Addenda to the EAMP November 04 version with supplementary information

25 January 2005

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SET OF STUDIES INCLUDED IN THE EAMP AND ROLE OF INDEPENDENT

PREFACE

Set of studies included in the EAMP and role of independent studies.

This paragraph is to be inserted in the Preface of the EAMP, under the "Development of the EAMP" section, before the last paragraph of the right column, page xxii.

The Annex A, References, presents the 236 main references used during the preparation of the EAMP. This list is made of reports that have been commissioned by NTPC, but also mainly of independent studies that are referenced in the EAMP. These independent studies have been published by the authors and, for some of them, in international magazines and journals, and most of them are available to the interested public.

INCORPORATION IN THE PROJECT DESIGN OF LESSONS LEARNED FROM OTHER HYDROPOWER PROJECTS

The following section is to be incorporated in **chapter 2** of the EAMP, between the "Evaluation of Alternative Configurations" and the "Description of Project Infrastructure" sections.

Incorporation in the Project Design of lessons learned from other hydropower projects

The experience from two recent hydropower projects in Lao PDR, the Theun-Hinboun 210 MW trans-basin project and the Nam Leuk 60 MW trans-basin project, and from the Pak Mun 136 MW run-of-river project in Thailand, but also the experience reflected in the report of the World Commission on Dams has been incorporated in the development of the Nam Theun 2 Project.

Table 1 describes how these experiences and some of the key lessons learned have been taken into account in the design of the Project.

Table 1. Lessons Learned

Lessons Learned	How Incorporated into Project Design
Consider project alternatives and design options and consider environmental and social impacts in an integrated manner with the economic and technical dimensions of the project.	• Two comprehensive analyses of alternatives have been carried out (in 1999 and 2004) to consider different options for power generation in Thailand as well as feasible hydropower development in Lao PDR for export of power to Thailand. • These analyses of alternatives also looked at alternative configurations for the project site on the basis of social and environmental impacts (dam and reservoir size, the number of persons to be resettled) and technical and economic analysis. •
Carefully consider downstream environmental and social impacts, collect adequate baseline data, identify those directly and indirectly impacted by the project, and create adequate mitigation and compensation programs covering all project areas, with associated financial commitments, ahead of	• Downstream impacts in the Nam Theun, Nam Kading, Nam Kathang and Xe Bang Fai drainage areas have been identified and quantified as part of the environmental impact assessment. • Operational measures to reduce impacts include a provision in the PPA to suspend power generation during flood periods. Design features include an outlet structure, regulating pond, aeration devices and a downstream channel to minimize erosion and improve water quality; and provision of predictable and consistent environmental flows. • Where feasible and economical, baseline data has been collected during the development of the EAMP. Long-term studies of fisheries impacts in the XBF, in the Nam Theun and upstream of the Nakai Dam will collect data throughout the construction period.

Lessons Learned	How Incorporated into Project Design
construction.	• A proactive mitigation and compensation programme is being developed with a dedicated budget and contingencies for the resettled population on the Nakai Plateau and in the downstream areas. Mitigation measures are expected to compensate fisheries impacts, loss of riverbank structures and gardens, and other effects. The specific level of funding is indicated in the SDP. • Project financing includes contingency funds to cover cost over-runs, costs of unanticipated impacts, and failure to achieve agreed programme targets.
Identify, prepare and implement development and mitigation measures in consultation with project-affected people. Involve concerned civil society through participatory dialogue and be pro-active in response to issues raised; periodically disseminate project-related information.	• Formal and informal public briefings have taken place throughout the project preparation period. Major public consultations and workshops took place in 1997. New local consultations began in May 2004, followed by international workshops with civil society. The views expressed have been documented and are being taken into account in project decision making. • Sitting of resettlement villages has reflected the preference of affected people. Citizen concerns led to a change from relocation on the Gnommalath plain to relocation on the Nakai Plateau and so that relocated villages are generally within "spirit village" areas. Village layout design has also been changed based on stated preferences. • GoL and NTPC have provided considerable project information on their respective websites to engage civil society in dialogue on the Project. • Informed and meaningful participation of project affected persons, and outreach to local populations, will continue throughout the remaining preparation and implementation periods.
Clearly define the roles and responsibilities of all entities involved in implementation; address capacity gaps; develop adequate monitoring arrangements with task plans, budgets and sufficient long-term funding for all tasks to be certain that supervision continues long after project completion so that careful attention is paid during construction and operations to ensure sound engineering	• Project includes establishment and strengthening of GoL institutions for conservation, social and environment oversight. The project has been instrumental in establishing the NNT WMPA for watershed management, which will be funded by project revenues over a 30 year period. • Extensive monitoring, including GoL, NTPC, IFIs, IAG, DSRP and PoE, and independent monitors, is an integral part of the project design. • An independent professional firm will monitor key project issues for the lenders throughout construction and into the operational period, potentially until the commercial debt has been fully repaid, a period of about 17 years from financial close.

Lessons Learned	How Incorporated into Project Design
and construction and proper compliance with environmental and social mitigation measures.	
Carefully scrutinize procurement aspects to minimize the risk of cost and time overruns and inferior long-term operational performance. Scrutinize contractor selection.	• Specialist consultants completed a review of the procurement process and the structure and cost of the head construction contract (HCC) and subcontracts in April 2004. • Review concluded that there was adequate competition for two of the three civil works subcontracts and the two electromechanical subcontracts and that the agreed prices of all six contracts were generally consistent with, or better than, the prices which might have been expected from greater competition. • Supervision of the entire procurement process by an independent engineering firm reporting to GoL and another independent engineering firm reporting directly to the lenders will help to ensure procurement transparency and efficient implementation. • Thorough staff supervision by IFIs involved. • Qualifications of HCC and subcontractors have been vetted. Financial institutions will need to approve qualifications of key operational personnel.
Hydrological uncertainties have plagued past hydro projects in Lao PDR and elsewhere.	• Project preparation has included detailed hydrological modeling, dam safety planning for a 1000 year flood, and protection of the watershed to prevent sedimentation. • The PPA includes clauses to shelter NTPC from output losses due to XBF flooding and dry years. • Active monitoring and timely warning of XBF flooding is an important feature of NT2 operations.
Geological uncertainties, due both to the paucity of investigations undertaken and the rigors of the terrain, have been the single largest cause of cost and time overruns in past projects.	• Extensive, in-depth geological investigations have been carried out; geological risks in the near-vertical water conduits from the reservoir to the power house have been well catalogued and provisions made in the contract documents for accommodating design changes. • Power house design has been changed from under- to above-ground at some additional cost. • Target pricing has been included in the HCC to shift a portion of the added cost to the project sponsors from the subcontractor in the event of unforeseen problems in the underground works.
Where governance and expenditure management systems are weak, specific	• Proposed revenue management arrangements will target NT2 revenues to eligible priority programs in the GoL's NGPES. • Parallel PEMSP is being designed to strengthen commitment to PEM reform

Lessons Learned	How Incorporated into Project Design
arrangements may be needed to ensure that project revenues are targeted and used transparently, while efforts continue to strengthen national systems.	program and improve implementation with multi-donor financial support.

LOWER XE BANG FAI

This section replaces the text of the Lower Xe Bang Fai section of the EAMP page 51 of the November 04 EAMP version.

Lower Xe Bang Fai

Background
The region of the Xe Bang Fai between the Road 13 bridge and the Mekong River is referred to as the lower region of the Xe Bang Fai. Discharge in this region will also be increased by approximately 220 m3/s, as averaged over the entire year. Under normal conditions, this area is flooded every year due to backwater effects of the Mekong and flooding in the Xe Bang Fai. According to the 36-year hydrologic record obtained at Road 13 Bridge, the Xe Bang Fai flooded in 31 years – without any supplemental discharge from the Project. Because the Project will affect discharge of water from the Nam Theun/Nam Kading into the Mekong, it is estimated that there will be a fall of about 15 cm in the Mekong during flood events (SMEC, 1996). This should allow for quicker drainage of the lower Xe Bang Fai during times of flooding, and consequently partially offset the impact of the increased flows in this portion of the river.

SMEC hydrological modeling
In order to quantify the impacts of the Project discharge on the existing flood regime in the lower Xe Bang Fai area two mathematical models were constructed by SMEC, a hydrologic model of the whole Xe Bang Fai up to the Mekong, and a hydraulic model of the Mekong and of the Lower Xe Bang Fai (SMEC, 2004). A number of surveys were carried out to collect data on river cross-sections, floodplain topography, river bank profiles and flood control structures for input to the hydraulic model. The hydrologic and hydraulic models were calibrated and verified using the data recorded for floods that occurred in 1994, 1995 and 2000 for which records were readily available. Flood frequency analysis carried out on the historic flood records of flows and levels recorded on the Mekong and Xe Bang Fai during other investigations (SMEC, 1996 and SMEC, 2004a) were utilized to determine the appropriate design flood conditions in the Mekong to be applied in conjunction with flood events in the Xe Bang Fai, for the assessment of design flood cases.
It has to be noted that the results of the SMEC report can be considered as a worst case scenario as the release of water from the regulating pong will be stopped before the natural flow reaches 2,270 m3/s at Mahaxai, thereby preventing any additional flooding caused by the Project.

Overall results of the SMEC modeling
The main results of the hydraulic model were as follows: A release of 315 m3/s will increase by 3.75% the extent of the area flooded when added to the maximum flood flow allowed in the Xe Bang Fai immediately before discharges from the Regulating Dam are reduced. Figure 3.26 shows the increased extent of the flooded area, from 324 km2 without the Project to 335 km2 with a project discharge of 315 m3/s. The flood levels in the river and floodplain are expected to increase by approximately 0.5, 0.4 and 0.2 m in the upper, middle and lower reaches of the lower Xe Bang Fai respectively when combined with floods exceeding the bankfull flow. Velocities in the river channel are expected to increase by 20% along the Xe Bang Fai for a 1 year ARI flood that is confined within the banks, and up to 7% for the over-bank floods. The hydraulic model showed that the duration of overtopping of the flood levees was increased on average by 3.6 days each year.

Quantification of the impacts

The results of the SMEC study were then further analysed in terms of impacts on agricultural lands only.

It was considered that the areas under more than 1 m of water during the 1.6 ARI flood events, without the additional release from the Project, will not be further impacted in terms of agricultural production, as, even without the additional release from the Regulating Pond, they are already under too much water to enable such production. The focus is therefore put

on the areas that are currently subject to a flood of less than 1 m, and represented on figure 1.

The model indicates that 5,230 ha of land will be put under more than one meter of water because of the additional release of 315 m3/s for an average duration of 3.6 days per year. The agricultural production on these areas might be impacted.

In addition the model indicates that 1,530 ha of land will be flooded during an average of 3.6 days per year when they are not without the release from the regulating dam. However these areas will be under less than 50 cm, therefore not threatening rice paddy production. The extent of the areas is shown on figure 2.

In addition, it is possible that the extended duration of the flood event on average by 3.6 days per year, could put at risk some of the 2,497 ha of land, which will be under a depth of water varying from 0.75 m to 1 m if the flood takes place before the paddy has been able to grow sufficiently in height.

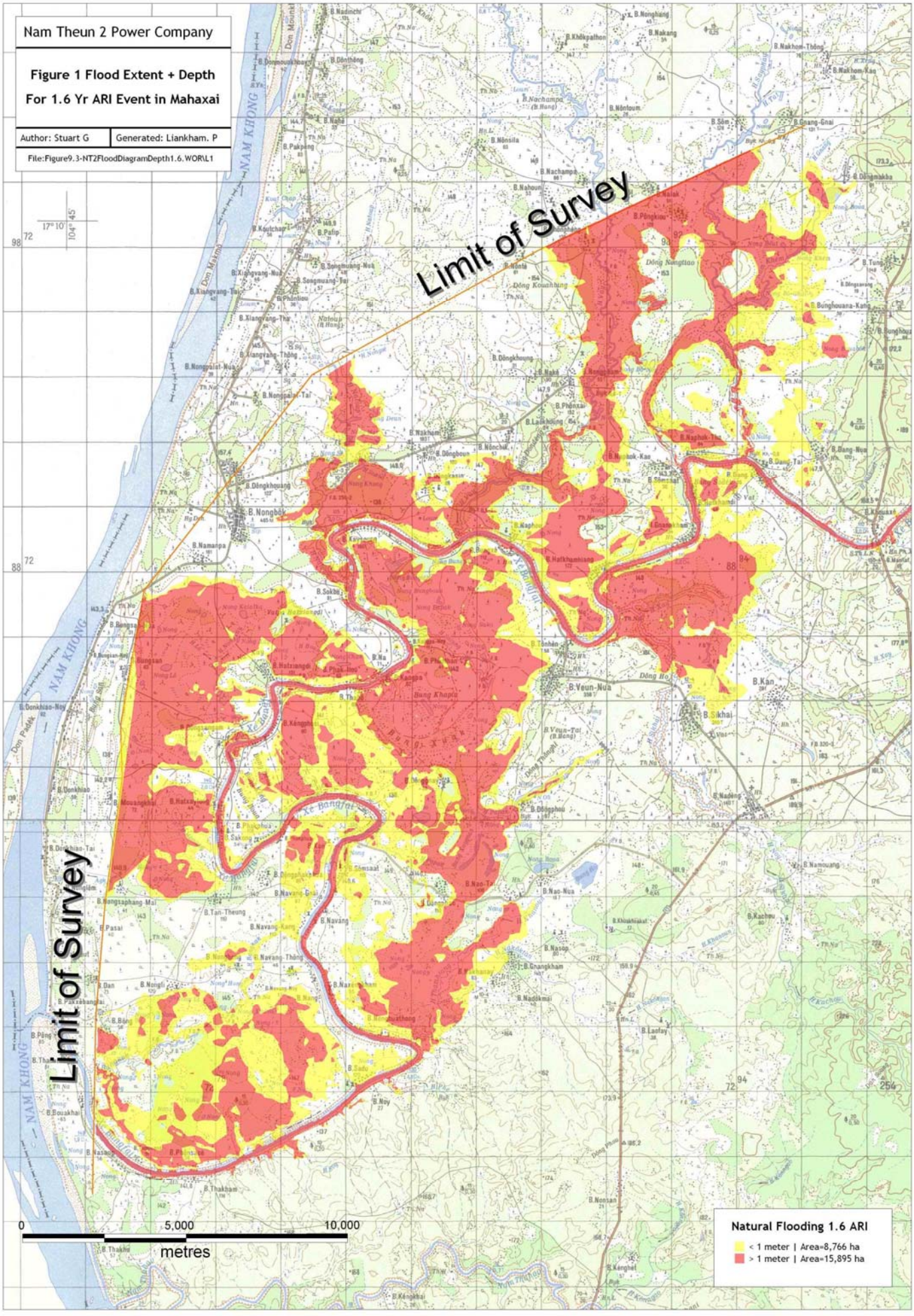
The current use of the land will have to be confirmed as productive agricultural land during the rainy season.

The increased flood plain created because of the additional release of water could impact positively fish production in the area.

Mitigations measures

Several measures could be considered to mitigate the impacts:

- Optimisation of the use of the existing irrigation schemes, including the timing of the opening/closure of the various gates.
- Use of rice varieties that are tolerant to flood episodes, in terms of duration of flood and depth of flood.
- Development of fisheries production.

