngiep (about 7km downstream from Ban Pou). Ls can pass through this area in both the dry and wet season (bi-directional).	Nam Chian and Nam Ngiep.
None reported at this location.	Very important dry season refuge habitat and deep pool (*Wang Mak*) approximately 1km upstream from the confluence point on the Nam Chian. Ls can stay here throughout the dry season instead of going back to the Nam Ngiep.	Ls can pass through this area (bi-directional) in wet season.	Nam Chian.
None reported at this location.	Dry season refuge point (Xiengthong FCZ III)	Ls can pass through (bi-directional) during wet season months.	Nam Ngiep mainstream.
None reported at this location.	Dry season refuge point (Xiengthong FCZ II – *Wang Hin Ngon*).	Ls can pass through (bi-directional) during wet season months.	Nam Ngiep mainstream.
Dry season spawning site for Ls.	Dry season refuge point (Xiengkhong FCZ I – *Wang Khouak*).	Ls can pass through (bi-directional) during wet season months.	Nam Ngiep mainstream
None reported at this location.	Not a dry season refuge point (Nam Thong)	Ban Sanphouxai. Ls can pass through (bi-directional) during wet season months.	Nam Thong mainstream
None reported at this location.	Not a dry season refuge point (Nam Thong).	Ls can pass through (bi-directional) during wet season months. Ls enters Nam Thong in wet season but only in the lower reaches.	Nam Thong flows into the Nam Ngiep at Ban Viengthong.
None reported at this location.	Dry season refuge point (Viengthong FCZ I – *Wang*?	Ls can pass through (bi-directional) during wet season months.	Nam Ngiep mainstream.
None reported at this location.	Dry season refuge point (Naxong FCZ II – *Wang Gua*).	Ls can pass through (bi-directional) during wet season months.	Nam Ngiep mainstream.
Dry season spawning site for Ls.	Dry season refuge point (Naxong FCZ I – *Wang Ngiow*).	Ls can pass through (bi-directional) during wet season months.	Nam Ngiep mainstream.
Dry season spawning site for Ls before road construction in 2003.	Dry season refuge point (Thaviang Sai FCZ II – *Wang Tham*).	Ls can pass through (bi-directional) during wet season months.	Nam Ngiep mainstream.
None reported at this location.	Dry season refuge point (Thaviang Sai FCZ I – *Wang Sop Pang*).	Ls can pass through (bi-directional) during wet season months.	Nam Ngiep mainstream.

Known Ls spawning habitat	Temporary or permanent Ls dry season refuge habitat (deep pool)	Village / site reference. Temporary Ls wet season habitat	Stream name
Dry season spawning site witnessed in 1988 / 89.	Dry season refuge point (Phiangta FCZ I – *Wang Som Lom*).	Ls can pass through (bi-directional) during wet season months.	Nam Ngiep mainstream.
Dry season spawning site for Ls.	Dry season refuge point (Hat Sam Khon FCZ I – *Wang Hat Sam Khon*).	Ls can pass through (bi-directional) during wet season months.	Nam Ngiep mainstream.
None reported at this location.	Dry season refuge point (Pou FCZ I – *Wang Sop Pou*).	Ls can pass through (bi-directional) during wet season months.	Nam Ngiep mainstream.
Dry season spawning site for Ls.	Dry season refuge point (*Wang Hat Ken Tow*). Point on Nam Ngiep mainstream between Ban Pou and the Nam Chian – Nam Ngiep confluence point.	Ls can pass through (bi-directional) during wet season months.	Nam Ngiep mainstream.

290000 300000 310000 320000 330000 340000 350000 360000

2150000 2140000 2130000 2120000 2110000 2100000 2090000 2080000 2070000 2060000 2050000 2040000

Dhu
Nam Ngum
Nam Gnouang
Plain of Jars
Phonsavan
Nam Kho
Nam Kat
Nam Khoun
Nam Tong
Nam Phan
Nam Khian
Nam Ye
Nam Phong
Nam Tom
Nam Thuang
Nam Xing
Nam kai
Nam Ko
Nam Ngou
Nam Xo
Nam Pouy
Muang Khoun
Nam Linsoung
Ban Thaenphoun
Nam Sen
Name Chia
Tad-a Tong Waterfall
NN3 Dam
Ban Sang
Phaxai
NN2 Main Reservoir
NN2 Tributary Diversion Project
Nam Kang
Ban Keokoang
Ban Sanlouang
Nam Phok - Han
Ban Nabong
Ban Dtun Tai
Ban Pakhing
Nam Chian
Ban Khek
Ban Nam Siam
Nam Pot
Ban Poucafe
Ban Boong
Nam Chane Project
Ban Phouvieng
Nam Ghan
Nam Sane 3A Project
Nam Sane 3B Project
Ban Nam Sia
Nam Pha
Nam Siam
Ban Chanam
NN2 Powerhouse
Ban Xiengkhong
Ban Naxong
Ban Thaviang Sai
Nam Long
Nam Bansan
Ban Pou
Wang Hat Sam Khon
Nam Chiang
Thathom
Nam Tai
Nam Xan
Nam Mo
Nam Teng
Nam Hok
Nam Feng
Nam Khong
Nam Gnao
H. Noi
Nam Louang
Nam Ngiep
Thongkhoun
H. Komon
Nam Hao
H. Phouson
H. Pomon
Nam Tinna
Nam Chia
Nam Phouan
H. Nasang
Nam Xao
Nam Ma
Nam Bak
Nam Han
Nam Huang
Nam Kap
Nam Pang
Nam Kiang
H. Samsao
H. Sangtay
Nam Gnok
Nam Sou
Nam Gniou
Nam Hom
Nam Gnok - Noy
Nam Toum
Nam Tak
H. Miang
Xiengmi
Ban Thahuea
Ban Hatsaykham
Ban Hat Gniun
Nam Khiao
Nam Bousamka
H. Katha
H. Soup
H. Khin-Nguak
Nam Louan
H. Khinguak-Noy
Nam Mang
Nam Pa
Ban Sisavath
Nam Thoay
H. Kokkhen
Ban Nonsomboun
Nam Lo

Legend

- Fish Conservation Zone
- *L striolatus* Spawning Site
- Nam Ngiep Catchment Boundary
- Road
- Watercourse
- City, Town or Village

Interviewed Villages:

- *L. stiolatus* caught in last three years
- *L. stiolatus* not caught in last three years

Nam Ngiep 1 Hydropower Project:

- Full Supply Level (Inundation Area)
- Re-regulation Dam
- Re-settlement Area
- Proposed Access Road

N

0 2.5 5 7.5Km

1:300,000

Basemap: Bing Maps

Client:	Nam Ngiep Power Company Ltd.		
Drawing No:	0185065b_LSTRIOL_PROFILE_G001_R0.mxd		
Date:	25/06/2014	Drawing Size: A3	
Drawn By:	TC	Reviewed By: KT	

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

Figure 3.2 - *Luciocyprinus Striolatus* Locations

Nam Ngiep 1 Hydropower Project
Species Profile - *Luciocyprinus Striolatus*

Environmental Resources Management ANZ

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

ERM

4 THREATS TO THE SPECIES

4.1 THREATS IN LAO PDR

The main threats to freshwater fish biodiversity in Indo-Burma region relate to alteration of river morphology (from hydropower, irrigation and navigation), pollution, mining, exploitation and invasive species (Kottelat *et al*. 2008). The *L. striolatus* population is vulnerable to dams, exploitation and habitat degradation through impacts to the aquatic environment associated with mining, deforestation and agriculture. Kottelat (2014) notes that most populations of the species in Lao PDR are impacted, or are likely to be impacted, by hydropower and/or mining projects.

Hydropower and other dam development result in physical blockage of up- and downstream fish movement. *L. striolatus* is not a long-distance migrator however is expected to move within river basins to access feeding and spawning habitat areas (as described in Section 2). The barrier induced by dam infrastructure has potential to limit natural movements and interrupt reproductive behaviours.

Similarly, the water flow barrier leads to an alteration in the hydrological pattern and volume to downstream. This is likely to include an increase in dry-season discharge, reduction in discharge at the beginning of the wet season and potentially daily fluctuations of discharge. Specific to the Nam Ngiep population, the discharge from the NN2 project and NN3, located upstream of the spawning locations identified, may already threaten the downstream habitat. Daily fluctuation in water level is a well-known cause of destruction of fish habitat, especially spawning sites (Kottelat 2014).

Eggs attached to vegetation or deposited in sand/gravel (as observed for *L. striolatus*) become exposed and die within a few minutes. The extent of this potential impact is unknown with additional detail regarding the wet-season condition of the spawning sites and the planned discharge from NN2. The testing phase of NN2 also presents a threat to the habitats within the Nam Ngiep with the short but potentially intense discharge flows. These threats are likely to be associated with all dam installations in *L. striolatus* inhabited rivers.

Fishing using illegal fishing techniques and exploitation of the fisheries resource for sale is also a threat to the species. Fishing using explosives ichthyocides and ichthyoanesthetics used to be common in some catchments in the 1990s. The rate of use of these techniques currently is not well understood. With development occurring across Lao PDR there is a rapidly expanding human population and as such fishing is no longer only for subsistence but also for income.

Large scale changes to the landscape, for example rubber plantations, mining and other agricultural conversion, have been associated with declines in fish population and diversity (Kottelat et. al. 2008). Consequences such as pollution from activities as well as siltation and river bed and bank disturbance, destroys and degrades habitat for fish species.

5 CRITICAL HABITAT STATUS

5.1 CRITICAL HABITAT CRITERIA

The Asian Development Bank Environmental Safeguards Good Practice Source Book (the 'Source Book') (ADB 2012) contain specific requirements for different habitat types that relate to their likely conservation value. Relevant to *L. striolatus*, the Source Book describes critical habitat as:

'*an area that has high biodiversity value, including habitat required for the survival of critically endangered or endangered species; areas having special significance for endemic or restricted-range species; …*'

L. striolatus is an Endangered species on the IUCN Red List and as such critical habitat would be present if the habitat is considered *critical to the survival of the species*.

In order to identify if the Project is located within habitat critical to the survival of *L. striolatus*, the critical habitat criteria and thresholds described in the International Finance Corporation (IFC) Performance Standard 6 Guidance Note 2012 have been used to guide the determination. Information available specific to the species distribution and population is screened against the criteria and thresholds. The criteria for Critically Endangered and Endangered species include two tiers for assessment:

Tier 1

a) Habitat required to sustain >10 percent of the global population of a CR or EN species/subspecies where there are known, regular occurrences of the species and where that habitat could be considered a discrete management unit for that species.
b) Habitat with known, regular occurrences of CR or EN species where that habitat is one of 10 or fewer discrete management sites globally for that species.

Tier 2

c) Habitat that supports the regular occurrence of a single individuals or a CR species and/or habitat containing regionally-important concentrations of a Red-listed EN species where that habitat could be considered a discrete management unit for that species/subspecies.
d) Habitat of significant importance to CR or EN species that are wide-ranging and/or whose population distribution is not well understood and where the loss of such a habitat could potentially impact the long-term survivability of the species.
e) As appropriate, habitat containing nationally/regionally important concentrations of an EN, CR or equivalent national/regional listing.

Information requirements needed to assess against the criteria are largely associated with discrete management units and importance of concentrations or populations.

5.2 POPULATION MANAGEMENT UNITS AND IMPORTANCE

5.2.1 Discrete management unit

The criteria for critical habitat (Tier 1 and 2) reference discrete management units (DMU) for a species. For the purposes of this assessment each catchment where the species has been reported is considered to be a management unit. It is recognised that there may be more than one management unit within each catchment however the available information is insufficient with confirm this aspect.

The analysis to date has identified fourteen (14) DMUs for the species across its range in Lao PDR and Southern China.

5.2.2 Important concentration

The criteria for critical habitat (Tier 2) reference regionally-important concentrations of a species. For the purposes of this assessment a regionally-important concentration has been defined as a population that can be maintained and as such support the recovery of the species, considering the existing and future threats; health and stability of the population and the conservation status of habitat.

In order to recognise the importance of the Nam Ngiep concentration of *L. striolatus* in the context of all DMU concentrations, Warren (2014) undertook an assessment that considered the population status, local and regional threats and protection status for each DMU. The outcomes of the assessment ranked each DMU from 1 to 14 with the lower end of the scale representing more sustainable DMU concentrations. Each DMU was assigned a score. The scoring criteria relating to the threat and conservation factors used in understanding the relative importance of the Nam Ngiep River are summarised in *Table 5.1* and *Table 5.2*. The outcomes of the ranking are summarised in *Table 5.3*. Warren (2014) reports the details of each DMU based on the surveys undertaken, information collated and specialist knowledge. Overall, the Nam Ngiep DMU was ranked number 6 of 14 with a score of 23 (of 33).

Table 5.1 DMU Threat Factor Criteria (Warren 2014)

Threat Type	Score	Score Criteria
Habitat fragmentation and resource over extraction caused by human settlement	1	Stable: slow or indiscernible rate of change up to five years
Infrastructure expansion		
Population pressure on fisheries (exploitative processes)	2	Changing: can be observed in the DMU area of the medium term (4-5 years)
Reduced dry season flows		
Increased sedimentation of habitat	3	Rapid: current and obvious changes in the short term (1-3 years)
Pollutants in waterways		

Table 5.2 DMU Conservation Factor Criteria

Conservation Factor	Score	Score Criteria
DMU location with respect to provincial or national protected area, or conservation zone	1	DMU located almost entirely or is entirely inside a protected area
	2	DMU is within the buffer zone or adjacent to a protected area
	3	DMU is located outside a protected area
DMU degree for human population	1	No or very few villages in the DMU
	2	Clusters of villages in the DMU
	3	Large number of villages or a large urban centre in the DMU
Accessibility of the DMU by humans	1	DMU is remote and access is difficult
	2	DMU is remote but access is not difficult
	3	DMU is readily accessed
Population size (using size classes as an indicator)	1	High degree of mixed sizes, regularly caught
	2	Small to medium sizes caught irregularly
	3	Small sizes caught intermittently
Stability of the population	1	No obvious change in catch size over past 10 years
	2	Noticeable reduction in catch size over past 10 years
	3	Significant reduction in catch size over past 10 years

Table 5.3 DMU Importance ranking summary

	Nam Fa	Xe Bang Fai	Nam Ou	Nam Theun	Nam Ngum	Nam Ngiep	Nam Nga	Xekong	Nam Tha	Nam Ma	Luosuo River (China)	Langcang mainstream	Puwen River (China)	Nam Beng
THREAT FACTORS														
Habitat fragmentation and resource over extraction caused by human settlement	1	2	1	2	2	2	2	2	3	3	3	2	3	3
Infrastructure expansion	1	1	3	3	3	3	2	2	2	2	3	3	3	2
Population pressure on fisheries (exploitative process)	2	3	1	2	2	3	3	2	3	3	3	3	3	3
Reduced dry season flows	2	1	1	1	1	2	2	2	2	3	2	2	2	3
Increased sedimentation of habitat	2	1	2	1	1	2	2	3	2	3	2	2	2	3
Pollutants in waterways	1	1	1	1	1	1	1	2	2	3	2	2	2	2
CONSERVATION FACTORS														
DMU location in a provincial or national protected area, or conservation zone	1	1	1	1	3	3	1	1	1	2	3	3	3	3
DMU human population occupation	1	1	1	2	2	2	2	2	2	2	2	3	2	2
Difficulty of access to DMU	1	1	2	1	2	2	2	2	3	1	3	3	3	3
Large L s population	1	1	2	2	3	2	3	2	3	3	3	2	3	3
Stable L s population	1	1	1	1	3	2	3	2	3	3	3	3	3	3

5.3 CRITICAL HABITAT ASSESSMENT

An assessment of critical habitat for *L. striolatus* within the Project area is required as the species is listed as endangered on the IUCN Red List. In accordance with ADB Source Book the habitat is considered 'critical habitat' if it is required for the survival of the species. The criteria defined by IFC PS6 have been used to guide this assessment. *Table 5.1* summarises the outcomes of screening against the critical habitat assessment criteria and in turn determine if the habitat is considered critical to the survival of the species. The information collated identifies that the habitat associated with the Project area does not meet the threshold for the Tier 1 or Tier 2 criteria, and as such is not considered critical habitat.

Table 5.4 Critical habitat criterion screening – L. striolatus

IFC PS6 Criterion/Threshold	Comment
Tier 1	
(a) Habitat required to sustain >10 percent of the global population of a CR or EN species/subspecies where there are known, regular occurrences of the species and where that habitat could be considered a discrete management unit for that species.	Species population size is not well documented. The specialist studies undertaken, and as summarised in this report, identified a number of locations where the species is known by local villagers that have not been previously reported in literature. A total of 14 discrete management units were identified during specialist studies, including the Nam Ngiep. The population status for the Nam Ngiep DMU reported a noticeable reduction in the past 10 years and only small to medium fish sizes caught irregularly. Through comparison with other DMU population status, where mixed sizes are regularly caught, the Nam Ngiep DMU is **not** considered to support >10 percent of the population.
(b) Habitat with known, regular occurrences of CR or EN species where that habitat is one of 10 or fewer discrete management sites globally for that species.	Village interviews indicate that although rare there are regular occurrences of the species in the Nam Ngiep Collation of information regarding the distribution of the species, and as such the location of populations, identified at least 14 river basins where there are known records of the species occurring. As such this population **is not** one of 10 or fewer discrete management sites globally for the species.
Tier 2	
(c) Habitat that supports the regular occurrence of a single individuals of a CR species and/or habitat containing regionally-important concentrations of a Red-listed EN species where that habitat could be considered a discrete management unit for that species/subspecies.	An assessment of each DMU population status and threats ranked the Nam Ngiep concentration number 6 of 14. In this context DMUs ranked 1-4 are largely those exhibiting evidence of a more stable population with relatively lower localised and regional threats and evidence that the current population has exhibited no, to limited, reduction over the past 10 years. The Nam Ngiep concentration is not considered to be a regionally-important for the survival of the species given the challenges associated with existing threat conditions and the presence of other DMU concentrations more likely to support the recovery of the species.

IFC PS6 Criterion/Threshold	Comment
(d) Habitat of significant importance to CR or EN species that are wide-ranging and/or whose population distribution is not well understood and where the loss of such a habitat could potentially impact the long-term survivability of the species.	Collation of information regarding the distribution of the species, and as such the location of populations, identified at least 14 river basins where there are known records of the species occurring. In considering the current level of threat to each of the DMUs, the Nam Ngiep River is not considered of significant importance to the survival of the species. It is expected that more stable populations are more likely to contribute to the recovery of the species.
(e) As appropriate, habitat containing nationally/regionally important concentrations of an EN, CR or equivalent national/regional listing.	The Nam Ngiep River concentration is not considered to be a regionally-important for the survival of the species given the challenges associated with existing threat conditions and the presence of other DMU concentrations more likely to support the recovery of the species.

The information collated in this report has characterised the distribution of the species (in terms of DMUs) to be wider than previously documented. The recent habitat surveys (Warren 2014b) identified a number of Nam Ngiep tributaries where the species has been reported and habitat is suitable. Some of these, for example Nam Chain and Nam Siam, are unlikely to be impacted by the NNP1 Project.

Distribution of the species within Lao PDR and Southern China indicates that the species is found in a greater number of river basins that previously thought. Up to 14 DMUs have been identified across its range.

While the habitat associated with the Project location does not meet the criteria for critical habitat (and therefore not critical to the survival of the *L. striolatus*), an impact assessment has been undertaken (*Section 6*) given the IUCN status of the species. Mitigation and management options have been investigated that target maintaining the population size for the species and managing the potential impacts and threats to habitat areas upstream of the FSL. These are described in *Section 7.*

Specific to *L. striolatus*, the Project has the potential to impact the population in the Nam Ngiep River in terms of:

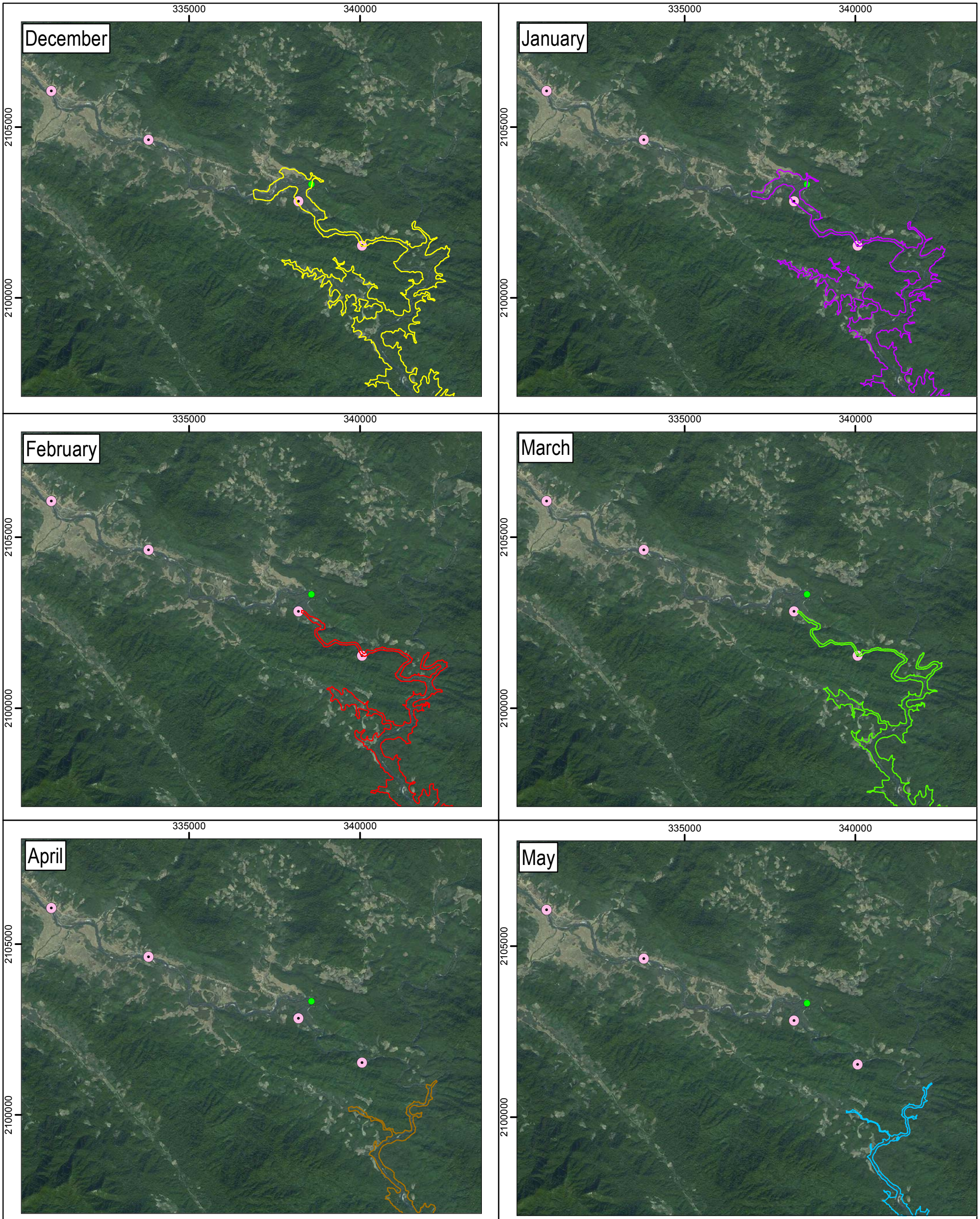
- Loss of habitat, including spawning habitat;
- Permanent fragmentation of habitat; and
- Degradation of habitat.

There are also threats associated with the hydropower infrastructure upstream (Nam Ngiep 2 Hydro Scheme) of NNP1 that may also impact other spawning areas that may occur, though the extent of these effects is unknown.

Approximately 73 km of the Nam Ngiep River will be inundated and the existing lotic habitat will be transitioned to lentic habitat (within the inundation area). The habitat within FSL includes two known spawning areas. Village interviews identified six spawning areas upstream of the FSL and suggest it is likely others would occur. Two are currently known to be within designated fish conservation pools. The interviews also reported the species to occur in the Nam Siam and Nam Chain tributaries of the Nam Ngiep catchment which are unlikely to be impacted by the Project. *Section 2* indicates that spawning habitat is characterised to be shallow, flowing and pebble, gravel or sand. As such inundation is likely to transition these areas to deeper water not necessarily suitable for spawning.

Impact to a breeding area has potential to lead to an adverse impact to the population by limiting opportunity for reproduction and thus survival of the population. An analysis has been undertaken on the inundation of spawning sites within the upper reaches of the Nam Ngiep. During the spawning season (January to April each year), it is likely that 2 of the 3 known spawning locations in the upper reservoir area will not be inundated during this period, indicating that they will likely remain viable following inundation.

Figure 6.1 shows the inundation water levels in the upper reservoir and the location of spawning locations in the upper reservoir area.



Legend

- Fish Conservation Zone
- *L striolatus* Spawning Site

Inundation Area

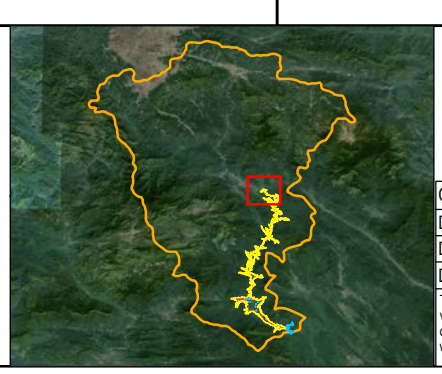
- December
- January
- February
- March
- April
- May

N

0 1 2 3Km

1:100,000

Datum: WGS84



Client:	Nam Ngiep Power Company Ltd.	
Drawing No:	Inundation Area_all.mxd	
Date:	24/06/2014	Drawing Size: A3
Drawn By:	GG	Reviewed By: DN

Figure 7.1 Inundation Area

Nam Ngiep 1 Hydropower Project
Environmental Impact Assessment Revision

Environmental Resources Management ANZ

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

ERM

Consistent with the Project EIS, risk to the species is assessed using the risk assessment matrix shown in *Table 6.1.*

The species is listed as endangered and as such is assigned a sensitivity of *High*. Given that the Project has potential to remove two spawning sites this may have a *Medium* impact to the species population. Removal of spawning habitat is likely to reduce opportunity for recovery of the species. Without any management or mitigation the risk to the species is considered to be *Major*.

Table 6.1 Assessment of risks to Species

Species Sensitivity/Value		Magnitude of Effect			
		Negligible	**Small**	**Medium**	**Large**
Low	Species which are included on the IUCN Red List of Threatened Species as Least Concern (LC) (IUCN 2011).	Not significant	Not significant	Minor	Moderate
Medium	Species included on the IUCN Red List of Threatened Species as Vulnerable (VU), Near Threatened (NT) or Data Deficient (DD) (IUCN 2011). Species protected under national legislation. Nationally restricted range species. Nationally important number of migratory or congregatory species.	Not significant	Minor	Moderate	Major
High	Species included on the IUCN Red List of Threatened Species as Critically Endangered (CR) or Endangered (EN) (IUCN 2011). Species having a globally Restricted Range (i.e. plants endemic to a site or found globally at fewer than 10 sites, fauna having a distribution range (or globally breeding range for bird species) less than 50,000 km². Internationally important numbers of migratory or congregatory species. Key evolutionary species.	Not significant	Moderate	Major	Critical
Magnitude of Effect Definition					
Negligible	*Effect is within the normal range of variation.*				
Small	*Affects a small proportion of a population, but does not substantially affect other species dependent on it, or the populations of the species itself*				
Medium	*Affects a sufficient proportion of a species population that it may bring about a substantial change in abundance and /or reduction in distribution over one or more generations, but does not threaten the long term viability of that population or any population dependent on it.*				
Large	*Affects an entire population or species at sufficient scale to cause a substantial decline in abundance and/or change in distribution beyond with natural recruitment (reproduction, immigration from unaffected areas) may not return that population or species, or any population or species dependent upon it, to its former level within several generations, or when there is no possibility of recovery.*				

7 PROPOSED MITIGATION MEASURES

7.1 APPROACH

Mitigation has been considered for *L. striolatus*. The purpose of the mitigation is to recommend approaches to minimise the magnitude of the impact to the species.

The impacts from the project as defined include:

- Loss of habitat, including spawning habitat;
- Permanent fragmentation of habitat; and
- Degradation of habitat.

7.2 WATERSHED MANAGEMENT ABOVE FULL SUPPLY LEVEL

The key threats identified in the Nam Ngiep River above FSL include: impacts from water releases from the Nam Ngiep 2 Hydro Scheme; fishing and poaching; and impacts on habitat associated from soil erosion, sedimentation and chemical pollution associated with logging, deforestation and agriculture.

The approach proposed for watershed management to protect the species habitat necessary for its lifecycle and mitigate against the threats identified. An adaptive management framework would be necessary to be designed to aid in mitigation against these impacts from the threats. The approach is outlined in *Table 7.1*.

Implementation of this management framework will require a close working relationship with landholders, Ministry of Natural Resources and Environment (MoNRE) and the Nam Ngiep 2 Hydro Power Scheme.

Table 7.1 Watershed Management Framework for L. striolatus

Activity	Action	Responsibility
Research	• Undertake research into the biology of the species, including population size, breeding cycle and habitat requirements. • Undertake a comprehensive assessment of key threats to the species. • Map the suitable deep pools and spawning habitats upstream of the NNP1 FSL, including in the Nam Ngiep tributaries in order to target habitat management in these areas.	NNP1PC
Management	• Develop a management plan for the species in the Nam Ngiep aligned with conservation outcomes for the species and peer reviewed by relevant scientists. • Manage key threats, including impacts to spawning and deep pool habitats from landuse impacts such as	NNP1; MoNRE

Activity	Action	Responsibility
	forestry and agriculture. • Incorporate key actions into the Watershed Management Plan being prepared by MoNRE. • Approach and discuss management actions with NN2 Hydro Power Scheme and NN3 to investigate opportunity for coordinated release. Coordinated release could aim to maintain suitable seasonal depth in key habitat areas. • Align the watershed management program with the captive breeding program (See *Section 6.2.1*).	
Education	• Undertake an education program with local villagers regarding the species, including informing them of the declining population and the requirement for conservation.	NNP1; MoNRE
Monitoring	• Monitoring of the species presence in the Nam Ngiep River (and tributaries) including: population size; threats; effectiveness of education programs; location of spawning sites and water quality should occur on a regular basis.	NNP1; MoNRE
Governance	• NNP1 Offset Advisory Committee to oversee the implementation of the management framework, including reporting and adaptive management approaches to the species conservation.	NNP1PC; MoNRE

These actions would be built into the Watershed Management Plan to be prepared by MoNRE. Consultation with the Nam Ngiep 2 Hydropower scheme should occur as a matter of priority.

7.3 CAPTIVE BREEDING (OPTIONAL)

Captive breeding of *L. striolatus* would have the objective of preserving the genetic resource of the population as well as ensuring that the population could be restocked in the Nam Ngiep River. This measure would guard against future population decline in the river due to threats. This measure is not intended to occur in isolation and will be undertaken with strategic watershed management activities to protect and enhance the habitat with the Nam Ngiep for the species.

Contact has been made with fisheries experts to determine the suitability of captive breeding for the population of *L. striolatus* in the Nam Ngiep River. Dr Morioka from the Japan International Research Center for Agricultural Sciences (JIRCAS) has provided initial advice on the practicality of captive breeding for the species. Contact has also been made with Dr Philippe Cacot from the French Agricultural Research Centre for International Development (CIRAD). Dr Cacot has provided a recommended approach for a scoping study to investigate the potential to captive breed *L. striolatus* (See *Annex E*).

Both of these scientists work with the Living Aquatic Resources Research Centre (LaRREC) in Lao PDR.

The recommendations from Dr Morioka suggest that captive breeding for the species is feasible. The approach would require further ecological assessment of the species lifecycle, including information on the biology of the species and its breeding triggers and population size in the Nam Ngiep River. Capture of mature individuals would then be required to form a captive population of both sexes. For genetic diversity, the number of individuals captured should be representative of the population size (10 or more of each sex has been recommended. Dr Morioka believes that LaRREC has the resources available to undertake the research and captive breeding of the species at their facilities in Vientiane.

The estimated timeframe for research and establishment of breeding stock is around 5 years.

8 RESIDUAL IMPACT TO THE SPECIES

8.1 RESIDUAL IMPACT

Section 7 describes the recommended mitigation specific to the potential impacts to *L. striolatus* in the Nam Ngiep River. The mitigation recommendations focus on maintaining reproduction of the species and protecting the remainder of habitat in the Nam Ngiep River catchment to compensate for the loss of one spawning site within the upper reservoir due to inundation.

The watershed management framework would work toward protection of Nam Ngiep River habitat outside the inundation area from impact associated with habitat degradation, pollution (sedimentation and chemical) and exploitation. This approach would complement the breeding program by maintaining or improving the Nam Ngiep River habitat quality for the sustainability of the population and suitability of the habitat for any released individuals.

These approaches would reduce the magnitude of the effect by contributing to the long term viability of the Nam Ngiep River population (and potential contribute to other populations) resulting in impact to a smaller proportion of the population affected and as such maintaining biodiversity value. Through maintaining suitable habitat in Nam Ngiep tributaries the ecosystem would continue to support the persistence of the species in the catchment.

A captive breeding program (*Section 7.3*) could be used as a last resort to establish a program to preserve the genetic resource while facilitating restocking of the Nam Ngiep River. Given the threats to other known populations of the species as well as potential threats to habitat associated with infrastructure upstream of NNP1, the approach is designed in attempt to guard against future population decline.

Additional conservation efforts are recommended as in-kind offsets. These measures are described in *Section 8.1* and play a role in compensating for the impacts described in Section 6 (loss of a spawning and other habitat, fragmentation of habitat and degradation of habitat) for *L. striolatus*.

8.2 ADDITIONAL CONSERVATION ACTIONS

In-kind offsetting can be used where significant residual losses exist for the species following mitigation. These conservation actions would need to occur to ensure the survival and persistence of the species across its range by improving scientific information on the species lifecycle, managing threats and conserving viable populations.

8.2.1 Species Recovery Coordination

To assist in planning of recovery actions for the species across Lao PDR, it is recommended that a species recovery taskforce for *L. striolatus* be established. This approach would work with Government of Lao to establish a framework for coordination across government agencies to facilitate research and conservation for the species. The recovery taskforce would be led by MoNRE and include key members from DESIA, Department of Forestry and Resource Management, Department of Finance and LaRREC. The key objectives of the committee would be to: coordinate research on the species biology; establish a framework to raise awareness of the species within GoL and the community; work with hydropower companies to promote conservation; coordinate captive breeding programs; and undertake education campaigns across the species range to raise awareness of the conservation status of the species and methods to assist conservation.

8.2.2 Co-management of Nam Theun Population

To offset any residual impacts on the species and to ensure the long term persistence of the species, it is recommended that a co-management program occur in conjunction with the Nam Theun 2 HydroPower Company (NT2).

L. striolatus is not threatened upstream of the NT2 Reservoir as the majority of the watershed is contained within a protected area. During fish population monitoring, young and adult specimens were found 4 years after impoundment upstream of the Reservoir and downstream of the Nakai Dam. The presence of this species upstream of the Reservoir is mainly due to the configuration of the dams.

Preliminary discussions have occurred with Dr Maud Cottet from NT2 regarding potential co-management of the species within the Nam Theun and Nam Ggouang watersheds. The focus of the co-management will be to fund research into the biology of the species; education within the Nam Theun/Nam Ngouang watershed to protect the species from fishing; and establishment or extension of the conservation area.

8.3 RISK AREAS

There are risks associated with the success of each of the approaches identified which must be considered in assessing the suitability of the recommended measures. The risks of each approach are summarised in *Table 8.1.*

These risks are expected to be consistent with mitigation and offset measures of this nature. Through recognising these risks at this stage of planning, it is recommended the mitigation and offset approach incorporate additional measures to manage the risk of potential for failure.