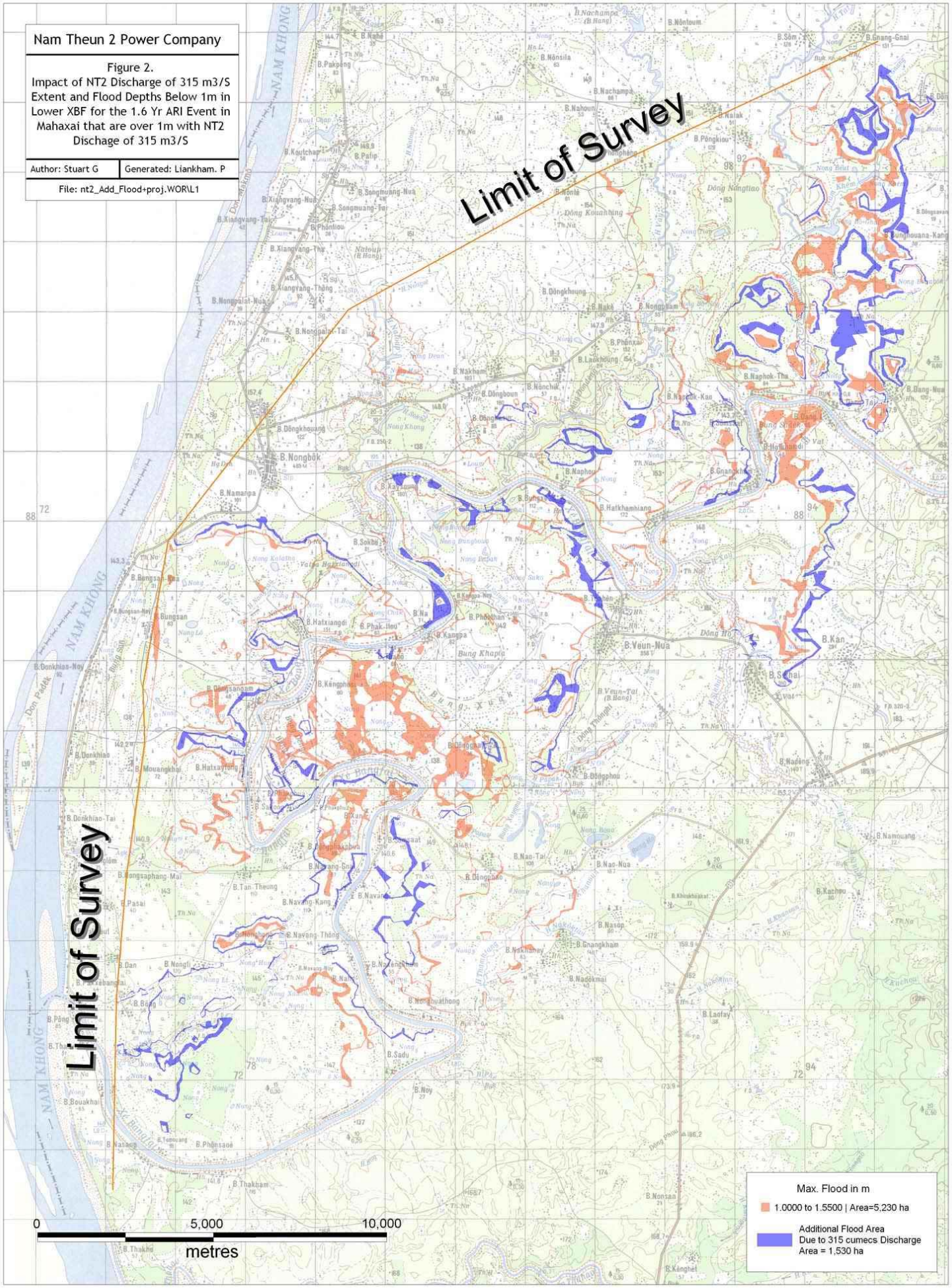

Nam Theun 2 Power Company
Figure 1 Flood Extent + Depth
For 1.6 Yr ARI Event in Mahaxai
Author: Stuart G
Generated: Liankham. P
File:Figure9.3-NT2FloodDiagramDepth1.6.WOR\L1
Limit of Survey
Limit of Survey
NAM KHONG
0
5,000
10,000
metres
Natural Flooding 1.6 ARI
< 1 meter | Area=8,766 ha
> 1 meter | Area=15,895 ha

Nam Theun 2 Power Company

Figure 2.
Impact of NT2 Discharge of 315 m3/S Extent and Flood Depths Below 1m in Lower XBF for the 1.6 Yr ARI Event in Mahaxai that are over 1m with NT2 Dischage of 315 m3/S

Author: Stuart G	Generated: Liankham. P

File: nt2_Add_Flood+proj.WOR\L1



RIPARIAN RELEASE

The following text is an update of the Riparian Release section of the EAMP and replace the section under the same title starting page 58 of the EAMP Nov 04 (chapter 3).

Riparian Release

The Project will result in a reduction of flow in the Nam Theun and Nam Kading downstream of the Nakai Dam. In 2004, Kellogg, Brown and Root (KBR) were commissioned by NTPC to (i) qualify and whenever possible quantify environmental and social impact associated with the reduction of flow; and (ii) suggest operational procedures for the riparian release and complementary discharge to minimize impacts. The majority of the following sections is based on the findings of this KBR's assessment.

1. The Riparian Release

In order to help maintain the ecological value of the Nam Theun the Project will release a guaranteed minimum riparian release of 2 m^3/s from the Nakai Dam. An additional annual complementary release of 5 million m3 will also be provided for adaptive management of flows, especially during the dry season and early wet season.

The riparian release is intended to provide a minimum amount of water to maintain a basic level of natural processes and ecological value in the aquatic ecosystem. In particular, it is intended to maintain connectivity between pools to ensure that a heterogeneity of aquatic habitats remain and habitats are not isolated. The ability to vary the flow will be the basis for a strategically focused adaptive management programme. The programme will target the maintenance of aquatic productivity in the Nam Theun.

2. Geographical Description

Figure [1] presents the entire length and catchment areas at major confluences of the Nam Theun and Nam Kading from downstream of the Nakai Dam to the confluence with the Mekong. As the impacts of the Project are expected to decrease downstream and because of the distinct hydrological features and the different types of impacts that might be realized, the Nam Theun/Nam Kading have been divided into three main reaches: (i) the Nam Theun directly downstream of the Nakai Dam to the first tributary, the Nam Phao; (ii) the Nam Theun downstream of the Nam Phao confluence until the Theun-Hinboun (TH) Dam Site; and the Nam Kading from the TH Dam site until the confluence with the Mekong. Where appropriate the discussion is presented by these three geographical river reaches.

3. Sources of Baseline Data

The baseline data comprises of a critical review of exiting reports as well as additional data gathered specifically for the assessment of the riparian release.

For the assessment of the riparian release impacts, biophysical and hydrological characteristics were collected from representative sites and extrapolated to the entire river. Six in-stream flow requirement (IFR) sites were assigned to be representative of reaches along the Nam Theun/Nam Kading (KBR 2004), the locationof these IFR sites are shown in Figure [1].

A survey of river profiles for each IFR site was undertaken (VGS 2004). Outputs from this topographic survey were inputted into a hydrological model in order to assess (i) the reduction in the wetted perimeter; and (ii) the ability of fish to negotiate the rapids during periods of low flow.

For the fisheries and social aspects, LARReC (2004) undertook a consultation-based fisheries survey to use local knowledge to develop an understanding of fishery dynamics and assess the level of socio-economic dependence upon the fisheries resource in the communities in the area downstream of the Nakai Dam. Villages that participated in the survey are presented in Figure [x-1]. The villages were selected through advice from the Khamkeut DAFO as being places with important fishing activities in the Nam Theun or its tributaries.
The population data is based on data provided by Khamkeut district in 2004.

4. BASELINE

4.1. DEMOGRAPHIC BASELINE AND IMPACT ZONES

The study area between the Nakai Dam and the TH Dam site falls entirely under the authority of Khamkeut District. In total 70 villages have been identified as being located within the district and the number of households for each village is presented in Table [x-1]. The 70 villages within Khamkeut District were populated in 2004 by approximately 8,556 households and 53,754 people. For the purpose analysis of impacts the villages in Khamkeut have been separated into seven zones based on their use of different waterbodies and therefore the likely degree to which they will be impacted. The seven zones consist of (i) Lower Nam Phao, (ii) Upper Nam Phao, (iii) Nam Phouang/Nam Phiat, (iv) Nam Kata, (v) Nam Ngoy, (vi) TH headpond and (vii) Nam Gnouang. The location of these villages and the designated zones are presented in Figure 3.34.

No permanent villages lie along the Nam Theun and no land is cultivated from below the Nakai Dam site until the TH headpond, some 40 km downstream.

4.2. HYDROLOGY

The baseline hydrology and rainfall data used for the riparian release assessment is presented in Chapter 3. The baseline hydrology for the IFR sites in the dry season and wet season is presented in Table 5.6.

TH Spills and riparian release

The average diversion from the TH Dam is 80 m3/s, which represents over 30% of the total incremental flow, or 15% of the total flow. Figure [3] shows that there is currently significant reduction in dry season discharge downstream of the TH dam resulting from TH Project operations.

4.3. WATER QUALITY

Baseline water quality data for the Nam Theun are presented later in this chapter. In addition, KBR (2004) recorded the value of key parameters at each of the IFR sites (Table xx). The input from the Nam Phao seems to influence water quality in the Nam Theun with conductivity downstream of the confluence being approximately twice the levels measured above the confluence. This increase in conductivity reflects the greater population densities that exist in the Nam Phao catchment.

4.4. TERRESTRIAL

Analysis of aerial and helicopter photography shows similar vegetation in the geographic sections, from the Nakai Dam to the Nam Phao confluence and Nam Phao confluence to TH headpond. At all IFR sites, vegetation closest to the river tends to be dominated by grasses, woody shrubs and fast-growing tree species (KBR 2004). Tree species dominated 20 m above wet season water level. Local informants indicated that grasses, shrubs and tree species that were present along the Nam Theun were also common in ditches, drains or wetland sites outside of the Nam Theun river valley.

4.5. COMMUNITY USE

An overview of the baseline community usage of riparian resources of the Nam Theun indicates that this is limited to mainly aquatic resources and some terrestrial wildlife, however, these activities occur in only accessible areas (KBR 2004). The river corridor between Nakai Dam and TH headpond is inaccessible and therefore the riparian resources usage by communities in these areas is minimal (KBR 2004).

For those riparian resources that are used by communities, most terrestrial flora and fauna species collected by communities were present in both in the Nam Theun and sites outside the

direct river valley (Table [1]). These species were mainly collected in forest habitats not close to the river. These species are generally widely distributed and were recorded as being collected both within the river valley as well as other areas of the catchment. One exception was the Big-headed Turtle (Platysternon megacephalum) which specifically inhabits fast-flowing and rocky stream habitats. This habitat will be significantly reduced once riparian flows commence.

4.6. FISHERIES

The LARReC (2004) survey included approximately 9% of households (HH) (169 HH and 1,109 Project Affected Persons (PAP)) in 20 villages representing a population of 12,600 people and 1,929 HH. The 20 villages surveyed formed a sub-sample of the total population of 70 villages and were selected on the basis of their likely fishing activity and their direct use of the main stream Nam Theun. The villages were also selected on the basis of their distribution within the catchment, and aimed to establish (i) any differentiation between communities engaged in fisheries activities within the major tributaries, in relation to communities with a higher dependence on resource utilization of the Nam Theun mainstream; and (ii) the relationship between seasonal distribution and composition of fish stocks within the tributaries and the mainstream of the Nam Theun. In addition, persons interviewed were chosen specifically as the "fishers" of the village. Therefore, all estimates of the population mean fish catch from the Nam Theun should be considered as an overestimate of the true sample mean.

Table [2] illustrates the population data for the villages surveyed, and the estimated numbers of HH engaged in fisheries and aquatic resource collection. An underlying assumption is that 80% of HH are engaged in some form of aquatic resource extraction. Variation between villages is significant (between 20 and 100%) however it indicates that fisheries are an important element of their livelihood strategies. This is reinforced by the importance attached to fish and aquatic animal capture. The fish and aquatic resource production is ranked second or third in terms of household food security after rice and vegetable cultivation, or other forms of natural resource exploitation (hunting and gathering of NTFP's).

Accordingly, results from the survey include two possible geographic delineations; the Nam Theun fisheries and, other tributaries and waterbodies (such as rice fields, ponds etc.). In terms of describing current use of fisheries resources and ultimately, ascribing potential impacts it is important to clearly distinguish areas that will experience impacts of different levels. Adopting the above assumption it is concluded that 6,844 HH are engaged in fisheries and aquatic resource collection with an average of approximately 15% or 227 HH in the Lower Nam Phao zone, 9% or 54 HH in the Nam Phouang/Nam Phiat zone and 6% or 91 HH in the Nam Kata zone engaged in exploiting fish resources directly on the mainstream Nam Theun,.

A qualitative ranking of waterbodies in terms of fishery importance showed that tributaries of the Nam Theun tended to be of greater importance than the Nam Theun mainstream itself. Table [x-2] shows that approximately 40% of respondent ranked the Nam Phao and Nam Kata as the most important waterbodies. The mainstream Nam Theun ranked only seventh in terms of fishery importance with only 5.6% of respondent ranking it as the most important.

In summary, the Nam Theun mainstream is not an exclusive source of fisheries production. Fishing activity on the Nam Theun above the confluence with the Nam Phao is limited to flooding periods only. A range of habitats are exploited, from rapids and waterfalls to ponds and rice fields. Again, no one habitat appeared to be utilised exclusively.

Effort

Figures [4] to [6] illustrate respectively, distribution of fishing effort, annual production trend, and mean household production per month.

The distribution of fishing effort and production correspond to the anticipated trend associated with exploitation of migrating stocks between April and July. The production trend peaks more sharply than the fishing effort due to the influx of migrating stocks and a correspondingly

higher yield per unit of effort during this period. The trend between August and December is perhaps a little surprising in that downstream migration in October/November might be expected to yield rather higher catch rates.

Socio-economic benefits

Fish Catch

A further analysis comparing catch rates within and between villages and locations utilizing all the villages that participated in the LARReC survey has been undertaken (Table [x-3]). Based on the LARReC (2004) and Schouten et al (2004) reports some useful statistics on household catches and production trends emerge. There is a distinct spatial variation in the size of fish catches and the use of the Nam Theun mainstream. Villages in the Lower Nam Phao tend to have the greatest catches with an average of 142 kg/hh/yr or 12 kg/hh/month. Where as the mean annual household catches for villages in the Nam Phouang/Nam Phiat and Nam Kata catchments were slightly less at just under 100 kg/hh/yr. The mean annual household catch for villages in the Upper Nam Phao was very low at just 16 kg/hh/yr. This may reflect the fact that these villages at located on a main trade route, between Lao PDR and Vietnam, and have other opportunities to generate income.

Overall fish catches by communities in the downstream Nam Theun area are significantly lower than the mean monthly catch of 27 kg reported in the Xe Bang Fai area. This probably reflects that those villages in the Nam Theun area are generally poorer, which is also indicated in the fact that 85% of fish production is utilized for subsistence purposes.

In terms of dependency on the mainstream Nam Theun, predictably the villages in the Lower Nam Phao have the greatest use with an annual mean household catch of approximately 64 kg being sourced from the Nam Theun mainstream. This represents almost 45% of their total annual catch. Further up the Nam Phao catchment, in the Nam Phoang/Nam Phiat and Nam Kata zones the dependency on the mainstream Nam Theun is proportionally less. Only 10% and 6% of their annual catch respectively is being sourced from the Nam Theun. Mean annual household fish catches from the Nam Theun in these villages only amount to 9.6 kg and 2.0 kg. The majority of their fish catch is sourced from either the Nam Phao or its tributaries. Further still up the Nam Phao catchment, villages in the Upper Nam Phao zone do not use the mainstream Nam Theun which is probably a result of the distance required to travel and the difficult terrain.

Income

The range of income generated through fish and aquatic products varies considerably. The highest incomes are from HH engaged in fishing in the Nam Theun and Nam Phao, where there are a higher proportion of professional fishermen. In these rivers the average reported household income from the 90% recorded as generating income is US$70 and US$71 respectively.

The lowest contribution to income comes from the Nam Ngoy and Nam Kata with US$19 and US$22 respectively. It is also the case that there is a greater household effort in the collection of aquatic animals in these locations and these are utilized to supplement household consumption.

Based on 127 HH reporting some level of income from collection of fish and aquatic products, the average across all villages and river systems is US$41.2/HH/annum. Only 3% of those engaged in fish/aquatic animal collection utilise the catch for commercial purposes and for the 96% of household that utilise fish and aquatic animal production for household food security, 82% of the total catch is consumed within the household (Table [x-8]). In the 20 villages surveyed in the present study 57% of all HH generated income from a proportion of their catches, and 43% of HH utilised their catch entirely for domestic consumption. The distribution of income and consumption among HH is presented in Table [4] and the percentage contribution to household consumption is presented in Figure [7].

Generally, fishing activities were more important for income and household food supply. However, other aquatic products ranked highly as a food supply, with fewer respondents indicating these types of resources offered significant income in lieu of fishing. It is indicated that most of the aquatic products were collected from tributaries and other areas (such as rice fields, ponds) outside of the Nam Theun.