Table 8.1 Mitigation and Offsetting Risks

Mitigation / offset measure	Key risks	Safeguards
Coordination of species recovery	There is not currently a species recovery plan or taskforce for this threatened species in Lao PDR. Risks of failure of this approach relate to the capacity of the Taskforce to be able to implement activities to fulfil the objectives of the recovery plan.	To minimise risk of failure clear objectives must be set for the taskforce with realistic timeframes and funding.
Watershed management	This approach relies on good relationships and cooperation with NN2, landholders and MoNRE. If these relationships and negotiations are unsuccessful it will be difficult to fulfil the aims of this measure.	A strategy for developing and maintaining stakeholder relationships will be developed for implementation. This may include input from specialists. Co-management arrangements may be required
Captive Breeding (Optional)	Preliminary consultation indicates that captive breeding *may* be possible however there are limited examples of captive breeding for this species to draw upon. There are however examples of captive breeding for other large freshwater predatory fish species available. There are facilities and technical specialists suitable to undertake the program locally in Vientiane however additional biological and behavioural information is required prior to trialling the captive breeding. As with all breeding programs there is a risk that the species is difficult to breed in captivity.	This is an inherent risk of captive breeding. To minimise this risk it is recommended that the program is run by experienced specialists and the appropriate level of biological information is obtained prior to inception
	Mature individuals of both sexes are required to form the captured population and further ecological assessment of the lifecycle is required. These activities will need to be completed prior to commencement of the Project. Similarly, given threats to habitat associated with NN2 operations it will be a priority to obtain the necessary fish stock and information while available.	Early negotiations with NN2 will be required to establish a cooperative working relationship whereby information exchange and collaboration is the foundation. A strategy for maintaining the relation will be required.
Co-management of Nam Theun population	This approach relies on good relationships and cooperation with NT2. If these relationships and negotiations are unsuccessful it will be difficult to fulfil the aims of this measure.	As for watershed management

10 CONCLUSION

Luciocyprinus striolatus is a large predatory fish listed as Endangered on the IUCN Red List of threatened species. Recently collected anecdotal evidence (Kottelat 2014; Warren 2014b) for NNP1 EIA biodiversity studies suggest a population of the species occurs in the upper Nam Ngiep area and the Nam Xan catchment, as well as a number of other catchments in Lao PDR.

Globally the species is known from Lao PDR and Southern China. In Lao PDR, the species has been found in upper Xe Kong, upper Nam Kading (Nam Theun and Nam Ngouang), upper Nam Ou, the upper Xekaman, Nam Ngum and upper Nam Tha rivers (Kottelat 2014) and has recently been confirmed in the Nam Fa, Nam Tha and Nam Ma rivers in Luang Namtha Province; Nam Nga in Bokeo Province; Nam Beng in Oudomxai Province; Song Ma River in Houaphan Province; as well as the Puwen River; Luosio and Langcang Rivers in Southern China. The number of DMUs for the species is up to 14 across its range.

Detection of the species in Nam Ngiep River by Kottelat (2014) is the first evidence of the species in this catchment.

Threats to the species relate to alteration of river morphology (including hydropower dams), pollution and exploitation. An assessment of these threats in the context of the known populations of the species identified that all known populations are currently under threat from these activities, including the Nam Ngiep population. The proposed NNP1 Project is an additional threat to spawning habitat for the species. The main dam FSL will inundate the two known spawning habitat areas.

The assessment of critical habitat status for the species within the Project area highlighted the overall paucity of information regarding the population and in particular distribution of the species. Already reported, and additional information collated in this report identified that the concentration of *L. striolatus* in the Nam Ngiep River basin is not considered to meet the criteria for critical habitat.

Mitigation and management options have been identified to limit the likelihood of impact to the species, maintain the population of the species and manage impacts to biodiversity. Implementation of these approaches is considered to reduce the residual impact to the species. In addition to the mitigation measures, conservation actions are also recommended in the form of in-kind offset programs. There are risks associated with the success of each of the mitigation and conservation action proposed and strategies will need to be included during planning phases to manage the risk of potential failure.

10.1 RECOMMENDATIONS

The following recommendations are made regarding *L. striolatus* in relation to the NNP1 Project:

1. Contact should be made with NN2 Hydro power Scheme regarding opportunities for co-management of the species within the Nam Ngiep watershed;
2. Contact with MoNRE and the Lao PDR Fisheries Department should be made regarding the preparation for a Species Recovery Plan for *L. striolatus* within Lao PDR; and
3. Monitoring of the upper inundation area during the spawning period of *L. striolatus* should be undertaken to determine the use of the deep pools and FCZs during this period;
4. Monitoring of the fish population should be undertaken, including assessment of population and abundance from year to year. This should include monitoring of all spawning areas within the catchment (through villager interviews) to determine the persistence of the species;
5. Monitoring of habitat quality should considered to determine the long term viability of the habitat and the success or otherwise of management actions; and
6. Management of the species should be incorporated into the Watershed Management Planning Framework and the Biodiversity Offset Management Plans being prepared for the NNP1 Project.

11 REFERENCES

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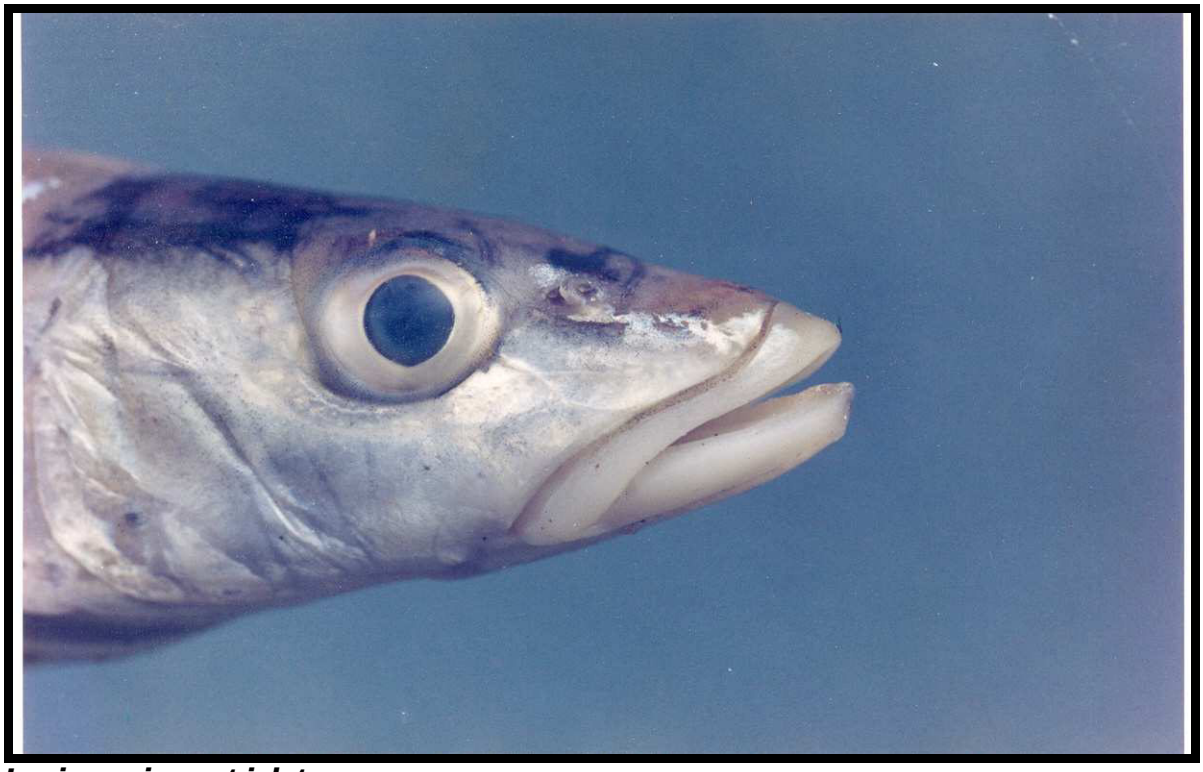
Warren, T. 2014b. Final Report Big Fish – *Luciocyprinus striolatus* (Pba Gooan Sai) Study April 3 to 8 2014. Prepared for Nam Ngiep Power Company

Warren T. 2014c. Final Report on the status of *Luciocyprinus striolatus* (Ls) populations within the Nam Ngiep catchment and adjacent catchments (Phase 1 and Phase 2 studies - April and May 2014)

Annex A

Luciocyprinus striolatus Field Survey Report (Phase 1 and 2) (Warren 2014a)

Final Report on the status of ***Luciocyprinus striolatus*** (Ls) populations within the Nam Ngiep catchment and adjacent catchments (Phase 1 and Phase 2 studies - April and May 2014)



Luciocyprinus striolatus

Prepared by

Mr. Terry J. Warren

For

The Nam Ngiep Hydropower Company Ltd

May 2014

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1 Executive summary

Construction is shortly due to begin on the 290 megawatt (290MW) Nam Ngiep 1 Hydropower Project in Bolikhamxay and Xaysomboun Provinces of the Lao PDR and COD is planned for year 2019. The Project is a joint venture between Kansai Electric Power of Japan, the Electricity Generating Authority of Thailand (EGAT) and the Lao Holding State Enterprise (LHSE) of the Lao PDR.

An Environmental Impact Assessment (EIA) for the NN1 Power Company was prepared by the Environmental Research Institute of Chulalongkorn University (ERIC) in March 2012 and revised by Environmental Research Management (ERM) Siam in January 2014. It was during the course of carrying out extensive field surveys of aquatic biodiversity throughout the Nam Ngiep catchment that at least one species of fish was found to be present that the IUCN (2013) has placed under its endangered (EN) category in its Red List of species. A taxon is placed in the endangered category when the best available evidence indicates that it is facing a very high risk of becoming extinct in the wild.

This report highlights the findings of field surveys carried out in two separate phases during April and May 2014 directed at gaining a much broader understanding of the current pre-impoundment status of populations of ***Luciocyprinus striolatus*** (Ls) in the Nam Ngiep mainstream and its major tributaries within the Nam Ngiep catchment and adjacent catchments. Phase 1 part of the study was carried out over a large geographical area specifically to identify where Ls was found and identify and describe the critical habitats that allow it to carry out essential life-cycle events. Phase 2 part of the study focused on recording detailed information concerning critical habitats on all tributaries and mainstream reaches where populations of Ls were anecdotally reported to be present. These populations are considered to be beyond impacts created by all hydropower development throughout the Nam Ngiep catchment, and immediate adjacent catchments that are thus far unregulated.

This assessment marks the beginning of the process of providing important information in preparing a Critical Habitat Assessment (CHA) for which the developer and stakeholder will need to gain an understanding of the number and condition of other Discrete Management Unit (DMUs) sites throughout the country and the likely threats facing them. Understanding the status of Ls populations other than those inside the Nam Ngiep catchment is important in defining the potential for conservation measures as a biodiversity offset to ensure the persistence of viable populations of Ls in other river systems. Phase 3 studies are currently being planned and will commence shortly to address this issue.

Phase 1 surveys were able to establish that a population of Ls currently resides in the upper Nam Ngiep catchment and that highly defined spawning habitats are found over certain stretches of the mainstream. Although based on anecdotal reports only, the evidence provided by local people on spawning habitat was overwhelming. In almost all cases, the sites where Ls was reported to spawn have also been declared as Fishery Conservation Zones (FCZs) by nearby villages. Between the villages of Ban Pou and Ban Xiengthong, Thathom District a total of seven villages have established 11 FCZs. All the FCZs have been established over deep holes in the river bed at a depth of up to three or four meters during the dry season months. They vary in length from approximate 100 meters to 800 meters and are estimated to be anything from about 30 meters to 80 meters in width. In all cases where reports were provided by local people, spawning takes place between the months of January and April each year, and specifically takes place at the top end of gentle riffle and at the downstream end of deep pools. The actual spawning event itself follows a period of gathering of up to 30 individuals that can easily be observed at a respectful distance along

the river bank. After spawning takes place, masses of adhesive eggs can be observed sticking to rocks and boulders downstream of the deep pool.

A population of Ls is known to be resident in the upper Nam Ngiep catchment and is also found in certain large tributaries such as the Nam Chian and perhaps also the Nam Phouan. At certain times of the year the resident population becomes migratory and it appears that two distinct types of migration take place. The first appears to be a trophic migration involving smaller individuals weighing up to approximately one kilogram. These fish move up and into smaller tributaries such as the Nam Siam and the Nam Gnok at the beginning of the annual flood pulse. They presumably feed on the many other smaller fish species that also enter the tributaries for spawning and foraging, but then totally or almost totally exit the system during the early flood recession period and take up refuge in deep pools in the Nam Ngiep mainstream. When individual specimens have reached sexual maturity, a different type of migration takes place mainly in the Nam Ngiep mainstream. This involves an upstream or downstream movement to a spawning site. After spawning, presumably the fish disperse and assume a relatively solitary existence.

One major impact on Nam Ngiep mainstream Ls populations will be the likely inundation of some of the known spawning sites where Ls is known to breed at the current set NN1 FSL. An important issue that currently remains unknown is whether or not Ls can thrive within a reservoir environment; that is feeding and growth but not spawning. There are numerous examples of riverine Cyprinid fish species that can do this but that must also return to flowing-water habitats in order to breed. Most Cyprinid fish species are wet season spawners and not dry season spawners like Ls. Would it be possible for perhaps 50% of known Ls spawning sites to remain non-inundated and that would allow Ls to return to spawning sites after spending inter-spawning periods feeding in the newly created reservoir? This possible scenario needs to be explored.

As far as is currently known, Ls populations together with many other fish species in the Nam Ngiep and other Mekong tributaries are threatened by a wide range of indirect or background impacts not necessarily associated with dam construction. However, NN1 Project will inevitably impact on fish populations in the Nam Ngiep including populations of Ls. Further hydropower development upstream from the NN1 reservoir may also impact on Ls populations in what remains of the non-inundated sections of the Nam Ngiep through altered hydrology and possibly changes in water quality.

The Nam Ngiep 1 Hydropower Project has the potential to cause extirpation of Ls populations over certain stretches of the Nam Ngiep mainstream, but it will never cause the extinction of the species because it is already known from a number of other catchments throughout the Lao PDR. Further surveys are planned to study these catchments under a Phase 3 stage of this overall study of ***Luciocyprinus striolatus***.

2 Acknowledgements

I would especially like to thank Mr. Souksavanh (Boey) from the Nam Ngiep Hydropower Company Offices in Pakxan, Mr. Vongphet Vilahoun from the District Agriculture and Forestry Offices at Thathom and drivers Mr. Pradith and Mr. Ley for all their helpful assistance during the field work part of this study. I also gratefully acknowledge the help and assistance provided to me by many members of the Nam Ngiep Hydropower Company Offices in Vientiane, including Mr. Cliff Massey, Mr. Apirat Lamsiri from Electricity Generating Authority of Thailand and Mr. Suksumek from the Vientiane Offices. Finally I would like to thank all of the villagers who gave their time for interviews and took us to see special habitats and features of a number of different river systems.

3 Introduction

3.1 General

In a first phase from April 3 to 8 (Phase 1), a survey of the upper Nam Ngiep catchment and upper adjacent catchments (Nam Xan) was made to better understand the likely extent of Ls populations and habitat ranges that might be affected by the Nam Ngiep 1, the NN2 and NN3 Projects. In a second phase, surveys were conducted from April 30 to May 4 that concentrated on the Nam Gnok (Youak), the Houayxay, the Nam Phouan, the Nam Thaen, and the Nam Chian (Jey) within the Nam Ngiep catchment (photos 3646, 3647, 3655 and 3651). The Nam Xan, just outside of the Nam Ngiep catchment was also surveyed during Phase 2 and so far remains unregulated in the middle and lower sections of the river system (photos 3799 and 3797). Both Phase 1 and Phase 2 surveys have been able to identify where Ls is found in the upper Nam Ngiep catchment and the types of habitat that it requires for dry season refuge and spawning (photos 3692, 3703, 3553, 3782, 3761, 3769 and 3757). Fishery Conservation Zones (FCZs) have been established at a number of different sites on the Nam Ngiep mainstream in the upper catchment area and also in the Nam Chian (photos 3553, 3730, 3663, 3782, 3761, 3769 and 3757). In many cases FCZs are designated as such because they represent dry season refuge and spawning habitat for many fish species including Ls. At least eleven FCZs have been visited, photographed and referenced using GPS from Ban Pou to Ban Xiengkhong on the Nam Ngiep mainstream.

3.2 Purpose of the Phase 1 and Phase 2 surveys

The overall purpose of these surveys was aimed at trying to assess the current status of Ls populations and their condition in relation to IFC Critical Habitat Threshold limits. In addition, these surveys aimed to identify how and to what extent the cumulative impacts of NN1, NN2 (photos 3361 and 3408) and NN3 (3461) will affect the population status of Ls throughout the Nam Ngiep catchment. The overall study also aims to apportion certain types of impact created by the three known Nam Ngiep Hydropower Projects currently under different stages of construction.

4 Methodology (Phase 1 and 2)

4.1 Literature search and survey planning

A literature search was carried out prior to beginning any field work. A short report was prepared based on the literature search (Warren 2014a). The field work was planned / based on 1) previous field surveys and studies, 2) the likely Project / inundation area footprint, 3) the unregulated parts of the upper Nam Ngiep catchment and 4) selecting areas where it was thought that Ls might be found based on the presence of specific habitat type in other rivers in the Lao PDR where it is known to exist (the Nam Theun / Kading, the Nam Mouan, the Nam Ngouang, the Nam Ou and the Xe Kong are examples).

4.2 Village interviews

At each of the villages where interviews took place the village chief was contacted and asked for assistance to carry out an interview with five or six people that had knowledge of fishing and fishery issues. This took place on each occasion (photos 3660 and 3793). A detailed description of Ls was provided to interviewees prior to showing any photographs of the fish. Ls is an easy fish to describe because of its size (adult fish weighing up to 30kg), shape and habits (spawning behavior and predatory nature). It was easy to gauge from interviewee reaction whether they knew the fish or not. Some were able to say that they knew it, but it was not found in the river / stream near their village. After the description was provided all

interviewees were shown photographs of the fish previously taken by the author from the Nam Theun and the Nam Ou and one taken by Dr. Maurice Kottelat. All information was recorded in notebooks and typed up each day. Each interview took anything up to 45 minutes to complete. A total of 19 interviews took place in villages during Phase 1 of this study (Warren 2014b) and 12 interviews took place in Phase 2.

5 Results (Phase 1 and 2)

5.1 Nam Ngiep mainstream and tributaries, deep pools and fish migration

The upper Nam Ngiep mainstream represents an aquatic environment where Ls can live and apparently carry out its entire life-cycle within the system. Juvenile Ls are reported present at many locations where surveys took place both in the mainstream Nam Ngiep and certain types of mainstream tributary. Apart from the mainstream Nam Ngiep, two other tributary habitats appear to support Ls populations. One is permanent in that Ls does not seem to leave major tributaries such as the Nam Chian (photos 3730 and 3722), whereas the second represents smaller tributaries that support temporary migratory populations of Ls during the wet season months only (the Nam Siam and Nam Gnok). These migrations mostly consist of smaller Ls individuals weighing up to about one kilogram. Occasionally much larger Ls are captured during these seasonal migrations weighing several kilograms. During the dry season months, all or almost all Ls exit the smaller tributaries and return to dry season refuge habitats (deep pools) in the Nam Ngiep mainstream. Very large Nam Ngiep tributaries such as the Nam Chian and perhaps the Nam Phouan (photo 3663) appear to provide some dry season refuge habitat for Ls and as such do not require that Ls returns to the Nam Ngiep mainstream. Anecdotal evidence strongly suggests that some of the deep pools / FCZs found in large tributaries also represent spawning sites for Ls observed within the last decade at least, and reports were provided to the study team of observed spawning events within the last two or three years at a few sites.

Based on all available evidence, Ls is not found in the Nam Xan from Ban Namphang in Thathom District downstream to Ban Simouangkhoun in Borikham District (photos 3799 and 3797). There is a very remote possibility that Ls is present in the Nam Xan river section upstream from the new access road to the Nam Xan 3B and 3A Hydropower Projects, but this section of river has no villages where interviews could be carried out and is characterized by series of strong rapids and small waterfalls.

5.2 Spawning habitat

Based on observations at other survey sites along the Nam Ngiep mainstream, it seems highly unlikely that the Nam Xan has suitable spawning habitat in the river section described above at 5.1 because there are few if any deep pool habitats with relatively gentle riffle leading away from them in the dry season. Ls is a dry season spawner and apparently breeds between January and April based on anecdotal evidence. Local people from a number of locations have provided evidence based on direct observation that Ls gathers in groups at the top of riffle / gentle rapids just below deep pool environments during both daylight and nighttime prior to spawning. After about one day of gathering, spawning takes place leaving adhesive eggs sticking to rocks scattered over a wide area below the deep pool environment. Female Ls were reported to be considerably larger that males during the period of gathering prior to the spawning event itself (Phase 1 and 2 interviews as part of this study). Based on anecdotal evidence juvenile Ls up to about ten or 15 centimeters in length are often observed or caught around the perimeters of large pools at almost any time of the year, but particularly during the dry season months. This may simply be a time when they are more easily observed and can be caught more easily.

5.3 Preliminary results from investigations into populations of ***L. striolatus*** in China and Vietnam

5.3.1 China

Initial investigations into the presence of Ls populations in China have been undertaken by ERM's Shanghai Offices. A number of people and organizations have contributed to the investigation (see Appendix 3).

Populations of Ls have been found in southern China. They are known from the middle to lower reaches of the Puwen River (a Langcang River tributary) and the Luosuo River (also a Langcang River tributary). Other reports strongly suggest that it is found in the lower reaches of the mainstream Langcang River and other non specified tributaries of it. No information or research has been carried out on the life-cycle of Ls and nothing much is known about it. No other research has been carried out on Ls in China so far. Research is generally quite difficult because Ls is caught so infrequently.

The main threats that Ls populations face in southern China are from overfishing, soil erosion and siltation of rivers, ecological and environmental degradation, pollution, hydropower development and climate change. In China, it is not recognized as a protected species but officials appreciate that it is endangered. It is assigned the category of vulnerable (VU) under China's Red List system. According to one source, fisheries have been banned along the Puwen River due to a local government established national protection zone for Fishery Genetic Resources (2012). However, there are reports that fishing still continues.

5.3.2 Vietnam

Evidence to date strongly suggests that Ls is not present in Vietnam. However, a species belonging to the same genus (***Luciocyprinus langsoni***) is found in Vietnam. As far as is known at present, there are only two species found within the ***Luciocyprinus*** genus. ***L. langsoni*** has been placed in Vietnam's Red List, but the exact category is not known. ***L. langsoni*** has been found in the Ky Cung River located in Lang Son Province in the northern mountainous region of China. According to Vietnamese scientists (Nguyen Van Hao and Ngo Si Van 2001), the difference between ***L. striolatus*** and ***L. langsoni*** is based on the number of stripes along the body, differences in dentition and the number of vertebrae present.

Some of the reasons why it is considered that Ls is not found in Vietnam are that: 1) Ls has specific requirements regarding habitat and is a large, vulnerable fish when fully mature. The terrain and aquatic habitat in southern Vietnam is not suitable for Ls. 2) The river networks in the central highlands are usually narrow, short and are high gradient and lack water in the dry season period. 3) The many hydropower dams built in the region prohibit the existence of large fish of this type. The river networks in the northern highlands represent suitable habitat for Ls, but so far only ***L. langsoni*** has been found. Generally speaking, very little research has been carried out on ***L. langsoni*** to date.

5.4 The physical barriers of the Nam Ngiep catchment population of ***Luciocyprinus striolatus*** and its restricted geographical range

The population of Ls in the upper Nam Ngiep catchment is restricted by the Tad-a-Tong waterfalls and rapids. Above these physical barriers the name of the river changes from the Nam Ngiep (below) to the Nam Ngiow (above). Ls is not present in the Nam Ngiow based on strong anecdotal evidence. This appears to be the limit of its upstream range because it represents a zoogeographical barrier (0325829 / 2133724) and other factors are not necessarily involved.

At present, the lower limits of the geographical range of Ls in the upper Ngam Ngiep mainstream can only be placed at the last reference point based on anecdotal information. This was at the Ban Pou FCZ – Wang Sop Pou - (0338585 / 2103326). Nothing is known about how far downstream Ls populations exist in the Nam Ngiep mainstream downstream of Ban Pou, but it has never been recorded from the Lower Mekong Countries (LMB) in the Mekong mainstream itself as far as the author is aware. It is however reported from the Langcang River (Mekong River) in southern China.

In the Nam Chian (Nam Jey) the known physical range of Ls is from the Nam Jey / Nam Ngiep confluence point to the last anecdotally reported capture of Ls at a "no name" deep pool some way up the rapids - ***Keng Pa Sang*** (0342720 / 2106788). It may persist above this deep pool habitat, but terrain was very difficult to access given the time and resource limitations of the study. The last anecdotally reported presence of Ls was at a deep pool ***Wang Mak*** (0341763 / 2101157) approximately one kilometer above the confluence of the Nam Chian (Nam Jey) and the Nam Ngiep mainstream. Nothing is known about Ls populations below this point in the Nam Ngiep mainstream.

Populations of Ls in the upper Nam Ngiep mainstream and tributaries may represent a single population and not necessarily sub-populations, although this is a possibility in certain large tributaries (Nam Chian and Nam Phouan). A hydropower project is now proposed for the Nam Phouan, but details are not clear at present and construction and operation will probably take place over the coming years.

The Nam Siam, a tributary of the Nam Ngiep mainstream and that had a seasonal migratory population of Ls (trophic migration) will be blocked by the NN2 Main Project Dam (0322177 / 2116873) and Ls will no longer be able to migrate in and out of this stream. Migrations have possibly been disrupted by the construction of the NN2 Main Project that is now well underway.

L. ***striolatus*** will still be able to enter the mainstream tributaries of Nam Phouan and Nam Gnok (Nam Youak) in the upper Nam Ngiep catchment, but only as far as the Nam Phouan Hydropower Project site, if this is to proceed as planned.

The stretch of river between Ban Pou (FCZ ***Wang Sop Pou*** - 0338585 / 2103326) and Ban Xiengkhong (0325632 / 2112784) remains critical in that this river stretch is host to important spawning sites for Ls. The current NN1 FSL will determine which ones will be inundated.

5.5 Conservation intervention

Table 1 Table 1 shows a rank score for various Nam Ngiep and major Nam Ngiep tributary river-sections where conservation intervention strategies may provide protection for populations of ***Luciocyprinus striolatus*** pre- and post NN1 impoundment.

Definition and rank of river stretch based on viable habitat	**Nam Ngiep mainstream locations**	**Tributary locations**	**Rank based on most viable habitat and least risk from threat**
1. This stretch of the Nam Ngiep mainstream consists of deep pool habitats (3 to 5 meters in depth) separated by sections of gentle rapids and riffle. Base substrates are either rocky in areas where rapids are found or sandy and muddy at some deep pool sites. There are seven main villages along this stretch of the river and FCZs have been established at 11 deep pool sites. A number of these deep pools / FCZs are locally recognized as, and confirmed as spawning sites for Ls.	1. The stretch of river between Ban Pou (coordinates available later) and Ban Xiengkhong (0325632 / 2112784).		RANK 1. 1. This river section is placed under Rank 1 because it represents critical spawning habitat and deep pool refuge habitat for Ls. BUT, approximately half of this habitat is under severe threat due to inundation from present NN1 FSL. The river sections that will remain non-inundated should remain under Rank 1. NN2 and NN3 HPP's can be expected to impact on this river stretch, but until more is known about how both project's will be operated, more detail on conservation intervention cannot be provided at present.

Table 1 …. continued

Definition and rank of river stretch based on viable habitat	Nam Ngiep mainstream locations	Tributary locations	Rank based on most viable habitat and least risk from threat
2. This stretch of major tributary river undoubtedly contains several deep pool habitats that act as vital dry season refuge sites for Ls. One deep pool (***Wang Mak***) is reported to be 13 meters deep in the dry season months. This may mean that Ls does not need to return to the Nam Ngiep mainstream deep pools as local knowledge suggests. However, Ls found there may still represent part of the Nam Ngiep Ls population. Of all six deep pools surveyed over this stretch of river, only one has been designated as an FCZ.		2. The stretch of the Nam Chian (Nam Jey) between the confluence point of the Chian / Ngiep (0342042 / 2100812) and the deep pool (0342720 / 2106788) at the ***Keng Pa Sang*** rapids (same coordinates as above).	RANK 1. 2. This river section is placed under Rank 1 because it contains several important deep pools that Ls uses for dry season refuge: 1. ***Wang Mak*** (0341763 / 2101157) is not an FCZ and may be inundated by NN1 FSL. 2. Two deep pools (no names) connected to each other (0342738 / 2104483) approximately 1.3 kilometers downstream of the road-bridge over the Nam Chian. Neither are FCZs. 3. ***Wang Kok Hai*** (0342776 / 2104706) approximately one kilometer downstream of the road-bridge over the Nam Chian and not an FCZ. 4. ***Wang Sangouan*** (0342182 / 2105901) and formerly known as ***Wang Tang Kham*** before it was made an FCZ in 2009 and is an FCZ. 5. ***Wang*** at the ***Keng Pa Sang*** rapids, not an FCZ (0342720 / 2106788). It is likely that ***Wang Mak*** will be inundated by NN1 FSL and if so, then important deep water habitat will be lost. Other deep pools upstream from ***Wang Mak*** may be above the NN1 FSL inundation limit.

Table 1 …. continued

Definition and rank of river stretch based on viable habitat	Nam Ngiep mainstream locations	Tributary locations	Rank based on most viable habitat and least risk from threat
3. The Nam Gnok (Nam Youak) is joined by the Houay Xay which is a small stream of approximately 10 to 15 meters wetted width in the dry season. It has several deep pools (< 1.5 meters deep) and long stretches of rapids and riffle. This stream is used by small Ls (≤ 1.0kg) during the wet season months for foraging, trophic type migrations. Ls does not stay in this stream during the dry season because habitat is not suitable (shallow and perhaps warm water).		3. The stretch of river between the Nam Gnok (Nam Youak) – Nam Ngiep confluence point (0334902 / 2069915) and Ban Houay Xay (0323385 / 2070823).	RANK 1. This stream is placed under Rank 1 because it is unregulated and there are no immediate plans for water-related development as far as known in year 2014. It is highly likely that the lower reaches of the Nam Gnok will be inundated by NN1 FSL, but it may still represent important foraging ground for Ls IF it is capable of living and feeding in the reservoir environment.

Table 1 …. continued

Definition and rank of river stretch based on viable habitat	Nam Ngiep mainstream locations	Tributary locations	Rank based on most viable habitat and least risk from threat
4. The Nam Phouan is a large Nam Ngiep tributary up to 30 or 40 meters wide and contains many deep pool habitats, and Ls has reportedly been caught in at least one of these close to Ban Sopphouan.		4. The stretch of river between the Nam Phouan – Nam Ngiep confluence point (0334762 / 2077310) and ***Wang Pba Deng*** (0334222 / 2077752) and beyond this point (not surveyed).	RANK 2. This stream is placed under Rank 2 because it is large deep pool / rapids and riffle stream. Ls are known to take up partial residence in the dry season months, but most fish probably return to the Nam Ngiep mainstream to dry season refuge habitats during the early to mid low water period. It has just been recently announced (late May 2014) that the Nam Phouan is being targeted for hydropower development. Conservation efforts may still be important for this major stream depending on where the hydropower plant will be located. ***Wang Pba Deng*** was designated as an FCZ in 2010 but was abandoned two years ago due to continued use of illegal fishing practices (bombs and electrical devices).
5. The Nam Ngiep mainstream between the NN2 Main Project discharge point and upstream to Ban Keokoang. Ls is known to be present between these two locations and exists as deep pools and sections of rapids and riffle.	5. The stretch of the Nam Ngiep mainstream between the NN2 discharge point (0322177 / 2116873) and Ban Keokoang (0328773 / 2129165).		RANK 3. This river stretch is placed under Rank 3 because it is threatened by upstream hydropower development, altered hydrology (de-watering) and possible changes to water quality. More detail on how the NN2 and NN3 companies intend to operate their dams is required.

Table 2 Table 2 provides a background summary of the main hydropower projects under construction or proposed in the Nam Ngiep catchment and the Nam Xan catchment.

Dam name	Catchment (map name)	Tributary name (local)	Coordinates
Nam Ngiep 3	Nam Ngiep	A tributary (s) of the Nam Ngiep	0326818 / 2134811 (at one end of the dam itself).
Nam Ngiep 2 Tributary Diversion Project.	Nam Ngiep.	Nam Sen	0319877 / 2128351 (looking at dam wall and into main reservoir.
Nam Ngiep 2 Main Project.	Nam Ngiep / Nam Siam.	Nam Siam	0322177 / 2116873 (looking straight at the dam construction).
Nam Ngiep 1 Project.	Nam Ngiep.	Mainstream Nam Ngiep	Coordinates not known at present but are available from NN1 Project offices.
Nam Chane Project (large bill board on route 1D). The Nam Chian (Nam Jey) HPP.	Nam Ngiep.	Nam Chian / Nam Chane (map and billboard names respectively) and my vernacular name for what I hear is Nam Jey.	0348126 / 2117801 (looking straight at the “V” walls of the dam under construction).
Nam Sane 3B Project (large billboard on route 1D). The Nam Xan 3B HPP.	Nam Xan.	Mainstream Nam Xan.	0354851 / 2110929 (looking directly at the dam under construction).
Nam Sane 3A Project (large billboard on route 1D). The Nam Xan 3A HPP.	Nam Xan	Mainstream Nam Xan.	0359249 / 2115479 (looking directly at the dam under construction).

Table 3 Table 3 presents a list of the eleven FCZs established by seven villages from Ban Xiengkhong downstream to Ban Pou on the Nam Ngiep mainstream.

Name of village closest to and responsible for the FCZ (descending order downstream from NN2 Main Project)	**Local name of FCZ**	**Coordinates**
Ban Xiengkhong	Xiengkhong FCZ (III) ***Wang***?	0325360 / 2113485
Ban Xiengkhong	Xiengkhong FCZ (II) ***Wang Hin Ngon***	0326019 / 2110950
Ban Xiengkhong	Xiengkhong FCZ (I) ***Wang Khouak***	0326443 / 2112467
Ban Viengthong	Viengthong FCZ (I) ***Wang Saphan***	0326723 / 2108798
Ban Naxong	Naxong FCZ (II) ***Wang Gua***	0328767 / 2106968
Ban Naxong	Naxong FCZ (I) ***Wang Ngiow***	0329194 / 2106856
Ban Thaviang Sai	Thaviang Sai FCZ (II) ***Wang Tham***	0330969 / 2106060
Ban Thaviang Sai	Thaviang Sai FCZ (I) ***Wang Sop Pang***	0331352 / 2105565
Ban Phiangta	Phiangta FCZ (I) ***Wang Som Lom***	0333814 / 2104624
Ban Hat Sam Khon	Hat Sam Khon FCZ (I) ***Wang Hat Sam Khon***	0335830 / 2103908
Ban Pou	Pou FCZ (I) ***Wang Sop Pou***	0338585 / 2103326

Table 4 Table 4 shows where Ls spawns in the Nam Ngiep tributaries and Nam Ngiep mainstream and where there is temporary dry season habitat and temporary wet season habitat.

a) Nam Gnok (Nam Youak) and Houay Xay – Nam Youak is a tributary of the Nam Ngiep and Houay Xay is a tributary of the Nam Gnok

Ls spawning habitat outside of hydropower development	**Temporary or permanent Ls dry season refuge habitat (deep pool) but not recognized as spawning habitat outside of hydropower development**	**Village / site reference. Temporary Ls wet season habitat outside of hydropower development**	**Stream name**	**Coordinates**
None reported during survey.	At least one deep pool between Ban Houayxay and confluence point with Nam Youak.	Ban Houayxay. Yes, Ls reported present here each year in wet season (mostly small around 1kg).	Houayxay (stream that joins the Nam Youak).	0323385 / 2070823 (Village). 0325059 / 2070772 (deep pool not FCZ)).
None reported during survey.	Two deep pools referenced between Ban Nam Youak and confluence point with the Houay Xay.	Ban Nam Youak. Yes, Ls reported present in this stream, but only during wet season. Ls moves back to Nam Ngiep by early to mid dry season.	Nam Youak (stream that flows into Nam Ngiep).	0331551 / 2071102 (Village). 0328434 / 2071085 (deep pool not FCZ). 0330260 / 2071127 (deep pool not FCZ).

b) Nam Phouan is a major tributary of the Nam Ngiep mainstream

Ls spawning habitat outside of hydropower development	**Ls dry season refuge habitat (deep pool) but not recognized as spawning habitat outside of hydropower development**	**Village / site reference. Temporary Ls wet season habitat outside of hydropower development**	**Stream name**	**Coordinates**
None reported during survey.	One deep pool (***Wang Pba Deng***) referenced approximately 1km upstream from Nam Phouan – Nam Ngiep confluence point. May represent a dry season refuge habitat.	Ban Sopphouan. Yes, Ls reported from this stream and caught in both dry and wet season. If deep pools are very large and deep, Ls stays throughout dry season.	Nam Phouan (stream that flows into Nam Ngiep).	0334373 / 2076996 (Village). 0334222 / 2077752 (***Wang Pba Deng*** no longer FCZ and abandoned two years ago).

b) Continued ….