Aquatic Products

A variety of aquatic products are also caught either to supplement fish catches or for sale. Aquatic products catches almost exclusively consist of frogs, snails and shrimp. Aquatic products tend to be caught by the women and children of the household and can represent a substantial input into the household.

In terms of consumption and sale of aquatic products, an average of 81% of households participate in collecting and consuming aquatic products. Table [x-9] shows that of those households collecting aquatic products, 21% sell some of their catch but the proportion of aquatic product catch sold (11%) is low compared with the proportion consumed (89%). Similar to the situation that exists for fish, aquatic products are collected on a subsistence basis.

Only villages in the Lower Nam Phao, Nam Phouang/Phiat and Nam Kata zones utilize the mainstream Nam Theun for collection of aquatic products. Catches are extremely low, with the highest mean annual household catch of 0.5 kg being report for villages in the Nam Kata zone. Collection of aquatic products in the Nam Theun mainstream by villages from the Lower Nam Phao and Nam Phouang/Phiat is almost negligible. This is probably due the effort required to reach the Nam Theun therefore only the higher value fish are sought.

Fish Consumption by Vulnerable Groups

LARReC (2004) requested survey participants to indicate whether vulnerable groups targeted or avoided consumption of certain species of fish. These vulnerable groups included the elderly (>60 years), pregnant women, breast feeding women and children. The survey found that these vulnerable groups had no preference for eating certain species of fish, although the majority indicated that breast feeding women activity avoided eating some species. These fish species that are avoided by breast feeding women are presented in Table [x-5].

Spawning and Migration

The knowledge of the spawning and migratory behaviour of fish species in the Nam Theun is limited. An overview of the spawning and migratory behaviour of key Nam Theun fish species is presented in Annex K.

Communities suggest that the key period for spawning is February to May with peak spawning period for all water bodies occurring in March (Figure [8]) (KBR 2004). A secondary spawning in some species occurs in October which coincides with the downstream migration period.

There is sufficient difference between individual species and individual tributaries to suggest that discrete spawning groups probably occur within tributaries and that spawning activity occurs over many months within individual species. It seems clear that peak migration occurs somewhat later than the peak spawning period.

Figure [9] presents the distribution of species numbers in the catches over the year. The diversity of species during the downstream migration is significantly lower than for the upstream migration, and for this there is no clear explanation at this stage (KBR 2004).

During the LARReC (2004) survey, twelve species were identified as being vulnerable to high low flow conditions. These are listed in Table [5].

Non-migratory exotic species of fish, Common Carp *Cyprinus carpio* and Tilapia *Oreochromis niloticus*, were recorded as common captures (KBR 2004). The presence of these fish is linked to escapees from fish culture programs in the upper catchment. These species are edible and may form an important local source of readily accessible protein.

Trends in Fisheries

In the tributaries between the TH dam and the proposed Nakai Dam, evidence suggests that there has already been a decline in fisheries productivity and biodiversity as a consequence of the TH Project (KBR 2004). This is likely attributed to the change in flow conditions and water quality in the TH headpond and the inability of some downstream fish stocks to pass over the dam during upstream migrations. Villagers also suggest that there is a proliferation in the populations of non-indigenous fish species that probably originate from aquaculture or introductions into the TH Headpoind.

Aquaculture

Aquaculture appears not be very well developed in the area. An average of only 8 % of households own a fish pond, with almost half of the villages having no fish ponds at all (Table [x-6]). Reasons for such a lack of development of aquaculture are likely to be similar to those in the Xe Bang Fai areas, in that there is currently abundant fish in the rivers and TH headpond, the lack of infrastructure and well-developed market systems or transportation services, as well as the lack of knowledge about fish culturing techniques.

4.7. OTHER WATER USES

Other uses of the mainstream Nam Theun appears to be minimal. Apart from the fisheries and a small amount of aquatic product collection, no other direct beneficial uses of the Nam Theun mainstream were indicated by persons consulted during the LARReC survey (2004). Table [x-7] shows that the villages of Ban Keng Bid, Ban Nong Kor and Ban Tabac all use the Nam Theun for domestic water supply, transportation and watering livestock, but these villages are located along the banks of the TH Headpond and source their waters from here and not the Nam Theun mainstream.

Water abstraction from the mainstream Nam Theun for irrigation is negligible (KBR 2004). There is no evidence of any infrastructure associated with abstraction at any of the IFR sites and no evidence on the banks traveling to these sites. Ban Tabac is the only village indicating the Nam Theun as a source of water for irrigation but this village is located along the TH Headpond.

4.8. ASSETS

No permanent assets were identified during along the banks of the Nam Theun at IFR sites S1 to S5 but some temporary fishing were present at sites S2, S4 and S5.

5. IMPACTS

5.1. HYDROLOGY

An assessment of the impacts on hydrology is required in order to assess the subsequent impacts on the fisheries. Hydrologic regimes play a major role in determining the biotic composition, structure and function of aquatic ecosystems.

Table [6] compares the present and future flow conditions in terms of percentage of the mean annual runoff (MAR). MAR of the Nam Theun, between Nakai Dam and the Nam Phao confluence, will be reduced to 12.5%. This would increase on average to 30% below the Nam Phao confluence. On average only 50% of the Nam Kading flow will reach the Mekong River.

The minimum wet season flows of the first 12 km reach of the Nam Theun will be reduced to about 3% of the existing flows, while the maximum dry season flow will be reduced to 4%

(Table [7]). Similarly the absolute maximum flow during the dry season will be reduced to 0.3%.
Upon commencement of riparian releases, approximately half of the minimum dry season flow will be recorded between the Nakai dam site and the TH Headpond (IFR sites S1 to S4). There is no expected change in the minimum dry season flow downstream of the TH dam (IFR sites S5 and S6). Reductions in minimum wet season flows range from 10.5 to 3 times lower at the dam site (IFR sites S1) and above the TH Headpond (IFR site S4), respectively. Minimum wet season flows below the TH dam (IFR sites S5 and S6) are not expected to change.

Spills
Based on the daily time step reservoir simulation, water is spilled approximately once every 2.7 years. The average annual spill volume is 454 MCM with the largest annual flow of 3,428 MCM. A more detailed description of the spills from the Nakai Dam is presented in Annex F.

5.2. HYDRAULIC PARAMETERS AND WETTED PERIMETER

The wetted perimeter method has been adopted to assess the impact of the reduced flow on fisheries in the Nam Theun and surrounding tributaries. This method is a commonly used hydraulic rating methodology that is applied worldwide. It uses the relationship derived from changes in river wetted perimeter at representative cross-sections with changes in discharge. The method assumes that fish production is related to food production, which in turn is related to the amount of wetted river bed. Because of this assumption uncertainties are associated with using the wetted perimeter method. The method is based on general principles and is not proven to be relevant for specific fish in a particular river.

VGS (2004) measured ten cross sections at 100m intervals at each IFR site. These cross sections were inputted in a one-dimensional steady state model, HEC-RAS (KBR 2004). This model has been developed by the US Army Corps of Engineering and simulates backwater profiles through a river reach for a given inflow. The downstream and upstream boundary conditions for the model were the surveyed river water levels and the estimated flows from nearby streamflow gauging stations, respectively. The stream channel roughness or Manning's n values were estimated during the model calibration process. The model was calibrated using the recorded river flows at Nakai Dam downstream gauging station.

Initial results are available only for a typical cross section of a rapid and a pool at each of the IFR sites. The wetted perimeter analysis for the remaining cross sections at each IFR site will be conducted and the results incorporated into the future revision of the EAMP. The additional analysis will provide a more refined estimate of the reduction in the wetted perimeter and the subsequent impact on the fisheries.

Figure [x-2] illustrates an example of the graphical information provided for the analysis and Table [x-10] presents outputs generated by the model. The example provided is for a typical cross section in a pool and a rapid at IFR Site 1, and similar information is provided for all the IFR sites.

Figure [x-3] shows the wetted perimeter-discharge curves for the rapids at the respective sites with a summary of the reduction in wetted perimeter resulting from the 2m3/s riparian release presented in Table[x-11].

At IFR Site S1, for a rapid habitat, a mean minimum discharge of 25.4 m3/s at the Nakai Dam site during the dry season would create a wetted perimeter of 29.4 m. The riparian release of $2m^3/s$ flowing through the same rapid would give a wetted perimeter of only 7.9 m, which corresponds to a 21.5 m or 73% decrease in the length of river bed that is covered in water. For a pool habitat, the mean minimum dry season discharge would result in a wetted perimeter of approximately 108.8m. The riparian release of 2m3/s would create a wetted perimeter of 101.1m in the same pool, which is an impact of only 6.8%.

The severity of impact on the wetted perimeter generally diminishes with distance downstream of the Nakai Dam. For example, the impact on the wetted perimeter in rapid habitat of IFR sites S2, S3 and S4 is 54%, 56% and 6.9% respectively.

The impact of the riparian release on the wetted perimeter of the pools is significantly less than the impact in the rapids.

Impacts of the riparian release on other hydraulic parameters in the Nam Theun/Nam Kading are presented in Table [8]. In the reach of the Nam Theun, between the Nakai Dam and the Nam Phao confluence, flow will be significantly reduced, by 90%, and as a consequence of the water depth in the rapids will be reduced by 60% and the flow area by 85% while in the pools the water depth is only reduced by 21%. The flow velocity will be reduced by 97%. Flow velocities in the pools are important since they are the key elements for the survival of aquatic species. Downstream of the TH Dam the impact of NT2 Project on the dry season flows are insignificant, as the average minimum dry season flows will be maintained by the TH releases.

5.3. RIVER MORPHOLOGY

For the riparian release scenario the flow velocities in rapids are greater than 0.3m/s in all reaches of Nam Theun and Nam Kading, this means that biofilm development may not take place because the mobilization of sediments will provide sufficient scouring. However, in some pools the flow velocities are below the threshold velocities of 0.3m/s required to mobilize fine sediment and there will be a potential for biofilm development during the dry season. Wet season spills with flows greater than 450m3/s should mobilise the biofilms from the pool section.

Reservoir operation modeling indicates that flood flows below Nakai Dam will be severely reduced. Table [9] shows the comparison of the maximum floods for present and the future condition. The flood peak between Nakai Dam and the Nam Phao confluence would be reduced by 50%. In terms of occurrence 1-year Average Recurrence Interval (ARI) flood will be virtually lost from the system between Nakai Dam and the TH headpond (Table [10]). The loss of this important flood event will cause channel morphological changes in terms of reduction in flow area and wetted perimeter, which are important features for the aquatic habitat integrity.

Colloidal Sediment Deposition

This is the only component of the total sediment load that will pass through the Nakai Dam and hence the colloidal load will increase proportionally in the reach between the Nakai Dam and the Nam Phao. If clay deposits become consolidated, then high velocities are required to remobilise these. The deposits may influence nutrient dynamics and turbidity in pools

Sand Deposition

Critical velocities for the motion of coarse and fine sand are 0.8 m/s and 0.3 m/s, respectively. Directly downstream of the Nakai Dam, sand deposits will become reduced with time. Sand deposits are breeding habitats for some aquatic species.

Gravel/cobbles/boulders Deposition

The coarser bed materials are transported at much higher velocities than sands. Decreased velocities will lead to increased infilling of interstitial spaces and when the larger elements are not displaced occasionally, then the bed could become solidified. The interstitial spaces in between coarse bed materials are an important habitat zone. However, during a spill event sufficient volume will be discharged into the Nam Theun to generate flow velocities greater than 2m/s and then mobilise the accumulated material, avoiding the solidification of the river bed. During periods when Nakai Dam does not spill it may be necessary to release flows to mobilise these sorts of materials.

Below Nam Phao confluence the impact to the movement of gravel/cobbles and boulders will be minimal.

5.4. WATER QUALITY

Water quality modeling will be carried out to provide a detail assessment of the evolution of key parameters and the subsequent impacts that may result. Based on the hydrological impacts the relationship between these key water quality parameters and specific features are described below. The focus of these descriptions is for dry season flows, when water quality in rapids and pools will be directly influenced by a number of biological, physical and chemical factors. These relationships will determine the suitability and sustainability of some waterbodies for fish survival.

5.4.1. Rapids

The quality of water in rapids during the dry season will relate to flow rate and turbulence. Turbulent conditions tend to replenish the concentration of oxygen. The available turbulent flow of rapids will be reduced markedly under riparian release conditions. The profile of typical rapids directly below the proposed dam will be a depth of less than 0.8 m and an available flow area of just over 6 m2. At a velocity of approximately 0.33 m/s, water will continue to flow over the rapids. The general impacts on key water quality in areas of rapids are as follows: (i) with a larger surface to volume ratio the water temperature will be influence more by the ambient temperature. Below the Nam Phao confluence, water temperature will be more influenced by tributaries and may increase due to the reduced depth of rapids; (ii) conductivity above the Nam Phao confluence will not change markedly with reduced flows. Conductivity measures below the Nam Phao may be expected to rise, as the Nam Theun will no longer provide a level of dilution; (iii) pH will remain similar above the confluence, but may be influenced by inputs from the Nam Phao in lower reaches; (iv) dissolved oxygen will remain high in areas of turbulent water movement.

5.4.2. Pools

In the area immediately downstream of the Nakai Dam, the flow area of pools will not reduce significantly, but flow velocity will reduce to 3%. Based on this reduced flow the general water quality parameters in pools will be as follows: (i) water temperature will be more influenced by ambient temperatures; (ii) periodic flooding events will reduce pool temperatures; (iii) conductivity in pools below the Nam Phao confluence will be directly influenced by inputs from tributaries and higher than current values; (iv) pH in pools will fluctuate according to biological conditions; and (v) dissolved oxygen pools below the Nam Phao confluence could be expected to remain higher than for pools above the confluence.

Plant and animal material deposited in pools will likely remain for longer periods under reduced flow conditions, so bacterial decomposition of any organic material will tend to deplete dissolved oxygen. With decreased availability of dissolved oxygen, the composition of biological resources in the pools will vary considerably and may not be conducive to supporting larger macroinvertebrate or vertebrate species.

Production of biofilms in pools located above the Nam Phao confluence will increase as the velocity decreases. In slow-flowing conditions, phytoplankton densities may increase, causing fluctuation in water quality that reflects the diurnal patterns in photosynthesis.

5.4.3. Supersaturation

Spill waters exiting Nakai Dam may produce supersaturated conditions during periods of high flow. However, the scale of impacts from these conditions should not be detrimental to downstream fish populations and will be rapidly assimilated into downstream waters. Spills will be received into a relatively shallow spill-pool, reducing the likelihood of creating concentrations of supersaturated waters lethal to fish species.

5.5. TERRESTRIAL

Vegetation

The exposure of river banks under the reduced flow conditions will cause encroachment of terrestrial vegetation onto suitable substrates. The exposed river banks will be suitable for

colonization by fast growing species such as gasses. However, the suitability of bank substrates for vegetation colonisation is variable. Analysis of photographs between the Nakai Dam and the Nam Phao confluence indicates only limited areas where significant transgression of vegetation towards the limits of dry season flow could be expected (KBR 2004). This section of the Nam Theun includes large areas boulders and it is unlikely that these substrates would contain sufficient deposits of topsoil to support significant vegetation growth.

Downstream of the Nam Phao confluence to the TH headpond, the frequency of boulder and rock adjacent to the river is less. Reduction in river height in these areas may result in significant transgression of fast-growing species such as grasses and woody shrubs.

Stripping of vegetation between the dam site and TH headpond is likely to occur only intermittently with the periodic spill events.

Below the TH dam site, contributions from the Nam Phao, Nam Gnouang and Nam Mouan will influence the distribution of vegetation and few changes in the species composition and distribution of plant communities is likely to result from riparian releases.

Wildlife

Riparian flows should maintain existing terrestrial wildlife corridors and habitats in the Nam Theun valley. Current sources of drinking water, shelter, breeding sites, foraging and connectivity above the current high water level are not likely to be compromised with the reduced flow rate.

Riparian flows should not impact on the quality of habitat available for most of the terrestrial species recorded in the area. Expansion of vegetation onto exposed river banks may provide additional habitat resources for some wildlife groups. Species that currently exploit resources within forest will not be significantly impacted. Species that utilise arboreal, cryptic or ground-dwelling habitats are unlikely to be negatively impacted as their existing habitat is above current high water level.