Ls <u>spawning</u> habitat outside of hydropower development	**Ls dry season refuge habitat (deep pool) but not recognized as spawning habitat outside of hydropower development**	**Village / site reference. Temporary Ls wet season habitat outside of hydropower development**	**Stream name**	**Coordinates**
None reported during survey.	One deep pool (***Wang Hong Mor***) referenced 300 meters downstream from Ban Sopphouan on the Nam Ngiep mainstream. Definite Ls dry season refuge habitat.	Ban Sopphouan. Not defined as a wet season habitat but Ls probably pass through it.	Nam Ngiep mainstream.	0334373 / 2076996 (Village). 0334403 / 2076753 (***Wang Hong Mor*** no longer FCZ and abandoned two years ago).

c) Nam Chian (Nam Jey) is a major tributary of the Nam Ngiep, and Nam Long a right-bank tributary of the Nam Chian

Ls <u>spawning</u> habitat outside of hydropower development	**Ls dry season refuge habitat (deep pool) but not recognized as spawning habitat outside of hydropower development**	**Village / site reference. Temporary Ls wet season habitat outside of hydropower development**	**Stream name**	**Coordinates**
Not reported at this location.	Deep pool adjacent to road bridge (route 1D) over Nam Chian. Definite entire dry season habitat. Ls stays and does not go back to Nam Ngiep.	Road bridge (route 1D) over the Nam Chian.	Nam Chian (stream that flows into Nam Ngiep).	0342182 / 2105901 (FCZ / bridge). Formerly called ***Wang Tang Kham*** (now is FCZ and known as ***Wang Sangouan*** at the bridge).
Not reported at this location.	Deep pool approximately 2km upstream from road bridge / FCZ. Ls reported to stay in deep pool over entire dry season.	***Keng Pa Sang*** rapids just above deep pool in column 2. No name for deep pool.	Nam Chian (stream that flows into Nam Ngiep).	0342720 / 2106788 (Not an FCZ).

c) Continued …..

Ls <u>spawning</u> habitat outside of hydropower development	**Ls dry season refuge habitat (deep pool) but not recognized as spawning habitat outside of hydropower development**	**Village / site reference. Temporary Ls wet season habitat outside of hydropower development**	**Stream name**	**Coordinates**
None reported at this location.	Not a dry season refuge point.	Rapids just upstream from the Nam Chian road bridge and FCZ. Ls can pass rapids (bi-directional) only in wet season.	Nam Chian (stream that flows into Nam Ngiep).	0342199 / 2106137 (Rapids, no name).
None reported at this location.	Deep pool approximately 1.3km downstream below Nam Chian road bridge. No name for deep pool.	Deep pool on Nam Chian.	Nam Chian (stream that flows into Nam Ngiep).	0342738 / 2104483 (Deep pool).
None reported at this location.	Deep pool (***Wang Kok Hai***) approximately 100m above the deep pool mentioned above towards the Nam Chian road bridge. Very important entire dry season refuge habitat for Ls.	Deep pool on Nam Chian. Ls can pass (bi-directional) though it in wet season.	Nam Chian (stream that flows into Nam Ngiep).	0342776 / 2104706 (Deep pool, ***Wang Kok Hai***).
None reported at this location.	Ford crossing point through Nam Chian approximately 4km downstream from road bridge over the Nam Chian. Deep pool, but not important for Ls.	Deep pool on Nam Chian. Ls can pass (bi-directional) though it in wet season.	Nam Chian (stream that flows into Nam Ngiep).	0342147 / 2104072 (Ford crossing point through Nam Chian. Deep pool but not FCZ).
None reported at this location.	Right-hand bank tributary of the Nam Chian close to the road bridge over the Nam Chian. Ls does not enter this stream at any time of the year.	Right-hand bank tributary of Nam Chian.	Nam Long (stream that flows into Nam Chian	0342135 / 2105400 (Approximately 100m upstream from confluence with the Nam Chian).

c) Continued …..

Ls <u>spawning</u> habitat outside of hydropower development	**Ls dry season refuge habitat (deep pool) but not recognized as spawning habitat outside of hydropower development**	**Village / site reference. Temporary Ls wet season habitat outside of hydropower development**	**Stream name**	**Coordinates**
None reported at this location.	Not reported at this location.	The confluence point of the Nam Chian and the Nam Ngiep (about 7km downstream from Ban Pou). Ls can pass through this area in both the dry and wet season (bi-directional).	Nam Chian and Nam Ngiep.	0342042 / 2100812 (Confluence point of Nam Chian and Nam Ngiep.
None reported at this location.	Very important dry season refuge habitat and deep pool (***Wang Mak***) approximately 1km upstream from the confluence point on the Nam Chian. Ls can stay here throughout the dry season instead of going back to the Nam Ngiep.	Ls can pass through this area (bi-directional) in wet season.	Nam Chian.	0341763 / 2101157 (***Wang Mak*** deep pool and not an FCZ).

d) Nam Ngiep mainstream from Ban Xiengkhong to the Nam Chian – Nam Ngiep confluence point, and the Nam Thong (Nam Thaeng)

Ls <u>spawning</u> habitat outside of hydropower development	**Ls dry season refuge habitat (deep pool) but not recognized as spawning habitat outside of hydropower development**	**Village / site reference. Temporary Ls wet season habitat outside of hydropower development**	**Stream name**	**Coordinates**
None reported at this location.	Dry season refuge point (Xiengthong FCZ III)	Ls can pass through (bi-directional) during wet season months.	Nam Ngiep mainstream.	0325360 / 2113485 (FCZ)
None reported at this location.	Dry season refuge point (Xiengthong FCZ II – ***Wang Hin Ngon***).	Ls can pass through (bi-directional) during wet season months.	Nam Ngiep mainstream.	0326019 / 2110950 (FCZ)

d) Continued …..

Ls <u>spawning</u> habitat outside of hydropower development	**Ls dry season refuge habitat (deep pool) but not recognized as spawning habitat outside of hydropower development**	**Village / site reference. Temporary Ls wet season habitat outside of hydropower development**	**Stream name**	**Coordinates**
Dry season spawning site for Ls.	Dry season refuge point (Xiengkhong FCZ I – ***Wang Khouak***).	Ls can pass through (bi-directional) during wet season months.	Nam Ngiep mainstream	0326443 / 2112467 (FCZ)
None reported at this location.	Not a dry season refuge point (Nam Thong)	Ban Sanphouxai. Ls can pass through (bi-directional) during wet season months.	Nam Thong mainstream	0322554 / 2107531 (Village).
None reported at this location.	Not a dry season refuge point (Nam Thong).	Ls can pass through (bi-directional) during wet season months. Ls enters Nam Thong in wet season but only in the lower reaches.	Nam Thong flows into the Nam Ngiep at Ban Viengthong.	0327201 / 2108765 (Nam Thong – Nam Ngiep confluence point).
None reported at this location.	Dry season refuge point (Viengthong FCZ I – ***Wang***?	Ls can pass through (bi-directional) during wet season months.	Nam Ngiep mainstream.	0326723 / 2108798 (FCZ).
None reported at this location.	Dry season refuge point (Naxong FCZ II – ***Wang Gua***).	Ls can pass through (bi-directional) during wet season months.	Nam Ngiep mainstream.	0328767 / 2106968 (FCZ).
Dry season spawning site for Ls.	Dry season refuge point (Naxong FCZ I – ***Wang Ngiow***).	Ls can pass through (bi-directional) during wet season months.	Nam Ngiep mainstream.	0329194 / 2106856 (FCZ).
Dry season spawning site for Ls before road construction in 2003.	Dry season refuge point (Thaviang Sai FCZ II – ***Wang Tham***).	Ls can pass through (bi-directional) during wet season months.	Nam Ngiep mainstream.	0330969 / 2106060 (FCZ).

d) Continued ….

Ls <u>spawning</u> habitat outside of hydropower development	**Ls dry season refuge habitat (deep pool) but not recognized as spawning habitat outside of hydropower development**	**Village / site reference. Temporary Ls wet season habitat outside of hydropower development**	**Stream name**	**Coordinates**
None reported at this location.	Dry season refuge point (Thaviang Sai FCZ I – ***Wang Sop Pang***).	Ls can pass through (bi-directional) during wet season months.	Nam Ngiep mainstream.	0331352 / 2105565 (FCZ).
Dry season spawning site witnessed in 1988 / 89.	Dry season refuge point (Phiangta FCZ I – ***Wang Som Lom***).	Ls can pass through (bi-directional) during wet season months.	Nam Ngiep mainstream.	0333814 / 2104624 (FCZ).
Dry season spawning site for Ls.	Dry season refuge point (Hat Sam Khon FCZ I – ***Wang Hat Sam Khon***).	Ls can pass through (bi-directional) during wet season months.	Nam Ngiep mainstream.	0335830 / 2103908 (FCZ).
None reported at this location.	Dry season refuge point (Pou FCZ I – ***Wang Sop Pou***).	Ls can pass through (bi-directional) during wet season months.	Nam Ngiep mainstream.	0338585 / 2103326 (FCZ).
Dry season spawning site for Ls.	Dry season refuge point (***Wang Hat Ken Tow***). Point on Nam Ngiep mainstream between Ban Pou and the Nam Chian – Nam Ngiep confluence point.	Ls can pass through (bi-directional) during wet season months.	Nam Ngiep mainstream.	No direct reference because cannot be easily accessed.

6 Discussion

Luciocyprinus striolatus is a predatory Cyprinid fish species capable of reaching lengths of over one meter and weighing just in excess of 30 kilograms within the Nam Ngiep catchment. There were no reports of specimens weighing more than this after conducting interviews in 31 villages. Its preferred dry season habitat is deep pools up to about five meters in depth. Overwhelming anecdotal evidence gathered during surveys in April and May 2014 suggests that viable populations of Ls are still present in the Nam Ngiep mainstream and other tributaries of it. Juvenile Ls up to about one kilogram enter smaller tributaries (Nam Siam and Nam Gnok) on what appears to be a trophic migration during the early to late wet season period (May to about October). This is during a period when many other fish species (some of them small and weighing only two to three hundred grams each also enter tributaries for either spawning or for foraging. It may be the case that Ls juveniles find it easier to locate prey in certain types of tributary habitat rather than foraging in swiftly flowing currents during the wet season period in the Nam Ngiep mainstream. At the end of the wet season period Ls migrates back downstream again in most tributaries to dry season refuge habitats in the Nam Ngiep mainstream. However, some large Nam Ngiep tributaries such as the Nam Chian (Nam Jey) can also provide deep pool habitats during the dry season months and many fish species, including Ls, likely remain there and do not move back to the deep pools of the Nam Ngiep mainstream. When Ls reaches sexual maturity at about four or five kilograms in body weight for females, Ls probably then undertakes a spawning migration to a special habitat type and reproduces. It is not known if adult Ls return or 'home' to parental spawning sites.

The Nam Ngiep 1 Hydropower Project will block the Nam Ngiep mainstream close to Ban Hatsaykham with a 148 meter high dam. A re-regulation dam and reservoir will represent a year-round insurmountable barrier to almost all bi-directional fish movement in the downstream sections of the Nam Ngiep mainstream. This will have important implications for local fisheries in general and will involve a transition from a riverine fishery based on migratory and sedentary fish species to a static water fishery. This issue needs to be addressed under a separate study and anyway does not appear to affect Ls populations immediately apart from the inundation of known spawning habitats that will be lost through inundation due to NN1 FSL from about Ban Pou to about Ban Naxong (320 meters asl). One important question that remains unanswered from the Phase 1 and 2 surveys is; "can Ls survive in a reservoir environment and still gain seasonal access to historical spawning grounds that remain in free-flowing areas above NN1 FSL inundation? If so, could a population survive if all other factors remain equal?". Other riverine / rheophilic Cyprinid fish species **were** able to do this in the Nam Ngum 1 reservoir before access to the free-flowing feeder rivers were blocked by further upstream hydropower development. In theory, if at least half of the deep pools / FCZs / potential spawning grounds remain non-inundated between Ban Nam Pou and Ban Xiengkhong (photos 3782, 3761, 3769, 3757 and 3763) then perhaps there would be the possibility of a population of Ls surviving above the NN1 FSL. This of course will depend on what hydropower development takes place upstream of NN1 FSL and how it will be operated and managed (NN2 and NN3 Projects). Both the NN2 and NN3 Hydropower Projects have the **potential** to alter natural hydrological regimes and possibly produce changes in water quality in the Nam Ngiep mainstream where Ls is currently known to breed and carry out other essential life-cycle events.

Apart from the direct impacts that the NN1 Hydropower Project may have on populations of Ls throughout the Nam Ngiep catchment in the future, a number of indirect or background impacts have already taken place over the past two to three decades at least. Some of the most important ones involve catchment deforestation, indiscriminate use of illegal fishing methods (fishing using electrical devices, use of home-made bombs and use of fish toxins and anesthetics to catch fish), human population expansion linked to increased fishing

pressure (semi-commercial fish as opposed to subsistence fishing), pollution arising from a number of sources and general environmental degradation caused by widespread road and infrastructure development. Dam construction is having a major impact on fisheries and populations of Ls throughout the Nam Ngiep catchment and will continue to do so in the future, but it is not the only cause of a decline in fisheries in general that includes Ls populations. Reduced dry season flows, attributable to deforestation and perhaps changes in climate also represent major concerns for the viability of wilderness fish populations throughout the Lao PDR in general including the Nam Ngiep catchment.

This study is aimed specifically at populations of Ls throughout and within the Nam Ngiep catchment, but this is not the only geographical area where Ls populations are either known or thought to exist. Ls was first described from specimens caught in rivers in southern China (Yunnan Province) and is also reported to be present in upland river systems along the Annamite mountain range in neibouring Vietnam. Of even more importance to the Lao PDR, populations of Ls are found in at least the Nam Ou, the Nam Theun-Kading-Mouan-Ngouang system and the Xe Kong catchments. Its presence is also strongly suspected in the Nam Tha in Louang Nam Tha Province.

In a worst case scenario, the Nam Ngiep 1 Hydropower Project has the potential to bring about localized extirpation of this fish species over certain river stretches simply because it will inundate places where it spawns and lives during the annual dry season period. It will not cause, and could never cause the extinction of this species. Nothing is known about sub-species of this fish or even if they exist at all. Ls does appear to be resident in some other large Nam Ngiep tributaries that provide it with the types of habitat that it requires to carry out various critical life-cycle events (Nam Chian). The final decision, if not already made, on the height of NN1 FSL may prove very important to the continued existence of Ls populations in the Nam Ngiep mainstream. Of equal importance in maintaining a population of Ls in the Nam Ngiep mainstream will be to establish a close dialogue with the companies operating upstream hydropower projects (NN2 and NN3). Throughout the Nam Ngiep catchment, it may be possible to maintain a viable population of Ls even with the NN1 Hydropower Project in place, unless these populations become impacted by other events and activities not necessarily related to, or perhaps directly related to dams.

7 Conclusions

- ***Luciocyprinus striolatus*** populations are still present (May 2014) in the Nam Ngiep catchment and are found in certain types of large upper Nam Ngiep tributaries.
- The upper Nam Ngiep mainstream represents an aquatic environment where Ls can live and apparently carry out its entire life-cycle within the system.
- It is not yet known if it might be possible for Ls to thrive in a reservoir habitat outside of its known breeding period. If this could be demonstrated in some way, and linked presumably to its apparent absolute requirement to return to flowing water habitat in order to reproduce, this may have vital implications regarding its future existence within the Nam Ngiep catchment even if hydropower development continues as planned.
- The actual size of the population cannot be enumerated using known methods at present because it is caught infrequently and at some sites it is only encountered two or three times per year based on anecdotal reports.
- Because it is a large Cyprinid species, it is highly probable that it takes several years to reach sexual maturity (females at least). This, along with many other Mekong Basin giant fish species makes it highly vulnerable to the impact of over-fishing.
- Juvenile Ls (up to about one kilogram) appear to make a trophic migration into certain types of small tributary (Nam Siam and Nam Gnok) during the wet season months from May to October. However, there is sufficient anecdotal evidence to suggest that

Ls does not remain in these smaller tributaries and in fact moves back downstream again at the end of the wet season to take up residence in deep pools in the Nam Ngiep mainstream over the dry season period.

- There appear to be deep pool habitats in certain tributaries (Nam Chian and perhaps Nam Phouan) where Ls takes up residence during the dry season period and does not move back to the Nam Ngiep mainstream.
- Breeding almost certainly takes place during the dry season months of January to April each year at the top end of riffle sections at the downstream end of deep pools. Despite similarity of habitat to known places where Ls breeds, Ls does not appear to breed at **all** of the deep pool / riffle habitats surveyed in April and May 2014 based on information obtained during interviews.
- Ls populations throughout the Nam Ngiep catchment are threatened by a wide range of impacts including, but certainly not limited to hydropower development only.
- Upstream hydropower development (NN2 and NN3 Projects) have the potential to negatively impact on populations of Ls above NN1 FSL.
- Zoogeographical barriers to Ls movements are present in the Nam Ngiep and some of its tributaries in the form of powerful rapids and waterfalls (Nam Chian).
- Based on all available evidence to date, Ls does not appear to be resident in the Nam Xan from Ban Namphang to Ban Simouangkhoun that confluences with the Mekong at Pakxan. The reasons for this are unknown but may be related to elevation-temperature and shallow water during the dry season months.
- Upstream dam construction is producing high levels of siltation in the Nam Ngiep and the Nam Xan and has done so during the past three years at least. It is not known if this has impacted Ls populations or not.
- According to local sources, the establishment of eleven FCZs from Ban Pou to Ban Xiengkhong has been effective over the past decade in providing a measure of protection for fisheries resources. Some of the eleven FCZs will be inundated by the current NN1 FSL prediction.
- The artificial breeding of Ls remains an intriguing and challenging task, but it will be of very limited value or even useless unless the causes of the assumed decline in populations of Ls are addressed to begin with.

8. Recommendations

- Contact should be made with other hydropower companies in other river catchments within the Lao PDR or elsewhere that are running fisheries monitoring programs and that are known, or were known to have resident populations of Ls before impoundment took place. Every effort should be made to establish conclusive evidence if Ls is able to thrive in a reservoir environment outside of its normal spawning period.
- Efforts must be made to identify viable populations of Ls at as many other discrete river catchment areas as possible within the Lao PDR where Ls populations are thought to have a high probability of being resident (see Table 5 below). The objective of a Phase 3 part of this overall study will be to assess the persistence of Ls across its range in Lao PDR and define the potential for conservation measures as a biodiversity offset to ensure the persistence of viable populations of Ls in other discrete river catchments.
- As a recommendation (more of a suggestion) it must be stated that the lower the NN1 FSL can be set at, there will be more of a positive benefit regarding protection of Ls spawning and dry season refuge habitat. It is acknowledged that the NN1 FSL may need to be fixed based on optimum hydropower output and or economics.

- All efforts need to be directed towards establishing exactly what the NN1 FSL level will be and maps produced so that the impacts of inundation of Ls habitat can be best assessed.
- Effort and money spent on an artificial breeding program for Ls may be better directed towards protecting the known habitats where Ls spawns and lives. Also, it would be highly desirable to know if Ls can live within a static reservoir habitat.
- Direct dialogue must be established with the NN2 and NN3 Projects to understand exactly how these projects will be operated and managed.

Table 5 Table 5 shows a number of discrete river catchments (Discrete Management Units – DMUs) in various provinces placed in the rank of high probability of occurrence but adjusted for a priority rating based on selection criteria that will be surveyed in Phase 3 of the present study.

Name of province and name of discrete catchment	Priority rank and priority rating	Selected for by rank based on certain criteria
Luang Namtha Nam Tha catchment, the Nam Fa catchment and the Nam Ma catchment. ***Three possibilities, but Nam Tha is priority***.	High (1)	Province of Luang Nam Tha is bordered by Yunnan Province in China to the north where Ls was first described from in 1986. The Phou mountains range runs along the China / Lao border. Mountainous areas. December – February temperatures as low as 5 degrees Celsius. Northern Highlands zone elevations between 1,000-2,000 meters asl. Large tracts of dense forest on mountain slopes. Three large rivers drain westwards / southwards into the Mekong; Nam Tha, Nam Fa and Nam Long. Province known for its very wide range of wildlife. Easily accessed by air travel. Good communications / good roads.
Bokeo Nam Ngam (Nam Nga) catchment.	High (2)	Province of Bokeo borders Luang Namtha Province to the northeast, Oudomxai Province to the east and Xaignabouli Province to the south. The protected areas in Bokeo Province are characterized by mixed deciduous forest and mountainous terrain with elevation ranging from 500 to 1500 meters asl. Wildlife is in abundance throughout the province and the largest river that passes through the province is Nam Nga. Road access is reasonable and air connections with the capital needs to be checked (map).
Oudomxai Middle and upper Nam Beng catchment.	High (2)	Province Oudomxai borders China to the north, Phongsali Province to the northeast, Luang Prabang Province to the east and southeast, Xaignabouli Province to the south and southwest, Bokeo Province to the west, and Luang Namtha Province to the northwest. The topography of Oudomxai is mountainous, between 300 and 1,800 meters asl. Altogether approximately 60 rivers flow through Oudomxai Province. An air connection exists between Oudomxai and Vientiane and road connections and communications are generally good.
Houaphan Song Ma catchment and or Nam Sam catchment. ***Two possibilities, but Song Ma is priority***.	High (3)	Province of Houaphan is bordered by Vietnam to the north, east and southeast, Xiang Khouang Province to the south and southwest, and Luang Prabang to the west. The terrain is rugged, with dense mountainous forest forming much of the province especially on the western side. Main Route 6 runs through the center of the province. The Song Ma flows from and back into Vietnam. The province is characterized by hills and low mountains 300 to 1,800 meters asl. Wildlife is found in abundance. The province can be easily reached by air travel.

9 Mitigation and biodiversity offset

- As part of the recommendations section, mitigation primarily involves keeping the NN1 FSL as low as possible. This will help to protect important Ls spawning grounds and dry season habitat.
- As many “critical habitat” river sections should be preserved as possible and designated as FCZs to ensure protection for Ls populations in addition to those already present.
- Future studies should be aimed at identifying other populations of Ls both within the international borders of the Lao PDR and those in Yunnan Province in China and also in Vietnam.

10 Limitations and short comings of study

- Few limitations or shortcoming have been experienced during the field work part of this study apart from the obvious time restraints placed on all studies of this nature. However, it is difficult to imagine that much more information could have been gathered in the field from this remarkable and uncommon species of fish.

11 References

- Warren, T. J. (2014a) Preliminary report on the status of ***Luciocyprinus striolatus*** populations within the Lao PDR’s national boundaries within the Nam Ngiep catchment area.
- Warren, T. J. (2014b) Final Report Big Fish – ***Luciocyprinus striolatus*** (Pba Gooan Sai) Study April 3 to 8 2014.

12 Appendices

Appendix 1 – Photograph Captions

List of photo numbers and photo locations (April - May 2014)

3646 The Houay Xay close to Ban Houayxay.

3647 A deep pool (no name) on the Houayxay just before confluence with the Nam Youak.

3655 The Nam Gnok (Nam Youak is local name).

3651 The Nam Gnok approximately two to three kilometers above Ban Nam Youak.

3661 The Nam Phouan at the very end of ***Wang Pba Deng*** that was abandoned as an FCZ two years ago due to too much illegal fishing activity from people outside the village.

3667 The confluence point of the Nam Phouan and the Nam Ngiep.

3692 An FCZ on the Nam Chian (Nam Jey is local name) that is now referred to as Wang Sangouan after it was designated as an FCZ five years ago. Before that it was known as Wang Tang Kham. Ls was last seen and caught here five years ago. Now, nobody fishes here because it is an FCZ.

3693 This is a deep pool on the Nam Chian approximately 1.5 kilometers upstream from the FCZ at the road bridge (3692). This is the last place where Ls has been caught in recent years according to our guide and expert on Ls.

3697 This photograph is of a series of rapids (***Keng Pa Sang***) taken approximately 500 meters upstream from the Nam Chian road bridge.

3703 This is a photograph of ***Wang Kok Hai*** and is found approximately one kilometer downstream from the Nam Chian road bridge. This, according to our guide is a dry season hot spot for catching Ls. It is not an FCZ and Ls regard it as a dry season refuge habitat and up to 30 or 40 Ls are caught here each year.

3553 This is a photograph of Wang Khouak, an FCZ / deep pool close to Ban Xiengkhong and a known spawning site of Ls.

3361 The NN2 Main Project under construction.

3408 The NN2 Tributary Diversion Project under construction.

3461 The sluice gate for releasing water to the Nam Ngiep in the valley below at the NN3 project.

3660 Interview with villagers at Ban Sopphouan.

3793 Interview with villagers at Ban Wang Hai.

3730 ***Wang Mak*** on the lower Nam Chian approximately one kilometer upstream from the confluence with the Nam Ngiep.

3722 The confluence of the Nam Chian and the Nam Ngiep.

3663 The Nam Phouan close to Ban Sopphouan.

3799 The Nam Xan in Thathom District.

3797 The Nam Xan in Thathom District.

3761 ***Wang Gua*** close to Ban Naxong and FCZ.

3769 ***Wang Saphan*** close to Ban Viengthong and FCZ.

3757 ***Wang Tham*** close to Ban Thaviang Sai and FCZ.

3763 A village sign laying out the rules for the Wang Gua FCZ close to Ban Naxong.

Appendix 2 - Photographs

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Appendix 3 – Excel spreadsheets and a map of Ls distribution in southern China

1. Copy of L striolatus data form China (I).xlsx (Data from ERM Shanghai office, China)

2. Copy of L striolatus data form_China .xlsx (Data from ERM Shanghai office, China)

3. L striolatus data form - Mai Dinh Yen .xlsx (Data from ERM Ho Chi Minh office, Vietnam)

4. L striolatus data form - Nguyen Van Hao. xlsx (Data from ERM Ho Chi Minh office, Vietnam)

5. L striolatus data form - Nguyen Van Trong. xlsx (Data from ERM Ho Chi Minh office, Vietnam)

6. Location of Puwen River and Luosuo River 2.pptx (Data from ERM Shanghai office, China)

Annex B

Luciocyprinus Striolatus Habitat Field Survey Report (Phase 3) (Warren 2014b)

Final Report on the ***Luciocyprinus striolatus*** population impacts and conservation status in Lao PDR, Southern China and Vietnam (July 2014)

Prepared by

Mr. Terry J. Warren

For

The Nam Ngiep 1 Hydropower Company

July 2014

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Acknowledgements

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Executive Summary

Luciocyprinus striolatus (Ls) was placed under the IUCN red list Endangered (EN) category, and is a species likely to be impacted by the Nam Ngiep 1 HPP. The overall purpose of the study on *Ls* has been to ascertain population distribution and condition in relation to IFC Critical Habitat threshold limits.

A total of 69 separate interviews were undertaken in 10 major river systems of Lao PDR, which identified that the fish exists in at least six of these systems. In addition, a literature review revealed the Ls exists in another five rivers systems in Lao PDR, and three rivers in Southern China. In total, 14 Ls DMUs have been positively identified. Information on the distribution of the Ls is scant, and the fish is also likely to be present in rivers not yet surveyed.

As 14 DMUs have been positively identified, the threshold limits for the IFC Critical Habitat threshold Tier 1 sub-criterion (a) and (b) have been satisfied.

The studies found that Ls DMUs were clustered in Lao PDR, but this might only be a consequence of study constraints. It also determined that Ls appears to be a Mekong species, having only been found in Mekong tributaries where particular habitat types occur. In this context, the DMUs are of regional importance to the Mekong.

In addition to determining the distribution of the species it was necessary to understand the current condition and threats to the populations, as well as ascertain whether or not conservation mechanisms currently in place provide any form of protection toward its longer-term survival. This information was required to determine if limits for the IFC Critical Habitat threshold for Tier 2 sub-criterion (c), (d) and (e) are satisfied.

To help understand this, each of the 14 DMU was given an overall rank score to identifying its relative importance against the regional (Mekong) Ls population. The rank score (Regional Importance Ranking) was derived from a comparison assessment of DMU Condition, Threats and Conservation Status criteria. From this it was determined that the most important Ls population is the Nam Fa DMU, Luang Nam Tha Province, while the Nam Beng and Nam Ma DMUs in Oudomxai and Luang Nam Tha Provinces respectively were equally determined to be the least important. The Nam Ngiep DMU was ranked 6th overall.

Importantly, the study revealed that Ls species persists in tributaries were the major trunk stream of the rivers have been regulated by hydropower. This indicates that with appropriate mitigations the Nam Ngiep DMU can be sustained if tributary populations are managed accordingly. In any event, while the Nam Ngiep DMU is important (as currently only 14 DMUs are known) its possible extirpation is not likely to impact on the species regionally, given the low level of threats and high conservation status afforded to other DMUs and in particular the Nam Fa, Nam Theun / Kading and the Xe Bang Fai. As such the IFC Criteria for Tier 2 (c), (d) and (e) have been satisfied.

This assessment has been based on information gathered from a large of number of group interviews, field observations and literature research but it is recommended that further verification be undertaken in order to identify additional DMUs and build on current knowledge that was used to reach the current conclusions.

1 Introduction

The Nam Ngiep 1 Hydropower Project (NNP1) involves the construction of a 290MW hydropower dam on the lower Nam Ngiep, a left bank tributary of the Mekong River in Lao PDR. The project covers parts of the provinces of Bolikhamxay and Xaysomboun. The Nam Ngiep River flows in a south-southeast direction through a mountainous region. Part of the dam FSL location has been identified as potential habitat of the IUCN Red (EN) listed *Luciocyprinus striolatus* (Ls).

The study objective is to assess the persistence of Ls across its range in the Nam Ngiep, Lao PDR and beyond. It is also required to identify the current condition and threats on the population, and understanding the status conservation measures afforded to it.

The study provides important information for the preparation of a Critical Habitat Assessment (CHA), which was triggered by the positive identification of Ls in the NNP1 Project Area. This CHA is in accordance with Asian Development Bank Environmental Safeguard Policy Statement (2009).

This study compliments the *Comprehensive Species Profile,* which outlines taxonomy, biological characteristics, ecological role, life history, environmental requirements, and importance (economic or cultural) to Lao villagers.

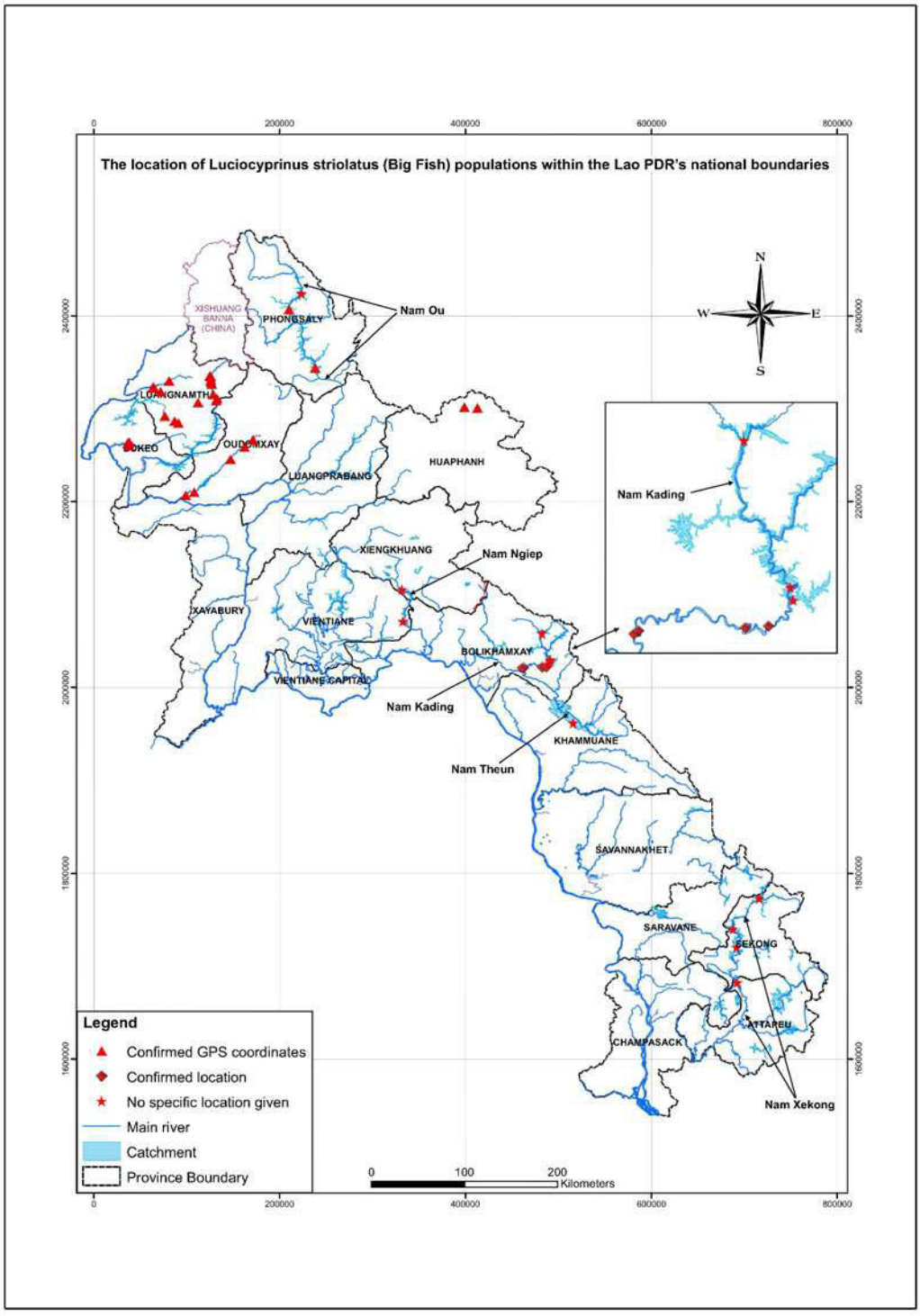

Figure 1. The location of ***Luciocyprinus striolatus*** populations identified during this study in the Lao PDR

2 Study Method

2.1 Field Investigation

Spatial data and maps were used to identify probable locations (catchments and unique habitat) of Ls populations. Semi structured interviews, 69 in total, were then conducted with villagers close by to these areas. The interviews were conducted with experienced fishers, generally six per village, chosen by the village chief, who also contributed. The interviews were used to obtain the following key information:

a) The presence of absence of Ls;
b) The location of Fishing Conservation Zones as they relate to Ls;
c) Known Ls spawning grounds;
d) Local fishing techniques;
e) Local land and water use;
f) Observed changes in river condition;
g) Trends in Ls fish populations including catch size, frequency, age and size class.

A literature review was also undertaken to identify all existing information of Ls populations in Lao PDR, Vietnam and Southern China.

2.2 Data Analysis

The study objective was to assess the persistence of Ls across its range in the Nam Ngiep, Lao PDR and beyond. It was also required to identify the current condition and threats on the population, and understanding of the status conservation measures afforded to it. For this approach refer to section on **3.1 Regional Ranking Procedure**.

The criteria for critical habitat reference is the *discrete management units* for the species. For the purposes of this assessment, the ADB has instructed that each catchment where the Ls has been reported from is considered to be a single management unit. In this context, the following analysis procedures have been applied.

3 Results

Eighteen major catchments were considered as part of the overall Ls study. Fourteen were found to contain Ls populations (Table 1 below).

Table 1 Major catchments assessed for Ls populations

River Number	Catchments considered in this assessment	Method of Assessment	L.s Identified
1	Nam Fa	Field Observations, Literature Review and Villager Interviews	Yes
2	Xe Bang Fai	Literature Review	Yes
3	Nam Ou	Literature Review	Yes
4	Nam Theun - Kading	Literature Review	Yes
5	Nam Ngum	Literature Review	Yes
6	Nam Ngiep	Field Observations, Literature Review and Villager Interviews	Yes
7	Nam Nga	Field Observations, Literature Review and Villager Interviews	Yes
8	Xekong	Literature Review	Yes
9	Nam Tha	Field Observations, Literature Review and Villager Interviews	Yes
10	Nam Beng	Field Observations, Literature Review and Villager Interviews	Yes
11	Nam Ma	Field Observations, Literature Review and Villager Interviews	Yes
12	Luosuo River (China)	Literature Review	Yes
13	Langcang Mainstream (China)	Literature Review	Yes
14	Puwen River (China)	Literature Review	Yes
15	Nam Xan (Vietnam)	Field Observations, Literature Review and Villager Interviews	No
16	Nam Xan (Laos)	Field Observations, Literature Review and Villager Interviews	No
17	Song Ma (Vietnam)	Field Observations, Literature Review and Villager Interviews	No
18	Nam Long	Field Observations, Literature Review and Villager Interviews	No

Table 2 Number of interviews at each location and the various categories of villager responses to fish catch questions.

DMU	Province	Number of interview villages / sites in total	Number of villages to report recent capture (last 2 years) but only small fish (≤ 3 - 400g) and not very many	Number of villages report to recent capture (last 2 years) but larger fish (≤ 1kg +) mixed with small fish but very few	Number of villages report to they used to catch it 3 to 10 years ago but very few now	Number of villages report they used to see it 10 + to 20 years ago but never see now	Number of villages reporting they do not know the fish and never caught it
Nam Tha (above NT3 dam)	Luang Namtha	4	3		1		
Nam Tha (below NT3 dam)	Luang Namtha	5		2	2	1	
Nam Ma	Luang Namtha	4		1	1	2	
Nam Fa	Luang Namtha	5	1	3		1	
Nam Nga	Bokeo	4	4				
Nam Beng(above Nam Beng 1 under construction)	Oudomxai	6	4			1	1
Nam Beng (below Nam Beng 1 under construction)	Oudomxai	3	1		1		1
Song Ma (Nam Ma)	Houaphan	4	1		1	1	1
Nam Sam	Houaphan	3					3
Nam Ngiep	Bolikhamxai and Xaysomboun	31	5	10	8		8
TOTAL		69					

Table 3 presents a summary of key information gathered during the field surveys, observations and literature review. (Comments made by the author are cited.)

Regional Priority Ranking	DMU Name	Key Comments and Observations
#1	Nam Fa	- Earlier this year (2014) two Ls caught, one 22 kg and one 19.5kg - Ls regularly appears (weekly) in the market at Muang Long from Nam Fa - At Muang Long, old people talk of the days (20 years ago) when Ls was "common" - Best fishing grounds are in deep pool areas towards Mekong confluence - There are many FCZs along lower reaches of the Nam Fa towards confluence with the Mekong - Largest population of Ls of all rivers surveyed during the entire study (author's observation) - No spawning sites were confirmed along Nam Fa (author's note)
#2	Xe Bang Fai	- Upper catchment remains well forested - Many deep pool habitats remain intact - River free from pollution - Many FCZs along various sections of the river - Relatively low numbers of people present - Illegal fishing methods employed because many remote areas - Protected area
#3	Nam Ou	- Low impact on fisheries resources due to low population numbers - Very productive fisheries observed in middle and upper reaches during surveys carried out in 2010 - Dam cascade now under construction - Phou Den Din NPA in place - Remote area and difficult to access road networks - Stable population of Ls observed in 2010
#4	Nam Theun - Kading	- -Comparatively pristine habitats above Nakai Plateau - Many deep pool habitats - Several reports of spawning behavior in Nam Mouan (Kading tributary) in 1990s - -River not affected greatly by reduced dry season flow - Clear water river and low levels of pollution - Large problem with illegal fishing according to interviews with fishers in 1990s - Impacts from dams - Low human population numbers - Large areas protected by NBCA

#5	Nam Ngum	- Low DMU population numbers - Dam cascade now in place involving at least four built - Remote area and difficult to access - No legally protected conservation or protected area in place
#6	Nam Ngiep	- Isolated reports of large (>10kg) Ls being caught - Small Ls still being caught in the NN1 FSL area - Many reports from villagers about negative impacts from road construction - Many deep water habitats being lost to sedimentation - Over-fishing becoming a serious problem - High levels of sedimentation - Eleven FCZs identified near to NN1 FSL tailwaters - Four spawning sites identified for Ls where fish have been seen to spawn within the last two or three years - No legally binding protected area - Some large deep pools now resemble static reservoirs (May 2014) where flow can barely be detected
#7	Nam Nga	- River mostly in a healthy condition in lower reaches, but human population numbers quite high (author's note) - Many bridges but no dams yet (author's note) - Contract farming of bananas cause great deal of surface run-off carrying high sediment load with it(extending over kilometers of riparian land) - Fish catch in general has declined considerably over past 10 years - Teenager in village said he caught Ls two years ago on rod and line - Many FCZs along Nam Nga and anyone can witness large numbers of small and large fish generally in the deep pools (author's note) - -Nam Nga runs through a protected area - Some large deep pools now resemble static reservoirs (May 2014) where flow can barely be detected - Many deep pools badly silted up - Villagers commented that many deep pools have silted up in recent years - Villagers said that some deep pools so badly silted now that they are more "like ponds" (May 2014)

#8	Xekong	- Large fish very vulnerable to attack with spears when spawning in very shallow water - Villagers report that fish very sensitive to waters with high sediment loadings in the dry season - Widespread impacts now from gold-dredging boats creating turbid conditions - Dams may threaten areas where Ls is known to live - Many FCZs throughout Xekong catchment and have proved to be very successful in protecting many fish species including Ls - Xe Sap NBCA may have helped to protect Ls - Xekong used to have a large population of Ls about 15 years ago as personally witnessed, but becoming more rare now.
#9	Nam Tha	- Villagers say that since the dam (Nam Tha 3) in 2005, they no longer see large Ls above the dam, only small ones (<12cm) - Villagers think that Ls still spawns somewhere above dam, because small fish appear at the high water period each year - Villagers said that road construction caused much damage to fisheries - One dam worker said that he caught one Ls fish below the dam on a rod and line in 2013 - Villagers just north of Luang Nam Tha reported that they knew Ls well and remember large Ls up to 20kg about 20 years ago - Many FCZs now being ignored along sections of the Nam Tha - Many villagers report that only very rarely is Ls caught around 1kg - - Old people from villages above the dam remember catching Ls over 15kg

#10	Nam Ma	- Now many deep water dry season habitats are filled with silt - Nam Ma waters damaged by contract farming causing sediment run-off - -Villagers said that now they only see small Ls during wet season - From 2009 villagers said they no longer see large individuals of Ls - Villagers said that they blamed contract farming for releasing pesticides and herbicides into water and causing a reduction in fisheries- - People often make the journey from Nam Long to Nam Fa to go fishing now because fishing is much better there (stay for several days) - Old villager said that now people no longer go fishing in the Nam Ma and instead they travel 50km to the Nam Fa to go fishing - Nam Ma runs outside of any protected areas - Many FCZs abandoned now along Nam Ma - Only see small Ls fish now - Used to be many large Ls in the Nam Ma over 10 years ago
#11	Luosuo River (China)	- System degraded by cascade of hydropower dams - Degraded ecological system - High human settlement level - Low, possibly unstable population of Ls
#12	Langcang Mainstream (China)	- System degraded by cascade of hydropower dams - Degraded ecological system - High human settlement level - Low, possibly unstable population of Ls
#13	Puwen River (China)	- System degraded by cascade of hydropower dams - Degraded ecological system - High human settlement level - Low, possibly unstable population of Ls
#14	Nam Beng	- "Small Ls still appear each year in upper reaches" - Old people interviewed in the upper Nam Beng area immediately knew the fish and placed the name of *Pba Gwan* on it and then positively identified it when shown photographs - In the middle reaches of the Nam Beng, many people said then knew it before devastating landslides four years ago - Fishers do not know the fish at Nam Beng / Mekong confluence - Villagers commented that landslides are commonly occur - One fisher said he had caught a small (<12cm) Ls the day before our interview with him, but had consumed it - For small Ls to be showing up each year, spawning must be taking place at an unknown location within system - Middle reaches are now silt-laden with many previously deep water habitats now contain shallow warm water

3.1 Regional Ranking Procedure

From village interviews it was identified that six common direct impacts were affecting the habitat quality of DMUs.

A. Habitat fragmentation and resource over extraction caused by human settlement.
B. Infrastructure expansion.
C. Population pressure on fisheries (exploitative processes).
D. Reduced dry season flows.
E. Increased sedimentation of habitat.
F. Pollutants in waterways.

These common six impacts were affecting all DMU to more or less degrees. These impacts were scored according to responses provided by villagers. **Table 4** provides the scoring systems for each of the Common Direct Impacts. The higher the score the poorer the quality of the DMU habitat, alternatively, the lower the score the better quality habitat. (Refer to Column 2 and 3, Results Section)

Table 4 Common Impact-Threat score criteria

Common Impact Type	Score	Score Criteria
A. Habitat fragmentation and resource over extraction caused by human settlement? B. Infrastructure expansion? C. Population pressure on fisheries (exploitative processes)? D. Reduced dry season flows? E. Increased sedimentation of habitat? F. Pollutants in waterways?	1	Stable: slow or indiscernible rate of change up to five years.
	2	Changing: can be observed in the DMU area over the medium term (4-5 years).
	3	Rapid: current and obvious changes in the short term 1-3 years.

To determine the degree of 'conservation status' for each DMU the following criteria were applied:

A. Is the DMU located inside a provincial or national protected area, or conservation zone?
B. Does the area of the DMU currently experience low human population occupation?
C. Is the locality of the DMU difficult to access due to terrain or some other limiting factor, such no roads, or just minor tracks?
D. Does the DMU have a large Ls population?
E. Is the DMU population stable?

Table 5 to **Table 9** present the relative score for each conservation status criteria (A – E). The lower the score for a given DMU the higher the conservation status. (Refer to Column 4 and 5, Results Section)

Table 5 Conservation Status score criteria for DMU area legal status

Conservation Status Criteria A	Score	Score Criteria
Is the DMU located inside a provincial or national protected area, or conservation zone?	1	The DMU is located almost entirely or is entirely inside a protected area.
	2	The DMU is within the buffer zone or adjacent to a protected area.
	3	The DMU is located outside a protected area.

Table 6 Conservation Status score criteria for the population size of a given DMU area.

Conservation Status Criteria B	Score	Score Criteria
Does the area of the DMU currently experience low human population occupation?	1	In the area of the DMU are non or very few villages.
	2	In the area of the DMU there are clusters of villages.
	3	In the area of the DMU there are a large number of villages or a large urban center.

Table 7 Conservation Status score criteria for the relative remoteness of a DMU area.

Conservation Status Criteria C	Score	Score Criteria
Is the locality of the DMU difficult to access due to terrain or some other limiting factor, such no roads, or just minor tracks?	1	The DMU is remote and access is difficult.
	2	The DMU is remote but access is not difficult
	3	The DMU is readily accessed.

Table 8 Conservation Status Score criteria for the relative productivity of Ls in DMU

Conservation Status Criteria D	Score	Score Criteria
Does the DMU have a large L.s population?	1	High degree of mixed sizes, regularly caught.
	2	Small to medium sizes caught irregularly.
	3	Small sizes, caught intermittently.

Table 9 Conservation Status Score criteria for the relative stability of DMU

Conservation Status Criteria E	Score	Score Criteria
Is the DMU population stable?	1	No obvious change in catch size over the past 10 years.
	2	Noticeable reduction of Ls catch over the past 10 years.
	3	Significant reduction in Ls catch over the past 10 years.

3.2 Overall Regional Ranking

The overall habitat priority ranking (Regional Priority Ranking) was determined by adding the scores for conservation status and those assigned for Common Direct Impacts. The best possible Regional Priority Ranking that can be achieved is 14, whilst the worst is 30. The 14 DMUs were the ranked according to this total score. (Refer to Column 1 and 6, Results Section).

Table 10 Regional DMU Ranking

Column 1	Column 2	Column 3	Column 4	Column 5	Column 6
DMU	**Common Direct Impacts Indicated at Villager Interviews**	**Cumulative Impacts Score for each DMU (as per list in Column 2 A-F)**	**Conservation Status**	**Current status of Ls populations**	**Regional Importance of the DMU – TOTAL**
Nam Fa RANK #1	A. Habitat fragmentation and resource over extraction caused by human settlement? B. Infrastructure expansion? C. Population pressure on fisheries (exploitative processes)? D. Reduced dry season flows? E. Increased sedimentation of habitat? F. Pollutants in waterways?	A 1 B 1 C 2 D 2 E 2 F 1 TOTAL 9	A. Is the DMU located in a provincial or national protected area, or conservation zone? B. Does the area of the DMU currently experience low human population occupation? C. Is the locality of the DMU difficult to access due to terrain or some other limiting factor, such no roads? D. Does the DMU have a large L.s population. E. Is that population stable?	A 1 B 1 C 1 D 1 E 1 TOTAL 5	14 (Column 1 + Column 2)

Xe Bang Fai RANK #2	A. Habitat fragmentation and resource over extraction caused by human settlement? B. Infrastructure expansion? C. Population pressure on fisheries (exploitative processes)? D. Reduced dry season flows? E. Increased sedimentation of habitat? F. Pollutants in waterways?	A 2 B 1 C 3 D 1 E 1 F 1 TOTAL 9	A. Is the DMU located in a provincial or national protected area, or conservation zone? B. Does the area of the DMU currently experience low human population occupation? C. Is the locality of the DMU difficult to access due to terrain or some other limiting factor, such no roads? D. Does the DMU have a large L.s population? E. Is that population stable?	A 1 B 1 C 1 D 1 E 1 TOTAL 5	14 (Column 1 + Column 2)
Nam Ou RANK #3	A. Habitat fragmentation and resource over extraction caused by human settlement? B. Infrastructure expansion? C. Population pressure on fisheries (exploitative processes)? D. Reduced dry season flows? E. Increased sedimentation of habitat? F. Pollutants in waterways?	A 1 B 3 C 1 D 1 E 2 F 1 TOTAL 9	A. Is the DMU located in a provincial or national protected area, or conservation zone? B. Does the area of the DMU currently experience low human population occupation? C. Is the locality of the DMU difficult to access due to terrain or some other limiting factor, such no roads? D. Does the DMU have a large Ls population? E. Is that population stable?	A 1 B 1 C 2 D 2 E 1 TOTAL 7	16 (Column 1 + Column 2)

Nam Theun-Kading RANK #4	A. Habitat fragmentation and resource over extraction caused by human settlement? B. Infrastructure expansion? C. Population pressure on fisheries (exploitative processes)? D. Reduced dry season flows? E. Increased sedimentation of habitat? F. Pollutants in waterways?	A 2 B 3 C 2 D 1 E 1 F 1 TOTAL 10	A. Is the DMU located in a provincial or national protected area, or conservation zone? B. Does the area of the DMU currently experience low human population occupation? C. Is the locality of the DMU difficult to access due to terrain or some other limiting factor, such no roads or tracks only? D. Does the DMU have a large Ls population? E. Is that population stable?	A 1 B 2 C 1 D 2 E 1 TOTAL	17 (Column 1 + Column 2)
Nam Ngum RANK #5	A. Habitat fragmentation and resource over extraction caused by human settlement? B. Infrastructure expansion? C. Population pressure on fisheries (exploitative processes)? D. Reduced dry season flows? E. Increased sedimentation of habitat? F. Pollutants in waterways?	A 2 B 3 C 2 D 1 E 1 F 1 TOTAL 10	A. Is the DMU located in a provincial or national protected area, or conservation zone? B. Does the area of the DMU currently experience low human population occupation? C. Is the locality of the DMU difficult to access due to terrain or some other limiting factor, such no roads or tracks only? D. Does the DMU have a large Ls population? E. Is that population stable?	A 3 B 2 C 2 D 3 E 3 TOTAL 13	23 (Column 1 + Column 2)
Nam Ngiep RANK #6	A. Habitat fragmentation and resource over extraction caused by human settlement? B. Infrastructure expansion? C. Population pressure on fisheries (exploitative	A 2 B 3 C 3 D 2	A. Is the DMU located in a provincial or national protected area, or conservation zone? B. Does the area of the DMU currently experience low human population occupation? C. Is the locality of the DMU	A 3 B 2 C 2 D 2	23 (Column 1 + Column 2)

	processes)? D. Reduced dry season flows? E. Increased sedimentation of habitat? F. Pollutants in waterways?	E 2 F 1 TOTAL 13	difficult to access due to terrain or some other limiting factor, such no roads or tracks only? D. Does the DMU have a large Ls population? E. Is that population stable?	E 2 TOTAL 11	
Nam Nga RANK #7	A. Habitat fragmentation and resource over extraction caused by human settlement? B. Infrastructure expansion? C. Population pressure on fisheries (exploitative processes)? D. Reduced dry season flows? E. Increased sedimentation of habitat? F. Pollutants in waterways?	A 2 B 2 C 3 D 2 E 2 F 1 TOTAL 12	A. Is the DMU located in a provincial or national protected area, or conservation zone? B. Does the area of the DMU currently experience low human population occupation? C. Is the locality of the DMU difficult to access due to terrain or some other limiting factor, such no roads? D. Does the DMU have a large Ls population? E. Is that population stable?	A 1 B 2 C 2 D 3 E 3 TOTAL 11	23 (Column 1 + Column 2)
Xekong RANK #8	A. Habitat fragmentation and resource over extraction caused by human settlement? B. Infrastructure expansion? C. Population pressure on fisheries (exploitative processes)? D. Reduced dry season flows? E. Increased sedimentation of habitat? F. Pollutants in waterways?	A 2 B 2 C 2 D 2 E 3 F 2 TOTAL 13	A. Is the DMU located in a provincial or national protected area, or conservation zone? B. Does the area of the DMU currently experience low human population occupation? C. Is the locality of the DMU difficult to access due to terrain or some other limiting factor, such no roads? D. Does the DMU have a large L.s population. E. Is that population stable?	A 1 B 3 C 3 D 2 E 2 TOTAL 11	24 (Column 1 + Column 2)

Nam Tha RANK #9	A. Habitat fragmentation and resource over extraction caused by human settlement? B. Infrastructure expansion? C. Population pressure on fisheries (exploitative processes)? D. Reduced dry season flows? E. Increased sedimentation of habitat? F. Pollutants in waterways?	A 3 B 2 C 3 D 2 E 2 F 2 TOTAL 14	A. Is the DMU located in a provincial or national protected area, or conservation zone? B. Does the area of the DMU currently experience low human population occupation? C. Is the locality of the DMU difficult to access due to terrain or some other limiting factor, such no roads or tracks only? D. Does the DMU have a large Ls population? E. Is that population stable?	A 1 B 2 C 3 D 3 E 3 TOTAL 12	26 (Column 1 + Column 2)
Luosuo River **(China)** RANK #10	A. Habitat fragmentation and resource over extraction caused by human settlement? B. Infrastructure expansion? C. Population pressure on fisheries (exploitative processes)? D. Reduced dry season flows? E. Increased sedimentation of habitat? F. Pollutants in waterways?	A 3 B 3 C 3 D 2 E 2 F 2 TOTAL 14	A. Is the DMU located in a provincial or national protected area, or conservation zone? B. Does the area of the DMU currently experience low human population occupation? C. Is the locality of the DMU difficult to access due to terrain or some other limiting factor, such no roads? D. Does the DMU have a large Ls population. E. Is that population stable?	A 3 B 2 C 3 D 3 E 3 TOTAL 14	28 (Column 1 + Column 2)

Langcang mainstream RANK #11	A. Habitat fragmentation and resource over extraction caused by human settlement? B. Infrastructure expansion? C. Population pressure on fisheries (exploitative processes)? D. Reduced dry season flows? E. Increased sedimentation of habitat? F. Pollutants in waterways?	A 2 B 3 C 3 D 2 E 2 F 2 TOTAL 14	A. Is the DMU located in a provincial or national protected area, or conservation zone? B. Does the area of the DMU currently experience low human population occupation? C. Is the locality of the DMU difficult to access due to terrain or some other limiting factor, such no roads or tracks only? D. Does the DMU have a large Ls population? E. Is that population stable?	A 3 B 3 C 3 D 2 E 3 TOTAL 14	28 (Column 1 + Column 2)
Puwen River (China) RANK #12	A. Habitat fragmentation and resource over extraction caused by human settlement? B. Infrastructure expansion? C. Population pressure on fisheries (exploitative processes)? D. Reduced dry season flows? E. Increased sedimentation of habitat? F. Pollutants in waterways?	A 3 B 3 C 3 D 2 E 2 F 2 TOTAL 15	A. Is the DMU located in a provincial or national protected area, or conservation zone? B. Does the area of the DMU currently experience low human population occupation? C. Is the locality of the DMU difficult to access due to terrain or some other limiting factor, such no roads? D. Does the DMU have a large Ls population? E. Is that population stable?	A 3 B 2 C 3 D 3 E 3 TOTAL 14	29 (Column 1 + Column 2)

Nam Ma RANK #13	A. Habitat fragmentation and resource over extraction caused by human settlement? B. Infrastructure expansion? C. Population pressure on fisheries (exploitative processes)? D. Reduced dry season flows? E. Increased sedimentation of habitat? F. Pollutants in waterways?	A 3 B 2 C 3 D 3 E 3 F 3 TOTAL 17	A. Is the DMU located in a provincial or national protected area, or conservation zone? B. Does the area of the DMU currently experience low human population occupation? C. Is the locality of the DMU difficult to access due to terrain or some other limiting factor, such no roads? D. Does the DMU have a large Ls population. E. Is that population stable?	A 2 B 2 C 3 D 3 E 3 TOTAL 13	30 (Column 1 + Column 2)
Nam Beng RANK #14	A. Habitat fragmentation and resource over extraction caused by human settlement? B. Infrastructure expansion? C. Population pressure on fisheries (exploitative processes)? D. Reduced dry season flows? E. Increased sedimentation of habitat? F. Pollutants in waterways?	A 3 B 2 C 3 D 3 E 3 F 2 TOTAL 16	A. Is the DMU located in a provincial or national protected area, or conservation zone? B. Does the area of the DMU currently experience low human population occupation? C. Is the locality of the DMU difficult to access due to terrain or some other limiting factor, such no roads? D. Does the DMU have a large Ls population. E. Is that population stable?	A 3 B 2 C 3 D 3 E 3 TOTAL 14	30 (Column 1 + Column 2)

3.3 Summary of the results in Table 10 above

1) Condition Status (Common Impacts)

A) Habitat fragmentation and resource over-extraction caused by human settlement

A total of two out of 14 (14%) of the DMUs identified in this study were experiencing stable conditions; slow or indiscernible rate of change up to the past five years: 1) Nam Fa and 2) Nam Ou. Seven out of 14 (50%) DMUs identified were undergoing changing conditions; observed in the medium term (4-5 years) and five out of 14 (36%) were undergoing rapid changes; current and obvious changes in the short term (1-3 years).

B) Infrastructure expansion

A total of two out of 14 (14%) of the DMUs identified in this study were experiencing stable conditions; slow or indiscernible rate of change up to the past five years: 1) Nam Fa and 2) Xe Bang Fai. Five out of 14 (36%) DMUs identified were undergoing changing conditions; observed in the medium term (4-5 years) and seven out of 14 (50%) were undergoing rapid changes; current and obvious changes in the short term (1-3 years).

C) Population pressure on fisheries (exploitative processes)

Only one out of 14 (7%) of the DMUs identified in this study were experiencing stable conditions; slow or indiscernible rate of change up to the past five years: 1) Nam Ou. Four out of 14 (29%) DMUs identified were undergoing changing conditions; observed in the medium term (4-5 years) and nine out of 14 (64%) were undergoing rapid changes; current and obvious changes in the short term (1-3 years).

D) Reduced dry season flows

A total of four out of 14 (29%) of the DMUs identified in this study were experiencing stable conditions; slow or indiscernible rate of change up to the past five years: 1) Xe Bang Fai; 2) Nam Ou; 3) Nam Theun / Kading and 4) Nam Ngum. Eight out of 14 (57%) DMUs identified were undergoing changing conditions; observed in the medium term (4-5 years) and two out of 14 (14%) were undergoing rapid changes; current and obvious changes in the short term (1-3 years).

E) Increased sedimentation of habitat

A total of three out of 14 (21%) of the DMUs identified in this study were experiencing stable conditions; slow or indiscernible rate of change up to the past five years: 1) Xe Bang Fai; 2)Nam Theun / Kading and 3) Nam Ngum. Eight out of 14 (57%) DMUs identified were undergoing changing conditions; observed in the medium term (4-5 years) and three out of 14 (21%) were undergoing rapid changes; current and obvious changes in the short term (1-3 years).

F) Pollutants in waterways

A total of seven out of 14 (50%) of the DMUs identified in this study were experiencing stable conditions; slow or indiscernible rate of change up to the past five years: 1) Nam Fa; 2) Xe Bang Fai; 3) Nam Ou; 4) Nam Theun / Kading; 5) Nam Ngum; 6) Nam Ngiep and 7) Nam Nga. Six out of 14 (43%) DMUs identified were undergoing changing conditions; observed in the medium term (4-5 years) and only one out of 14 (7%) was undergoing rapid changes; current and obvious changes in the short term (1-3 years).

2) Conservation Status

A) Is the DMU located in a provincial or national protected area or conservation zone?

A total of seven out of the 14 (50%) of all DMUs identified during this study were found to lie almost entirely or completely inside some type of legally protected area: 1) Nam Fa; 2) Upper Xe Bang Fai; 3) Nam Ou; 4) Nam Theun / Kading; 5) Nam Nga; 6) Xekong and 7) Nam Tha. Six out of the 14 (43%) of the DMUs identified during this study were found to lie outside of any protected area and just one of the DMUs identified during the study was found to lie within a protected area buffer zone or adjacent to it.

B) Does the area of the DMU currently experience low human population occupation?

A total of just three out of 14 (21%) of the DMUs identified during this study were found to lie within areas where no villages or very few villages were present: 1) Nam Fa; 2) Upper Xe Bang Fai and 3) Nam Ou. Nine out of 14 (64%) of DMUs identified were found to lie within areas where there were only clusters of villages present and two DMUs (14%) only were found to lie within areas where there were large numbers of villages or within large urban centers.

C) Is the locality of the DMU difficult to access due to terrain or some other limiting factor, such as no roads?

A total of three out of 14 (21%) of the DMUs identified during this study were found to be in areas that were remote and very difficult to access: 1) Nam Fa; 2) Upper Xe bang Fai and 3) The Nam Theun / Kading. Four out of 14 (29%) of DMUs identified in the study were found to be remote areas but could be accessed with reasonable ease and seven DMUs (50%) were found to lie within areas that could be accessed easily.

D) Does the DMU have a large Ls population?

Only two out of 14 (14%) of the DMUs identified in this study were found to have a high degree of mixed sizes of Ls and caught regularly: 1) Nam Fa and 2) Xe Bang Fai. Five out of 14 (36%) of the DMUs were identified as having a population of Ls of small (<0.3 to 0.4kg) to medium sized fish (1.0 to 3.0kg) that were caught regularly and seven out of 14 (50%) DMUs were identified as having a population of Ls that were small in size (0.3 to 0.4kg).

E) Is the population at (D) above stable?

A total of four out of 14 (29%) of the DMUs identified during this study found that there was no obvious change in catch size over the past ten years: 1) Nam Fa; 2) Xe Bang Fai; 3) Nam Ou and 4) Nam Theun / Kading. Two out of the 14 (14%) of the DMUs identified found that there was a noticeable reduction in Ls catch over the past 10 years and eight out of 14 (57%) of DMUs identified were found to have experienced a large reduction in catch size over the past 10 years.

4 Discussion

4.1 Condition Status (Common Impacts)

A) Habitat fragmentation and resource over-extraction caused by human settlement

Habitat fragmentation occurs when habitats that were once contiguous are divided up into smaller isolated units or areas. One of the most obvious examples of fragmentation is when the construction of a hydropower dam takes place such as in the Nam Tha, Nam Theun / Kading and the Xekong for example but fragmentation of riverine habitat can also be caused by modified riparian land use patterns. Perhaps the greatest source of allochthonous nutrient input to riverine systems comes from riparian forest cover. This not only supplies nutrients to the system in the form of decaying leaf matter but also protects from bank soil erosion and provides shade. The removal of forest cover for the purposes of developing cash crops and subsistence agriculture can cause aquatic habitat fragmentation. Examples of this type of fragmentation have taken place along the Nam Ma and the Nam Beng. Conversely, the Na Fa and the Xe Bang Fai have not yet suffered this type of habitat degradation to such a greater extent. The Nam Fa DMU was one of two that were experiencing *stable conditions* with respect to habitat fragmentation and resource over-extraction caused by human settlement (Tables 4 and 10 and section 3.3 above).

Human settlement inevitably brings with it a demand for water for washing, drinking, sanitation, watering livestock, irrigation and all types of industry. Human settlement also brings with it a demand for fisheries and aquatic resources (see section C below). Both the Nam Ma and the Nam Beng have suffered from *rapid current* and *obvious changes* in the short term period of one to three years. This is in contrast to the Nam Fa DMU which has experienced stable conditions with respect to human settlement (Tables 4 and 10 and section 3.3 above).

B) Infrastructure expansion

Infrastructure expansion includes construction of barriers, bridges, sluice gates, flood protection schemes, irrigation schemes, mining plants, roads, water diversion and channelization. These all impact on aquatic habitat, fisheries in general which includes populations of Ls. The negative impacts from dams for example might include disruptions to fish migratory pathways, reductions in sediment flow, impacts to downstream water quality and the submergence of important upstream habitats. Ls is a migratory species as a sub-adult (trophic migrations) and as an adult (spawning migration). In the northern provinces of the Lao PDR, so far only one dam has been built on the Nam Tha (Nam Tha 3) but already villagers have reported that since its construction large Ls are not seen in the stream above the dam. But since its construction some villagers report that they still regularly see small Ls at their villages above the dam which leads to the conclusion that Ls is still able to locate spawning habitat there and adult fish must be attaining sexual maturity there. Another dam is under construction on the Nam Beng just 16 kilometers above the Nam Beng / Mekong confluence. The population of Ls in the Nam Beng is mainly restricted to the upper reaches and so may not necessarily be affected by the Nam Beng 1 Project. The same situation may occur above the 320m NN1 FSL in

the Nam Ngiep because only one of the four spawning sites currently identified may be inundated in a normal hydrological year during the spawning period of Ls (ERM data).

Dams have been constructed in the Xekong catchment, including the mainstream but being such a large catchment it may still be possible for isolated populations of Ls to continue to exist in tributaries of the Xekong at least. Dams have been built on the mainstream Nam Theun / Kading and at least one of its major tributaries, but it is highly likely that populations of Ls are able to survive above the Nam Theun 2 Nakai Plateau. Construction of a seven dam cascade has begun on the Nam Ou and it seems highly likely that Ls will become extirpated over much of its present range, but likewise may be able to thrive in the free-flowing parts of the river that will remain above the highest dam upstream from the Mekong confluence.

Road constructions that follow waterways have undoubtedly caused major negative impacts to the fisheries in many streams throughout the length of the Lao PDR over the past 20 years or so. The negative impacts have mostly been caused by excavated soil being pushed sideways over the side of the road that is immediately above the river. Much of the road construction takes place during the dry season months and the removed soil stays where it is until the first rains begin arriving in late April and May. Soil is flushed into river systems causing silt build-up in deep pool habitats and causing the smothering of primary production areas such as algal beds growing on rocks. This impact has undoubtedly affected populations of Ls and the populations of fish species that are Ls prey items.

Two large dams on the Nam Theun; the Theun Hinboun Project and the Nam Theun 2 Project by design are inter-basin transfer projects and divert water from the Nam Theun to the Nam Hinboun and the Xe Bang Fai Projects respectively. This inevitably has a de-watering effect on sections of the Nam Theun that flow below both dams. This has undoubtedly had a negative impact on Ls populations that were found in the sections of the river before the dams were built, but Ls may still be able to exist above the Nam Theun 2 reservoir.

In terms of infrastructure expansion, the Nam Fa and the upper Xe Bang Fai DMUs have been awarded *stable condition* status where there has been slow or indiscernible change over the past five years. However, the Nam Beng, the Nam Ma and DMUs in Southern China have scored high ranks for infrastructure expansion whereby this process has been rapid change in the short term period over the past one to three years. Fifty percent of all 14 DMUs currently identified are experiencing this latter situation (Tables 4 and 10 and section 3.3 above).

C) Population pressure on fisheries (exploitative processes)

Exploitation of resource is one of the most common types of direct impact reported by villagers all over the Lao PDR and elsewhere in SE Asia and is usually associated with an increase in human population numbers. Over-fishing can be thought of as removing the resource at a greater rate than it can be replaced through reproduction and growth. It can also be viewed in terms of fishing effort. If fishing effort remains constant, but catch is declining then over-fishing is taking place, and in a similar way if fishing effort is increasing and catch is remaining constant or declining, then over-fishing is also occurring. However, the widely reported decline in Ls populations are unlikely to be caused only by over-fishing because it rarely represents a singular

target species except perhaps on its spawning grounds. It is often caught just by accident as in the case of many other IUCN Red-listed endangered fish species. However, the over-fishing of many other fish species that form the prey items of Ls may be contributing to its overall decline. This is probably the case in the Nam Ma, the Nam Tha and the Nam Beng. Where human population pressures are lower and aquatic habitats can be described as more stable (Nam Fa, upper Xe Bang Fai and Nam Ou) then over-fishing is less of a problem. This is not to state that over-fishing acts in isolation; it is part of a series of cumulative impacts (Tables 4 and 10 and section 3.3 above).