The distribution of amphibians and other semi-aquatic species that rely upon fast-flowing water may be impacted between the Nakai dam before the Nam Phao confluence. The reduced flow area and velocity will likely influence the availability of breeding habitats and feeding resources for species reliant on fast flowing waters.

The presence of the endangered Big-headed Turtle species (Platysternon megacephalum) recorded downstream of the TH dam is important. This species is known to inhabit fast-flowing areas and is listed under IUCN and CITES conventions. The presence and extent of this species in the Nam Theun will be further investigated as part of the monitoring programs outlined below.

Community use of vegetation and wildlife

With the exception of the big headed turtle, all species identified by communities as being hunted for consumption can be found both within and outside the Nam Theun river valley. Given the known habits of species considered important by the local communities, the ecological requirements of most of these species should continue to be met by under the riparian release conditions. As a result, no significant social implications on riparian resource use should result from the riparian release.

5.6. FISHERIES

The broad implications is that reduced flows arising from the riparian release will modify the hydraulic and physico-chemical conditions in the mainstream Nam Theun, especially in reaches between the Nakai Dam and the Nam Phao confluence. Subsequent reduction in the flow will reduce the carrying capacity of the river, both in terms of fish diversity and abundance. The outputs from the wetted perimeter analysis will be used later in this section to determine the impact on the fisheries. This will have corresponding impacts on current fishing practices and

levels of fish production, and subsequently on socio-economic conditions in the Nam Theun and tributaries. The limited available information on the biological requirements and migratory behavior of fish species, together with the numerous seasonal fluctuations in variables that control fish productivity, make it difficult to assess the precise impact on the fisheries.

Biodiversity and abundance
Reduced flow during migration periods will place pressure on those species identified earlier in the section that demonstrate existing vulnerability to low flow conditions.

Modified water quality may be expected to modify spawning success in those species that spawn in the mainstream. Similarly the reduced depth and morphological changes will reduce access to spawning habitat among those species utilizing riparian vegetation. The area of spawning habitat will also be reduced. Although for those fish using vegetation as a spawning substrate, macrophyte stands that are initially stranded after dam closure should develop further down the bank to retain some heterogeneity of habitat. It is assumed spawning and recruitment in the tributaries will remain largely unchanged, albeit with a reduced spawning stock.

The reduced pool depth and water quality conditions may influence the availability of dry season refuge habitats, and correspondingly the carrying capacity of these areas will be impacted. The reduced water level will expose many of these refuges, limiting the complexity of habitat features above the Nam Phao.

It is likely that the abundance of exotic species (Common carp and Tilapia) will increase following the closure of the Nakai dam due to their capacity to adapt to a much wider range of conditions. This may put further pressure on the specialized indigenous fish species.

It is clear that following the construction of the TH dam the impounded stock have continued to migrate, spawn and sustain population in a significantly reduced environment. It is therefore expected that tributaries will continue to function although the overall stock will be reduced. The extent to which this impoundment will affect the gene pool is unknown. However, it is likely that susceptibility to disease will increase. Long distance migrant fish species that refuge in the Nam Theun during the dry season will be impacted by the Project. Those resident fish species of the tributaries that only undertake short distance migration will remain unaffected and may benefit from the reduced competition for resources by a decline in long distant migrants. A detailed discussion on the potential impacts on important migratory fish species in the Nam Theun is presented in Annex K.

Impacts on fish abundance will be most severe in the Nam Theun reach between the Nakai Dam and the confluence with the Nam Phao. Downstream of the Nam Phao confluence catchment inputs, including the Nam Phao itself, that are unaffected by the Nakai dam will help buffer the severity of any impacts.

Overall fish productivity will be reduced due to the significant reduction in the carrying capacity of the reduced discharge. However, unlike the Xe Bang Fai, the change in hydrology is not expected to result in the partial collapse of the food chain. Reductions in populations of species that are able to tolerate the modified hydrology may be buffered by any increases in productivity per unit area of periphyton, macrophytes and invertebrates that is promoted by an increase in water transparency and a reduction water depth.

Downstream of the TH Dam site, it is assumed that stream biota have adapted to a certain flow regime and can survive the current periods of low flow. Therefore in terms of biota, the status quo is likely to be retained if the minimum flow does not fall below the current average low flow. Because the mean minimum low flow is maintained below the TH dam no impacts significant on biota is anticipated.

5.7. SOCIO- ECONOMIC ANALYSIS

The environmental impacts of the Project proposed riparian release of 2m3/s on the Nam Theun will have several negative impacts on the communities located downstream of the Nakai Dam. These impacts can be summarized as loss of production of (i) fisheries; and (ii) aquatic products.

In order to evaluate the socio-economic impacts of the Project the villages have been divided into zones based on the level of use on the Nam Theun mainstream and therefore severity of impact on the communities.

Fisheries

The Nam Theun mainstream is generally not an exclusive source of fisheries production, indeed the Nam Theun ranked only seventh in terms of importance. Therefore the severity of the impact on the Nam Theun mainstream will be buffered by the community's preferential use of tributaries and other water bodies.

Impact on fisheries by river

The following section outlines 'ballpark" estimates for the maximum potential impact of the Project on annual fish yields and the value of any losses. The current fish catch data is sourced from the consultation based fisheries surveys of LARReC (2004) and Schouten et al. (2004). A market value of USD 0.8 per kg was adopted to calculate the value of the catch in monetary terms. Tables [x-12] and [x-13] provide a summary of the estimated impact by the Project by village zone and the subsequent value of the losses. The prediction of the impacts and the subsequent estimation of losses in fish yield can only be indicative at this stage. Only after dam closure when the impacts occur can the monitoring obtain a more accurate value.

Nam Theun mainstream

The productivity of the fish species taking dry season refuge in the mainstream Nam Theun will be impacted by the reduction in dry season flow. Assuming that productivity is related to the amount of river bed that is inundated, productivity of the Nam Theun fishery may decrease by the same order of magnitude that the wetted perimeter is reduced. Based on the wetted perimeter analysis, the reduction in amount of wetted river bed in the mainstream Nam Theun, and therefore the reduction in the area for primary and secondary production, at sites IFR S1 to S3 is 73%, 54% and 56% respectively. This gives a mean impact of approximately 60% of the mainstream Nam Theun between the Nakai Dam and the TH Headpond. A 60% impact in the Nam Theun mainstream fisheries equates to a decline in fish catch of 62,901 kg/yr or USD 50,321. The decline in fish catch will be experienced most by villages in the Lower Nam Phao zone.

TH Headpond

After inundation by the TH Project the number of fish species in the TH headpond declined but the annual fish yields increased, indicating an increase in fish productivity. The proliferation of one species (*Cyprinus carpio*) more than compensated for the loss of productivity in the other fish species. The NT2 Project will have relatively little effect on the hydrology of this already lacustrine environment and therefore no impact on the productivity of those fish already adapted to the new conditions is perceived.

Nam Phao and tributaries

Non migratory and short distance migrant fish species that are residents of Nam Phao and its tributaries will not be affected by the Project. Only those species that refuge in the mainstream Nam Theun during the dry season then move into the Nam Phao in wet season will be impacted. Based on the assumption that approximately 60% of the fish species in the Nam Phao and its tributaries catch are long distance migratory fish, and the impact on those migratory species in the Nam Theun mainstream is 60%, the overall impact on fish catches could be up to 35%. The scale of impact on the Nam Phao is less than that on the mainstream Nam Theun but because of the greater use of the Nam Phao the value of the loss in higher. A 35% impact in the Nam Phao fisheries equates to a decline in fish catch of 83,908 kg/yr at a value of USD 67,126. The decline in fish catch will be experienced most by villages in the

Lower Nam Phao zone, as well as the Nam Kata, Nam Phouang/Phiat and Upper Nam Phao zones.

The impacts on fish catch in the Nam Phao could be potentially buffered by migratory individuals in the Nam Theun being attracted into the Nam Phao during wet season by the relatively larger discharge in the Nam Phao compared to that in the Nam Theun above the Nam Phao confluence.

Nam Gnouang

Fish catches in the Nam Gnouang are already impacted by the presence of the TH dam which impedes the upstream migration of fish from the Nam Kading and Mekong. Although there is anecdotal evidence to suggest that some fish species can still navigate across the TH dam during the peak of the wet season, the TH Project has still resulted in a 40% decline in household fish catch in villages along the Nam Gnouang (Schouten et al. 2004). This decline is probably attributed to the inability of the majority of long distance migratory fish species to pass the TH dam or the timing of their migration not being compatible with TH spills. Therefore majority of the fish catches in the Nam Gnouang probably consist of non-migratory or short distance migratory fish species. The NT2 Project will have no impact on this proportion of the fish catch, however, because the NT2 Project will cause an average reduction in the numbers of days that the TH dam will spill, from 245 days to 190 days per year, the NT Project will have an additional impact on any long distance migratory fish species that currently manage to pass upstream of the TH dam. If we assume that 30% of the catch consists of long distant migrant species and the reduction in the number of spilling days is a conservative 30%, an estimated maximum potential impact of 10%, a 30% impact on 30% of the catch, has been attributed to the overall catch in the Nam Gnouang. A 10% impact in the Nam Gnouang fisheries equates to a decline in fish catch of 14,813 kg/yr at a value of USD 11,850. The decline in fish catch will be experienced mainly by villages in the Nam Gnouang zone.

Nam Ngoy

Similarly to the Nam Gnouang, fish cathes in the Nam Gnouang are already impacted by the physical presence of the TH dam, as well as, the TH Headpond. Whether the fish species that manage to negotiate the TH dam are attracted solely to the Nam Gnouang or continue to migrate upstream through the lacustrine TH Headpond and into the Nam Ngoy remains to be studied. Either way, the majority of fish catches in the Nam Ngoy are probably made up of short distance migrants from the TH headpond or non-migratory resident fish species. The NT2 Project will have no impact on this portion of the catch. Therefore an estimated maximum potential impact of 10% has been attributed to the overall catch. A 10% impact in the Nam Ngoy fisheries equates to a decline in fish catch of 2,331 kg/yr at a value of USD 1,865. The decline in fish catch will only be experienced by villages in the Nam Ngoy zone.

Pond and Rice Paddies

No villages source their domestic water from the mainstream Nam Theun. The Project will therefore have no impact on the limited aquaculture already established in the area.

Given the steep terrain directly adjacent to the Nam Theun mainstream, between the Nakai Dam and Nam Phao confluence, the Project will have no hydraulic related impacts on naturally stock ponds or rice field fish populations in this reach. There no evidence of ponds or rice paddies along this stretch of river.

The Project will have an impact on seasonal, naturally stocked ponds and rice fields adjacent to the Nam Theun tributaries that rely on long distance migrating fish species to enter these areas for feeding, spawning and nursery habitats. Given that the species in the mainstream and tributaries will move into these flooded areas, the assemblages in the naturally stocked ponds and rice fields may be similar. The severity of impact should reflect the impact on the tributaries adjacent to the ponds. The estimated impact on the ponds and rice field fisheries equates to a decline in fish catch of 9,043 kg/yr at a value of USD 7,235.

Unfortunately the LARReC (2004) survey did not distinguish between aquaculture ponds and seasonal, naturally stocked fish ponds/rice fields therefore allocating a precise value to the loss is difficult.

Summary of Loss of Fisheries

Over the entire study area above the TH dam the estimated impact will result in a decline in fish catch of 173,971 kg/yr which equates to USD 139,177. In terms of net present value the loss is approximately USD 1.17 million over the 25 years of operation of the Project.

Impacts on upstream NT

The following text is to be inserted under section 5.7, impacts on fisheries by river.

Nam Theun and tributaries upstream of the Nakai Dam (NNT NPA)

Fish catches in the NNT NPA are already impacted by the presence of the TH dam which impedes the upstream migration of long distance migrant fishes from the Nam Kading and Mekong. The majority of the fish catches in the NNT NPA will therefore probably consist of medium distance migrant species that adopt dry season refuge in the Nam Theun mainstream and non-migratory/short distance migratory fish species that are residents of the NNT NPA. The non-migratory/short distance migrant fish species will be unaffected by the Project. Only those species that refuge in the mainstream Nam Theun during the dry season then move into the NNT NPA during wet season will be affected by the physical presence of the Nakai dam and the conversion of the riverine environment to a lacustrine.

Based on the assumption that approximately 40% of the current fish catch in the NNT NPA consists of either long or medium distance migratory fish, and the impact on those migratory species is 80% due to the combination of the physical presence of the Nakai Dam and the conversion of a riverine to a lacustrine habitat, the overall impact on fish catches could be up to 35%. A similar severity of impact was observed in the Nam Gnouang after the closure of the TH dam (Schouten et al. 2004). However, as observed in Nam Ngum, many fish species that will adapt to the new lacustrine conditions will still continue to undertake migrations up the tributaries during spawning periods. Increases in the population of these fish species should buffer any impacts on the fish catch in the NNT NPA. Therefore an overall impact of 15% has been estimated. A list of fish species and their known or guessed adaptability to reservoir conditions is presented in Chapter 3.

Fish catch data for the villages within the NNT NPA is currently not available. Therefore the estimated value of the fish loss in the NNT NPA is based on the 2001 NPA population data (SEMFOP 2004) and a mean of the mean annual household fish catches for the Nam Theun tributaries of Nam Phao, Nam Phouang/Nam Phiat and Nam Kata (LARReC 2004). Based on a household population of 1,092 and a mean annual fish catch of approximately 72 kg/HH/yr, the value of the annual loss in the NNT NPA fisheries for a 15% impact is USD 9,400 or USD 79,000 in terms of Net Present Value.

To help mitigate any negative impacts on the fish catches in the NNT NPA a fish rescue programme will be implemented to collect those individuals blocked by the Nakai Dam and transport them to tributary confluences of the Nakai Reservoir to allow them to complete the remainder of their migration. The fisheries resource management component of the SEMFOP will also help to lessen the magnitude of the impact.

The collection of aquatic products within the NNT NPA will not be affected by the Project.

Aquatic Products

The Project will not have any impact on the aquatic products population in the TH headpond or in the tributaries of the Nam Theun. There will, however, be an impact on those populations inhabiting the Nam Theun mainstream between the Nakai Dam and the TH Headpond. The riparian release will cause a reduction in the wetted perimeter and therefore a decline in the area for primary and secondary production. Based on the wetted perimeter analysis an impact on productivity of 60% has been allocated.

The impact on productivity may be buffered by any increases in primary production in those areas still submerged. Primary production per unit area may increase due to a decrease in water velocity, a decrease in water depth and an increase in water transparency. These factors will favor photosynthesis and result in a proliferation of periphyton and macrophytes. This may buffer the negative impact on overall productivity of aquatic products.

Aquatic product collection in the Nam Theun mainstream is negligible. Only a few villages indicate use of the mainstream as a source of aquatic products. Villagers tend to collect aquatic products from local tributaries or ponds. Given that community use is so low the reduced populations of aquatic products may still be sufficient to provide a sustainable resource. Table [x-14] provides a summary of the estimated impact by the Project on aquatic product catch in the mainstream Nam Theun. The aquatic product catch data is based on the consultation based fisheries surveys of LARReC (2004) and a market value of USD 0.3 per kg was assumed for calculating the value of the catch. A 60% impact in the Nam Theun equates to a decline in aquatic product collection of only 588 kg/yr at a value of USD 407. In net present value terms this equates to only USD 4,000.

Note that no aquatic products catch data was available for the villages located long the Nam Gnouang. It is assumed that their aquatic products are obtained either from the Nam Gnouang or TH Headpond and therefore unaffected by the Project

Others Uses

Because communities indicated no "other uses" of the mainstream Nam Theun above the TH Headpond it is not expected to be any impacts to (i) riverside assets including riverbank gardens; (ii) domestic water use; (iii) irrigation systems; and (iv) navigation. Therefore the socio-economic analysis is limited assessing the value of the loss to the fishery and aquatic products, no value of loss has been attributed to "other uses" of the Nam Theun mainstream.

Value of the Riverine Ecosystem

At commencement of the riparian releases, the project will result in an impact on the aquatic ecosystems in the reach of the Nam Theun between the Nakai Dam and the TH Hinboun headpond. This ecosystem includes the habitats of at least one endangered species, the big-headed turtle.

Given this lack of quantified data in this area, the most plausible approach for assessing the magnitude of the impact on these aquatic habitats is to estimate values for the entire ecosystems, rather than the specific species, by imputing a value in relation to terrestrial habitats.