D) Reduced dry season flows

Almost without exception, this study and others completed in the Lao PDR villagers have noticed and reported that over the past 20 years or so dry-season water flows have become considerably reduced. There are probably multiple causes of this problem but many villagers believe that catchment deforestation is responsible for what has been observed. Some reports provided to us suggested that changing land use patterns linked to catchment deforestation was also a major factor. Some people thought that the abstraction of water for dry season agriculture was an important issue together with climate change. Many fish species have a requirement to return to deeper water habitats during the dry season months in order to escape the occasional harsh conditions during the low water period and this includes Ls populations. During this study, villagers made constant reference to the fact that because dry season flows were reduced and many deep water habitats had become silted up due to erosion and sedimentation that many fish no longer stayed where they used to seek refuge but instead moved much further downstream to deep water habitats closer to confluences with larger rivers. This may pose a significant negative issue for Ls populations because, as far as is understood, Ls prefers upland habitats where waters are cooler and more oxygenated.

Under the Regional Ranking Procedure (section 3.2) four DMUs identified during this study have been described as having *stable conditions* with respect to reduced dry-season flows whereby changes could be described slow or indiscernible over the past five years (Upper Xe Bang Fai; Nam Ou; Nam Theun / Kading and the Nam Ngum). The Nam Ma and the Nam Beng were placed in the category of undergoing rapid and obvious change with respect to a reduction in dry season flows (Tables 4 and 10 and section 3.3).

E) Increased sedimentation of habitat

Increase in sediment load carried by rivers close to almost all the villages visited made reference to increased sediment load in the dry-season, and in the wet-season also in some cases. Most people were clear in their views that two main factors were the causes: 1) catchment deforestation resulting in soil erosion; and 2) changes in land-use patterns resulting in increased sediment load carried by surface run-off. In some cases, the Nam Ma and the Nam Beng, villagers described rivers as carrying liquid soil in which fish could not survive although such conditions were described as extreme. Landslides along the Nam Beng valley were reported as serious over the last decade with human deaths occurring on occasion. Villagers reported that the increased sediment loading was responsible for “filling in” dry-season deep water refuge habitats in many of the river catchments visited and also causing the water to

become warmer in some case (Nam Beng). Shallow, warm and silty water are not conditions that Ls is known to tolerate.

Conversely, at least three DMUs have been assigned the status of *stable conditions* whereby changes in increased habitat sedimentation have been slow or imperceptible over the past five years (Tables 4 and 10 and section 3.3).

F) Pollutants in waterways

Large changes in riparian agricultural practices have brought about a necessity for the increase use of pesticides and herbicides in several of the DMUs visited (Nam Ma). This is in addition to the chemicals used to control pests and competitive plants associated with traditional rice farming practices for those farmers that still use them. Inevitably, some of these chemicals enter aquatic habitats via leeching or in surface run-off. It is difficult to generalize on what villagers said concerning the use of pesticides and herbicides because harmful effects on fish and humans vary widely on which chemicals were used and in what quantities and when they were applied. However, an expert on Ls based in Muang Long on the banks of the Nam Ma reported that Ls was especially sensitive to chemicals used in the contract banana farming businesses that have become established in the Nam Ma valley during the past seven years. He said that chemicals were in use and that since the plantations had been set up Ls population numbers dropped dramatically shortly afterwards. Human settlement inevitably means that all manner of house-hold chemicals come into use, perhaps some quite harmless but never-the-less enter local waterways.

Artisanal mining for gold was taking place along the Nam Ou in 2010 (70 back-hoes in operation) and ship-dredging for gold was taking place along the Xekong in 2012 (up to 30 ships counted). The chemicals used for the gold extraction process are usually either mercury or cyanide.

Fifty per cent of all DMUs visited during this survey came under the category of stable conditions and only one DMU was placed in the category of rapid and obvious change in the short term covering a period of one to three years (Tables 4 and 10 and section 3.3).

4.2 Conservation Status

A) Is the DMU located in a provincial or national protected area or conservation zone?

If a legal mechanism is in place for future protection of Ls populations in 50% of DMUs identified then realistic legislation can be applied if agreed to by all stakeholders involved. Under the IUCN Red List system Ls is placed in the category of Endangered (EN). A taxon is endangered when the best available evidence indicates that it meets any of the criteria A to E for Endangered, and it is therefore considered to be facing a very high risk of extinction in the wild.

Under Lao law (Forestry law 1996) aquatic animals and wildlife living naturally in the territory of Lao PDR are the property of the national community. It is the responsibility of the State, as

representative of the people, to determine the conditions of access, protection, propagation and use of these animals and wildlife (Article 39) (Cacaud and Latdavong 2009). The Wildlife and Aquatic Animals Act 2008 was adopted by the National Assembly in 2008. Under this Act exists the right to hunt wildlife and aquatic animals is provided to any individual or legal entity within the limits of the law (Article 9). Hunting certain species is prohibited or restricted. It is strictly prohibited to hunt species listed in Category I except for research or propagation purposes, whereas catching species of species under Category II is allowed with an authorization and during certain periods.

Species listed in Category III may be taken for customary purposes and to some extent for commercial purposes with an authorization from PAFO (Article 9). Species of wildlife and aquatic animals are classified into three categories a) Category I lists species that are considered to be rare, endangered or highly valuable in socio-economic terms. Ls therefore fits into Category I classification (Cacaud and Latdavong 2009). Realistically therefore this leads to the conclusion that Ls must be afforded protection at its spawning sites only and covering the period when it is known to spawn (January to April). Four known spawning sites along the Nam Ngiep above or close to NN1 FSL are already protected under village Fishery Conservation Zone (FCZ) initiatives, and only one may be inundated during the dry-season spawning period in a normal hydrological year (ERM data).

B) Does the area of the DMU currently experience low human population occupation?

Conservation and protection efforts might be best directed at the Nam Fa and upper Xe Bang Fai DMUs where few villages exist. These DMUs represent areas where fishing pressures are low and fish populations are most resilient including Ls. The Nam Ou has been targeted for a large-scale cascade hydropower scheme and the exact effects of this infrastructure development remain unclear at present (Tables 6 and 10 and section 3.3).

C) Is the locality of the DMU difficult to access due to terrain or some other limiting factor, such as no roads?

Part of the reason why the populations of Ls may be more robust and stable in the Nam Fa, the upper Xe Bang Fai and the Nam Theun / Kading is that it is difficult for people to access these areas (Tables 7 and 10 and section 3.3).

D) Does the DMU have a large Ls population?

Most of the populations of Ls in all 14 DMUs identified harbor small to medium sized fish only. This is consistent with an endangered species population that is under considerable stress (Tables 8 and 10 and section 3.3).

E) Is the population at (D) above stable?

The majority of the Ls populations within the 14 DMUs so far identified (about 70%) are experiencing various levels of instability and only about 30% might be described as stable. Populations that are faced with cumulative impacts and stress typically show an overall reduction in catch (landings) and a trend towards a reduction in the size of individuals of that population (Tables 9 and 10 and section 3.3).

5 Conclusions

1. There are numerous populations of Ls acting as Discrete Management Units throughout the Lao PDR and Southern China.

2. According to criteria (conservation status and common impacts) and related scoring results, the studies conclude that the Nam Fa is ranked regionally number one DMU because it contains a robust population resilient to current land use. The Nam Beng was identified as being the DMU worst affected by cumulative impacts.

3. Important information has been gathered on Ls spawning sites and spawning behavior in the upper Nam Ngiep mainstream. No information was forthcoming concerning spawning sites or spawning behavior in the three Northern provinces of the Lao PDR that were surveyed in 2014.

4. The Nam Ngiep DMU was ranked number six of regional significance. The studies identified Ls habitat above FSL 320m, namely the Nam Chian. In addition, of the four spawning sites identified only one will be inundated on an average hydrological year through the key spawning period. This suggests then that the habitat of the lower Nam Chian may in fact be less impacted than originally thought.

5. These studies have identified Ls populations that can persist in tributaries above reservoirs such as in the Nam Theun and also possibly in the Nam Tha above the Nam Tha 3 dam.

6. Of the 18 rivers assessed during these studies, fourteen were found to harbor populations of Ls. The fourteen rivers were all tributaries of the Mekong.

7. Given the above findings, it is reasonable to assume that other large Mekong tributaries with similar characteristics will also harbor populations of Ls in the Lao PDR (viz other DMUs). This might also be the case for right-banked Mekong tributaries in Northern Thailand and North-east Myanmar.

8. These studies have revealed that there has been a general decline in fish populations, including Ls, in all DMUs assessed in the field (a total of 10).

9. These studies have improved considerably the knowledge base of Ls. The studies have also highlighted the condition of the Nam Ngiep DMU and its relationship with known Ls range (rank #6 out of 14).

10. It is the view of the author that the possible extirpation of the Nam Ngiep population of Ls will not trigger species extinction. This position has been substantiated where the studies have identified Ls populations within areas of high conservation protection, low human occupation, slow rate of infrastructure development and existing robust populations such as Nam Theun, XBF and Nam Fa DMUs.

11. As the studies have shown that populations can persist in tributaries above reservoirs, it can be reasoned the Nam Ngiep tributary population can be sustained with appropriate intervention

12. It is acknowledged by the author that the conclusions in this report are based on material information collected through rapid survey and that additional biological quantitative investigation may support or challenge some of these conclusions.

13. It is highly possible that some of the other catchments that harbor Ls may be under far greater protection than the Nam Ngiep catchment and where populations of Ls will stand a much better chance of survival into the future.

6 Recommendations

1. It is recommended that biological investigations be undertaken in previously assessed DMUs to validate current knowledge and conclusions on Ls population dynamics. This is necessary to fill in major gaps still remaining concerning its life-cycle biology. It would involve the complete participation of local village fishers and should take place over one full calendar year.

2. It is recommended that a detailed profile of Ls habitat (water quality, geomorphology and hydrology) be developed to better inform life-cycle requirements within conservation strategies. This information can also be used to screen potential rivers with Ls populations.

3. Gaps still remain concerning precise details of conditions at spawning sites just before and after spawning has taken place. It is vital to gain a further understanding of the whole “spawning event” because this is the one main focus of any future protection and conservation measures. It is impossible to ask fishers to stop catching Ls because it, like many other IUCN Red-list endangered and critically endangered fish species are caught by accident. Protection at spawning sites would be a major step forward as a conservation strategy.

4. More detailed data and information is required on specific spawning habitats and bio-physical / chemical parameters of spawning sites pre- and post spawning event.

5. Undertake additional studies to conclude on full Ls population range. This would involve visiting three more DMUs where it is highly likely that Ls populations will be found. This

will help to bolster the case for the continued protection of Ls at other sites in the possible scenario that Ls becomes extirpated in the Nam Ngiep DMU as a result of all hydropower development over the coming years (NN1, NN2 and NN3 Projects). The three remaining DMUs where it is considered that Ls is present are the Xe Bang Hian in Savannakhet Province and the Nam Xuang and the Nam Khan in Luang Prabang Province. This survey work could be undertaken quite soon if required.

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Annex C

Nam Ngiep Fast Water Survey (Kottelat 2014)

Survey of fishes in fast water habitats in Nam Ngiep 1 project area

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1 Summary

The fishes of fast water habitats of the Nam Ngiep inundation zone were surveyed in January–February 2014. Samples were also obtained in adjacent drainages (Nam Mang, Nam Xan and Nam Xao) to obtain information on the distribution of the endemic species.

The survey recorded 53 fish species in the NNP1 inundation zone. Two species were not observed, but reliably reported. The survey found 4 species new to science (unnamed), two of them in the inundation zone and 2 above FSL. An additional 4 species present difficulties of identification and are potentially new to science too..

Five species are known only from the Nam Ngiep drainage. The identity of four additional species is still not clear and they are potentially endemic to the Nam Ngiep drainage. For three of them, the same or a similar species (unnamed) is known from the Nam Ngum and/or Nam Mang drainages. None of the observed species is known only from the area to be inundated.

Four of the species of concern are known in the inundation zone and headwaters, or only in headwaters. The species are expected to survive the impacts of NNP1 project, provided that significant areas of their habitats (torrents, hill streams and small forest streams) remain intact. For species known only from the inundation zone or also until about FSL, they are expected to survive if stretches of several of the main tributaries remain intact at and above FSL for some distance.

Schistura crabro was earlier considered to be endemic to the Nam Ngiep. The survey did not observe it in the Nam Ngiep but was found at two sites in the Nam Xan.

The giant pike-carp *Luciocyprinus striolatus* is present in the inundation zone. It is assessed as EN (endangered) in IUCN's Red List. Work must now be undertaken to determine whether or not the Nam Ngiep is a Critical Habitat for the species; work should consider the number of populations globally, the number of 'discrete management units' and their environment quality and threats. Mitigation to the impact of NNP1 project on this species could include research to increase knowledge on the biology of the species and habitat requirements, develop methods for artificial reproduction, and possibly habitat modification to protect or create spawning sites.

2 Introduction

The diversity of inland fishes in Southeast Asia is very high, with more than 1000 species known from western Indonesia (Kottelat et al., 1993; Kottelat & Whitten, 1996a) and some 900 known from mainland Southeast Asia (Kottelat, 1989). Despite this high diversity and their importance for humans, our knowledge of fish biology over most of Asia is still very incomplete and often is restricted to mere lists (Kottelat & Whitten, 1996b). Large areas are still unsurveyed.

The information on Laotian fishes published in the scientific litterature is still limited. Scientific surveys of the fish diversity started in the mid 1990s in conjunction with hydropower development. Unfortunately most of this information is of limited quality and not openly available.

Hydropower projects are usually installed on rivers with a high gradient and the inundated stretches of rivers are mainly characterized by fast to very fast waters, with rapids and waterfalls. These fast water habitats (= rheophilic habitats) are inhabited by aquatic animals specialised for these strong current conditions; most of them are unable to adapt to slow flowing or standing water and will disappear with inundation of the reservoir and reduced flow downstream. However, EIAs often neglect this rheophilic fauna, mainly because the sites are difficult to access and to sample.

This report presents the observations on fish diversity made during surveys conducted in January and February 2014 in the Nam Ngiep 1 project area and discusses impacts of the project in the rheophilic fauna and possible mitigations.

3.1 Survey participants

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Mr Thavone Phommavong, Living Aquatic Resources Research Center, Vientiane
Mr Soukhsavan _____, NNP1PC

Mr Adam Greenhalgh, ERM
Mr _____, Division of Fisheries, Vientiane

3.2 Methods and terminology

Most fish samples were obtained with a Grassl IG200/2 battery-powered electric fish shocker and with ichthyocides. Additional material was obtained by push-net and seine, and by inspecting catches of villagers and kitchens of restaurants. Ichthyocides were used to obtain samples from habitats that could not be sampled by other means (crevices, rapids, etc.); they were used only where their effect could be entirely controlled and where the river topography allowed an immediate dilution below toxicity level immediately downstream of the sampled area.

The sites were accessed by boat or by car. The Nam Ngiep itself could not be sampled between the dam site and Ban Sopyouak as it cannot be travelled by boat and there is no access by car. Access to tributaries on the west side was not possible upstream of Ban Pouan for security reason.

Identifications and nomenclature follow mainly Kottelat (2001), updated with knowledge acquired posteriorly (compiled in Kottelat, 2012, 2013).

Species are recorded only under their scientific names; these are made of two words, written in italics, and follow the International Code of Zoological Nomenclature. For species that present identification problems, the term 'cf.' is added between the generic name (the 'first name' written with a capitalised initial) and the species name ('second name') to refer to populations which are likely to belong to the species referred to but whose identification is not yet certain because of unresolved taxonomic problems. For example, what is referred to as *Oreoglanis* cf. *delacouri* is possibly *Oreoglanis delacouri* but a soubt subsists and more work, or more material, or more populations are needed to be absolutely sure. The term 'aff.' (for 'affinis') denotes populations that cannot be identified with any species known to me, or which probably are new species (that is unnamed, without scientific name). The use of 'aff.' is to ally this possibly new taxon with what is possibly its closest species. For example, *Schistura* aff. *ephelis* indicates that the species is distinct but close to *Schistura ephelis*. 'sp. n.' is used for species new to science, that is, species that have not yet received a formal name. For example *Glyptothorax* aff. *zanaensis*.

The term "sp." means an unidentified species. For example *Schistura* sp. indicates a species of *Schistura*, which cannot be identified at the species level, for example very small juveniles or mutilated individuals.

Spelling of names of villages and streams follow the 1985 1:100,000 Lao P.D.R. topographic maps, when feasible. Co-ordinates were obtained with four different GPS (two of them mounted in camera) and, in a few cases, from the maps. Datum: WGS 84, UTM zone 48. *Altitudes listed below are only indicative*; they were measured with these two GPS; they often differed and they also differed from those indicated in other documents and maps, or those obtained from Google Earth. The amplitude of the differences varied between 1 to 20 meters. As a result, some samples obtained around FSL may be somewhat above or below.

In the discussion, the word *endemic*, used as either a noun or an adjective, means: whose distribution is restricted to a geographically limited area. For example, a species endemic to the Nam Ngiep is a species that has been observed only in the Nam Ngiep drainage.

3.3 Abbreviations

FSL	Full Supply Level
IUCN	International Union for Conservation of Nature
MOL	Minimum Operation Level
NNP1, NNP2	the 2 hydropower projects on the Nam Ngiep
NNP1PC	Nam Ngiep 1 Power Company

4 Results of survey

4.1 Collecting sites and observed species

Sampling sites are numbered in chronological sequence. The sites are organised in the following order: NNP1 inundation zone; Nam Ngiep drainage above FSL of NNP1; and sites outside NNP1 project area (Nam Mang, Nam Xan, Nam Xao). Species are listed in alphabetical order of families, genera and species.

4.1.1 Nam Ngiep in NNP1 inundation zone

14-001 Nam Chae, immediately upstream of confluence with Nam Ngiep, about 7.5 km downstream of Ban Pou; 18°59'39.5"N 103°30'00.0"E, 300 masl; 28 Jan 2014.

Balitoridae	*Homaloptera yunnanensis*
Cyprinidae	*Onychostoma* aff. *gerlachi*
Cyprinidae	*Scaphiodonichthys acanthopterus*
Nemacheilidae	*Schistura* aff. *ephelis*
Sisoridae	*Glyptothorax horai*
Sisoridae	*Glyptothorax laosensis*
Sisoridae	*Glyptothorax* aff. *zanaensis*
Sisoridae	*Pseudecheneis sympelvica*

14-002 Houay None, immediately upstream of confluence with Nam Ngiep, about 9 km downstream of Ban Pou; 18°59'06.9"N 103°29'39.8"E, 279 masl; 28 Jan 2014.

Channidae	*Channa gachua*
Cyprinidae	*Barbodes aurotaeniatus*
Cyprinidae	*Danio acrostomus*
Cyprinidae	*Esomus metallicus*
Cyprinidae	*Opsarius pulchellus*
Cyprinidae	*Osteochilus striatus*
Cyprinidae	*Poropuntius* aff. *carinatus*
Cyprinidae	*Puntius brevis*
Cyprinidae	*Rasbora atridorsalis*
Cyprinidae	*Rasbora rubrodorsalis*
Cyprinidae	*Scaphiodonichthys acanthopterus*
Cyprinidae	*Systomus jacobusboehlkei*
Cyprinidae	*Tor laterivittatus*
Nemacheilidae	*Nemacheilus platiceps*
Nemacheilidae	*Schistura defectiva*
Nemacheilidae	*Schistura dorsizona*

14-003 Houay Hok, about 300 m uspstream of confluence with Nam Ngiep, which is about 15 km downstream of Ban Pou; 18°56'25.7"N 103°29'58.2"E, 295 masl; 29 Jan 2014.

Balitoridae	*Hemimyzon confluens*
Cyprinidae	*Bangana lippa*
Cyprinidae	*Garra theunensis*
Cyprinidae	*Onychostoma* aff. *gerlachi*
Cyprinidae	*Opsarius pulchellus*
Cyprinidae	*Poropuntius* aff. *carinatus*
Cyprinidae	*Raiamas guttatus*
Cyprinidae	*Scaphiodonichthys acanthopterus*
Nemacheilidae	*Schistura coruscans*
Nemacheilidae	*Schistura defectiva*
Nemacheilidae	*Schistura dorsizona*
Sisoridae	*Glyptothorax horai*
Tetraodontidae	*Pao turgidus*

14-004 Nam Ngiep, rapids about 8.2 km downstream of Ban Pou; 18°59'20.9"N 103°29'41.6"E, 305 masl; 29 Jan 2014.

Balitoridae	*Homaloptera yunnanensis*
Cyprinidae	*Hampala macrolepidota*

Cyprinidae	*Mystacoleucus greenwayi*
Cyprinidae	*Mystacoleucus marginatus*
Cyprinidae	*Onychostoma* aff. *gerlachi*
Cyprinidae	*Opsarius pulchellus*
Cyprinidae	*Osteochilus striatus*
Cyprinidae	*Poropuntius* aff. *carinatus*
Cyprinidae	*Raiamas guttatus*
Cyprinidae	*Scaphiodonichthys acanthopterus*
Gobiidae	*Papuligobius ocellatus*
Nemacheilidae	*Schistura coruscans*
Nemacheilidae	*Schistura defectiva*
Nemacheilidae	*Schistura dorsizona*
Nemacheilidae	*Schistura* aff. *defectiva*
Nemacheilidae	*Schistura* aff. *ephelis*
Nemacheilidae	*Schistura* sp. 'compact'
Sisoridae	*Glyptothorax horai*
Sisoridae	*Glyptothorax laosensis*
Sisoridae	*Glyptothorax* aff. *zanaensis*

14-005 Houay Pa Ko, a small creek entering Nam Ngiep from the west as a small waterfall about 5 km downstream of Ban Pou; 19°00'00.4"N 103°28'50.0"E, 324 masl; 29 Jan 2014.

Cyprinidae	*Barbodes aurotaeniatus*
Cyprinidae	*Danio acrostomus*
Cyprinidae	*Esomus metallicus*
Cyprinidae	*Rasbora atridorsalis*
Nemacheilidae	*Nemacheilus platiceps*
Nemacheilidae	*Schistura defectiva*

14-006 Nam Khai, immediately upstream of confluence with Nam Ngiep, about 22 km downstream of Ban Pou and 19 upstream of Ban Soppouan; 18°53'48.8"N 103°28'21.9"E, 286 masl; 30 Jan 2014.

Balitoridae	*Hemimyzon confluens*
Cyprinidae	*Bangana lippa*
Cyprinidae	*Barbodes aurotaeniatus*
Cyprinidae	*Mystacoleucus marginatus*
Cyprinidae	*Onychostoma* aff. *gerlachi*
Cyprinidae	*Opsarius pulchellus*
Cyprinidae	*Raiamas guttatus*
Cyprinidae	*Scaphiodonichthys acanthopterus*
Cyprinidae	*Tor laterivittatus*
Nemacheilidae	*Schistura coruscans*
Nemacheilidae	*Schistura defectiva*
Nemacheilidae	*Schistura dorsizona*
Nemacheilidae	*Schistura* aff. ephelis
Nemacheilidae	*Schistura* sp. n. 'slender'
Sisoridae	*Glyptothorax horai*

14-007 Houay San, immediately upstream of confluence with Nam Ngiep, about 23 km downstream of Ban Pou and 18 km upstream of Ban Sopphouan; 18°53'10.8"N 103°28'06.6"E, 300 masl; 30 Jan 2014.

Cyprinidae	*Barbodes aurotaeniatus*
Cyprinidae	*Danio acrostomus*
Cyprinidae	*Opsarius pulchellus*
Cyprinidae	*Puntius brevis*
Cyprinidae	*Scaphiodonichthys acanthopterus*
Gobiidae	*Rhinogobius albimaculatus*
Mastacembelidae	*Mastacembelus armatus*
Nemacheilidae	*Schistura coruscans*
Nemacheilidae	*Schistura defectiva*
Nemacheilidae	*Schistura* aff. ephelis
Nemacheilidae	*Schistura* sp. 'compact'

Sisoridae	*Glyptothorax laosensis*
Sisoridae	*Oreoglanis delacouri*

14-008 Nam Pouan, upstream of Ban Soppouan, about 300 m upstream of confluence with Nam Ngiep; 18°46'57.4"N 103°25'57.7"E, 244 masl; 31 Jan 2014.

Balitoridae	*Hemimyzon confluens*
Balitoridae	*Homaloptera yunnanensis*
Cyprinidae	*Bangana lippa*
Cyprinidae	*Barbodes aurotaeniatus*
Cyprinidae	*Scaphiodonichthys acanthopterus*
Gobiidae	*Papuligobius ocellatus*
Nemacheilidae	*Nemacheilus platiceps*
Nemacheilidae	*Schistura coruscans*
Nemacheilidae	*Schistura defectiva*
Nemacheilidae	*Schistura* aff. *ephelis*
Nemacheilidae	*Schistura* sp. 'compact'
Nemacheilidae	*Schistura* sp. n. 'slender'
Sisoridae	*Glyptothorax laosensis*

14-009 Houay Hok, a small creek entering Nam Ngiep, about 3.5 km south of Ban Soppouan on road to Ban Sopyouak; 18°44'57.0"N 103°25'27.7"E, 261 masl; 31 Jan 2014.

Channidae	*Channa gachua*
Clariidae	*Clarias batrachus*
Cyprinidae	*Bangana lippa*
Cyprinidae	*Danio acrostomus*
Cyprinidae	*Garra theunensis*
Cyprinidae	*Neolissochilus blanci*
Cyprinidae	*Opsarius pulchellus*
Cyprinidae	*Puntius brevis*
Cyprinidae	*Scaphiodonichthys acanthopterus*
Cyprinidae	*Systomus jacobusboehlkei*
Gobiidae	*Papuligobius ocellatus*
Mastacembelidae	*Mastacembelus armatus*
Nemacheilidae	*Schistura defectiva*
Nemacheilidae	*Schistura* aff. *ephelis*
Nemacheilidae	*Schistura* sp. 'compact'
Nemacheilidae	*Schistura* sp. n. 'Nam Youak'
Sisoridae	*Glyptothorax laosensis*
Synbranchidae	*Monopterus albus*

14-010 Nam Ngiep at Keng Wong Kou [rapids], about 2 km upstream of Ban Sopyouak [measured from ferry on road to Ban Bo]; 18°43'35.2"N 103°25'29.2"E, 233 masl; 1 Feb 2014.

Cyprinidae	*Bangana lippa*
Cyprinidae	*Mystacoleucus greenwayi*
Cyprinidae	*Mystacoleucus marginatus*
Cyprinidae	*Onychostoma* aff. *gerlachi*
Cyprinidae	*Poropuntius* aff. *carinatus*
Cyprinidae	*Scaphiodonichthys acanthopterus*
Nemacheilidae	*Schistura defectiva*
Nemacheilidae	*Schistura* aff. *ephelis*
Sisoridae	*Glyptothorax horai*

14-011 Nam Ngiep at Keng Chong [rapids], about 4.5 km upstream of Ban Sopyouak [measured from ferry on road to Ban Bo]; 18°44'32.5"N 103°25'24.2"E, 239 masl; 1 Feb 2014.

Balitoridae	*Homaloptera yunnanensis*
Cyprinidae	*Bangana lippa*
Cyprinidae	*Garra cambodgiensis*
Cyprinidae	*Mystacoleucus marginatus*
Cyprinidae	*Opsarius pulchellus*
Cyprinidae	*Poropuntius* aff. *carinatus*

Cyprinidae	*Scaphiodonichthys acanthopterus*
Gobiidae	*Papuligobius ocellatus*
Gyrinocheilidae	*Gyrinocheilus aymonieri*
Sisoridae	*Glyptothorax horai*
Sisoridae	*Glyptothorax laosensis*
Sisoridae	*Glyptothorax* aff. *zanaensis*

14-012 Nam Youak at Ban Sopyouak, about 200 m upstream of confluence with Nam Ngiep; 18°42'56.5"N 103°25'55.1"E, 236 masl; 2 Feb 2014.

Balitoridae	*Hemimyzon confluens*
Balitoridae	*Homaloptera yunnanensis*
Cyprinidae	*Barbodes aurotaeniatus*
Cyprinidae	*Esomus metallicus*
Cyprinidae	*Onychostoma* aff. *gerlachi*
Cyprinidae	*Opsarius pulchellus*
Cyprinidae	*Poropuntius* aff. *carinatus*
Cyprinidae	*Puntius brevis*
Cyprinidae	*Rasbora atridorsalis*
Cyprinidae	*Scaphiodonichthys acanthopterus*
Cyprinidae	*Systomus jacobusboehlkei*
Cyprinidae	*Tor laterivittatus*
Gobiidae	*Papuligobius ocellatus*
Nemacheilidae	*Schistura coruscans*
Nemacheilidae	*Schistura defectiva*
Nemacheilidae	*Schistura dorsizona*
Nemacheilidae	*Schistura* aff. *ephelis*
Nemacheilidae	*Schistura* sp. 'compact'
Sisoridae	*Glyptothorax horai*
Sisoridae	*Glyptothorax laosensis*
Sisoridae	*Pseudecheneis sympelvica*

14-013 Restaurant in Ban Thaviang, from Nam Ngiep, 19°02'31.4"N 103°23'34.9"E; 30 Jan 2014; most of them identified from cut pieces or cooked fishes.

Bagridae	*Hemibagrus nemurus*
Bagridae	*Hemibagrus wyckioides*
Cyprinidae	*Cirrhinus prosemion*
Cyprinidae	*Hampala macrolepidota*
Cyprinidae	*Hypsibarbus vernayi* ?
Cyprinidae	*Poropuntius* aff. *carinatus*
Cyprinidae	*Tor laterivittatus*
Cyprinidae	*Tor tambra*
Sisoridae	*Bagarius yarrellii*

4.1.2 Nam Ngiep drainage above FSL of NNP1

14-015 Nam Youak between Ban Sopyouak and Ban Houaysey, 18°43'26.7"N 103°22'39.4"E, 304 masl; 14 Feb 2014.

Balitoridae	*Balitora lancangjiangensis*
Balitoridae	*Homaloptera yunnanensis*
Cyprinidae	*Danio acrostomus*
Cyprinidae	*Garra theunensis*
Cyprinidae	*Neolissochilus blanci*
Cyprinidae	*Onychostoma* aff. *gerlachi*
Cyprinidae	*Opsarius pulchellus*
Cyprinidae	*Poropuntius* aff. *carinatus*
Cyprinidae	*Scaphiodonichthys acanthopterus*
Cyprinidae	*Tor laterivittatus*
Gobiidae	*Rhinogobius albimaculatus*
Nemacheilidae	*Schistura coruscans*

Nemacheilidae	*Schistura defectiva*
Nemacheilidae	*Schistura* aff. *ephelis*
Nemacheilidae	*Schistura* sp. 'compact'
Nemacheilidae	*Schistura* sp. n. 'Nam Youak'
Sisoridae	*Glyptothorax horai*
Sisoridae	*Glyptothorax laosensis*
Sisoridae	*Oreoglanis delacouri*
Synbranchidae	*Monopterus albus*

14-016 Houay Kolong, first creek crossing road from Ban Houaysey to Ban Sopyouak, 18°43'31.9"N 103°21'20.3"E, 415 masl ; 14 Feb 2014.

Channidae	*Channa gachua*
Cyprinidae	*Danio acrostomus*
Cyprinidae	*Neolissochilus blanci*
Cyprinidae	*Poropuntius* aff. *carinatus*
Cyprinidae	*Scaphiodonichthys acanthopterus*
Nemacheilidae	*Schistura coruscans*
Nemacheilidae	*Schistura defectiva*
Nemacheilidae	*Schistura* sp. n. 'Nam Youak'
Sisoridae	*Glyptothorax horai*
Sisoridae	*Oreoglanis delacouri*

14-017 Nam Long, a tributary of Nam Chae [Nam Chian], about 5 km upstream from bridge on road from Ban Thathom to Ban Pou, 19°04'01.4"N 103°28'20.5"E, 435 masl; 16 Feb 2014.

Balitoridae	*Hemimyzon confluens*
Cyprinidae	*Danio acrostomus*
Cyprinidae	*Garra theunensis*
Cyprinidae	*Neolissochilus blanci*
Cyprinidae	*Opsarius pulchellus*
Cyprinidae	*Scaphiodonichthys acanthopterus*
Nemacheilidae	*Schistura coruscans*
Sisoridae	*Glyptothorax horai*
Sisoridae	*Oreoglanis delacouri*

14-019 Nam Ngiep north of Ban Naxong, 19°03'23.7"N 103°22'06.4"E, 337 masl; 17 Feb 2014.

Cyprinidae	*Barbodes aurotaeniatus*
Cyprinidae	*Mystacoleucus marginatus*
Cyprinidae	*Opsarius pulchellus*
Cyprinidae	*Poropuntius* aff. *carinatus*
Cyprinidae	*Puntius brevis*
Cyprinidae	*Tor laterivittatus*
Gobiidae	*Papuligobius ocellatus*
Nemacheilidae	*Nemacheilus platiceps*
Nemacheilidae	*Schistura coruscans*
Nemacheilidae	*Schistura defectiva*
Nemacheilidae	*Schistura dorsizona*
Nemacheilidae	*Schistura* aff. *ephelis*
Nemacheilidae	*Schistura* aff. *defectiva*
Nemacheilidae	*Schistura* sp. n. 'slender'
Sisoridae	*Glyptothorax horai*

14-020 Nam Chae about 200 m downstream of bridge on road from Ban Thathom to Ban Pou, 19°02'15.4"N 103°30'07.8"E, 368 masl; 17 Feb 2014.

Cyprinidae	*Barbodes aurotaeniatus*
Cyprinidae	*Danio acrostomus*
Cyprinidae	*Garra theunensis*
Cyprinidae	*Neolissochilus blanci*
Cyprinidae	*Onychostoma* aff. *gerlachi*
Cyprinidae	*Opsarius pulchellus*
Cyprinidae	*Poropuntius* aff. *carinatus*

Cyprinidae	*Rasbora atridorsalis*
Cyprinidae	*Scaphiodonichthys acanthopterus*
Cyprinidae	*Tor laterivittatus*
Nemacheilidae	*Nemacheilus platiceps*
Nemacheilidae	*Schistura coruscans*
Nemacheilidae	*Schistura defectiva*
Nemacheilidae	*Schistura dorsizona*
Sisoridae	*Glyptothorax horai*
Sisoridae	*Glyptothorax laosensis*
Sisoridae	*Oreoglanis delacouri*

14-021 Nam Xong, upstream of Ban Naxong; 19°03'19.2"N 103°22'27.1"E; 321 masl; 18 Feb 2014.

Channidae	*Channa gachua*
Cyprinidae	*Barbodes aurotaeniatus*
Cyprinidae	*Danio acrostomus*
Cyprinidae	*Opsarius pulchellus*
Cyprinidae	*Puntius brevis*
Cyprinidae	*Scaphiodonichthys acanthopterus*
Gobiidae	*Rhinogobius albimaculatus*
Nemacheilidae	*Nemacheilus platiceps*
Nemacheilidae	*Schistura coruscans*
Nemacheilidae	*Schistura defectiva*
Nemacheilidae	*Schistura dorsizona*
Sisoridae	*Oreoglanis delacouri*

14-030 Houay Xo, a hill stream entering Nam Ngiep at about 18°51'42"N 103°27'16"E; 18°51'12.2" N 103°29'39.3"E, 402 masl; 20 Feb 2014.

Channidae	*Channa gachua*
Clariidae	*Clarias batrachus*
Cyprinidae	*Danio* sp. n.
Cyprinidae	*Poropuntius* sp. n.
Nemacheilidae	*Schistura* sp.

14-032 Nam Sao, a tributary of Nam Ngiep, entering it about 1 km downstream of Ban Sopyouak; 18°43'38.3"N 103°28'14.0"E, 308 masl; 21 Feb 2014.