Accordingly, it is assumed that one kilometer of river is equal, in conservation terms, to 50 hectares of terrestrial habitat (Louis Berger, 1997). The length of the river affected, between Nakai Dam and TH headpond, is 40 km. Using the same values as estimated on the Economic Impact Study of Nam Theun 2 Project (Louis Berger, 1997) of USD 75-125 per terrestrial hectare per year the Project would result in an estimated USD 150,000 – 250,000 per year of the loss for biodiversity, pharmaceutical and eco-tourism potential of these aquatic ecosystems. This is equivalent to a net present value in 2004 of USD 1.26 to 2.11 million.

Vulnerable Groups

If certain species of fish were exclusively consumed by a particular vulnerable group, such as pregnant mothers or children, then any impacts on those species would result in a disproportionately larger impact on those vulnerable groups. This would be important if the

fish species were consumed for special dietary requirements, such as nutrients during child development. The LARReC (2004) survey found that vulnerable groups had no preferences for certain types of fish therefore no disproportionate impact is expected on those vulnerable groups.

Other non-Project Impacts

In addition to those impacts caused by the Project several other factors will influence the productivity of the fisheries, these factors have been identified by villagers as resulting in an ongoing decline in fish catch that is independent of any Project activities. These non-Project impacts include (i) proliferation of non-indigenous fish species that are probably escapees from aquaculture; (ii) population increase resulting in increased fishing pressure; and (iii) increased use of more efficient fishing methods.

Trade-off

The potential socio-economic cost of the riparian release of 2 m3/s has been estimated as USD 1.17 million for the fisheries/aquatic products and USD 1.26 to 2.11 million for the aquatic ecosystem in net present value terms. The overall cost of the 2 m3/s riparian release is in the range of USD 2.43-3.28 million. Of these costs, the potential impacts to the aquatic ecosystem could be greater than the impacts to local communities in comparison to overall costs.

To determine the most appropriate riparian release a tradeoff analysis to estimate the potential financial costs and the ecological/social benefits of different riparian flow regimes was conducted. Based on the wetted perimeter analysis, the point of inflection of the wetted perimeter-discharge curve could be either 5 or 8 m3/s. The point of inflection on the wetted perimeter curve represents the maximum habitat for the minimum flow. A riparian release of 8 m3/s would be sufficient to meet the minimum wetted perimeter for sites above the Nam Phao confluence.

These additional riparian release discharges are still less then the current mean dry season flow so will themselves have an impact. Table [x-15] presents the wetted perimeter analysis and estimated magnitude of impact for the riparian release regimes of 5 m3/s and 8 m3/s.

The impact on the wetted perimeter, and the perceived impact on fish productivity, decreases with increasing discharge. For example, a riparian release of 5m3/s and 8 m3/s will have impacts of 62% and 27% respectively at IFR Site S1 which compares an impact of 73% resulting from the riparian release of 2m3/s. Limiting the overall reduction in the wetted perimeter will mean larger areas for productivity of the fisheries will remain. A summary of the estimated potential impact on fish productivity is shown in Table [x-16]. Similar assumptions as those for the 2m3/s were used to generate these estimates.

The improvements in fisheries productivity by increasing the riparian release are limited to only the fisheries in the mainstream Nam Theun and Nam Phao. Productivity for long distance migratory fish species that refuge in the Nam Theun will improve as wetted perimeter is increased. No significant improvements in the impact on the Nam Gnouang and Nam Ngoy fisheries are expected by increasing the riparian release. These fisheries are impacted mainly by a reduction in the volume and number of days the TH dam is spilling. Small volumetric increases in the riparian release cause little improvement relative to the total volume of the spill.

Table [x-17] presents the value of the losses in the fishery and aquatic products for the riparian release of 5 and 8 m3/s. The estimated value of the losses in the fisheries for the riparian releases of 5 and 8 m3/s, net presents value terms of USD 1.0 and USD 0.69 million respectively, are less than the value of the loss with the 2m3/s riparian release. The estimated value of the losses in the aquatic products for the same riparian release scenarios is approximately NPV USD 3,300 and 2,000.

At this stage it is too difficult to allocate the improvement to the aquatic ecosystem that is gained by increasing the riparian release. Therefore for the trade-off the value of the loss remains constant for all scenarios.

Increasing the riparian release to benefit the fisheries downstream of the Nakai Dam will have a cost in terms of loss of revenue from power production. The loss of revenue for the 5 m3/s and 8 m3/s riparian releases is USD 45 and 72 million respectively. Indeed for any significant reduction in the impact in the fisheries a 8 m3/s riparian release would be required. The financial cost of a 8m3/s riparian release is USD 72 million but the improvement in the fisheries only equates to approximately USD 0.5 million. The loss of revenue, a proportion of which will go directly into development programmes in the country, by far exceeds the ecological and social gains by providing the additional riparian release.

6. MITIGATION

6.1. MITIGATION AGAINST POOR WATER QUALITY

Like the Xe Bang Fai, the overall objectives of mitigation for water quality are to (i) maintain the current beneficial uses of water in the Nam Theun; and (ii) avoid or minimize any water quality impacts on the fisheries. It should be noted that, apart from fisheries, beneficial uses (irrigation, domestic water supply, etc.) has been indicated as minimal along the Nam Theun mainstream (LARReC 2004) with no permanent settlements existing between the Nakai Dam Site and the TH Headpond.

Biomass Reduction

In order to reduce the amount of biomass decomposition and therefore the extent of anoxic conditions that may develop in the reservoir in the initial years after inundation of the reservoir, the Project will encourage the removal of biomass through salvage logging and promotion of firewood collection and/or charcoal production by villagers.

Engineering Works

Multilevel Intake

The intake at the Nakai Dam site will help reduce the downstream impacts of any anoxic conditions that may develop in the Nakai Reservoir. The design of the intake will be such that water can be sourced from a specific depth in the Nakai Reservoir. The multilevel intake will source water for the downstream Nam Theun from only the good quality surface (epilimnion) water and not the potentially oxygen poor bottom (hypolimnion) water.

Cone Valve

At the Nakai Dam, the riparian release will be discharged through an aerating structure, a cone valve, into the stilling basin. It is anticipated that the cone valve can increase dissolved oxygen levels in the discharged water by up to 5 mg/l.

Detailed drawings of the structures associated with riparian release are presented in Annex D.

6.2. MITIGATION AGAINST SEDIMENTATION

To mitigate against any impacts associated with construction site erosion, the HC will prepare and implement an erosion and sedimentation plan for the various engineering works associated with the Nakai Dam. Mitigation measures will include drainage works, sediment traps and other structures designed to treat water to an acceptable quality before discharging into the Nam Theun. The HC will minimize working during the wet season to further minimize any erosion. Details of the requirement of this plan is presented in Annex L.

6.3. MITIGATION AGAINST INJURY FROM FLASH FLOODS

The Nakai Dam will be fitted with a siren that will be operated before any opening of the dam gates to warn people in the Nam Theun below of the impending increase in water depth and velocity.

6.4. MORPHOLOGY

A number of physical interventions to channel morphology may be suitable for improving the wetted area of rapids and the flow in deep pools. These interventions include (i) setting channel dimensions to simulate natural conditions, albeit on a smaller scale; (ii) increasing the complexity of pool shorelines to provide habitat protection zones for fry and small fish; (iii) reinstating meanders to trap transported sediments and avoid scouring of biofilm; (iv) re-establishing pool-riffle morphology, modify the downstream edge of low velocity pools to increase outflows; (v) in long, deep pools current deflector may be appropriate to increase hydraulic diversity to improve the habitat complexity and to develop erosion areas; (vi) increase the habitat complexity for fish; including selectively placing large boulders in pools, fish shelters to protect fry and smaller fish and large logs or other woody debris could be placed strategically.

The implementation of specific channel morphological techniques will require (i) a more accurate topographical study of the river profile; and (ii) a detailed assessment of important fish migration and spawning zones in the Nam Theun. However, the impacts of periodic flooding events are expected to significantly alter any channel morphological techniques that are implemented.

6.5. ADAPTIVE MANAGEMENT

Because there is some degree of uncertainty in the assessment of the impacts, adaptive management of the 2 m3/s riparian release and complementary 5 MCM will be adopted. The adaptive management of the riparian release will have the flexibility to respond to monitoring and evaluation of the environmental performance of the release regime. This will be an iterative process, repeated as long as it takes until the system stabilizes.

The adaptive management will cover two main periods of time, construction (including dam construction and impoundment) and operation. It will typically involve the following steps: (i) proactive experimentation, (ii) monitoring, (iii) reevaluation and experimental design, (iv) decision making involving multiple stakeholders.

The proactive experimentation will test the impact of different flow regimes on the downstream areas, within the operational limits of the riparian release and the modification of the morphology of the river. The monitoring will focus on water quality, flow and fisheries and this will be used to help optimize and test flow regimes. The monitoring data and modeling of the habitat, water quality, hydrology and potentially ecosystems of this area will be used to test and refine flow and habitat management approaches. An "environmental flow committee" including the EMO, the WMPA and local village resettlement committees representatives will make decisions on management objectives and approaches to flow management based on analysis and modeling provided by NTPC.

7. COMPENSATION

The current under development of aquaculture in the communities highlights a significant opportunity to develop and expand aquaculture activities as part of a compensation strategy.
The compensation entitlements of the project affected persons and the process of compensation are presented in detail in the SDP.

8. COMMUNITY CONSULTATION

A disclosure and consultation program will be implemented in all the potentially affected villages with the objectives to (i) obtain more quantitative socio-economic data; (ii) conduct an awareness program in advance of dam closure to prepare communities for the potential impacts; (iii) elicit potential affected persons concerns; and identify further mitigation measures.

Similar methodologies to those used for the consultation process in communities along the Xe Bang Fai will be adopted, details of which are presented in the SDP.

9. MONITORING

Adaptive management will determine how the total volume release should be managed to maintain the predetermined, valued use objectives for the ecosystem. Predetermined use objectives, reflective of the intended ecosystem condition, will be used to measure and assess the effectiveness of the riparian release regime. With the outputs of this monitoring, the management strategy of the release can revised, while maintaining the same total volume of water. A monitoring and evaluation approach will be the driving force for optimizing the riparian release regime within the same total of water. The following monitoring programmes have been identified in the CA.

The WQMAP will include sampling stations on the Nam Theun to monitor the evolution of water quality released from the Nakai Dam site. Sufficient monitoring will be conducted prior to the closure of the dam to obtain adequate baseline. The water quality monitoring shall continue during the first five years of operations to determine whether the potential effects of increased retention time in the pools are disturbing or adversely affecting aquatic life and wildlife population. An indication of parameters, sampling frequency and locations of the WQMAP is presented in Chapter 3.

A monitoring program will be developed to enable NTPC to determine the ecosystem values and components of the Nam Theun downstream of the Nakai Dam. To enhance biodiversity and productivity, further studies shall be undertaken as part of the adaptive management process; such as a seasonal study of hydrology and aquatic tropic dynamic.

As part of the adaptive management process, the monitoring programme shall be such to enable NTPC to determine productivity in fish populations downstream of the Nakai Dam during the first five years of operations.

The GOL and NTPC shall review the results of the studies. If necessary, based upon the results from the water quality and productivity/diversity monitoring recommendations on the management of the riparian and complementary releases will be made.

Figure X-1: Villages of Khamkeut District, village zones and LARReC survey participants

[Revised study area map showing updated Khamkeut villages and village zones]

Table x-1: Population data for Khamkeut District by village zone

No	Village	No of HH	No. of persons
Lower Nam Phao			
4	Senesoudom	150	872
5	Sengsavang	120	765
6	Namphuao	178	996
7	Nongdong	174	988
8	Somsanouk	168	1,085
10	Nongpong	409	2,420
47	Phonethong	97	576
24	Phonexay + Naphet	72	436
25	Namthi	143	1,015
	Total	**1,511**	**9,153**
Upper Nam Phao			
1	Lak 20	126	718
2	Phonemuangnoy	167	1,270
3	Phonehuong	188	1,174
9	Houaykeo	252	1,395
11	Phonepheng	248	1,490
12	Thongchalueng	226	1,490
13	Thaveng + Ban Phonesay	144	725
14	Samtheu	82	536
15	Nachalai	79	511
33	Nong Or	98	724
34	Napai	154	1,164
35	NaHat	71	465
36	Lak 5	95	632
37	Lak 7	143	761
38	Lak 10	112	788
39	Thongpet	243	1,886
40	Naheuang	183	1,010
41	Hangna	67	396
	Total	**2,678**	**17,135**
Nam Phouang/Nam Phiat			
42	Khammouane	107	656
43	Dongbang	167	874
44	Donesaat	49	306
45	Nadeua	95	506
46	Houaikeo	141	787
48	Sopphouan	45	254
	Total	**604**	**3,383**
Nam Kata			
17	Kor Hai	148	1,264

18	Phonesi	67	433
19	Phonevilai	133	1,044
20	Sophia + Nam Nian	77	455
21	Phonesaat	172	1,207
22	Vangpha	98	636
23	Nam Deuan	155	1,006
26	Nongmek	84	483
27	Thongket	127	835
28	Namuang	104	664
29	Nahai	96	637
30	Vangkor	67	442
31	Nagadonk + Ban Namhouai	99	653
32	Nathone + Banpoungkieut	102	826
	Total	**1,529**	**10,585**
Nam Ngoy			
57	Phonelom	32	171
58	Nakham	83	465
60	Nongsong	102	558
61	Phamuang	98	795
62	Nagnoi + Navaat	77	396
63	Phonegnap	53	302
	Total	**445**	**2,687**
TH Headpond			
54	Nong Kok + Latmuang	161	834
55	Sabgnuang	86	416
56	Thabak	175	1,112
59	Khengbeat	118	633
	Total	**540**	**2,995**
Nam Gnouang			
16	Thongviengkham + Ban Phonekham	138	948
49	Phonetan	120	732
50	Pakha	78	465
51	Khouachanh	125	749
53	Napavane	122	703
64	Sobkoub	164	1,064
65	Sobpon + Haileng	103	628
66	Sod	73	441
67	Phabang	60	367
68	Poug	67	399
69	Thasala	61	376
52	Pong + Ban Bo	69	502
70	Nonesomboun + Ban Don	69	442
	Total	**1,249**	**7,816**
	District Total	**8,556**	**53,754**

Table x-2: Ranked Importance of Waterbodies

Water Body	% importance
Nam Theun - mainstream	5.6
Nam Theun - TH Headpond	13.0
Nam Ao	0.6
Nam Phouane	5.7
Pond/Rice field	8.1
Nam Kata	19.9
Nam Phao	21.0
Nam Thin	4.1
Nam Ngoy	10.7
Huay Ping El	1.7
Nam Gnoung	2.0
Nam Phiat	2.3
Reservoir	1.2
Bought	0.5
No response	3.1

Table x-3: Number of fishers and catch, by waterbody and season, in 21 villages around Nam Theun Downstream

Village	# HH	% of HH fishing	# HH fishing	Season [1]	Water body: Nam Theun - mainstream # fishing HH [2]	Nam Theun - mainstream 1 Catch / HH (kg)	Nam Theun - mainstream Mix (1 and others) [3] Catch / HH (kg)	Nam Theun - mainstream Total Catch / village (kg)	Nam Theun - TH Headpond # fishing HH [2]	Nam Theun - TH Headpond 1 Catch / HH (kg)	Nam Theun - TH Headpond Mix (1 and others) [3] Catch / HH (kg)	Nam Theun - TH Headpond Total Catch / village (kg)	Nam Kading # fishing HH [2]	Nam Kading 2 Catch / HH (kg)	Nam Kading Mix (2 and others) [4] Catch / HH (kg)	Nam Kading Total Catch / village (kg)	Nam Ngoy # fishing HH [2]	Nam Ngoy 4 Catch / HH (kg)	Nam Ngoy 4 Catch / village (kg)	Nam Gnouang # fishing HH [2]	Nam Gnouang 5 Catch / HH (kg)	Nam Gnouang 5 Catch / village (kg)	Nam Mouan # fishing HH [2]	Nam Mouan 6 Catch / HH (kg)	Nam Mouan 6 Catch / village (kg)	Pond and rice field # fishing HH [2]	Pond and rice field 8, 9 Catch / HH (kg)	Pond and rice field 8, 9 Catch / village (kg)	Nam Phao and Tributaries # fishing HH [2]	Nam Phao 3 Catch / HH (kg)	Nam Phao and Tributaries Mouan 6 Catch / HH (kg)	Nam Phao and Tributaries Other 7 Catch / HH (kg)	Nam Phao and Tributaries Phouan 10 Catch / HH (kg)	Nam Phao and Tributaries Thin 11 Catch / HH (kg)	Nam Phao and Tributaries Kata 13 Catch / HH (kg)	Mix (3, 6-13) [5] Catch / HH (kg)	Total 3, 6-7, 10-13 plus mixes among 3, 6-13 Catch / HH (kg)	Total 3, 6-7, 10-13 plus mixes among 3, 6-13 Catch / village (kg)	Total Catch / village (kg)
Lower Nam Phao																																									
Phone Sy	67	12%	8	WS																				2	3	5	7			1				16	17	118	124
				DS																										1				10	10	72	72
Nam Phao [6]	99	45%	45	WS																	9	34	301	9	31	278	27	14		38					52	1,395	1,673
				DS																		32	285		26	232		13		30					43	1,149	1,381
Oudom	152	40%	61	WS	49	201	18	10,633																			61	162		23					185	11,230	21,862
				DS		179	18	9,572																				165		-					165	10,026	19,598
Mean seasonal HH Catch (kg)				**WS**				**33.44**																		**0.95**			**0.89**							**40.07**	**75.35**
				DS				**30.10**																		**0.90**			**0.73**							**35.37**	**67.10**
Mean annual HH catch (kg)				**-**				**63.54**																		**1.84**			**1.62**							**75.44**	**142.44**
Upper Nam Phao																																									
Lak 5	101	50%	51	WS																				23	40	908	51	12		5					17	836	1,743
				DS																					27	618		9		-					9	464	1,081
Lak 7	114	13%	15	WS																				7	30	219	15	24							32	56	835	1,053
				DS																					25	182		20							12	32	474	656
Lak 10 [6]	106	45%	48	WS									7		10	68								7	4	29	48	-		-					5	5	245	343
				DS											14	97												-		-					5	5	245	343
Mean seasonal HH Catch (kg)				**WS**												**0.21**										**3.60**										**5.97**	**9.78**
				DS												**0.30**										**2.49**										**3.69**	**6.48**
Mean annual HH catch (kg)				**-**												**0.52**										**6.09**										**9.65**	**16.26**
Nam Phouang/Nam Phiat																																									
Phonthong [6]	66	45%	30	WS	24	68	3	1,677																			27	202							202	5,399	7,077
				DS		39	12	1,200																				163							163	4,352	5,552
Sop Phouan	45	18%	8	WS																							8			22	9				67	98	783	783
				DS																										20	9				44	72	579	579
Khammouane	105	90%	95	WS																	12	0	2	12	0	3	95				11				93	104	9,804	9,807
				DS																		0	2		1	11					11				31	43	4,028	4,039
Nadeua [6]	90	45%	41	WS	5	5		23									5		4	5	3		15	14	7	96	27			1		7			4	11	307	441
				DS		5		23										1			1		3		6	75				1		12			2	15	394	498
Mean seasonal HH Catch (kg)				**WS**				**5.56**			**0.00**								**0.00**				**0.05**		**0.01**			**0.32**								**53.25**	**59.18**
				DS				**4.00**			**0.00**								**0.01**				**0.01**		**0.01**			**0.28**								**30.57**	**34.87**
Mean annual HH catch (kg)				**-**				**9.55**			**0.00**								**0.01**				**0.06**		**0.01**			**0.60**								**83.81**	**94.05**
Nam Kata																																									
Kor Phay	161	20%	32	WS	19	8	16	468																6	5	32	19			21				4	25	487	987
				DS		-	8	151																						14				6	20	394	545
Vang Pha	92	90%	83	WS																							83			8				45	53	4,370	4,370
				DS																										9				45	54	4,469	4,469
Thong Ker	131	20%	26	WS	7		29	191																			20						45	48	92	1,808	1,999
				DS			18	115																									39	61	100	1,955	2,070
Vang Kor	77	12%	9	WS																				2	1	3	9						3	76	79	715	717
				DS																					0	1							5	64	69	619	620
Mean seasonal HH Catch (kg)				**WS**				**1.43**			**0.00**								**0.00**				**0.00**		**0.00**			**0.08**								**16.01**	**17.51**
				DS				**0.58**			**0.00**								**0.00**				**0.00**		**0.00**			**0.00**								**16.13**	**16.71**
Mean annual HH catch (kg)				**-**				**2.00**			**0.00**								**0.00**				**0.00**		**0.00**			**0.08**								**32.14**	**34.22**
Nam Ngoy																																									
Phonlom	30	50%	15	WS					15	204	3	3,105					15	307	4,599																				7,704
				DS						172	3	2,623						231	3,459																				6,081
Nakham [6]	64	45%	29	WS					23	130		3,004					23	72	1,659																				4,726
				DS						87		2,009						212	4,884	6	11	32	187																7,080
Thong	92	80%	74	WS													11	0	1					74	0	26														27
				DS														0	4						0	5														9
Pha Meuang	99	80%	79	WS													20	8	153					79	16	1,296														1,449
				DS														8	166						15	1,194														1,360
Mean seasonal HH Catch (kg)				**WS**				**0.00**			**21.44**								**22.50**			**0.22**			**0.00**			**4.64**								**0.00**	**48.79**
				DS				**0.00**			**16.25**								**29.87**			**0.65**			**0.00**			**4.21**								**0.00**	**50.98**
Mean annual HH catch (kg)				**-**				**0.00**			**37.69**								**52.37**			**0.87**			**0.00**			**8.85**								**0.00**	**99.77**
TH Headpond																																									
Keng Bid	102	50%	51	WS					45	77	23	4,425												6	0	2	6								-	-	4,427
				DS						78	23	4,464													0	2									-	-	4,466
Nong Kor [6]	72	45%	32	WS					32	42	17	1,907									1	6								4					4	18	1,931
				DS						59	17	2,462								5	5	25					5			4					4	18	2,505
Tha Bac	169	50%	85	WS					85	38	28	5,566									8	79					11			2					2	25	5,671
				DS						43	28	5,978								11	8	79								3					3	28	6,085
Mean seasonal HH Catch (kg)				**WS**							**34.69**											**0.25**				**0.01**										**0.13**	**35.07**
				DS							**37.62**											**0.30**				**0.01**										**0.13**	**38.07**
Mean annual HH catch (kg)				**-**							**72.31**											**0.55**				**0.01**										**0.26**	**73.14**
Nam Gnouang																																									
Sobpone67	45																				132	5,940																5,940
Phabang67	17																				81	1,377																1,377
Mean annual HH catch (kg)				**-**																		**118.02**																**118.02**

Table x-4: Number of aquatic product collectors and catch, by waterbody and season, in 21 villages around Nam Theun Downstream

			Water body																															
			Nam Theun - mainstream				Nam Theun - Headpond				Nam Kading				Nam Gnouang			Tributary								Pond	Rice field		Total 3-4, 6-13 plus mixes among 3-4, 6-13		Grand Total
																		Phao	Ngoy	Mouan	Other	Phouan	Thin	Kata			Mix				
Village	# HH	Season [1]	# HH collecting AA [2]	1 Catch / HH (kg)	Mix (1 and others) [3] Catch / HH (kg)	Total Catch / village (kg)	# HH collecting AA [2]	1 Catch / HH (kg)	and others) [3] Catch / HH (kg)	Total Catch / village (kg)	# HH collecting AA [2]	2 Catch / HH (kg)	Mix (2 and others) [4] Catch / HH (kg)	Total Catch / village (kg)	# HH collecting AA [2]	5 Catch / HH (kg)	Catch / village (kg)	# HH collecting AA [2]	3 Catch / HH (kg)	4 Catch / HH (kg)	6 Catch / HH (kg)	7 Catch / HH (kg)	10 Catch / HH (kg)	11 Catch / HH (kg)	13 Catch / HH (kg)	8 Catch / HH (kg)	9 Catch / HH (kg)	(3-4, 6-13) [5] Catch / HH (kg)	Catch / HH (kg)	Catch / village (kg)	Catch / village (kg)
Lower Nam Phao																																		
Phone Sy	67	WS	-								8		1	7	-			59								2	8	10	20	1,181	1,188
		DS											1	7												1	-	8	9	500	507
Nam Phao [6]	99	WS	-								-				-			99			22						37	4	62	6,178	6,178
		DS																			21						24	-	45	4,475	4,475
Oudom	152	WS	19		1	26					-				19	1	27	38									10		10	371	424
		DS			0	5										1	12										-		-	-	17
Mean Seasonal HH Catch (kg)		WS			0.08																													
		DS			0.01																													
Mean Annual HH Catch (kg)					0.10																													
Upper Nam Phao																																		
Lak 5	101	WS	-								-				-			101								1	5	35	41	4,131	4,131
		DS																								4	-	20	23	2,353	2,353
Lak 7	114	WS	-								-				-			114									16	40	55	6,308	6,308
		DS																									-	8	8	912	912
Lak 10 [6]	106	WS	-								-				-			106								3	103	24	130	13,750	13,750
		DS																								20	10	21	51	5,451	5,451
Nam Phounag/Nam Phiat																																		
Phonthong [6]	66	WS	-								-				-			66	-								18	3	21	1,417	1,417
		DS																	0								1	3	5	332	332
Sop Phouan	45	WS	6		-	-					-				-			39				1				36	9	17	64	2,509	2,509
		DS			1	8																1				35	-	16	52	2,036	2,044
Khammouane	105	WS	-								30		69	2,070	15	18	268	60			3						0	26	29	1,736	4,074
		DS											70	2,096		20	300				3						-	39	41	2,486	4,881
Nadeua [6]	90	WS	-								-				-			90						0		28	9	22	60	5,361	5,361
		DS																						0		16	-	13	29	2,650	2,650
Mean Seasonal HH Catch (kg)		WS			0.00																													
		DS			0.03																													
Mean Annual HH Catch (kg)					0.03																													
Nam Kata																																		
Kor Phay	161	WS	-								-				-			161	-							4	1	20	25	3,993	3,993
		DS																	1							5	-	24	30	4,830	4,830
Vang Pha	92	WS	12		3	29					-				-			81							1		13	20	33	2,667	2,695
		DS			-	-																			1		-	17	18	1,479	1,479
Thong Ker	131	WS	33		6	207					-				-			115				2				1	8	23	34	3,883	4,090
		DS			0	8																5				2	-	17	24	2,765	2,774
Vang Kor	77	WS	-								-				-			77							10	1	5	28	45	3,447	3,447
		DS																							9	2	-	27	37	2,877	2,877
Mean Seasonal HH Catch (kg)		WS			0.51																													
		DS			0.02																													
Mean Annual HH Catch (kg)					0.53																													
Nam Ngoy																																		
Phonlom	30	WS	-				17		8	135	-				-			17									8		8	137	272
		DS							10	174																	4		4	73	247
Nakham [6]	64	WS	-								-				-			64									59	6	65	4,147	4,147
		DS																									26	4	30	1,907	1,907
Thong	92	WS	-								-				-			92		0						6	16	12	34	3,154	3,154
		DS																		1						7	1	-	8	775	775
Pha Meuang	99	WS	-								-				-			88								18	8	17	43	3,773	3,773
		DS																								4	-	10	14	1,265	1,265
TH Headpond																																		
Keng Bid	102	WS	-				73	91	21	8,222	-				-			44								1			1	50	8,272
		DS						92	21	8,285																2			2	66	8,350
Nong Kor [6]	72	WS	-				45	63	15	3,521	-				-			18								10			10	185	3,706
		DS						59	15	3,341																8			8	144	3,485
Tha Bac	169	WS	-				106	2	8	1,013	-				-			21										4	4	79	1,092
		DS						7	8	1,594																		4	4	79	1,673

Table x-5: Fish Species **Not** Consumed by Breast Feeding Women

Vulnerable Group	Fish Species Not Consumed
Breast Feeding Mothers	*Schistura* aff. *Breviceps*
	Danio sp.
	Cyclocheilichthys enoplos
	Mystacoleucus aff. *Atridorsalis*
	Hemibarbus maculatus
	Acheilognathus deignani
	Hampala dispar
	Clarias batrachus
	Clarias fuscus
	Indostomus spinosus
	Monopterus albus
	Chaudhuria fusipinnis
	Macrognathus circumcinctus
	Macrognathus siamensis
	Mastacembelus armatus
	Nandus oxyrhynchus
	Channa striata
	Amphotistius laosensis
	Himantura chaophraya
	Amyda cartilaginea
	Poecilia recticulata
	Hypsibarbus malcolmi
	Hampala macrolepidota

Table x-6: Numbers of Households with fish ponds

Village	No. HH with pond	No. Repondants	% with pond	Total HH with pond
Keng Bid	0	8	0.0	0.0
Khammmouane	1	8	12.5	13.1
Kor Phay	1	7	14.3	23.0
Lak 5	1	11	9.1	9.2
Lak 7	1	10	10.0	11.4
Lak 10	2	8	25.0	26.5
Nadeua	2	9	22.2	20.0
Nakam	0	5	0.0	0.0
Nam Phao	0	5	0.0	0.0
Nong Kor	1	8	12.5	9.0
Oudom	0	11	0.0	0.0
Phameuang	0	8	0.0	0.0
Phone Sy	0	8	0.0	0.0
Phonglom	0	7	0.0	0.0
Phongthong	0	10	0.0	0.0

Sop Phouan	0	8	0.0	0.0
Ta Bac	0	8	0.0	0.0
Nong Song	1	8	12.5	11.5
Thong Ket	2	8	25.0	32.8
Vang Kor	2	9	22.2	17.1
Vang Pha	0	8	0.0	0.0
Total	**14**	**172**	**8.1**	**165.6**

Table x-7: Other uses of the Nam Theun

	Use						
Village	**Transportation**	**Drinking water**	**Irrigation**	**Livestock**	**Fishing**	**Washing**	**Waste Disposal**
Keng Bid	**x**			**x**	**x**	**x**	**x**
Khammmouane							
Kor Phay							
Lak 5							
Lak 7							
Lak 10							
Nadeua							
Nong Kor	**x**	**x**		**x**	**x**	**x**	**x**
Phameuang							
Phone Sy							
Sop Phouan							
Ta Bac	**x**	**x**	**x**	**x**	**x**	**x**	
Nong Song							
Thong Ket							
Vang Kor							
Vang Pha							

Note: Ban Keng Bid, Nong Kor and Ta Bac are all located along the TH Headpond and not the Nam Theun mainstream.