Channidae	*Channa gachua*
Cyprinidae	*Barbodes aurotaeniatus*
Cyprinidae	*Danio acrostomus*
Cyprinidae	*Neolissochilus blanci*
Cyprinidae	*Opsarius pulchellus*
Cyprinidae	*Poropuntius* aff. *carinatus*
Cyprinidae	*Puntius brevis*
Cyprinidae	*Rasbora atridorsalis*
Cyprinidae	*Scaphiodonichthys acanthopterus*
Cyprinidae	*Systomus jacobusboehlkei*
Gobiidae	*Papuligobius ocellatus*
Mastacembelidae	*Mastacembelus armatus*
Nemacheilidae	*Nemacheilus platiceps*
Nemacheilidae	*Schistura coruscans*
Nemacheilidae	*Schistura defectiva* ?
Nemacheilidae	*Schistura dorsizona*

4.1.3 Sites outside Nam Ngiep drainage upstream of NNP1 dam site

4.1.3.1 Nam Mang drainage

14-014 Nam Mang near Ban Pa La Veak [Nam Mang drainage], 18°40'00.0"N 103°12'05.5"E, 456 masl; 13 Feb 2014.

Amblycipitidae	*Amblyceps mucronatum*

Channidae	*Channa gachua*
Cyprinidae	*Esomus metallicus*
Cyprinidae	*Neolissochilus blanci*
Cyprinidae	*Opsarius pulchellus*
Cyprinidae	*Puntius rhombeus*
Cyprinidae	*Rasbora paviana*
Mastacembelidae	*Mastacembelus armatus*
Nemacheilidae	? *Schistura* aff. *defectiva*
Nemacheilidae	*Schistura ephelis*
Nemacheilidae	*Schistura leukensis*
Sisoridae	*Glyptothorax horai*
Sisoridae	*Glyptothorax laosensis*
Synbranchidae	*Monopterus albus*

4.1.3.2 Nam Xan drainage

14-018 Nam Pha, a tributary of Nam Tai, about 3 km northeast of Ban Thathom, 19°00'22.6"N 103°36'44.1"E, 317 masl; 16 Feb 2014.

Balitoridae	*Hemimyzon confluens*
Cyprinidae	*Danio acrostomus*
Cyprinidae	*Garra theunensis*
Cyprinidae	*Neolissochilus blanci*
Cyprinidae	*Opsarius pulchellus*
Cyprinidae	*Scaphiodonichthys acanthopterus*
Nemacheilidae	*Schistura coruscans*
Nemacheilidae	*Schistura ephelis*
Sisoridae	*Glyptothorax horai*
Sisoridae	*Oreoglanis* cf. *delacouri*

14-022 Nam Mang, about 800 m upstream of confluence with Nam Xan; 18°49'49.9"N 103°47'51.8"E, 224 masl, 18 Feb 2014.

Balitoridae	*Hemimyzon confluens*
Balitoridae	*Homaloptera smithi*
Balitoridae	*Homaloptera yunnanensis*
Cyprinidae	*Garra cambodgiensis*
Cyprinidae	*Onychostoma* aff. *gerlachi*
Nemacheilidae	*Schistura crabro*
Nemacheilidae	*Schistura dorsizona*
Nemacheilidae	*Schistura ephelis*
Nemacheilidae	*Schistura sombooni*
Nemacheilidae	*Schistura* cf. *nicholsi*
Sisoridae	*Glyptothorax horai*
Sisoridae	*Glyptothorax laosensis*

14-023 Nam Lard [Nam Lat], immediately uptream of confluence with Nam Xan, downstream of bridge; 18°46'38.6"N 103°49'16.3"E, 212 masl; 18 Feb 2014.

Balitoridae	*Homaloptera smithi*
Cyprinidae	*Garra cambodgiensis*
Cyprinidae	*Hampala macrolepidota*
Cyprinidae	*Mystacoleucus greenwayi*
Cyprinidae	*Onychostoma* aff. *gerlachi*
Cyprinidae	*Opsarius koratensis*
Cyprinidae	*Scaphiodonichthys acanthopterus*
Nemacheilidae	*Schistura dorsizona*
Nemacheilidae	*Schistura ephelis*
Nemacheilidae	*Schistura* cf. *nicholsi*
Sisoridae	*Glyptothorax horai*
Tetraodontidae	*Pao turgidus*

14-024 Nam Xan at Keng Yakhou, about 9 km upstream of Ban Pakhuang, about 3 km downstream of Ban Khanyong; 18°44'03.3"N 103°47'04.6"E; 19 Feb 2014.

Balitoridae	*Hemimyzon confluens*
Balitoridae	*Homaloptera smithi*
Balitoridae	*Homaloptera yunnanensis*
Belonidae	*Xenentodon canciloides*
Cyprinidae	*Garra cambodgiensis*
Cyprinidae	*Garra fuliginosa*
Cyprinidae	*Onychostoma* aff. *gerlachi*
Nemacheilidae	*Schistura crabro*
Nemacheilidae	*Schistura dorsizona*
Nemacheilidae	*Schistura ephelis*
Nemacheilidae	*Schistura* cf. *nicholsi*
Nemacheilidae	*Schistura sombooni*
Sisoridae	*Glyptothorax horai*
Tetraodontidae	*Pao turgidus*

14-025 Nam Xan at Keng Kokxan, about 7 km upstream of Ban Pakhuang; 18°43'35.0"N 103°48'13.5"E, 187 masl; 19 Feb 2014.

Bagridae	*Hemibagrus nemurus*
Bagridae	*Pseudomystus siamensis*
Balitoridae	*Homaloptera smithi*
Balitoridae	*Homaloptera yunnanensis*
Cyprinidae	*Crossocheilus atrilimes*
Cyprinidae	*Garra cambodgiensis*
Cyprinidae	*Mystacoleucus marginatus*
Cyprinidae	*Onychostoma* aff. *gerlachi*
Cyprinidae	*Opsarius pulchellus*
Cyprinidae	*Poropuntius normani*
Gobiidae	*Papuligobius ocellatus*
Mastacembelidae	*Mastacembelus armatus*
Nemacheilidae	*Schistura coruscans*
Nemacheilidae	*Schistura dorsizona*
Nemacheilidae	*Schistura ephelis*
Sisoridae	*Glyptothorax horai*

14-026 Nam Xa, a tributary of Nam Xan entering it about 2 km upstream of Ban Pakhuang; 18°42'00.4"N 103°47'40.3"E, 183 masl, 19 Feb 2014; fished with electricity about once a week.

Bagridae	*Hemibagrus nemurus*
Bagridae	*Pseudomystus siamensis*
Balitoridae	*Homaloptera smithi*
Cyprinidae	*Osteochilus hasselti*
Cyprinidae	*Poropuntius normani*
Gobiidae	*Papuligobius ocellatus*
Mastacembelidae	*Macrognathus siamensis*
Nemacheilidae	*Nemacheilus pallidus*
Nemacheilidae	*Nemacheilus platiceps*
Nemacheilidae	*Schistura coruscans*
Pristolepididae	*Pristolepis fasciata*
Tetraodontidae	*Pao turgidus*

14-027 Nam Xan at Keng Tong, about 1 km upstream of Ban Pakhuang; 18°41'37.5"N 103°47'17.1"E, 167 masl; 19 Feb 2014.

Balitoridae	*Balitora* sp.
Balitoridae	*Homaloptera smithi*
Balitoridae	*Homaloptera yunnanensis*
Cyprinidae	*Garra cambodgiensis*
Cyprinidae	*Opsarius pulchellus*
Cyprinidae	*Poropuntius normani*
Cyprinidae	*Scaphiodonichthys acanthopterus*

Gobiidae	*Papuligobius ocellatus*
Nemacheilidae	*Schistura dorsizona*
Nemacheilidae	*Schistura* aff. *ephelis*
Sisoridae	*Glyptothorax horai*

14-028 Nam Xan at Keng Pakhuang, immediately downstream of Ban Pakhuang; 18°40'57.8"N 103°47'08.7"E, 160 masl; 19 Feb 2014.

Balitoridae	*Hemimyzon confluens*
Balitoridae	*Homaloptera smithi*
Balitoridae	*Homaloptera yunnanensis*
Cyprinidae	*Garra cambodgiensis*
Cyprinidae	*Garra fuliginosa*
Cyprinidae	*Poropuntius normani*
Mastacembelidae	*Mastacembelus armatus*
Sisoridae	*Glyptothorax horai*
Nemacheilidae	*Schistura* cf. *nicholsi*
Nemacheilidae	*Schistura dorsizona*
Nemacheilidae	*Schistura ephelis*
Nemacheilidae	*Schistura sombooni*

4.1.3.3 Nam Xao drainage

Nam Xao is a tributary of Nam Ngiep, entering it downstream of NNP1 dam site.

14-029 Nam Xao downstream of Ban Phounxong; 18°49'20.2"N 103°32'20.6"E, 231 masl; 20 Feb 2014.

Channidae	*Channa gachua*
Clariidae	*Clarias batrachus*
Cyprinidae	*Barbodes aurotaeniatus*
Cyprinidae	*Esomus metallicus*
Cyprinidae	*Garra* sp. juv.
Cyprinidae	*Laocypris hispida*
Cyprinidae	*Opsarius pulchellus*
Cyprinidae	*Osteochilus lini*
Cyprinidae	*Poropuntius normani*
Cyprinidae	*Puntius rhombeus*
Cyprinidae	*Rasbora paviana*
Cyprinidae	*Systomus jacobusboehlkei*
Gobiidae	*Papuligobius ocellatus*
Gobiidae	*Rhinogobius* cf. *albimaculatus*
Nemacheilidae	*Nemacheilus platiceps*
Nemacheilidae	*Schistura sigillata*
Nemacheilidae	*Schistura sombooni*

14-031 Houay Ken, a small tributary of Nam Xao, upstream of Ban Phounxong; 18°50'09.2"N 103°32'05.4"E, 295 masl; 20 Feb 2014.

Channidae	*Channa gachua*
Cyprinidae	*Barbodes aurotaeniatus*
Cyprinidae	*Esomus metallicus*
Cyprinidae	*Osteochilus lini*
Cyprinidae	*Poropuntius normani*
Gobiidae	*Papuligobius ocellatus*
Nemacheilidae	*Nemacheilus platiceps*
Nemacheilidae	*Schistura nicholsi*

14-033 Nam Xao upstream of bridge on road from Ban Muanghuang to Ban Nahan; 18°45'33.3"N 103°32'57.1"E, 217 masl; 21 Feb 2014.

Amblycipitidae	*Amblyceps mucronatum*
Bagridae	*Pseudomystus siamensis*
Balitoridae	*Hemimyzon confluens*
Channidae	*Channa gachua*

Cyprinidae	*Barbodes aurotaeniatus*
Cyprinidae	*Esomus metallicus*
Cyprinidae	*Onychostoma* aff. *gerlachi*
Cyprinidae	*Osteochilus lini*
Cyprinidae	*Poropuntius normani*
Cyprinidae	*Puntius rhombeus*
Cyprinidae	*Rasbora paviana*
Cyprinidae	*Systomus jacobusboehlkei*
Gobiidae	*Papuligobius ocellatus*
Gobiidae	*Rhinogobius* cf. *albimaculatus*
Mastacembelidae	*Macrognathus siamensis*
Mastacembelidae	*Mastacembelus armatus*
Nemacheilidae	*Nemacheilus platiceps*
Nemacheilidae	*Schistura dorsizona*
Nemacheilidae	*Schistura nicholsi*
Nemacheilidae	*Schistura sigillata*
Tetraodontidae	*Pao turgidus*

14-034 Nam Xao, Hart [Keng] Teen Heen, about 2 km upstream of Ban Thahua; 18°39'56.4"N 103°37'24.9"E, 172 masl; 22 Feb 2014.

Bagridae	*Hemibagrus nemurus*
Bagridae	*Pseudomystus siamensis*
Balitoridae	*Hemimyzon confluens*
Balitoridae	*Homaloptera smithi*
Balitoridae	*Homaloptera yunnanensis*
Chandidae	*Parambassis siamensis*
Cyprinidae	*Crossocheilus atrilimes*
Cyprinidae	*Onychostoma* aff. *gerlachi*
Cyprinidae	*Osteochilus lini*
Cyprinidae	*Poropuntius normani*
Gobiidae	*Papuligobius ocellatus*
Gobiidae	*Rhinogobius* cf. *albimaculatus*
Nemacheilidae	*Nemacheilus platiceps*
Nemacheilidae	*Schistura dorsizona*
Nemacheilidae	*Schistura nicholsi*
Pristolepididae	*Pristolepis fasciata*

14-035 Nam Xao, Hart [Keng] Sarng Pa Fa, about 2.5 km upstream of Ban Thahua; 18°40'13.0"N 103°37'25.6"E, 171 masl [actually upstream of 14-034]; 22 Feb 2014.

Bagridae	*Pseudomystus siamensis*
Balitoridae	*Homaloptera smithi*
Balitoridae	*Homaloptera yunnanensis*
Belonidae	*Xenentodon canciloides*
Chandidae	*Parambassis siamensis*
Cyprinidae	*Poropuntius normani*
Gobiidae	*Papuligobius ocellatus*
Gobiidae	*Rhinogobius* cf. *albimaculatus*
Mastacembelidae	*Mastacembelus armatus*
Nemacheilidae	*Schistura nicholsi*

14-036 Nam Xao in Ban Thahua; 18°39'18.1"N 103°36'46.3"E, 168 masl; 22 Feb 2014.

Bagridae	*Pseudomystus siamensis*
Balitoridae	*Homaloptera smithi*
Cyprinidae	*Mystacoleucus marginatus*
Gobiidae	*Papuligobius ocellatus*
Nemacheilidae	*Schistura nicholsi*
Nemacheilidae	*Schistura sigillata*

4.2 Fish fauna

4.2.1 Diversity, endemism

Fish were sampled or observed at 21 sites in the Nam Ngiep drainage upstream of the dam site, 14 of them in fast water habitats in the inundation zone of NNP1 reservoir. A total of 56 species were recorded in the surveyed part of the drainage (Table 1), 53 of them present in the inundation zone, and 34 species were observed in the samples from outside the inundation zone.

Although not observed during the survey, interviews with villagers in Ban Pou, Ban Thaviang, Ban Viengta abd Ban Xomxeun indicate the presence of *Luciocyprinus striolatus* (see Annex 1). In 2013 I have seen in a restaurant in Ban Vanglouang (Hom District; Nam Ngum drainage) a specimen of *Labeo pierrei* that had been brought from Ban Sopyouak; the species has not been obtained by the survey but the origin of the observed specimen is reliable and conforms with what is known of the species in other drainages (Nam Ou, Nam Ngum, Xe Bangfai, Xe Kong). The two species are included in the fish fauna of the Nam Ngiep in Tables 1–2.

Among the 53 species in the inundation zone (Table 1), 2 are new to science (*Schistura* sp. n. 'Nam Youak', *Schistura* sp. n. 'slender'). A further 4 species are potentially also new to science but this cannot be established within the time available for this report (*Schistura* aff. *ephelis*, *Schistura* sp. 'compact', *Schistura* aff. *defectiva*, *Poropuntius* aff. *carinatus*). Awaiting clarification, I adopt a precautionary approach and treat them here as if they effectively are new species. These new species have been discovered by the survey in the Nam Ngiep drainage and therefore they must be treated as endemic to the Nam Ngiep. For 3 of these species there is, however, suspicion that some (or similar-looking species) also exist in adjacent drainages (*Poropuntius* aff. *carinatus*, *Schistura* aff. *ephelis*, *Schistura* aff. *defectiva*).

A further 2 new species were discovered in a small hill stream of the Nam Ngiep drainage (site 14-30), but far above FSL (*Danio* sp. n., *Poropuntius* sp. n.). *Glyptothorax* aff. *zanaensis* and *Onychostoma* aff. *gerlachi* are also unnamed species obtained by the survey but they were already known from surveys in other areas of Laos.

All the endemic species found in the inundation zone have also been found above FSL. Some have a wide distribution in the inundation zone (*Schistura* sp. n. 'slender', *Schistura* aff. *ephelis*, *Schistura* sp. 'compact', *Poropuntius* aff. *carinatus*) but others seem to have a restricted range, but this might result from a sampling bias because most of the tributaries of the reservoir are not accessible.

Eight sites were sampled in the Nam Xan drainage, one in the Nam Mang and six in the Nam Xao, a tributary ofv the Nam Ngiep entering it downstream of NNP1 dam site.

Schistura crabro was earlier known only from an unspecified locality in the Nam Ngiep drainage. The survey observed it at two sites in the Nam Xan and therefore the species is no longer to be treated as endemic of the Nam Ngiep. The habitat in which it was observed (riffles on a substrate of gravel to small stones) was rare in the surveyed stretch of the Nam Ngiep and the species possibly does no occur in the NNP1 inundation zone.

4.2.1.3 Other drainages

The sampling in the adjacent drainages yielded 55 species (Table 2). 30 of them are also present in the surveyed parts of the Nam Ngiep drainage. These species will not be further mentioned here unless relevant to the discussion of the NNP1 project area.

4.2.2 Migrations

Only two of the recorded species are known to be long distance migratory in other tributaries of the Mekong: *Labeo pierrei* and *Cirrhinus molitorella*. Both species were observed in restaurants and said to come from the Nam Ngiep.

Labeo pierrei is known to undertake long migrations. This has been documented in the Xekong River, where it moves between the middle Xekong (for spawning) and the Mekong. Such long migrations will not be possible in the Nam Ngiep after construction of the NNP1 dam. However, a survey of the Nam Ngum in 2013 observed that juveniles 1-2 years old were present upstream of Nam Ngum 1 and Nam

Ngum 2 reservoirs. They were at about FSL of Nam Ngum 2, in rapids exposed in the dry season. This shows that reproduction was possible without access to the Mekong, but this observation may not be informative for long term evolution since Nam Ngum 2 dam was commissioned in 2011.

4.2.3 Conservation status

The threat status of all the named freshwater fishes of mainland Southeast Asia has been assessed in the IUCN Red List of Endangered Species (www.iucnredlist.org) (Allen et al., 2012). 46 of the 56 species recorded in the Nam Ngiep drainage upstream of NNP1 dam site have already been assessed (see Table 3). The Red List rating indicates the risk of extinction based on precisely defined criteria. The threat categories are: Critically Endangered (CR), Endangered (EN) and Vulnerable (VU). All species, even those not threatened, have been rated. Least Concerned (LC) are species not threatened; Near Threatened (NT) are species not in any of the threatened category but for which small changes in the habitat or population would immediately move them in a threat category. Data Deficient (DD) are species for which the available data did not allow to objectively rate them. Most of the DD species are newly discovered or rare species. The fate of DD species is not to remain DD but to eventually be evaluated; experience shows that once evaluated a fair number of the DD species are rated as threatened. Note that the assesment is based on the global range of a species, which means that a wide-ranging species could be locally abundant in a given area but globally threatened, or the reverse.

Among the 46 species observed by the survey and that had already been evaluated, none is CR, 1 is EN (*Luciocyprinus striolatus*), 3 are VU, 2 are NT, 29 are LC, and 11 are DD.

5 Species of concern, threats and mitigation

5.1. Endemics

5.1.1 *Schistura* sp. n. 'Nam Youak'

This is a new species discovered by the survey. It was observed in a small fast flowing stream tributary of the Nam Ngiep near Ban Soppouan (site 14-009) in the inundation zone, in the Nam Youak at about FSL (site 14-015) and in a small tributary of the Nam Youak about 100 m above FSL (site 14-016). It was most abundant at the last site where most individuals were obtained in the stretches with the fastest current. It is expected to be present in adjacent headwaters and its presence in the inundation zone is expected to be restricted to small tributaries. Most of the habitat of the species is expected to be above FSL.

The species is not directly threatened by the project. Indirect impacts will be the construction of access roads that will damage the streams and attract human activity, logging activity (road, camps, etc.) that result in deforestation, siltation, pollution and overfishing. Site 14-016 was along the road, about 1 km from village, in secondary forest, with some impact but still had a good fish population.

Mitigations. The most efficient way to manage the species is to ensure that stretches of streams where the species is present retain intact aquatic habitats. Key factors are small stream with fast water on large stones (torrent-type), with riparian forest cover, clear water and absence of siltation. An important point should be the absence of cause of siltation in the upper part of the catchment. Conservation of habitats for the species can be achieved in conjuction with the establishment of protected areas for other animals and forest. It will require knowing better the distribution of the species to ensure that it will be present in some of the protected areas.

5.1.2 *Schistura* sp. n. 'slender'

This is a new species discovered by the survey. It was observed in two tributaries of the Nam Ngiep on the west side (Nam Khai, site 14-006; Nam Pouan, site 14-008), in the inundation zone, and in the Nam Ngiep upstream of FSL of NNP1 reservoir (site 14-019). It was found on and in a substrate of coarse sand, gravel and small stones. Its preferred habitat seems to be stretches with moderate flow (in the dry season), which is not frequent in the inundation zone but makes most of the observed stretch of the Nam Ngiep upstream of FSL until at least Ban Naxong (site 14-019); the extent of its range upstream is not known. The upstream of the Nam Khai and Nam Pouan could not be

researched because of access difficulties and security reasons.

The species has not been collected in the main stream of the Nam Ngiep in the inundation zone but it was present in two tributaries. Species of the genus *Schistura* have not been observed to adapt to reservoir conditions and it is expected *Schistura* sp. n. 'slender' will disappear from the inundation zone. It is expected to subsist in the Nam Ngiep between NNP1 reservoir and NNP2 dams, if the substrate of gravel and stones is not covered by sediment resulting from construction and human activity further upstream.

Mitigations. The most efficient way to manage the species is to ensure that stretches of streams where the species is present retain intact aquatic habitats. Key factors seems to be the presence of a substrate of coarse sand, gravel and small stones and that this remain free from sediments or siltation. It would be better if such habitat could be located in tributaries located in protected areas for other animals and forest.

5.1.3 *Danio* sp. n.

This is a species new to science. It was found only at site 14-030, which is a small stream draining to the Nam Ngiep, in the hills almost at the divide between Nam Ngiep and Nam Xao, about 100 m above FSL. It is probably present in other headwaters; site 14-030 is along one of the only two tracks on which it was possible to cross the divide between the Nam Ngiep and the Nam Xao (near Ban Muang Bo). The species was not observed in the inundation zone and probably occurs only in small headwaters.

The species is not directly threatened by the project. Indirect impacts will be the construction of access roads that will damage the streams and attract human activity, logging activity (road, camps, etc.) that result in deforestation, siltation, pollution and overfishing. It was found together with *Poropuntius* sp. n. (see below).

Mitigations. The most efficient way to manage the species is to ensure that stretches of streams where the species is present retain intact aquatic habitats. Key factors are riparian forest cover, clear water, absence of siltation and human disturbance. An important point should be the absence of cause of siltation in the upper part of the catchment. Conservation of habitats for the species can be achieved in conjuction with the establishment of protected areas for other animals and forest. It will require knowing better the distribution of the species to ensure that it will be present in some of the protected areas.

5.1.4 *Poropuntius* sp. n.

This is a species new to science. It was found only at site 14-030, which is a small stream draining to the Nam Ngiep, in the hills almost at the divide between Nam Ngiep and Nam Xao, about 100 m above FSL. It is probably present in other headwaters; site 14-030 is along one of the only two tracks on which it was possible to cross the divide between the Nam Ngiep and the Nam Xao (near Ban Muang Bo). The species was not observed in the inundation zone and probably occurs only in small headwaters.

The species is not directly threatened by the project. Indirect impacts will be the construction of access roads that will damage the streams and attract human activity, logging activity (road, camps, etc.) that result in deforestation, siltation, pollution and overfishing. It was found together with *Danio* sp. n. (see above).

Mitigations. The most efficient way to manage the species is to ensure that stretches of streams with where the species is presentretain intact aquatic habitats. Key factors are riparian forest cover, clear water, absence of siltation and human disturbance. An important point should be the absence of cause of siltation in the upper part of the catchment. Conservation of habitats for the species can be achieved in conjuction with the establishment of protected areas for other animals and forest. It will require knowing better the distribution of the species to ensure that it will be present in some of the protected areas.

5.1.5 *Oreoglanis delacouri*

This species is endemic to the Nam Ngiep drainage (Ng & Kottelat, 1999; Kottelat, 2001). It was earlier recorded only from the headwaters of the Nam Ngiep. It was found in the Nam Ngiep in the inundation zone and from several small tributaries, above FSL. It inhabits very fast flowing water, especially headwaters and torrents. One sample from the Nam Xan (site 14-018) looks similar to *Oreoglanis delacouri*; since it includes only juveniles, adults are needed to confirm the identification.

Most of the habitat of the species is above FSL. Outside of the inundation zone, it will not be directly threatened by the project. Indirect impacts will be the construction of access roads that will damage the streams and attract human activity, logging activity (road, camps, etc.) that result in deforestation, siltation, pollution and overfishing. It was found together and abundant with *Schistura* sp. n. 'Nam Youak' (see below).

Mitigations. The most efficient way to manage the species is to ensure that stretches of streams with where the species is presentretain intact aquatic habitats. Key factors are riparian forest cover, clear water, absence of siltation and human disturbance. An important point should be the absence of cause of siltation in the upper part of the catchment. Conservation of habitats for the species can be achieved in conjuction with the establishment of protected areas for other animals and forest. It will require knowing better the distribution of the species to ensure that it will be present in some of the protected areas.

5.1.6 *Schistura crabro*

Schistura crabro was earlier known only from an unspecified locality in the Nam Ngiep drainage. The survey observed tzhe species at two sites in the Nam Xan and therefore it is no longer to be treated as endemic to the Nam Ngiep. The habitat in which it was observed (riffles on a substrate of gravel to small stones) was rare in the surveyed stretch of the Nam Ngiep and the species possibly does no occur in the NNP1 inundation zone.

5.2 Potential endemics

5.2.1 *Poropuntius* aff. *carinatus*

This species has been observed at most sampling sites in the Nam Ngiep drainage, in the inundation zone as well as above FSL. It is possibly new to science. A similar or the same species is also present in the middle and upper Nam Ngum to the west; the time available for this report was not sufficient to confirm that hypothesis. The species has affinities with *Poropuntius carinatus*, a species known from the Mekong drainage in Laos and Xishuangbanna (Yunnan, China).

The species is apparently present everywhere in the main stream of the Nam Ngiep and its tributaries and headwaters. Species of the genus *Poropuntius* have not been observed to adapt to reservoir conditions and it is expected that *Poropuntius* aff. *carinatus* will disappear from the inundation zone. It will subsist in tributaries, will probably subsist in the Nam Ngiep between NNP1 reservoir and NNP2 dams, and may subsist in the stretches of streams immediately below FSL and emerged during most of the year.

Mitigations. The most efficient way to manage the species is to ensure that stretches of streams with where the species is presentretain intact aquatic habitats. Key factors are riparian forest cover, clear water, absence of siltation and human disturbance. An important point should be the presence of relatively deeper areas to provide shelter during the dry season and gravel and stones along the shores in some stretches for spawning. The presence of dams operating at peak hours upstream could have negative impact in daily exposing gravel beds and shore vegetation in which eggs are deposited. Conservation of habitats for the species can be achieved in conjuction with the establishment of protected areas for other animals and forest.

5.2.2 *Schistura* aff. *ephelis*

This species has been observed at most sampling sites in the Nam Ngiep mainstream in the inundation zone as well as above FSL. It was also observed in tributaries near their confluence with Nam Ngiep (but these tributaries could not be sampled away from the main river for access or security

reasons). In the Nam Youak it was observed at about FSL and similar habitat exist further upstream but could not be accessed. A similar or the same species is also present in the middle Nam Ngum drainage to the west; the time available for this report was not sufficient to confirm that hypothesis. The species has similarity with *Schistura ephelis*, a species present in the Nam Ngum and Nam Xan drainages, but still is very distinct.

The species apparently occupies stretches of the Nam Ngiep and its tributaries with fast current and stone substrate. Species of the genus *Schistura* require moving, clear and well oxygenated water and do not adapt to reservoir conditions and it is expected that *Schistura* aff. *ephelis* will disappear from the inundation zone. It will subsist in larger tributaries with sufficient discharge and stone, will probably subsist in the Nam Ngiep between NNP1 reservoir and NNP2 dams, and may subsist in the stretches of streams immediately below FSL but emerged during most of the year.

Mitigations. The most efficient way to manage the species is to ensure that stretches of streams where the species is present retain intact aquatic habitats. Key factors are clear water, absence of siltation and absence of dayly variation of discharge (as typical downstream of dams operating at peak hours) that would exposed part of the habitat everyday and kill fish trying to occupy that part of the river bed. Conservation of habitats for the species can be achieved in conjuction with the establishment of protected areas for other animals and forest. Lower parts of tributaries immediately above FSL should be primary target areas (as our sampling site on the Nam Youak).

5.2.3 *Schistura* aff. *defectiva*

This species has been observed at two sites, one in the Nam Ngiep mainstream in the inundation zone (site 14-004) and one in the Nam Ngiep above FSL (site 14-019). The identity of the species is not clear. Only few individuals were observed and it still cannot be excluded that these are aberrant specimens of *Schistura defectiva*, a species present at both sites and widely distributed in the Nam Ngiep and Nam Ngum. A similar or the same species is also present in the Nam Mang (site 14-014) and in the middle Nam Ngum drainage to the west; the small number of individuals collected by the survey is not sufficient to reach a definitive conclusion.

With the presence of this species in only two samples and its unclear identity, it is difficult to make hypotheses on the preferred habitat. The two sites have in common a long run on a substratum of stones about 10-20 cm diameter, about 50 cm deep. This may not be the preferred habitat but the habitat where it is most easily captured. Species of the genus *Schistura* require moving, clear and well oxygenated water and do not adapt to reservoir conditions and it is expected that *Schistura* aff. *defectiva* will disappear from the inundation zone. It is expected to subsist in tributaries, will probably subsist in the Nam Ngiep between NNP1 reservoir and NNP2 dams, and may subsist in the stretches of streams immediately below FSL and emerged during most of the year. It might also be possible that most of the habitat of the species is above FSL and that its presence in the inundation zone is only marginal.

Mitigations. No mitigation may be proposed until the identity of the samples can be clarified, especially its identity with the species of the Nam Mang and Nam Ngum drainages. Generally, the most efficient way to manage such small species is to ensure that stretches of streams where the species is present retain intact aquatic habitats. Considering the doubts about the identity of the species and its presence at only two sites, it is not possible to speculate on the key characteristics of the habitat. Conservation of habitats for the species can be achieved in conjuction with the establishment of protected areas for other animals and forest. At both sites it was collected with *Schistura* aff. *ephelis*.

5.2.4 *Schistura* sp. 'compact'

This species has been observed in the Nam Ngiep mainstream in the inundation zone (site 14-004). It was also observed in tributaries near their confluence with Nam Ngiep (but these tributaries could not be sampled away from the main river, because of access and security reasons) (sites 14-007, 14-008, 14-009, 14-012). In the Nam Youak it was observed at about FSL (site 14-015) and similar habitat exist further upstream but could not be accessed. The specific distincness is still not clear. Only few individuals were observed and it still cannot be excluded that these are aberrant specimens of *Schistura coruscans*, a species present at most sites and widely distributed in the Nam Ngiep and

Nam Ngum.

The species apparently occupies stretches of the Nam Ngiep and its tributaries with fast current and stone substrate. Species of the genus *Schistura* require moving, clear and well oxygenated water and do not adapt to reservoir conditions and it is expected that *Schistura* sp. 'compact' will disappear from the inundation zone. It will subsist in larger tributaries with sufficient discharge and stone, and it may subsist in the stretches of streams immediately below FSL but emerged during most of the year.

Mitigations. The most efficient way to manage the species is to ensure that stretches of streams where the species is present retain intact aquatic habitats. Key factors are clear water, absence of siltation and absence of cyclical variation of discharge (as typical downstream of dams operating at peak hours) that would exposed part of the habitat everyday and kill fish trying to occupy that part of the river bed. Conservation of habitats for the species can be achieved in conjuction with the establishment of protected areas for other animals and forest. Lower parts of tributaries immediately above FSL should be primary target areas (as our sampling site on the Nam Youak). At most sites it was collected with *Schistura* aff. *ephelis*.

5.3 *Luciocyprinus striolatus*

Luciocyprinus striolatus is recorded in the literature from Nam Tha, Nam Ou, Nam Ngum, Nam Kading (Nam Theun and Nam Gnouan), Xe Kong and Xishuangbanna (China) (Cui & Chu, 1986; Kottelat, 1998, 2001; Rainboth et al., 2013) The survey recorded for the first time its presence in the Nam Ngiep and obtained information suggesting it is also present in the Nam Xan. No specimen could be obtained but the identification seems reliable. The summaries of interviews are in Annex 1.

Luciocyprinus striolatus reaches a large size (at least 1.5 m, reportedly up to about 2 m) and lives in deep pools and adjacent rapids in fast flowing stretches of large rivers. It is absent in the Mekong floodplain and is only recorded from the middle and upper part of its main tributaries. It spawns downstream of rapids, along shores made of pebble and small stones. It is a predatory fish, feeding on aquatic animals and reported to also capture small mammal that enter the water (monkeys, dogs, etc.) although this is probably only exceptional behavior of very large individuals.

Most populations of the species are impacted or will be impacted by a variety of projects, mainly hydropower and/or mining. In theory, only the population in Nam Theun drainage upstream of the Nam Theun reservoir, in Nakay NBCA, is not threatened by impacts happening upstream.

Mitigations. The available information on the biology of the species is very limited and does not allow at this stage to propose concrete actions. The first steps to the management of the species is to confirm the identity, to establish its present distribution in the Nam Ngiep and outside and to obtain biological data.

Because of its size, spectacular appearance, and stories about its feeding habits, *Luciocyprinus striolatus* has a potential to attract attention from the general public and the visibility of the company's attention (or lack of) to conservation issues.

Main points to consider:

1) <u>Distribution</u>
Document the exact distribution of the species, identify exact river stretches, in the inundation zone and between NNP1 reservoir and NNP2 dams

Survey the inundation zone with villagers and identify sites where they have caught or observed the species, especially ripe females. To be done with villagers from Ban Pou, Ban Soppouan and Ban Sopyouak. Although these habitats will be lost at inundation, mapping and describing them may allow to identify geomorphological parameters that can be used later for identification of sites for potential stocking, or provide information for the creation of new, substitution habitats. This should include collection of data on wet-season parameters of these sites.

Survey upstream, of the inundation zone will document the exact distribution of the species. Villagers interviews indicate that very large individuals do not occur upstream of Ban Pou and but villagers are

not certain about the possible existence of spawning sites. Given that the species is not migratory, if large individuals and small juveniles are present, spawning sites may be expected. This needs confirmation from inhabitants of villages upstream.

In regard to ADB Critical Habitat policies, the size and quality of the Nam Ngiep population should be assessed relative to the global population. The 'discrete management units' of the species must be identified as their number, size and habitat quality and integrity may modify the classification.

2) Biological data
Obtain biological data on the species in the project area and outside. Sound management requires to know the basic requirements of the species and the characteristics of its life cycle: feeding, growth, habitat at different stages of life cycle, age and size at maturity, spawning sites and habits, ecology of eggs and fry, incubation, growth and feeding of fry, local movements, etc.

The project might join effort with other projects in which the species is also present in order to conduct or fund the research. Nam Theun 2 could be a potential partner; the drainage of their reservoir includes what is apparently the population in the safest conditions; the existence on site of an hydrobiology lab and researchers might ease the setting up of a research program.

As the species is not very abundant (as is the case for most large predatory animals), methods should be used that require to sacrifice only a limited number of individuals.

3) Fishing activity
Capture of the species should be managed in the Nam Ngiep. Fishing methods that specifically target the species should be banned. Individuals caught alive should be released; admittedly this is far from local customs. Some conservation pools should be established or, if there are already some, they should be extended where needed (this traditional management method is used at community level in the country).

Non-specific fishing methods can probaby not be controlled.

4) Captive breeding
In parallel to the collection of biological data in (2) above, a small captive or semi-captive stock should be established in a safe area. It could be used to study the artificial reproduction of the species. The aim should not be to maintain a permanent captive stock but to develop the knowledge and capacity to quickly produce a large number of juveniles if the need appears. This way, should the need arise the information will already exist and can be used immediately; it will not need to be develop in emergency.

The production of a large number of individuals could be, for example, for stocking in the river to stengthen the local population (at the beginning of flooding, or following a heavy pollution upstream) or to create a new population.

5) Identity
Confirm the identity of the species present in the Nam Ngiep. Considering the number of disjunct populations reported as *Luciocyprinus striolatus*, it cannot be totally ruled out that more than one species are confused under that name. Apparently, there has been no attempt to scientifically compare individuals of the different populations, because the material for comparison is not available. A DNA test could be useful; however, it should be kept in mind that while a great difference at DNA level usually indicate species distinctness, the absence of difference or a very small difference does not automatically mean that only one species is involved.

The conservation status of the Nam Ngiep population will be better if all the disjunct populations effectively belong to a single species. If more than one species is involved, the conservation actions must be drastically adapted.

Before possibly stocking individuals obtained by artificial reproduction (see (4) above), if the stocked material originates from another population/drainage, it may become necessary to check that this does not impact genetic integrity of the receiving population. However, there will always be some genetic

difference between isolated populations and in some situations the loss of genetic integrity is a minor concern compared to the loss of a population.

6) Habitat modifications

The survival of the species will depend of the presence of habitats were it can complete its life cycle. It also depends of the continued presence of the preys it feeds on. The habitat components identify during the interviews (Annex 1) and in earlier observations of the species in the Nam Theun drainage (Kottelat, 2002) indicate that adults live in deep pools, with a possible preference for the upper and lower parts, near rapids, riffles and runs. For spawning, it moves to shallow areas with stone and gravel banks along the shores; this is the wet season morphology of the sites since the species spawns in November, not in the dry season.

These habitats will disappear in most of the reservoir. Some will emerge for a few months in the drawdown zone of the Nam Ngiep and its main tributaries. In the stretches immediately below FSL rapids and deep pools may be functional (at least hydrologically) part of the year. However, the reported spawning season is in November (but some villagers gave dates as late as March, which seemed less reliable), which is in the period in which the reservoir is at FSL. Even the two most ustream spawning sites identified by villagers in Ban Pou and Ban Viengta will be submerged at that time (Wang Mon, Kaen Tao).

The status of this last-mentioned sites calls for some reservation. Maps indicate they will will be below FSL and the rapids would not be functional in November. This is the dry season situation. It is not known what the current morphology is during the wet season. The water is certainly some meters higher and what appears as rapids in the dry season are no longer rapids in the wet season, other rapids may appear, and the spawning sites described as in shallow water on pebble banks are not in the position of the dry-season pebble banks. It might well be that the current wet-season topography of these spawning sites remain after inundation, or that inundation of the reservoir might create wet-season situation further upstream comparable to the current wet-season situation in the inundation zone.

Observation of the spawning sites identified under (1) above is needed during the spawning season to observe the wet season topography and the position actually occupied by the fish.

Depending of these observations, it might be desirable or possible to modify some sites in the Nam Ngiep and main tributaries, above or close to FSL, to mimic the identified spawning sites and that could possibly be adopted by the fish. Without information, further speculations on the kind of modifications is premature.

7) Upstream impacts

The discharge from NNP2 project upstream of NNP1 may have impacts on the population of *Luciocyprinus striolatus* downstream. The main impacts will be caused by the increase of the dry-season discharge, the reduced discharge at the beginning of the wet season, and, if it operates at peak hours, the daily fluctuations of the discharge.

Daily fluctuations of the water level downstream of dams/powerhouses is a well-know cause of destruction of fish habitats, and especially of spawning sites. Eggs typically hatch in a few days. Those eggs attached to vegetation or deposited in the sand or in gravel in shallow water become exposed and die in a few minutes. Most fish species spawn this way and it has been observed that *Luciocyprinus striolatus* spawns in shallow water on stone or gravel banks. These stone and gravel banks will be impacted by the daily variation in water level. Here again, without data on the wet-season conditions of the spawning sites, and the planned discharge from NNP2, it is not possible to speculate on the real impact of NNP2.

Further, the impact of NNP2 on the aquatic fauna in the drawdown zone of NNP1 will be very different before and after inundation of the NNP1 reservoir. There will also be specific, short but intense impacts at the end of the construction and during the testing phase of NNP2. This potentially can be devastating for the aquatic fauna downstream.

Information on operation model and planned discharge of NNP2 is needed for management of the aquatic fauna in NNP1 inundation zone. NNP2 has a potential to annilitated mitigation measures taken by NNP1 to support *Luciocyprinus striolatus* and other fish species.

6 General recommendations

Four of the endemic species have been observed mainly or only in small streams and headwaters (*Schistura* sp. n. 'Nam Youak', *Danio* sp. n., *Poropuntius* sp. n., *Oreoglanis delacouri*). The most efficient way to manage these species is to ensure that stretches of streams remain intact, under forest cover, and especially to avoid disturbance of the stream morphology and to avoid siltation in these stretches and upstream. The main cause of siltation is road construction, logging, mining and agriculture. Conservation of habitats for these species can be achieved in conjunction with the establishment of protected areas for other animals and forest. This conservation areas should extend to the uppermost part of these streams to avoid any siltation originating upstream. *Schistura* sp. n. 'Nam Youak and *Oreoglanis delacouri* inhabit torrent habitats. *Danio* sp. n. and *Poropuntius* sp. n. were found in a slower flowing forest stream.

Four of the endemic species and potentially endemic species have been observed mainly in the inundation zone, including close to FSL (*Schistura* sp. n. 'slender', *Schistura* aff. *ephelis*, *Schistura* aff. *defectiva*, *Schistura* sp. 'compact'). They apparently do not occur in headwaters and seem to require larger stream and stone substrate, which is most common in the main river and the lower parts of the main tributaries. However, site 14-009 was a small torrent-type stream and both *Schistura* aff. *ephelis* and *Schistura* sp. 'compact' were present. The efficient way to manage these species is to ensure that stretches of the Nam Ngiep and main tributaries above FSL remain intact for some distance and especially to ensure that no sediment covers the bottom of the streams.

The most interesting streams would be the Nam Youak, Nam Pouan and Nam Chae, but of these last two streams, the Nam Chae is already impacted by the construction of the Nam Chae dam, and the Nam Pouan will be impacted by the construction of the Nam Pouan dam. Smaller tributaries in the project area might have suitable habitats. The species were found near their confluence but access or security reasons did not allow to sample them further away from the main river (Houay Hok, site14-003; Nam Khai, site 14-006; Houay San, site 14-007).

Judging from maps, these species should also occur further upstream on the Nam Ngiep and other tributaries upstream of the surveyed area, for example the Nam Siam upstream of the NNP2 power house. Again, security reasons do not allow to sample this area.

Poropuntius aff. *carinatus* occurs in both stream types.

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Table 1. Fish species observed or recorded in 2014 by the fast water habitat survey in the Nam Ngiep drainage upstream of NNP1 dam site. **DD,** documented distribution outside Nam Ngiep drainage; **EN,** endemic to Nam Ngiep drainage; **IZ,** inundation zone; **UP,** upstream of NNP1 reservoir FSL.

	IZ	UP	EN	DD
Bagridae				
Hemibagrus nemurus	x			Southeast Asia
Hemibagrus wyckioides	x			Mekong and Chao Phraya drainages
Balitoridae				
Balitora lancangjiangensis		x		Mekong and Red River drainages
Hemimyzon confluens	x	x		Nam Ngum and Nam Xan drainages
Homaloptera yunnanensis	x	x		Mekong drainage
Channidae				
Channa gachua	x	x		Southeast Asia
Clariidae				
Clarias batrachus	x	x		Southeast Asia
Cyprinidae				
Bangana lippa	x			Mekong basin from Nam Ngiep to Yunnan
Barbodes aurotaeniatus	x	x		Mekong basin
Cirrhinus prosemion	x			Mekong and Chao Phraya basins
Danio acrostomus	x	x		Nam Mang
Danio sp. n.		x	x	
Esomus metallicus	x			Mainland Southeast Asia
Garra cambodgiensis	x			Mainland Southeast Asia
Garra theunensis	x	x		Mekong basin from Nam Kading to Nam Tha
Hampala macrolepidota	x			Southeast Asia
Hypsibarbus vernayi ?	x			Mekong and Chao Phraya basins
Labeo pierrei	x			Mekong basin
Luciocyprinus striolatus	x			Makong basin from Xe Kong to Xishuanbanna
Mystacoleucus greenwayi	x			Mekong basin in Laos, Thailand and Yunnan
Mystacoleucus marginatus	x	x		Southeast Asia
Neolissochilus blanci	x	x		Mekong basin
Onychostoma aff. *gerlachi*	x	x		Mekong basin in Northern Laos and Yunnan
Opsarius pulchellus	x	x		Mekong and Chao Phraya basins
Osteochilus striatus	x			Mekong basin from Xe Bangfai to Nam Ngiep
Poropuntius aff. *carinatus*	x	x	?	? Nam Ngum
Poropuntius sp. n.		x	x	
Puntius brevis	x	x		Southeast Asia
Raiamas guttatus	x			Southeast Asia
Rasbora atridorsalis	x	x		Mekong basin in Laos and Thailand

Rasbora rubrodorsalis	x			Mekong basin in Laos and Thailand
Scaphiodonichthys acanthopterus	x	x		Mekong basin
Systomus jacobusboehlkei	x			Mekong and Chao Phraya basins
Tor laterivittatus	x	x		Mekong basin
Tor tambra	x			Southeast Asia
Gobiidae				
Papuligobius ocellatus	x	x		Mekong basin
Rhinogobius albimaculatus	x	x		Nam Ngum drainage
Gyrinocheilidae				
Gyrinocheilus aymonieri	x			Southeast Asia
Mastacembelidae				
Mastacembelus armatus	x			Southeast and South Asia
Nemacheilidae				
Nemacheilus platiceps	x	x		Mekong basin
Schistura coruscans	x	x		Nam Ngum drainage
Schistura defectiva	x	x		Nam Ngum drainage
Schistura dorsizona	x	x		Mekong basin in Laos
Schistura aff. *defectiva*	x	x	?	?`Nam Ngum drainage
Schistura aff. *ephelis*	x	x	?	? Nam Ngum drainage
Schistura sp. 'compact'	x	x	x	
Schistura sp. n. 'Nam Youak'	x	x	x	
Schistura sp. n. 'slender'	x	x	x	
Sisoridae				
Glyptothorax horai	x	x		Mekong basin from Nam Kading to Yunnan
Glyptothorax laosensis	x	x		Mekong and Chao Phraya basins
Glyptothorax aff. *zanaensis*	x			Mekong basin from Xe Kong to Yunnan
Oreoglanis delacouri	x	x	x	
Pseudecheneis sympelvica	x			Nam Kading and Nam Ngum drainages
Bagarius yarrellii	x			Southeast and South Asia
Synbranchidae				
Monopterus albus	x	x		Southeast and East Asia
Tetraodontidae				
Pao turgidus	x			Mekong basin
Total	53	34	9 ?	

Table 2. Fish species observed in the Nam Mang, Nam Xao and Nam Xan drainages. The Nam Xao is a tributary of the Nam Ngiep, entering it downstream of NNP1 dam site. **NM,** Nam Mang; **NXA,** Nam Xan; **NXO,** Nam Xao.

family	species	NXA	NM	NXO
Amblycipitidae	*Amblyceps mucronatum*		x	x
Bagridae	*Hemibagrus nemurus*	x		x
Bagridae	*Pseudomystus siamensis*	x		x
Balitoridae	*Balitora lancangjiangensis*.	x		
Balitoridae	*Hemimyzon confluens*	x		x
Balitoridae	*Homaloptera smithi*	x		x
Balitoridae	*Homaloptera yunnanensis*	x		x
Belonidae	*Xenentodon canciloides*	x		x
Chandidae	*Parambassis siamensis*			x
Channidae	*Channa gachua*		x	x
Clariidae	*Clarias batrachus*			x
Cyprinidae	*Barbodes aurotaeniatus*			x
Cyprinidae	*Crossocheilus atrilimes*	x		x
Cyprinidae	*Danio acrostomus*	x		
Cyprinidae	*Esomus metallicus*		x	x
Cyprinidae	*Garra cambodgiensis*	x		
Cyprinidae	*Garra fuliginosa*	x		
Cyprinidae	*Garra theunensis*	x		
Cyprinidae	*Hampala macrolepidota*	x		
Cyprinidae	*Laocypris hispida*			x
Cyprinidae	*Mystacoleucus greenwayi*	x		
Cyprinidae	*Mystacoleucus marginatus*	x		x
Cyprinidae	*Neolissochilus blanci*	x	x	
Cyprinidae	*Onychostoma* aff. *gerlachi*	x		x
Cyprinidae	*Opsarius koratensis*	x		
Cyprinidae	*Opsarius pulchellus*	x	x	x
Cyprinidae	*Osteochilus hasselti*	x		
Cyprinidae	*Osteochilus lini*			x
Cyprinidae	*Poropuntius normani*	x	x	x
Cyprinidae	*Rasbora paviana*		x	x
Cyprinidae	*Scaphiodonichthys acanthopterus*	x		
Cyprinidae	*Systomus jacobusboehlkei*			x
Gobiidae	*Papuligobius ocellatus*	x		x
Gobiidae	*Rhinogobius* cf. *albimaculatus*			x
Mastacembelidae	*Macrognathus siamensis*	x		x
Mastacembelidae	*Mastacembelus armatus*	x	x	x
Nemacheilidae	*Nemacheilus pallidus*	x		
Nemacheilidae	*Nemacheilus platiceps*	x		x
Nemacheilidae	*Schistura coruscans*	x		
Nemacheilidae	*Schistura crabro*	x		
Nemacheilidae	*Schistura* aff. *defectiva*		?	
Nemacheilidae	*Schistura dorsizona*	x		x
Nemacheilidae	*Schistura ephelis*	x	x	
Nemacheilidae	*Schistura* aff. *ephelis*	?		
Nemacheilidae	*Schistura leukensis*		x	
Nemacheilidae	*Schistura nicholsi*			x
Nemacheilidae	*Schistura* cf. *nicholsi*	x		
Nemacheilidae	*Schistura sigillata*			x
Nemacheilidae	*Schistura sombooni*	x		x
Pristolepididae	*Pristolepis fasciata*	x		x
Sisoridae	*Glyptothorax horai*	x	x	
Sisoridae	*Glyptothorax laosensis*	x	x	
Sisoridae	*Oreoglanis* cf. *delacouri*	x		
Synbranchidae	*Monopterus albus*		x	
Tetraodontidae	*Pao turgidus*	x		x

Table 3. Fish species observed, obtained or reliably recorded in the Nam Ngiep drainage upstream of NNP1 dam site and their extinction risk in IUCN's Red List. **EN,** endangered; **VU,** vulnerable; **NT,** near threatened; **LC,** least concerned; **DD,** data deficient.

	Red List status 2014
Bagridae	
Hemibagrus nemurus	LC
Hemibagrus wyckioides	LC
Balitoridae	
Balitora lancangjiangensis	LC
Hemimyzon confluens	VU
Homaloptera yunnanensis	LC
Channidae	
Channa gachua	LC
Clariidae	
Clarias batrachus	LC
Cyprinidae	
Bangana lippa	DD
Barbodes aurotaeniatus	LC
Cirrhinus prosemion	—
Danio acrostomus	DD
Danio sp. n.	—
Esomus metallicus	LC
Garra cambodgiensis	LC
Garra theunensis	DD
Hampala macrolepidota	LC
Hypsibarbus vernayi	LC
Labeo pierrei	VU
Luciocyprinus striolatus	EN
Mystacoleucus greenwayi	LC
Mystacoleucus marginatus	LC
Neolissochilus blanci	NT
Onychostoma aff. *gerlachi*	—
Opsarius pulchellus	LC
Osteochilus striatus	DD
Poropuntius aff. *carinatus*	—
Poropuntius sp. n.	—
Puntius brevis	LC
Raiamas guttatus	LC
Rasbora atridorsalis	LC
Rasbora rubrodorsalis	LC
Scaphiodonichthys acanthopterus	LC
Systomus jacobusboehlkei	LC
Tor laterivittatus	DD
Tor tambra	DD
Gobiidae	
Papuligobius ocellatus	LC
Rhinogobius albimaculatus	VU
Gyrinocheilidae	
Gyrinocheilus aymonieri	LC
Mastacembelidae	
Mastacembelus armatus	LC
Nemacheilidae	
Nemacheilus platiceps	DD
Schistura coruscans	DD
Schistura defectiva	DD
Schistura dorsizona	LC
Schistura aff. *defectiva*	—
Schistura aff. *ephelis*	—

Schistura sp. 'compact'	—
Schistura sp. n. 'Nam Youak'	—
Schistura sp. n. 'slender'	—
Sisoridae	
Glyptothorax horai	LC
Glyptothorax laosensis	LC
Glyptothorax aff. *zanaensis*	LC
Oreoglanis delacouri	DD
Pseudecheneis sympelvica	DD
Bagarius yarrellii	NT
Synbranchidae	
Monopterus albus	LC
Tetraodontidae	
Pao turgidus	LC

Annex 1. *Luciocyprinus striolatus*, data from interviews

Interviews were conducted upstream of FSL in Ban Thaviang, Ban Viengta and Ban Pou, and downstream of the dams site in Ban Xomxeun.

Luciocyprinus striolatus is called *Pa Kouan Say* upstream and *Pa Ern* downstream. The name Pa Kharm earlier reported in Ban Thathom is erroneous and resulted from confusion with *Raiamas guttatus*.

Ban Viengta
Information obtained from a fisherman usually working between Ban Viengta and Ban Soppouan.

Luciocyprinus striolatus (*L. s.*) extends upstream to Sop Syem [7 km upstream of Ban Thaviang, near NNP2 power house]. He has fished in Sop Syem and in the Nam Ngiap upstream but has not seen *L. s.* upstream. He thinks it is not present because the river is too steep and the water too cold.

According to him, *L. s.* is present in Nam Chae. He guesses that its distribution extends downstream to Mekong because he sees more individuals downstream near Sop Pouan but in fact he has never been further downstream). Maybe *L. s.* migrates because it is rare in dry season in Ban Viengta. At an usual fishing site about 8-10 km dowstream of Ban Pou, the fish is also rarer at the same time as in the village.

L. s. is usually caught in sectors about 2 m deep, between rapids and pools.

L. s. breeds in November. He knows it because he has seen a pair spawning, he caught one by net. The fish caught was a female that released eggs when brought out of the water. This is the only time he obsrved actual spawning. This spawning site was about 1 km downstream of village (not clear whether Ban Viengta or Ban Pou), at Wang Mon 'beach', on sand, in very shallow water, the back of the fishes was outside the water. Several pairs were observed at the same time on this 'beach'.

Ban Pou
Information obtained from three fishermen, fishing mainly between Nam Chae and Ban Pou.

L. s. lives in deep water, downstream of strong current but before deep pools. The depth is at least 2 m.

The distribution of *L. s.* extends upstream to Ban Sop Syem. They guess that *L. s.* is not present upstream because the river is too small and not deep enough. (But they do not go fishing upstream of Sop Syem; they have seen the river and think the fish cannot live there).

They guess that *L. s.* might go downstream to the Mekong, because the water is deeper downstream, but they do not go fishing downstream of Ban Sopppouan, because their boats cannot pass the rapids. They fish in the Nam Chae but they do not catch *L. s.* in that river. They know that villagers in Ban Soppouan go fishing in Nam Pouan, but they have never seen *L. s.* among the catches obtained from that river.

L. s. spawns only in December. They observed it at Kaen Tao 'beach', about 4 km downstrean of Ban Pou. Kaen Tao is about opposite sampling site 14-005. Only one of them has seen actual spawning and only once.The water was 40-50 cm deep and the back of the fish was out of the water. They have seen a small group spawning; they counted 4 but there were probably more. They killed one by gun. It was about 1.5 m long (when carried by two people on a pole, the tail was touching the ground). It was a female, 22 kg, of which 1 kg of eggs. Females grow larger than males.

Juveniles live in whirl pools downstream of rapids. At around 40 cm they are caught by gill nets, with 40-50 mm meshes. The fishermen guess that smaller juveniles also inhabit the same area.

L. s. moves downstream to big pools from November to May.

The fishermen think that there are also some large *L. s.* in Sop Syem, but they cannot be as big as downstream. Large individuals are not known from Ban Pou; they occur only from Kaen Tao downwards.

Ban Thaviang
Information obtained from villagers who catch between Sop Pouan and Ban Houay Pa Mom.

In the dry season, the river upstream of Ban Thaviang is too shallow for *L. s.*

L. s. spawns in shallow, flowing water. Mentioned supposed spawning sites are Keng Mai and Keng Mgoua near Sop San (site 14-007). *L. s.* spawns in January-March. It breeds in groups of about 10 individuals (they know because they hunt them with guns when they see groups of big fish). The fishes make a group in very close contact.

The maximum size is 1.5 m, up to 16 kg.

L. s. is also known from upstream until the upper part of Thaviang, but it only reaches a smaller size and there they are caught by net. The maximum known upstream extent is Sop Syem (Ban Sop Syem).

Ban Xomxeun.
Information obtained from 3 fishermen.

This village is located on the Nam Ngiep, it is the second village downstream of the dam site. *L. s.* is recognised on the photograph as Pa Ern. It is caught in October-November at Hat Nguen, below the confluence of Nam Ngiep and Nam Xao. They never catch *L. s.* at other times of the year.

L. s. is caught with 'drifting gill net'. The fish caught are about 60 cm. They never catch larger individuals, but this might be because the meshes they use (80 mm) would not allow to catch bigger fish. They have never see smaller individuals, although they also catch with smaller meshes. The fish they catch never have eggs or sperm.

Conclusions
Fish are observed downstream only at the end of the rainy season, when the discharge is highest; these are apparently vagrant individuals that came downstream with the current. This does not seem to be migrating individuals. This is very few km upstream of the confluence with the Mekong. If this species were migrating to the Mekong, it would certainly already have been noted by surveys and fisheries studies in Laos and Thailand.

The maximum extent of the species upstream is Sop Syem, about 15 km upstream of Ban Thaviang, near NNP2 power house. The species is reported not to grow as big as downstream, but there are still large individuals, and possibly spawning locally. Larger individuals and higher density are downstream of Ban Pou.

L. s. inhabits fast water between rapids and large pools. For spawning, it comes towards the shore, along beaches of pebbles, gravel or sand. These are shallow water habitats in the wet season, probably several meters above river level in the dry season.

Largest recorded individuals are females, about 1.5 m long. Males are smaller. On spawning sites, they form small groups and spawn (apparently as pairs) in shallow water, about 40-50 cm deep.

Spawning time is November-December. The mention of spawning in January-March seems less well informed. However, there might be local variation. For comparison, the information I obtained in the Nam Theun was that the species spawns in January-February in rapids (Kottelat, 1996); in 2002 I was told that in the Nam Kading drainage it spawns in October-December.

In the inundation zone, the two mentioned sites close to FSL are Kaen Tao 'beach', about 4 km downstrean of Ban Pou, opposite site 14-005 (19°00'00.4"N 103°28'50.0"E) and Wang Mon 1 km downstream of Ban Pou.

Annex 2. Fishes of Nam Ngiep drainage, upstream of damsite

Note: Not all species are figured. Material suitable for photography was not obtained for all species (small juveniles, individuals already cut in pieces for cooking, etc.).

Bagridae

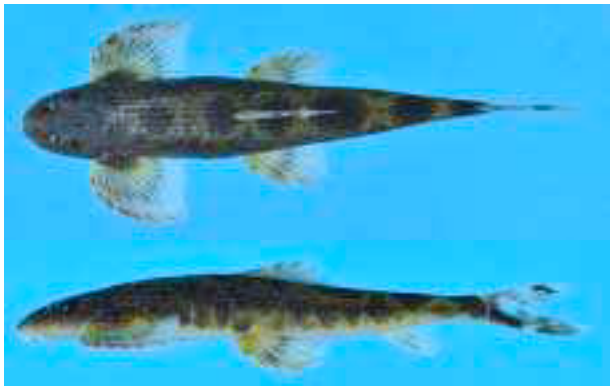
Hemibagrus nemurus, 98 mm SL

Hemibagrus wyckioides, about 400 mm SL

Balitoridae

Balitora lancangjiangensis, 62 mm SL

Hemimyzon confluens, 57 mm SL



Homaloptera yunnanensis, 58 mm SL

Channidae

Channa gachua, 89 mm SL

Clariidae

Clarias batrachus, 102 mm SL

Cyprinidae

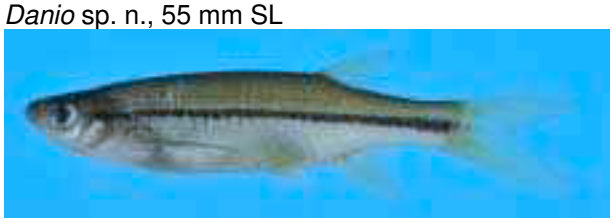
Bangana lippa, 110 mm SL

Barbodes aurotaeniatus, 62 mm SL

Cirrhinus prosemion, about 500 mm SL

Danio acrostomus, 40 mm SL

Danio sp. n., 55 mm SL



Esomus metallicus, 36 mm SL

Garra cambodgiensis, 77 mm SL

Garra theunensis, 121 mm SL

Hampala macrolepidota, 65 mm SL

Mystacoleucus greenwayi, 86 mm SL

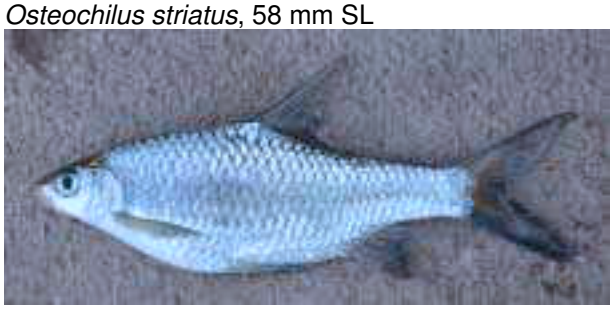
Mystacoleucus marginatus, 82 mm SL

Neolissochilus blanci, 80.0 mm SL

Onychostoma aff. *gerlachi*, 126 mm SL

Opsarius pulchellus, 88 mm SL

Osteochilus striatus, 58 mm SL



Poropuntius aff. *carinatus*, about 250 mm SL

Poropuntius normani, 88 mm SL

Poropuntius sp. n., 80 mm SL

Puntius brevis, 50 mm SL

Rasbora atridorsalis, 50 mm SL

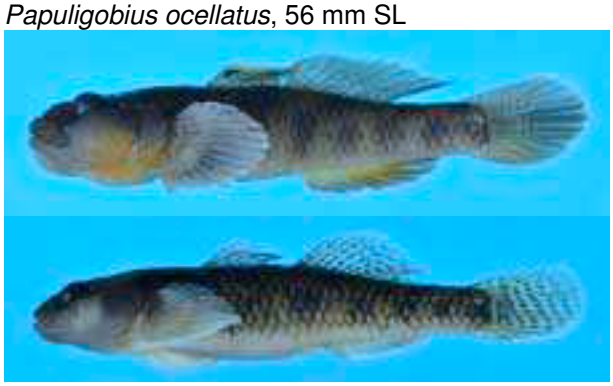
Rasbora rubrodorsalis, 15 mm SL

Scaphiodonichthys acanthopterus, 95 mm SL

Systomus jacobusboehlkei, 73 mm SL

Gobiidae

Papuligobius ocellatus, 56 mm SL



Rhinogobius albimaculatus, male, 56 mm SL (above) and female, 49 mm SL (below)

Mastacembelidae

Mastacembelus armatus, 270 mm SL

Nemacheilidae

Nemacheilus platiceps, 52 mm SL

Schistura coruscans, 68 mm SL

Schistura defectiva, 49 mm SL

Schistura dorsizona, 33 mm SL

Schistura aff. *defectiva*, 33 mm SL

Schistura aff. *ephelis*, 65 mm SL

Schistura sp. 'compact', 47 mm SL

Schistura sp. n. 'Nam Youak', 38 mm SL

Schistura sp. n. 'slender', 44 mm SL

Sisoridae

Glyptothorax horai, 90 mm SL

Glyptothorax laosensis, 57 mm SL

Glyptothorax aff. *zanaensis*, 74 mm SL

Oreoglanis delacouri, 104 mm SL

Pseudecheneis sympelvica, 40 mm SL

Synbranchidae

Monopterus albus, 295 mm SL

Tetraodontidae

Pao turgidus, 60 mm SL

Annex D

NNP1 to Nam Xieng and Nam Sieme Rivers (Viravong and Phommovong 2014)

Biological/Ecological survey of Nam Ngiep River *Luciocyprinus striolatus* between NNP1 northern most reservoir and the conjunction of the two rivers meet (Nam Xieng and Nam Sieme Rivers)

By Sinthavong VIRAVONG and Thavone PHOMMAVONG

The survey was conducted in Nam Ngiep within the distance of about 15 km of the river laying in the part downstream starting from upper part of NNP1 reservoir and go further upon downstream of NNP2 where the two rivers (Nam Xieng and Nam Sieme rivers) form a conjunction from which the river is started to call "Nam Ngiep River".

Three villages were conducted the survey by the team: Nasong, Viengthong[@] and Xiengkhong villages. Through the coordination among the surveyed team with Provincial and District; DAFO has requested chief of each village to provide fishing experience fishers/villagers to join the interview for at least 5 to 6 people/village. And the date and time of appointment had made arrangement according to the time appropriate of the villagers. In consequence, the additional survey in the specific locations has been conducted in order to elaborate detail information which obtained from fishers during the interview process.

Characteristic of River

Leaving the conjunction of the two rivers (Xieng and Sieme Rivers), Nam Ngiep follows downwards its course through the three villages (between Xiengkhong and Nasong villages) over the distance of 15 km long before passing Thavieng village. The river along this stretch located maximum level at 368 m to minimum level at 329 m above sea level. Topography of the Nam Ngiep here is hillock along which the river forms many of riffles and pools in dry season (in March) and some Rapids. Based on the interview and sites visit found 16 pools, 14 riffles and 4 rapids that located nearby the villages. Different pools have difference in depth and vary from 2 to 8 meters, but the pools with the medium depth of 2-4 meters are dominated. Riffles are form by the deposition of the big to small gravel bars in a characteristic of one side of the river. Some riffles by the deposition of small rock bars in a characteristic alternation from one side to another of the river. Riffle areas displays regular shallow water with 30 to 35 cm depth and high velocity of the flow by 1-2 m/sec. The river, along which still have found many different size of islands emerging in the dry seasons.

@ - Viengthong village is currently combined in one by the two villages such Viengthong and Nasay villages. The new name called "Vienthong village". For Nasay village we call "Vienthong village Nasay cluster"

Instantaneous fish distribution

Based on the specific characteristic of river in this stretch, Nam Ngiep plays host for about 30 fish species, one of which *Luciocyrpinus striolatus* is found in this stretch of the river including adult and juvenile individuals. *Luciocyprinus striolatus* is reported been the biggest fish in the river reaching to or more than 20 kg.per fish. It is characterized as very strong fish comparing to other species. The occurrence of big size of *Luciocyprinus striolatus* in the river was found seasonally, especially during the spawning season. For small size fish was reported found in the pools all round the year although they are considered now as rare specie.

Fishing and fishing gears

When after 1975 some villages had been re-established and many moved from Xiengkhouang Province deciding to dwell in this area. At that time fishing was a part of livelihood for villagers. Fishing every day before dusk was aims to get food for the dinner other than selling. Most popular fishing gears were cast net, stationary gill net and hooks. Fishing gear such Lee trap was also used at time but during September to October. These kinds of fishing gears could not able to catch the big like *Luciocyprinus striolatus* except Lee trap. Only two fishes of *Luciocyprinus striolatus* of 60 kg/fish were reported catching by Lee trap since before 1991. And Lee trap had been identified as destructive fishing gear and prohibited to use since 1994.

Currently, the most fishing gears that fishers used are cast net, gill net and hook and line and only hook and line can sometime be able to catch *LS* with the big size but in small amount of number. Two week ago, one fisher in Viengthong village caught *LS* of 17kg weigh with hook and line. Other fisher caught one juvenile of *LS* of 30 cm long by gill net. Juvenile les than 20 cm long also found in this stretch line of the river.

Currrent Status of *LS*

LS is reported as rare specie in the Nam Ngiep around the villages. Villagers were not able to catch them with such traditional fishing gear types that mentioned above because fishes are so strong especially the big fish size. All these fishing gears can be destroyed by fishes when after fishes were trapped. Villagers do not know how much number of eggs contained in fish due to never caught them.

Spawning season of *LS*

During March of each year, fishes were migrated down from deep pools “Vang Kva” to riffle area “Hat Kva” (as reported by fishers in Xiengkhong village) where the shallow

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with flowing water. Fishers can see even their dorsal fin emerged from the water during their spawn due to shallow water. More than 30 years ago, about 10 pair of fishes were migrated to spawn in this riffle. Now the number remaining one to two pairs of fish found in the riffle during the spawning season.

Another village such Nasong village, fishers also mentioned about finding big *LS* at deep pool “Vang Song” and riffle “Hat Song” during the spawning season in March this year.

Fish and fisheries management

Result from interview found that each village territory belong to many deep pools and riffles. So each village had set up their own deep pool as be a conservation pool for year round. Attempt to establish a new conservation pool “Vang Peuai pool” by Xiengkhong villager and the company “Xayakheue company” is in the process. They will manage and save the aquatic resources together not only LS but also other fish species. The use of illegal fishing gear in the river is prohibited. Some destructive fishing gears such Lee traps were not allowed to use since 1994.

Critical habitats

As result from interview and sites survey found that the river of 15 km long pertain complexity of critical habitats such refuge habitat, spawning habitat, feeding habitat. LS use the nearest riffle from deep pools where they refuge as spawning habitat. Juvenile of Ls with the size of 20-30 cm are currently found the pool around the village. We strongly expected that there are more than two spawning habitats for LS in this stretch line of the river because some part of the river course is far off the village as a result fisher has transferred less information on LS critical habitats.

@ - Viengthong village is currently combined in one by the two villages such Viengthong and Nasay villages. The new name called “Vienthong village”. For Nasay village we call “Vienthong village Nasay cluster”

Annex E

DRAFT Scoping Study
Outline for Captive Breeding

Captive breeding of *Luciocyprinus striolatus* in the frame of the Nam Nghiep 1 Hydropower Project (NN1)

Proposal for the scoping study

Presented by Philippe CACOT[a] and Marc LEGENDRE[b]

18 April 2014

[a]: CIRAD (International Cooperation Center of Research in Agronomy for Development), France

[b]: IRD (Institute of Research for Development), France

1. FRAMEWORK AND OBJECTIVES

The construction of the dam on the Nam Nghiep River is going to threaten the rare fish species *Luciocyprinus striolatus* in this River. Therefore, NN1 is willing to preserve this species through induced breeding. The present proposal is following a first discussion between stakeholders on the 10.4.14 (phone conference).

Here are described tentative terms of reference for the scoping study. This study is aiming to (1) assess the feasibility of the captive breeding of *L. striolatus*, (2) list the requirements and (3) draw a program proposal with several options.

2. INDUCED BREEDING

Fish breeding requires sexually mature fishes. Mature fishes can be obtained by two different ways. The first way is to collecting mature fishes from the River during the natural breeding period. The second way is to setting up a captive broodstock. The two ways have different requirements.

Fish breeding allows to getting hatched fish larvae. Afterwards, the usual nursing duration is about two months. After nursing, the "fingerlings" can be transferred in grow-out structure or released in the River (or reservoirs). Part of the fingerlings can be kept over few years to become the next generation of fish breeders. Nursing and grow-out require specific facilities.

3. CONTENT OF THE STUDY

Objective 1: Assessing the feasibility of the induced breeding.