Table x-8: Percentage of Fish Catch Consumed and Sold

Village	HH Pop	Total No. HH that catch and consume fish	% of HH that catch and consume fish	Total No. HH that sell fish	% of HH that sell fish	% fish consumed1	% fish sold
Keng Bid	102	102.0	100.0	76.5	75.0	73.8	26.3
Khammmouane	105	105.0	100.0	26.3	25.0	83.8	16.3
Kor Phay	161	138.0	85.7	46.0	33.3	88.3	11.7
Lak 5	101	101.0	100.0	64.3	63.6	64.5	35.5
Lak 7	114	102.6	90.0	45.6	44.4	77.8	22.2
Lak 10	106	92.8	87.5	66.3	71.4	71.9	28.1
Nadeua	90	90.0	100.0	30.0	33.3	91.1	8.9
Nong Kor	72	72.0	100.0	45.0	62.5	76.3	23.8
Phameuang	99	99.0	100.0	37.1	37.5	91.3	8.8
Phone Sy	67	67.0	100.0	16.8	25.0	96.9	3.1
Sop Phouan	45	45.0	100.0	16.9	37.5	86.3	13.8
Ta Bac	169	147.9	87.5	126.8	85.7	62.9	37.1
Nong Song	92	80.5	87.5	34.5	42.9	76.7	23.3
Thong Ket	131	131.0	100.0	49.1	37.5	91.3	8.8
Vang Kor	77	77.0	100.0	34.2	44.4	81.1	18.9
Vang Pha	92	92.0	100.0	23.0	25.0	92.5	7.5
Mean			**96.1**		**46.5**	**81.6**	**18.4**
Total		**1542.7**		**738.2**			

Table x-9: Percentage of Aquatic Products Catch Consumed and Sold

Village	HH Pop	Total No. HH that consume Aq. Prod.	%	Total No. HH that sell Aq. Prod.	%	% Aq. Prod consumed 1	% Aq. Prod sold
Keng Bid	102	51.0	50.0	0.0	0.0	100.0	0.0
Khammmouane	105	65.6	62.5	0.0	0.0	100.0	0.0
Kor Phay	161	115.0	71.4	0.0	0.0	100.0	0.0
Lak 5	101	73.5	72.7	18.4	18.2	87.5	12.5
Lak 7	114	102.6	90.0	34.2	30.0	75.5	24.5
Lak 10	106	106.0	100.0	66.3	62.5	67.5	32.5
Nadeua	90	80.0	88.9	40.0	44.4	85.6	14.4
Nong Kor	72	45.0	62.5	0.0	0.0	100.0	0.0
Phameuang	99	86.6	87.5	37.1	37.5	82.9	17.1
Phone Sy	67	67.0	100.0	0.0	0.0	93.8	6.3
Sop Phouan	45	45.0	100.0	33.8	75.0	65.0	35.0
Ta Bac	169	63.4	37.5	21.1	12.5	93.3	6.7
Nong Song	92	80.5	87.5	34.5	37.5	80.7	19.3
Thong Ket	131	131.0	100.0	16.4	12.5	93.8	6.3
Vang Kor	77	68.4	88.9	0.0	0.0	100.0	0.0
Vang Pha	92	92.0	100.0	11.5	12.5	97.5	2.5
Mean			**81.2**		**21.4**	**88.9**	**11.1**
Total		**1272.6**		**313.2**			

Table x-10: Example of Wetted Perimeter Analysis at IFR S1

HEC-RAS Plan: Plan 04 River: Nam Theun Reach: Main IFR S1

Reach	River Station	Profile	Q Total (m3/s)	Depth (m)	Hydr Depth (m)	Vel Chnl (m/s)	Flow Area (m2)	Top Width (m)	Wetted. Perimeter (m)
TYPICAL RAPID / WATER FALL									
Main	0	PF 1	2	0.72	0.85	0.33	6.04	7.07	7.88
Main	0	PF 2	5	1.03	1.2	0.42	12.04	10.06	11.19
Main	0	PF 3	8	1.24	1.07	0.39	20.67	19.40	21.34
Main	0	PF 4	10	1.36	1.17	0.41	24.3	20.73	22.91
Main	0	PF 5	21	1.84	1.62	0.5	41.61	25.75	28.87
Main	0	PF 6	33	2.19	2.08	0.59	55.7	26.74	30.37
Main	0	PF 7	51	2.65	2.65	0.69	74.1	27.98	32.26
Main	0	PF 8	99	3.40	3.04	0.74	133.38	43.85	51.89
Main	0	PF 9	420	5.41	3.97	1.23	377.94	95.10	57.53
Main	0	PF 10	1757	9.51	7.6	1.87	1145.03	150.69	57.53
Main	0	PF 11	3467	12.63	11.11	2.29	1822.37	164.00	57.53
TYPICAL POOL									
Main	150	PF 1	2	8.427	5.2	0.001	512.86	98.6	101.1
Main	150	PF 2	5	9.133	5.79	0.01	583.35	100.7	103.66
Main	150	PF 3	8	9.772	6.34	0.01	648.19	102.16	105.62
Main	150	PF 4	10	9.955	6.5	0.01	666.9	102.58	106.18
Main	150	PF 5	21	10.701	7.14	0.03	744.08	104.28	108.46
Main	150	PF 6	33	11.246	7.59	0.04	801.28	105.52	110.13
Main	150	PF 7	51	11.927	8.16	0.06	873.68	107.09	112.23
Main	150	PF 8	99	13.613	9.52	0.09	1057.52	111.04	117.48
Main	150	PF 9	420	17.56	12.01	0.28	1527.2	127.17	117.96
Main	150	PF 10	1757	23.386	16.05	0.79	2316.69	144.34	117.96
Main	150	PF 11	3467	27.726	18.54	1.25	2977.67	160.65	117.96

Figure x-2: A Typical Rapid and Pool Cross section at IFR S1 with Various Discharges

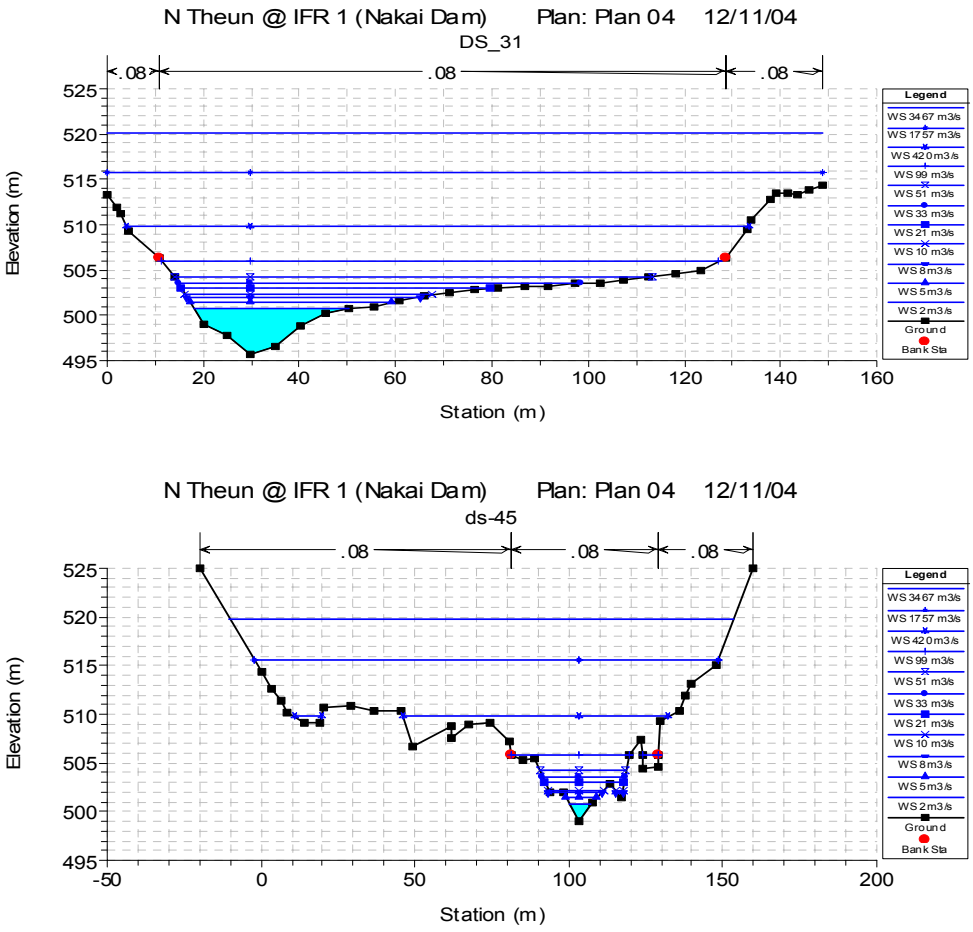


Figure x-3: Wetted perimeter-discharge curve at IFR S1

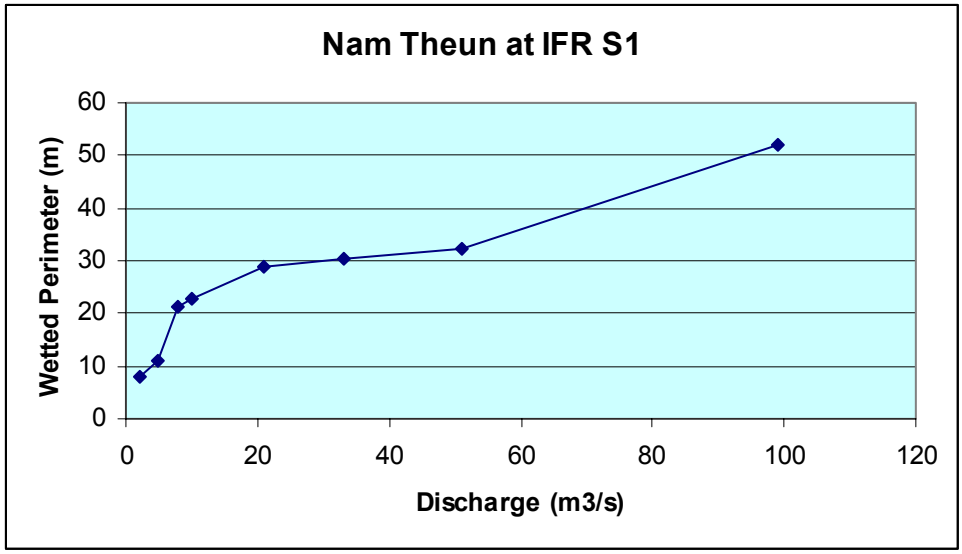


Table x-11: Summary of wetted perimeter analysis for 2m3/s Riparian Release

IFR Site	Habitat type	Present mean dry season discharge	Present wetted perimeter	Riparian Release	Future mean dry season discharge	Future wetted perimeter	Impact on wetted perimeter
		m3/s	m	m3/s	m3/s	m	%
S1	Rapid	25	29.4	2	2	7.88	73
	Pool	25	108.8	2	2	101.10	7
S2	Rapid	26	43.7	2	3	20.08	54
	Pool	26			Data not available		
S3	Rapid	33	23.3	2	15	10.29	56
	Pool	33	28.4	2	15	21.98	23
S4	Rapid	34	27.5	2	17	25.6	6.9
	Pool	34	34.9	2	17	12.16	65

Table x-12: % impact on the fisheries caused by 2m3/s riparian release

Waterbody	% Impact
NT mainstream	60
TH Headpond	0
Nam Phao	35
Nam Ngoy	10
Nam Gnouang	10
Ponds/rice fields	Dependant on tributary

Table x-13: Estimated value of fisheries loss for the riparian release of 2 m3/

NT Mainstream

Village Zone	Number of Villages	Number of HH	Average annual HH catch in NT mainstream	Average annual yield in NT mainstream	Predicted annual decline in fish yield	Predicted decline in annual fish yield	Estimated value of decline in annual fish yield
			(kg/hh/yr)	(kg/yr)		(kg/yr)	USD/yr
Lower Nam Phao	9	1,511	63.54	96,009	60%	57,605	46,084
Upper Nam Phao	18	2,678	0	0	60%	0	0
Nam Phouang/Nam Phiat	6	604	9.55	5,768	60%	3,461	2,769
Nam Kata	14	1,529	2	3,058	60%	1,835	1,468
Nam Ngoy	6	445	0	0	60%	0	0
TH Headpond	4	540	0	0	60%	0	0
Nam Gnouang	13	1,249	0	0	60%	0	0
					Total	**62,901**	**50,321**

NT Headpond

Village Zone	Number of Villages	Number of HH	Average annual HH catch in NT Headpond	Average annual yield in NT Headpond	Predicted annual decline in fish yield	Predicted decline in annual fish yield	Estimated value of decline in annual fish yield
			(kg/hh/yr)	(kg/yr)	%	(kg/yr)	USD/yr
Lower Nam Phao	9	1,511	0	0	0	0	0
Upper Nam Phao	18	2,678	0	0	0	0	0
Nam Phouang/Nam Phiat	6	604	0	0	0	0	0
Nam Kata	14	1,529	0	0	0	0	0
Nam Ngoy	6	445	37.69	16772.05	0	0	0
TH Headpond	4	540	72.31	39047.4	0	0	0
Nam Gnouang	13	1,249	0	0	0	0	0
					Total	**0**	**0**

Nam Phao and Tributaries

Village Zone	Number of Villages	Number of HH	Average annual HH catch in Nam Phao and Tributaries	Average annual yield in Nam Phao and Tributaries	Predicted annual decline in fish yield	Predicted decline in annual fish yield	Estimated value of decline in annual fish yield
			(kg/hh/yr)	(kg/yr)	%	(kg/yr)	USD/yr
Lower Nam Phao	9	1,511	75.44	113,990	35%	39,896	31,917
Upper Nam Phao	18	2,678	9.65	25,843	35%	9,045	7,236
Nam Phouang/Nam Phiat	6	604	83.81	50,621	35%	17,717	14,174
Nam Kata	14	1,529	32.14	49,142	35%	17,200	13,760
Nam Ngoy	6	445	0	0	35%	0	0
TH Headpond	4	540	0.26	140	35%	49	39
Nam Gnouang	13	1,249	0	0	35%	0	0
					Total	**83,908**	**67,126**

Nam Mouan

Village Zone	Number of Villages	Number of HH	Average annual HH catch in Nam Phao and Tributaries	Average annual yield in Nam Phao and Tributaries	Predicted annual decline in fish yield	Predicted decline in annual fish yield	Estimated value of decline in annual fish yield
			(kg/hh/yr)	(kg/yr)	%	(kg/yr)	USD/yr
Lower Nam Phao	9	1,511	1.84	2,780	35%	973	778
Upper Nam Phao	18	2,678	0	0	35%	0	0
Nam Phouang/Nam Phiat	6	604	0.01	6	35%	2	2
Nam Kata	14	1,529	0	0	35%	0	0
Nam Ngoy	6	445	0	0	35%	0	0
TH Headpond	4	540	0	0	35%	0	0
Nam Gnouang	13	1,249	0	0	35%	0	0
					Total	**975**	**780**

Nam Ngoy

Village Zone	Number of Villages	Number of HH	Average annual HH catch in Nan Ngioy	Average annual yield in Nam Ngoy	Predicted annual decline in fish yield	Predicted decline in annual fish yield	Estimated value of decline in annual fish yield
			(kg/hh/yr)	(kg/yr)	%	(kg/yr)	USD/yr
Lower Nam Phao	9	1,511	0	0	10%	0	0
Upper Nam Phao	18	2,678	0	0	10%	0	0
Nam Phouang/Nam Phiat	6	604	0.01	6	10%	1	0
Nam Kata	14	1,529	0	0	10%	0	0
Nam Ngoy	6	445	52.37	23,305	10%	2,330	1,864
TH Headpond	4	540	0	0	10%	0	0
Nam Gnouang	13	1,249	0	0	10%	0	0
					Total	**2,331**	**1,865**

Nam Gnouang

Village Zone	Number of Villages	Number of HH	Average annual HH catch in NT Headpond	Average annual yield in NT Headpond	Predicted annual decline in fish yield	Predicted decline in annual fish yield	Estimated value of decline in annual fish yield
			(kg/hh/yr)	(kg/yr)	%	(kg/yr)	USD/yr
Lower Nam Phao	9	1,511	0	0	10%	0	0
Upper Nam Phao	18	2,678	0	0	10%	0	0
Nam Phouang/Nam Phiat	6	604	0.06	36	10%	4	3
Nam Kata	14	1,529	0	0	10%	0	0
Nam Ngoy	6	445	0.87	387	10%	39	31
TH Headpond	4	540	0.55	297	10%	30	24
Nam Gnouang	13	1,249	118.02	147,407	10%	14,741	11,793
					Total	**14,813**	**11,850**

Ponds and rice fields

Village Zone	Number of Villages	Number of HH	Average annual HH catch in NT Headpond	Average annual yield in NT Headpond	Predicted annual decline in fish yield	Predicted decline in annual fish yield	Estimated value of decline in annual fish yield
			(kg/hh/yr)	(kg/yr)	%	(kg/yr)	USD/yr
Lower Nam Phao	9	1,511	1.62	2,448	35%	857	685
Upper Nam Phao	18	2,678	6.09	16,309	35%	5,708	4,567
Nam Phouang/Nam Phiat	6	604	0.6	362	35%	127	101
Nam Kata	14	1,529	0.08	122	35%	43	34
Nam Ngoy	6	445	8.85	3,938	20%	788	630
TH Headpond	4	540	0.01	5	0%	0	0
Nam Gnouang*	13	1,249	6.09	7,606	20%	1,521	1,217
					Total	**9,043**	**7,235**

* no data available therefore Upper Nam Phao catch rate assumed

Grand Total	**173,971**	**139,177**
NPV		**1,172,113**

Table x-14: Estimated value of aquatic products loss for the riparian release of 2 m3/