The two different ways of obtaining mature broodfish for induced breeding will be considered. The availability of fishes will be the first and the most critical parameter.

For the breeding with wild mature fishes, collection of at least 10 healthy specimens will be required. The fish breeding will be performed either close to the fishing site, with a "mobile hatchery", or in a conventional fish hatchery. The latter will require to transferring the fish over a certain distance in proper condition.

Reproduction of captive broodfish will require setting up a broodstock either in earthen ponds, floating cages or tanks. Fishes will be collected from the River all along the year. Any size and age of fish can be collected, from fingerling to adult. Fishes should be split by size into different rearing structures to avoid possible cannibalism. Possibly several tens of healthy fish specimens will be required and raised over at least one year before the first reproduction.

The two different ways of obtaining mature broodfish can be conducted in parallel.

Objective 2: List of the requirements.

Once the collection of healthy wild fish is ensured, we will list the different means required for the inducement of reproduction and the nursing of the fish larvae. We will rely as much as possible on the existing aquaculture facilities along the Nam Nghiep River and in the vicinity. Among the required infrastructure, there are fish ponds, tanks, floating cages.

Beside infrastructures, we will list the requirements in terms of supplies and services. For the latter, the project should rely on few key people including fisheries and aquaculture experts and local fishermen.

Technical assistance should be gathered by the project among staff of the PAFO, DAFOs, LARReC and possibly MRC aquaculture units in the neighbouring countries.

Objective 3: Drawing a programme.

A tentative schedule will be established in details for the first year with the associated objectives and budget. An extended programme will be proposed for the next two years in the main lines.

Suggestion:

Beside *Luciocyprinus striolatus*, it might be relevant to perform the captive breeding of one or even two additional indigenous fish species. The latter will be selected based on the following criteria: threatening by the dam construction, ease of induced reproduction, value on the fish markets and potential for aquaculture or restocking in the reservoir. By this way, if the breeding of *L. striolatus* appears as very difficult, the project would be able to contribute to the conservation of fish diversity and sustainable exploitation. Moreover, the level of investment in the infrastructures for breeding and nursing one or more fish species would be not too different.

4. ORGANISATION OF THE STUDY

Two out of the three experts from France will be involved in the scoping study, including Philippe CACOT and Marc LEGENDRE. They will be also available for contribution during the implementation of the project. A third expert, Jacques SLEMBROUCK from IRD, is also ready to be involved in future actions related to the project.

The scoping study will be done in the frame of an expertise contract between NN1 and the CIRAD and IRD. The cost of the expertise will be established by the accountants of CIRAD and IRD.

The proposed duration for the scoping study is two weeks on the field and one week for the preparation and the writing of the report. This study should be conducted within May to August 2014.

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Annex J

Socio-economic Survey Results

J.1 PROPOSED OFFSET AREA SOCIO-ECONOMIC AND CULTURAL RESULTS

J.1.1 Introduction

ERM undertook an assessment of the ecosystem services to supplement the biodiversity assessment completed for the NNPI project. The aim is to provide a social context to the establishment of biodiversity offsets.

The assessment included two field visits to collect relevant social data. The first visit involved engagement with key stakeholders (e.g. government officials) and village and market surveys to understand utilisation of ecosystem services by project affected people (PAP). The results of the first visit are presented in the *Inception Report*, prepared by ERM in July 2013.

The following sections present the results from the second field visit, which was undertaken 24 to 29 July 2013 in Bolikham District, Lao PDR. The focus of the second field was twofold:

(1) *An assessment of provisioning and cultural ecosystem services in the proposed offset area*. The field team mapped natural resources and cultural site locations as well as undertook a significance ranking exercise to prioritize natural and cultural resources. The focus was on prioritizing the species and resources to be conserved.

(2) *Stakeholder engagement to determine the level of community acceptance of offset measures in the area*. The field team conducted focus group discussions and in-depth interviews with hunters and gatherers from six villages (both male and female representatives) along Nam Ngiep River and Nam Xan River. The aim was to generate inputs to the *Biodiversity Offset Report*. The list of villages is provided in *Table 1.2*.

The villagers interviewed were largely lowland Lao, which differ from highland Laos in a number of ways. The Lao government classify the population by their location of residence for this reason Lao people can be categorized into three main groups - lowland Laos, highland Laos and upland Lao. The lowland Lao refer to groups of Lao people who reside in the lower part of mountains or on the flat areas. The lowland Laos practice Buddhism and engage in agricultural farming as a way of sustaining their livelihood. The majority of Lao population is the lowland Lao.

The highland Lao refer to those who reside in the mountainous region of the country. The highland Laos consist of different tribal groups, such as the Hmong, Kamoon and Yaoo. The highland Laos speak their own dialects and practice animism. In this report, no upland Laos were identified.

J.1.2 Stakeholder Engagement Outcomes

Based on the focus group discussions, villagers are aware that the Project is being constructed and may adversely impact their livelihood.

During the focus groups, villagers were asked about the concept of 'biodiversity offset'. Villagers appear to understand the concept as a conservation area that is like or similar to the one that is being used impacted (by the Project). The villagers are aware that areas located around their residence may be utilized as biodiversity offset areas.

In addition, villagers were informed, and appeared to be accepting, that the biodiversity offset proposal, is still in its initial stages of development by the NNP1PC. Villagers were aware that biodiversity offset will not be established without consent from villagers.

Villagers were aware that biodiversity offset areas, once established, may restrict their use of natural resources as well as access to significant cultural or spiritual sites that are frequently used or owned by the villagers.

Although villagers expressed concerns regarding the implementation of biodiversity offset areas, no villagers were openly opposed to the establishment of the biodiversity offset area. Instead most villagers interviewed appeared to have a neutral position. This may be due to the fact that villagers do not perceive the biodiversity offsets as a threat to their livelihood.

Much of the understanding within local villages comes from existing experience. According to the villagers in the Thatom district, including Ban Pou and Ban Pakyong, they were already conserving community forest in nearby areas through the Village Forest Committee. This was a result of a duty allocated by the Thatom District in which the villages are asked to manage and oversee their community forests and natural resources. Therefore, potential impacts from the implementation of biodiversity offset were understood by the villagers from Ban Pou and Ban Pakyong.

Similar to Ban Pou and Ban Pakyong, the lower villages including Ban Kanyong, Ban Pakheaung, Ban Don and Ban Xomxeun have also developed village police groups to oversee both legal and illegal doings, such as hunting and gathering related to the Provincial Protective Forests.

Based on their experience with conservation, villagers indicated that if their forests are used as conservation areas there should be other areas established where key activities can continue to occur, such as hunting and gathering. In this manner, villagers can continue to sustain their subsistence living and/ or livelihood without altering their way of life. This was the preferred to financial compensation.

The villagers indicated that the existing village forest committees could help manage the biodiversity areas. The committees, which have been set-up to oversee forest use, consist of village headmen, respected older male representatives from the Lao youth committee, and female representatives from the women's union.

Furthermore, the villagers suggested that the Lao government should be an actor in deciding which areas will be conserved. In addition, villagers indicated that they (and others) would be more willing to comply with the decision (e.g. prohibition on hunting in a conservation area) if the Lao government was the decision-maker.

J.1.3 Results Of Market Surveys

Two markets were surveyed (see Table I.1). This included the Bolikham and Thabok markets. The market surveys at Ban Pou and Pakxan markets indicated no signs of wildlife sales. The Bolikham and Thabok markets were selected to widen the pool in order better understand the potential sale of wildlife species.

The Bolikham market is located between Ban Don and Xomxeun and includes a stop for Laos's public transportation. From visual observations, there are approximately 50 stalls of fresh vegetables, 20 stalls of fresh meats (e.g. chicken and pork), and 60 general commodity stores, such as manufactured household products and clothes. Several of the stalls sell NTFP, including mushrooms and bamboo shoots.

The Thabok market is located in the Thapabrad district, next to the Phou Khao Kouay National Protective Area. Based on observations, there are approximately 60 stalls of fresh produce and 20 stalls for general household merchandises, such as manufactured food and clothes. Some of the fresh produce stalls also sold wild species such as wild boar, wild chicken, and frogs. However, not always were the species on site, instead the species are stored at the vendor's residence and can be ordered.

Mr. Fongsalee Chaiyasarn, a government official from the Agriculture and Forestry Department, informed the survey team that vendors in local village markets were highly unlikely to be selling endangered species sourced from protected areas as it is prohibited in Loa. The field team observations align with the officer's comments as no endangered species were observed at the vendors' stalls at the Bolikham market. This may be because the market is located near the district's central administration office and government officers visit the market frequently.

Table J.1 Market Surveys

Market	Notable species observed
Bolikham	No notable species observed
Thabok	Wild boar, wild chicken, frogs

Figure J.1 Stalls at Bolikham Market

Stalls at Bolikham market

Fresh produce stall

Fresh produce stall

Selling of small frogs

Figure J.2 ***Stalls at Thabok Market***

Commodity stalls at Thabok market

Fresh produce stall

Wrapped wild chicken

Sale of endangered species
(A leg of wild boar was stored in the blue storage)

J.1.4 Results of the Village Surveys

In addition to stakeholder engagement and market surveys, focus groups were run with village representatives (*Table I.2.)*.

Table J.2 Villages Surveyed

Location	Focus groups and In-depth interviews
Ban Pou	25th July 2013
Ban Pakyong	25th July 2013
Ban Kanyong	26th July 2013
Ban Pakheaung	26th July 2013
Ban Don	27th July 2013
Ban Xomxeun	27th July 2013

Villagers were aware of a number of proposed developments for the local area, including Nam Ngiep 1, Nam Ngiep 2 and the Nam Xan project. (The Nam Xan project is a proposed weir, which will serve to generate electricity for village consumption.) Villagers at Ban Kanyong mentioned construction of Keang Tong and Keang Dao dam, which will generate electricity. The villagers did not identify any proposed mining projects.

Villagers also commented on unexploded ordnance (UXO) contamination. In most villages ordinances have been cleared. The exception is Ban Kanyong, where a small number of remaining UXOs exist. Government officers regularly visit the village to terminate UXOs.

J.1.5 Provisioning Services

Fauna

A flipbook was used during the focus groups to guide the discussion and generate dialogue. The flipbook included photographs of species that have been reported to exist in the Project area by the Environmental Research Institute Chulalongkorn University (ERIC) in 2011. Detailed information about the species found by villagers is contained in *Table I.3*, including species name and sight frequency.

Table J.3 Sight frequency of reported species

No.	Common Name	Scientific Name	IUCN Status	Sight Frequency					
				Nam Ngiep River			Nam Xan River		
	English (Lao) Name			Ban Pou	Ban Xomxuen	Ban Pakyong	Ban Kanyong	Ban Pakheuang	Ban Don
Mammals									
1	Red-shanked Douc Langur (Khadeng)	*Pygathrix nemaeus*	EN	N	N	N	N	N	N
2	Asian Wild Dog (Ma Nai)	*Cuon alpinus*	EN	A	A	A	N	N	A
3	Phayre's Langur	*Trachypithecus phayrei*	EN	A	C	N	C	N	N
4	Asiatic Elephant (Xang)	*Elephas maximus*	EN	N	N	LC	N	N	N
5	Fishing cat (Seua Pa)	*Prionailurus viverrinus*	EN	LC	N	LC	C	N	C
6	Tiger (Seua Khong)	*Panthera tigris*	EN	LC	N	N	N	N	N
7	Pangolin (Liin)	*Manis javanica*	EN	C	LC	LC	LC	C	A
8	Gaur (Meuey)	*Bos gaurus*	VU	N	N	N	N	N	N
9	Stump-Tailed Macaque (Ling Kung)	*Macaca arctoides*	VU	A	A	A	A	LC	A
10	Sambar Deer (Kouang)	*Rusa unicolor*	VU	A	LC	C	A	A	C
11	Marbled Cat (Seua Maeo)	*Pardofelis marmorata*	VU	C	A	A	A	A	C
12	Asian Slow Loris (Ling Lom)	*Nycticebus bengalensis*	VU	A	A	A	A	A	A
13	Pygmy Loris	*Nycticebus pygmaeus*	VU	A	A	A	A	A	A
14	Malayan Sun Bear (Mee Born)	*Helarctos malayanus*	VU	LC	LC	N	A	C	N
15	Asian Black Bear (Meuey)	*Ursus thibetanus*	VU	LC	LC	LC	C	C	N
16	Three-Striped Palm Civet	*Viverra zibetha*	NT	A	C	A	A	LC	A
17	Binturong (Ngen Hang Kho)	*Arctictis binturong*	VU	C	LC	A	A	N	C
18	White cheeked crested gibbon (Thany)	*Hoolock leuconedys*	VU	C	N	A	C	N	N
19	Chinese Serow (Nheuang)	*Capricornis milneedwardsi*	NT	N	A	C	N	N	N

No.	Common Name	Scientific Name	IUCN Status	Sight Frequency					
				Nam Ngiep River			Nam Xan River		
	English (Lao) Name			Ban Pou	Ban Xomxuen	Ban Pakyong	Ban Kanyong	Ban Pakheuang	Ban Don
20	Siamese Macaque (Ling Sehn)	*Macaca assamensis*	NT	LC	N	C	A	N	N
21	Asian Golden Cat (Seua Fai (Seua Daeng))	*Pardofelis temminckii*	NT	N	N	N	C	N	N
22	Hog Badger (Mu Leung)	*Arctonyx collaris*	NT	A	C	C	C	A	C
23	Common Otter (Nahk)	*Lutra lutra*	NT	A	A	A	N	N	N
24	Asiatic Jackal (Ma Jork)	*Canis aureus*	LC	N	A	N	A	A	N
25	Barking Deer (Fan)	*Muntiacus muntjak*	LC	A	A,LC	A	A	C	A
26	Colugo (Malayan Flying Lemur) (Bahng Hog (Bahng Nai))	*Galeopterus variegatus*	LC	A	C	N	C	N	N
27	Wildcat/Leopard cat (Seua Meo)	*Prionailurus bengalensis*	LC	N	C	N	C	A	A
28	Greater Short-Nosed Fruit Bat	*Cynopterus sphinx*	LC	C	A	C	C	A	A
29	Geoffrey's Rousettle	*Rousettus amplexicaudatus*	LC	A	A	C	C	A	A
30	Back Striped Weasel (Phung Porn)	*Mustela strigidorsa*	LC	A	A	A	A	A	A
31	Hoary Bamboo Rat (Onn Khaem)	*Rhizomys pruinosus*	LC	A	A	A	A	A	A
32	Large Bamboo Rat (Onn Hok)	*Rhizomys sumatrensis*	LC	LC	A	A	C	C	A
33	Asiatic Brush-tailed Porcupine (Hone)	*Atherurus macrourus*	LC	LC	A	LC	C	A	C
34	Variable Squirrel (Ka Hok Lark Sy)	*Callosciurus finlaysonii*	LC	A	A	A	C	A	A
35	Red-Cheeked Squirrel	*Dremomys rufigenis*	LC	LC	A	A	C	A	A
36	Phayre's Flying Squirrel	*Hylopetes phayrei*	LC	A	A	N	C	N	A
37	Lesser Giant Flying Squirrel (Bahng Lua)	*Petaurista elegans*	LC	A	C	N	C	N	C
38	Red Giant Flying Squirrel (Bahng Lua)	*Petaurista petaurista*	LC	A	N	N	N	N	N

No.	Common Name	Scientific Name	IUCN Status	Sight Frequency					
				Nam Ngiep River			Nam Xan River		
	English (Lao) Name			Ban Pou	Ban Xomxuen	Ban Pakyong	Ban Kanyong	Ban Pakheuang	Ban Don
39	Wild boar (Mou Paa)	*Sus scrofa*	LC	A	A	A	A	A	A
40	Kloss's Mole (Teung)	*Euroscaptor klossi*	LC	N	N	N	N	N	N
41	Three Striped Palm Civet (Ngen Omm Na Daen)	*Arctogalidia trivirgata*	LC	LC	N	A	C	N	N
42	Javan Mongoose (Phung Porn)	*Herpestes javanicus*	LC	A	C	N	C	N	A
43	Masked Palm Civet (Ngen Kheua Khow)	*Paguma iarvata*	LC	A	A	A	C	C	A
44	Common Palm Civet (Ngen Omm Tin Tam)	*Paradoxurus hermaphrodites*	LC	A	C	LC	C	N	C
45	Northern Treeshrew (Ka Tae)	*Tupaia belangeri*	LC	A	A	N	C	A	A
46	Small Indian Civet	*Viverricula indica*	LC	N	N	C	N	N	C
47	Porcupine	*Hystrix brachyuran*	LC	A	A	A	C	C	C
48	Lesser Mouse Deer (Kaay)	*Tragulus javanicus*	DD	A	A	A	A	A	A
49	Large-toothed Ferret-Badger (Ma Leung)	*Melogale personata*	DD	N	C	N	C	N	N
50	Grey-Bellied Squirrel	*Callosciurus caniceps caniceps*	unknown	A	A	A	A	A	A
51	Rhesus Macaque	*Mecaca mulatta*	unknown	N	A	A	N	C	C
52	Flying squirrel (Baang)	Subfamily Sciurinae, Tribe Pteromyini	unknown	A	C	A	LC	C	C
Reptiles and Amphibians									
53	(Khiet Lai/Hin)	*Amolops cremnobatus*	NT	A	A	A	A	A	A
54	(Khiet Ta Pat Leuang)	*Rhacophorus calcaneus*	NT	A	C	A	A	A	A
55	(Khiet Ta Pat Tong)	*Rhacophorus reinwardtii*	NT	N	LC	A	A	N	N
56	Indochinese Sand Snake (Ngou Xeuak Phat)	*Psammophis condanarrus*	unknown	A	A	A	A	A	A
57	Asian Water Dragon (Kathang)	*Physignathus cocincinus*	unknown	N	A	A	C	A	A
58	Common Ratsnake (Ngou Sing)	*Ptyas mucosus*	unknown	A	A	A	A	A	A

No.	Common Name	Scientific Name	IUCN Status	Sight Frequency					
				Nam Ngiep River			Nam Xan River		
	English (Lao) Name			Ban Pou	Ban Xomxuen	Ban Pakyong	Ban Kanyong	Ban Pakheuang	Ban Don
59	Black Rat Snake	*Ptyas carinatus*	unknown	A	A	A	A	A	A
60	Red-Necked Keelback Snake	*Rhabdopsis subminiatus*	unknown	A	A	A	A	A	A
61	King Cobra	*Ophiophagus hanah*	unknown	A	C	A	C	A	A
62	Monocled cobra (Ngou Haou)	*Naja kaouthia*	unknown	A	A	C	C	A	A
63	Reticulated Python (Gnou Leuam)	*Python reticulates*	unknown	A	A	A	C	A	A
64	Green Snake (Ngou Khieo)	-	unknown	A	A	A	A	A	A
65	Sun Skink	*Mabuya multifasciata*	unknown	A	A	A	A	A	A
66	Tortoises (Tau)	*Testudo* spp.	unknown	A	C	A	A	A	A
67	Water monitor (Hiaa)	*Varanus salvattor*	unknown	A	A	A	A	A	C
68	Jellow Tree Monitor (Len)	*Varanus bengalensis*	unknown	A	A	A	A	A	A
69	Kob Dong	*Annandia delacouri*	DD	A	C	A	A	A	N
70	Kiet Keoung	*Microhyra berdmorei*	LC	N	A	N	A	A	A
Avian Species									
71	White backed vulture (Heng Khorkham)	*Gyps bengalensis*	CR	N	N	N	N	N	N
72	White winged duck (Nok Pet Nam)	*Cairina scutulata*	EN	N	C	C	C	A	C
73	Imperial Eagle (Leo)	*Aquila heliacal*	VU	N	N	N	N	N	A
74	Rufous-necked Hornbill (Nokkok kho-kham)	*Aceros nipalensis*	VU	N	N	C	C	N	N
75	Oriental Darter (Nok Khor Gnou)	*Anhinga melanogaster*	NT	N	A	N	A	N	C
76	Red Crowned Barbet	*Megalaima rafflesii*	NT	LC	A	C	A	A	A
77	Helmeted Hornbill(Nok kok)	*Rhinoplax vigil*	NT	N	N	C	C	N	N
78	Blue Winged Leaf Bird	*Chloropsis cyanopogon*	NT	A	A	A	C	A	A

No.	Common Name	Scientific Name	IUCN Status	Sight Frequency					
				Nam Ngiep River			Nam Xan River		
	English (Lao) Name			Ban Pou	Ban Xomxuen	Ban Pakyong	Ban Kanyong	Ban Pakheuang	Ban Don
79	Scaly-breasted Partridge (Nok Kho)	*Arborophila charltonii*	NT	N	LC	A	C	A	A
80	Siamese Fireback (Kay Khoua)	*Lophura diardi*	NT	A	A	C	A	A	A
81	Puff Backed Bulbul	*Pycnonotus eutilotus*	NT	A	C	A	A	A	A
82	Scarlet Rumped Trogon	*Harpactes duvaucelii*	NT	A	C	C	C	A	N

Remark: A: very common C: common, LC: less common, N: never
IUCN Red list Category: CR: Critically Endangered EN: Endangered VU: Vulnerable species NT: Near Threaten LC: Low concern DD: Data Deficient

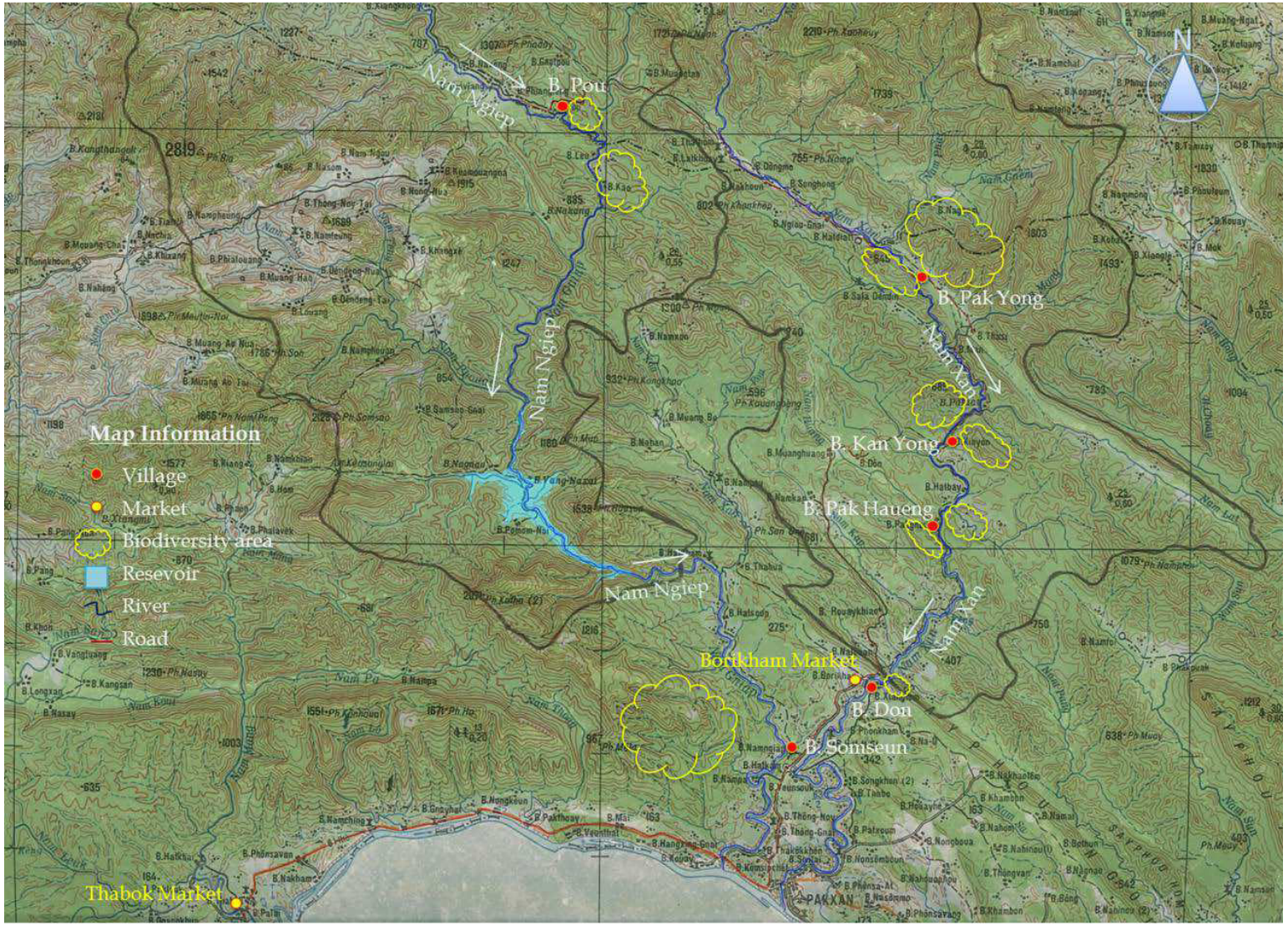
Most of the villagers identified the areas where the above-mentioned species are seen in and around their village and along Nam Ngiep and Nam Xan Rivers (*Table I.4*). In a number of instances, the reported locations align with the community forests, which are located adjacent to the villages.

Table J.4 Biodiversity areas reported by each village

No.	Village name	Community forest	Other reported areas
1.	Ban Pou	Houy Tarin, Poo Kor hai	-
2.	Ban Pakyong	Poo Padeang, Poo Namxan	-
3.	Ban Kanyong	-	Poo Padeang, Poo Nam Xan, Ban Ngua
4.	Ban Pakheaung		Nam Heaung, Pa Meaung cave
5.	Ban Don		Ban Nong, Pak Beuang, Houy sai, Lak Xao, Poo Mor, Poo Tuen, Pa dong, Pa Hea, Pa Sod and along Nam Xan River, Nam Ngiep River
6.	Ban Xomxeun		Keang Kai, Huay Ngua, Napeun, Houy Kee Yeuak, Poo Hong, Pa Dan Takytan, , Nam Pa, Lak xao, Nam Houy, Nam Dong and along Nam Ngiep River

The locations identified in *Table I.4* have been mapped in *Figure J.3*.

Figure J.3 Map with identified biodiversity areas



During the focus group discussions a significance ranking exercise was conducted. Results of this activity led to a prioritized list of significant species which hold relative importance to the villagers.

For the mammal species, the villagers viewed big animals as the most important species due to their tracks (i.e. footprints). The villagers reasoned that the tracks, when hunting, lead them to areas rich in biodiversity. When asked to prioritize species that should be conserved, the villagers ranked large mammals in the following order Asian Elephant, Southern Red Muntjak, Tiger, Gaur, Bears, Pangolin and Red-shanked Douc Langur.

As for reptiles and amphibian species, the villagers did not identify any of the flipbook species as significant (i.e. that need to be conserved). However, they mentioned a soft-shelled turtle (*Trionyx cartilageneus*) as a valuable amphibian species. Since the soft-shelled turtle draws a high price at market, which means that if caught it will be sold for income. Apart from market value, the soft-shelled turtle does not hold other significant values to villagers.

For avian species, the Hornbill, including the Rufous-necked Hornbill and Helmeted Hornbill, were identified as important species that should be conserved. The villagers indicated that these species have gradually disappeared from the areas around the villages, which means that they are now rare. In order to conserve the Hornbills, the villagers suggested maintaining and growing Hornbill habitat (e.g. areas where Hornbills nest).

Generally, villagers agreed that endangered species, and if possible, all species should be conserved for future generations (e.g. to see and consume).

In terms of locations, the species are typically found around the villages as well as in the provincial protective forests. The village areas are owned by the villagers.

The provincial protective forests are owned by the Lao government. The forests are divided into reserved and productive areas. Villagers are allowed to access the productive areas, while access to the reserved lands is strictly prohibited. The productive areas are allocated on an annual basis to villagers to ensure that the land is used on a rotation basis. The boundaries are delineated by poles placed around the productive areas by government and announced by the village headman to ensure compliance.

As for private areas, or areas which are privately owned by individual villagers the lands are normally utilized by planting crops. The villagers then know that these areas have ownership and they are not allowed to hunt in such areas.

Terrestrial

Male: Male hunters generally hunt species primarily for household consumption; any surplus is sold to intermediaries. Approximately, 10% to 50% of species are sold to the market. The money generated by this activity is spent on household expenses such as buying food from markets, clothes and education.

Male hunters normally go hunting individually, unless big animals such as cow or deer are needed for events, such as weddings. Male hunters then go hunting in groups of four to five to hunt big animals. They typically hunt in the designated productive forest areas.

Hunting frequency ranges from two to three times per week to once a month in most villages. However, male hunters from Ban Don mentioned that they have not hunted for the past six years, which is when hunting became illegal. Enforcement has been strictly implemented around Ban Don

A variety of weapons are used. This includes gun, knife, rubber band, traps and nets were also impounded by the district officials.

Typically, male hunters tend to catch what they see, rather than a pre-determined species. Frequently caught species include small species such as squirrels, birds and lesser mouse deer; however, once in a while big animals such as Rusa Unicolor, Southern Red Muntjak and Pangolin are caught. The villagers explained that small species, if caught, will be consumed in the household. Big species, on the other hand, are sold to intermediaries. According to male hunters, the most prized mammals species is the Pangolin, the price for which ranges from 100,000 KIP (13 USD) to 1 million KIP (130 USD) per kilogram. (The price correlates to the availability of the species – e.g. in areas where the species is more readily available the price is lower.) This is because of its rarity and medicinal purpose – it is believed to have sexual stimulation powers and is preferred alive.

In terms of cultural importance, male hunters did not identify any species which possess culture or spiritual value.

Hunters reported that the availability of resources has been declining since around 2000. The villagers believed that the cause of such decline is the increasing number of new settlers who have migrated to the village areas and started accessing the existing natural resources.

Female: Similar to males, female villagers also hunt; however, females hunt smaller species such as squirrels, bamboo rats, reptiles, and birds. These species are hunted primarily for household consumption; any surplus is sold to intermediaries.

Female hunters usually go hunting in groups of four to five. Female hunters are less likely to go to forests alone.

Hunting frequency ranges from daily to once a once a month. The frequency largely depends on the season and the villager's desires for dinner.

In the same manner with the male hunters, female hunters when they go hunting, they do not have specific species in mind. They claimed to catch whatever species they see. In terms of location, female hunters hunt in the government's designated productive forest areas.

Similar to male hunters, female hunters mentioned that the availability of the existing resources has been declining since 2000. This was attributed to the increasing numbers of people coming into the area to hunt.

In context of cultural importance, female villagers did not identify any animal or plant species which hold significant values to them.

Aquatic

Villagers indicated that fishing is mainly the role of females rather than males. Female hunters claimed to go fishing in groups of three to four at a frequency of daily to two to three times per week (depending on, again, on what they want for dinner).

Females indicated that they go fishing more often during the rainy season. This is largely because species that dwell in Mekong River flow downstream to the Nam Ngiep and Nam Xan rivers during the rainy season.

Fishing primarily occurs along the Nam Ngiep and Nam Xan rivers (and their tributaries). Female hunters use nets, baits and traps to fish year round (*Figure I.4*).

Figure J.4 Female fishing method

Female fishing

Catch of the day

Female fishing with net

Female fishing

The majority of fish caught are consumed within household. Only surplus or the prized species are sold to intermediaries. Hence, family income derived from selling fish is relatively low - ranging from 20% to zero.

In terms of species, female hunters typically catch cat fish and scale fish. Scale fish are reported to be the most prized species – it can attract up to 130,000 KIP (17 USD) per kilogram at market.

Regarding availability of fish, female hunters mentioned that such resources have been declining due to the increasing number of people fishing. In addition, villagers noted many of these people are fishing for commercial purposes, not household consumption.

The villagers noted that the fish catch are unlikely to be found only in the Project area. Instead, the fish can be caught elsewhere.

Flora

Information regarding flora species was also investigated during the focus groups. Females are responsible for gathering flora species and usually

operate in groups of three to four in the productive forest areas. They typically use knifes and basket when collecting species.

Female gatherers reported that they visit forests more often at the start of the rainy season (i.e. May) given that the bamboo shoots and ground vegetation are abundant and ripe at this type of year.

No specific flora species were identified during the focus group discussions. This included no specific plant species for medicinal or ceremonial purposes. This aligns with the information obtained about cultural practices – i.e. villagers do not hold any particular important ceremonies.

In terms of non-timber forest products (NTFPs), a number of species are collected, including mushrooms and bamboo shoots, which are gathered at different times of the year, depending on the species' growing season.

Flora species were, again, primarily used for household consumption and only surplus is sold to intermediaries. However, from time to time, specific species will be request by intermediaries, such as Nor boon (1,000 KIP (15 cent) per piece) and Nor Xang (50,000 KIP (7 USD) per kilogram). These are the most prized plants due to their taste.

Female gatherers tend to engage in other activities, such as planting rice or textile production, in order to provide family income (instead of gathering flora species for income).

In terms of availability of existing resources, similar to fauna species, it was reported that flora species have been declining due to the increasing number people settling in the area.

J.1.6 Cultural Services

During the village surveys, information was collected on histories and migration stories. Most of the villages have common stories that involve involuntary migration as the result of the Laotian Civil War (1953-1975).

Ban Pou was settled in 1975 after the Civil War for strategic reasons. The villagers mainly migrated from the Xaysomboon province. At present, the villager consists of 70 percent Hmong people, while the remaining 30 percent is lowland Laos.

Ban Pakyong was founded in 1987 with the old name of Ban Nayae. The villagers moved back and forth between Thatom and Bolikham to avoid the Civil War before finally settling in the current location in 1987. The village consists of equal numbers of lowland Laos and Kamoo tribe people.

Villagers in Ban Kanyong, similar to other villages, moved back and forth due to the Civil War. The village was officially founded in 1989. The composition of the villagers is 100 percent lowland Lao.

The villagers in Ban Pakheaung migrated back and forth along the Nam Xan River as required by the Lao government before finally settling the village in 1977. The composition of the villagers is 100 percent lowland Lao.

Ban Don was founded in 1975. Prior to settlement, villagers migrated from Kumkerd, which was located Bolikhamxay province but no longer exists, and the Xiangkwang province. The village proportionally consists of both highland and lowland Laos.

Ban Xomxeun is believed to be over 100 years old with the former name of Ban Meung Mai. The composition of the villagers is 100 percent lowland Lao.

J.1.7 Tangible Cultural Heritage

In terms of tangible cultural heritage, most of the villages identified two specific cultural sites deemed important to their way of life - village temples and cremation sites. The cultural sites are typically located in close proximity to each of the villages, but are communally owned by the village.

For example, Ban Don reported to have village temple named Ban Don Chaiyaram, which is located at the centre of the village. Religious ceremonies are held at the site from time to time. The villagers reported conduct religious activities, such as release fish, turtles at the temple.

Ban Xomxeun identified *Tad Jaokumheaung*, a place where Buddhist relics are located. Villagers go to the location to pay respects to the remains of Ban Xomxeun's founder or Jao Kam Heaung. Another cultural site identified is Buddha's footprint was located between Nam Xan and Nam Ngiep River since 1974.

When asked, the villagers indicated that the sites can be moved elsewhere or destroyed and rebuilt elsewhere. In order for this to occur, compensation in the form of land or money is required. The only exception was the Ban Hat Seung Tom, a historic cultural site where artefacts are buried, in Ban Pakheaung. The site was established prior to the founding of the village itself.

Figure J.5 Cultural sites at Ban Xomxeun

Tad Jaokumheaung at Xomxeun

Buddha's footprint at Xomxeun

Pagoda next to Buddha's footprint

Historical description

Intangible Cultural Heritage

As for intangible cultural heritage, no significant sites were identified. This is partly due to the fact that the village residences were largely lowland Laos who are Buddhist. Accordingly, religious ceremonies are conducted in village temples. Another possible underlying factor is that the villagers have migrated many times prior to settling after the Laotian Civil War. Hence, concerns of originality and native lands are of low importance.

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