NT Mainstream

Village Zone	Number of Villages	Number of HH	Average annual HH catch in NT mainstream	Average annual yield in NT mainstream	Predicted annual decline in fish yield	Predicted decline in annual fish yield	Estimated value of decline in annual fish yield
			(kg/hh/yr)	(kg/yr)		(kg/yr)	USD/yr
Lower Nam Phao	9	1,511	0.1	151	60%	91	73
Upper Nam Phao	18	2,678	0	0	60%	0	0
Nam Phouang/Nam Phiat	6	604	0.03	18	60%	11	9
Nam Kata	14	1,529	0.53	810	60%	486	389
Nam Ngoy	6	445	0	0	60%	0	0
TH Headpond	4	540	0	0	60%	0	0
Nam Gnouang	13	1,249	0	0	60%	0	0
					Total	**588**	**470**

* no data available therefore Upper Nam Phao catch rate assumed

Grand Total	**588**	**470**
NPV		**3,960**

Table x-15: Summary of wetted perimeter analysis for the trade-off

IFR Site	Habitat type	Present mean dry season discharge	Present wetted perimeter	Riparian Release	Future mean dry season discharge	Future wetted perimeter	Impact on wetted perimeter
		m3/s	m	m3/s	m3/s	m	%
S1	Rapid	25	29.4	2	2	7.88	73
				5	5	11.19	62
				8	8	21.34	27
	Pool	25	108.8	2	2	101.10	7
				5	5	103.66	5
				8	8	105.62	3
S2	Rapid	26	43.7	2	3	20.08	54
				5	6	31.11	29
				8	9	34.19	22
	Pool	26					
			Data not available				
S3	Rapid	33	23.3	2	15	10.29	56
				5	18	11.69	50
				8	23	31.10	46
	Pool	33	28.4	2	15	21.98	23
				5	18	22.74	20
				8	23	23.50	17
S4	Rapid	34	27.5	2	17	25.6	6.9
				5	20	26.2	4.7
				8	25	27.1	1.5
	Pool	34	34.9	2	17	12.16	65
				5	20	18.56	47
				8	25	29.22	16

Table x-16: Summary of Impacts on Fisheries Production for different riparian releases

	% reduction in fish productivity for different riparian release		
	2 m3/s	5m3/s	8m3/s
NT mainstream	60	50	30
TH Headpond	0	0	0
Nam Phao	35	30	20
Nam Ngoy	10	10	10
Nam Gnouang	10	10	10
Ponds/rice fields	Dependant on tributary	Dependant on tributary	Dependant on tributary

Table x-17: Trade-off analysis of different riparian release regimes

Riparian Release	Value of Fisheries Loss	Value of Aquatic Product Loss	Value of Aquatic Ecosystem	Total	Value of reduction of loss	Cost of Addition Discharge
m3/s	NPV MUSD	NPV MUSD	NPV MUSD	NPV MUSD	NPV MUSD	NPV MUSD
2	1.172	0.004	1.26 to 2.11	2.436 to 3.286	-	-
5	1.005	0.003	1.26 to 2.11	2.268 to 3.118	0.168	45
8	0.689	0.002	1.26 to 2.11	1.951 to 2.801	0.485	72

NATURAL HABITATS ACCOUNTING AND ADEQUACY OF OFFSETS

This section is to be inserted in Chapter 3 before the section dealing with construction impacts and titled "Impacts associated with construction", page 109.

NATURAL HABITATS ACCOUNTING AND ADEQUACY OF OFFSETS

Interacting biophysical, climatic and anthropogenic factors have resulted in a complex mosaic of vegetation types in the Project area. A summary of the habitat types found in the Project area is presented in Table 1. Eleven habitat types are found in the Project footprint of 130,589 ha. The Project footprint plotted on the maps does not represent the actual area to be impacted, but rather the limits within which the final construction zones will be located. The actual area to be directly impacted will be significantly less than the Project footprint.

Table 1: Summary of thematic habitats found in the Project Footprint (based on FIPD, 2002)

FIPD forest thematic habitats	Area (ha)	% of Project footprint area
Forest		
Disturbed/regenerating or unstocked forest	29,236	22.4
Mixed broadleaf & coniferous forest	27,217	20.8
Upper mixed deciduous	21,688	16.6
Dry Dipterocarp	14,430	11.0
Upper dry evergreen	13,596	10.4
Lower mixed deciduous	3,140	2.4
Gallery/riverine forest	254	0.2
Coniferous forest	59	0.0
Total all forest	**109,620**	**83.8**
Non forest		
General agriculture	11,995	9.2
Swamp	4,682	3.6
Water	2,535	1.9
Grassland	846	0.6
Rock	717	0.5
Urban	194	0.1
Total non forest	**20,969**	**16.2**
Grand Total	**130,589**	**100.0**

The most dominant habitat in the Project footprint is disturbed/regenerating forest. The second most dominant is mixed broadleaf and coniferous, followed by upper mixed deciduous forest. In total, 109,620 ha of forest habitat is represented with disturbed/regenerating forest making up 27% of this forested area. The remaining 20,969 ha is made up from non-forest habitat types, of which agriculture and swamp habitats cover an area of 11,995 ha (57%) and 4,682 ha (22%) respectively.

Natural Habitats of High Conservation Significance

The coniferous forest on the Nakai Plateau, probably the most extensive in Indochina, is dominated by *Pinus latteri* both in terms of stem density and biomass. *P. latteri* has been raised out of synonymy with *Pinus merkusii*. *P. merkusii* is found only in northern Sumatra and the Philippines, and *P. latteri* is distributed in Viet-nam, Lao PDR, Cambodia, Thailand and southern Myanmar; also in extreme southern China (Hainan Island), but possibly introduced there. It is found from sea level to El 900 m, usually in open, savannah-like areas that are frequently burned by native peoples (de Laubenfels, 1988). *P. latteri* is listed as "threatened" by IUCN but in the lowest category of "low risk". On the Nakai Plateau, the tree density of the coniferous pine forest averages 58.6 trees per
hectare, with trees exhibiting an average diameter at breast height of 57.1 cm, indicating that this is old growth forest (Robichaud, 2002; Margules Groome Poyry 1996), probably about 60 years old. The species is adapted to fire and is a light demanding, heat and drought tolerant

tree, growing well on sandy soils, such as those on the Nakai Plateau. *P. latteri* does not regenerate under its own canopy unless there is fire. It is therefore likely possible that their presence on the Nakai Plateau is linked to human-set fires for agriculture. Though low in plant diversity in comparison to other tropical forested ecosystems, this natural habitat is a valuable ecosystem which is poorly represented in Lao PDR.

The riverine forest of the Nakai Plateau, which has yet to be ecologically or botanically characterised, is likely an ecosystem of high conservation significance. Similar natural habitats are found elsewhere in the Nam Theun catchment, along the Nam Choun and Nam Seng, but these are unlikely to be as extensive as on the Plateau.

Current Threats

A variety of threats to the integrity of the natural habitats and the survival of its biodiversity currently exist and are identified below. These threats are independent of the Project and would probably also exist in a no-Project scenario.

Logging

P. latteri is a medium-value timber that has been extracted from areas both within and outside the reservoir inundation area, and from the NBCA. This logging will continue – legally or illegally – unless proper management and enforcement is instituted (Salter et al., 1991 in Malaysian Environmental Consultants, 2003). GOL is making efforts to ensure that remaining stands outside the inundation area are conserved by imposing a total ban. Current controls appear to be effective, but the value and location of the remaining *P. latteri* stands puts them in jeopardy.

Fokienia hodginsii is one of the most valuable timbers in Lao PDR and grows in areas of high-altitude near the Vietnam border (Timmins and Evans, 1996). Logging within the NBCA took place in the mid-1990s, but appears to have ceased for now.

In addition to the direct impacts that logging has on the forest, construction of logging roads facilitates access to critical natural habitats within the NBCA and leads to increased hunting and extraction of resources.

Commercial Extraction of Wildlife & Non-Timber Forest Products

The wildlife trade is currently a major drain on NNT NBCA resources (Robichaud, 2002), with a variety of mammal, birds and reptiles being hunted for consumption or medicine. Vietnamese traders regularly cross the border to hunt or purchase wildlife from villagers. These cross-border poachers are intensively snaring wildlife up to 20 km inside the NNT NBCA (IUCN, 1999). Considerable extraction of rattan and *Aquilaria malaccensis* (a fragrant resinous wood) has been observed in the interior of the NBCA (Timmins and Evans, 1996). With increasing population and commercial demand, these products and other NTFPs, are likely to be subjected to unsustainable collection.

Unsustainable Agricultural Practice

Long-term residents of the NBCA tend to use traditionally sustainable agricultural practices. However, it has been observed that recent arrivals to the NBCA practice a short-cycle, unsustainable form of farming (WCS, 1995). These swidden agriculture systems clear new land once their present site is exhausted. This unsustainable agricultural practice, coupled with increasing population, is placing increased pressure on NNT NBCA natural resources.

On-going Land Development Activities on the Plateau

Natural habitats are currently being converted as a result of human activities. It is not possible to determine quantitatively what percentage of this ongoing degradation of natural habitat could be perceived as having occurred in anticipation of the Project. Clearance may well have been a continuation of practices not related
to the Project; such as planned harvesting, collection by local communities or uncontrolled commercial logging.

Project Impacts

Project impacts on forest and forest biodiversity will occur during pre-construction, construction and operational phases, and are characterised as either direct or indirect impacts.

Direct impacts are related to the clearance, degradation or disturbance of forest and forest biodiversity as a result of Project construction activities and operations. Indirect impacts may result from increased population and improved access to the forest, therefore generating increased pressures on forest resources. With the exception of fragmentation and buffer zones, the following account on natural habitat degradation focuses primarily on the direct impacts. A discussion on indirect impacts is earlier in Chapter 3.

Accounting for Degradation & Conversion

The impacts within the immediate footprint are taken to be absolute land-take; where degradation or conversion resulting from vegetation removal, construction, inundation or suffcient disturbance is considered as total degradation of the current habitat. However, in reality, with the exception of the Nakai Reservoir, the Project footprint is larger than the actual long-term requirement for construction and associated activities. The outstanding areas not required for construction may experience some disturbance in terms of temporary vegetation clearance, water quality, erosion, etc. For the most part, this disturbance will be temporary in nature and eventually, those impacted areas not required for direct construction might, in some instances, be able to re-establish their original natural habitat assemblage, although the duration will be determined by the extent of disturbance. Therefore, the extent of natural habitat degradation discussed below can be considered as a worst case scenario and an over representation of actual extent of impact.

Table 2: Thematic habitat types ranked by area to be affected by the Project (FP: Footprint)

		Total area within the Project area (ha)			Percentage of respective totals		
Rank of Area	FIPD thematic habitat	FP	Fragments	Total FP+ Fragments	FP	Fragments	Total FP+ Fragments
1	Mixed broadleaved & coniferous	26,972	246	27,217	27.5	0.8	20.8
2	Disturbed/ regenerating & unstocked forest	18,667	8,340	27,007	19.0	25.6	20.7
3	Upper mixed deciduous	18,450	3,239	21,689	18.8	9.9	16.6
4	Dry dipterocarp	5,225	9,204	14,429	5.3	28.3	11.0
5	Upper dry evergreen	9,508	4,088	13,596	9.7	12.6	10.4
6	Rice paddy	8,617	3,291	11,908	8.8	10.1	9.1
7	Swamp	4,596	86	4,682	4.7	0.3	3.6
8	Lower mixed deciduous	441	2,700	3,140	0.4	8.3	2.4
9	Water	2,535	0	2,535	2.6	0.0	1.9
10	Ray	1,365	95	1,460	1.4	0.3	1.1
11	Grassland	838	7	845	0.9	0.0	0.6
12	Scrub	152	615	767	0.2	1.9	0.6
13	Barren land & rock	63	654	716	0.1	2.0	0.5
14	Gallery/riverine forest	254	0	254	0.3	0.0	0.2
15	Urban	194	0	194	0.2	0.0	0.1
16	Other agriculture	88	0	88	0.1	0.0	0.1
17	Coniferous forest	59	0	59	0.1	0.0	0.0
18	Unclassified	0	1	1	0.0	0.0	0.0
	Totals	98,020	32,567	130,588	100	100	100

Calculations indicate that of 130,589 ha of Project footprint, 62% will be natural habitat and

the remaining 38% will be either non forest habitat, or disturbed/regenerating and unstocked forest. For specific habitat types, the ranked extent to be affected is presented in Table 2. The major habitat degradation will be in mixed broadleaved and coniferous (20.8%), disturbed/regenerating and unstocked (20.7%), and upper mixed deciduous (16.6%) natural habitats. Other habitats that will be significantly impacted are dry dipterocarp, upper dry evergreen and rice paddy, representing between 9-11% of the Project footprint. Details of the habitat areas to be disturbed by individual components of the Project are presented in Annex I and discussed below.

Reservoir

The inundation of the 450 km2 Nakai reservoir will submerge vegetation below El 538 m, covering approximately 38% of the total Nakai Plateau. For the majority of these habitat types, their value will be lost. The degradation of habitats on the Nakai Plateau due to inundation of the reservoir is an unavoidable consequence of the Project. However, not all habitats within the inundation area are natural habitats – some have already been extensively disturbed by human activity. Approximately 15% of habitats on the Nakai Plateau have already been disturbed, of which 12.6% is within the inundation area (Table 3). Therefore 13% of the area to be inundated by the Nakai Reservoir has already been disturbed. Natural habitats remaining in the inundation area are mainly primary forest bordering slow-flowing rivers, small lakes and wetlands. These natural habitats to be affected by inundation include mixed broadleaf and coniferous (28%), upper mixed deciduous (18%) and upper dry evergreen (5%). An estimated 4,363 ha of swamp habitat will be affected to some degree, but depending on their location and the annual drawdown cycle of the reservoir these habitats may not be permanently lost.

Table 3: Extent of natural habitats & disturbed habitats within & outside of the inundation area

Area	Natural Habitat Area (ha)	Natural Habitat % of Plateau	Disturbed Areas (ha)	Disturbed Area % of Plateau	Total Area (ha)	Total % of Plateau
Reservoir (Plateau land take)	32,128	25.1	16,103	12.6	48,231	37.7
NNT NBCA Plateau	76,802	60.0	3,051	2.4	79,853	62.3
Total Plateau Area	108,930	85.0	19,154	15.0	128,084	100.0

Fragmentation

In addition to the 98,020 ha of land potentially directly occupied, 32,567 ha of land will be encircled by Project components. These encircled habitats will experience indirect impacts resulting from fragmentation. This fragmentation accounts for 25% of the total 130,588 ha in the Project area (Table 4). The majority of this fragmentation will occur in the Reservoir Zone. In terms of area, the predominant habitat types that will be impacted by fragmentation are dry dipterocarp (9,204 ha) and disturbed/regenerating and unstocked forest (8,340 ha), which respectively represent 28% and 26% of the total area to be fragmented. In terms of proportion fragmentation, for lower mixed deciduous and dry dipterocarp forest over 60% of the total impacted area is due to fragmentation. Approximately 30% of the total impacted area for upper dry evergreen and disturbed/regenerating and unstocked forest is also due to fragmentation.

Though these habitats are not directly replaced or altered, the Project will result in fragmentation of this once contiguous habitat area. The constraints made by Project components on the biological exchange between fragments are not quantifiable, and therefore the significance of this fragmentation is unknown. Nevertheless, the severity of impact will be less than the total loss caused by land-take for construction.

Table 4. Fragmentation of habitats caused by the Project

Habitat Type	Area Fragmented (ha)	Total Area Impacted (ha)	Fragmentation as a % of Total Area
Barren land & rock	654	716	91.3
Lower mixed deciduous	2,700	3,140	86.0
Scrub	615	767	80.2
Dry dipterocarp	9,204	14,429	63.8
Disturbed/regenerating & unstocked forest	8,340	27,007	30.9
Upper dry evergreen	4,088	13,596	30.1
Rice paddy	3,291	11,908	27.6
Upper mixed deciduous	3,239	21,689	14.9
Ray	95	1,460	6.5
Swamp	86	4,682	1.8
Mixed broadleaved & coniferous	246	27,217	0.9
Grassland	7	845	0.8
Water	0	2,535	0.0
Gallery/riverine forest	0	254	0.0
Urban	0	194	0.0
Other agriculture	0	88	0.0
Coniferous forest	0	59	0.0
Total	32,567	130,588	24.9

Construction

Resettlement Area

The proposed resettlement area of 18,732 ha will be situated on the southwest side of the reservoir. Figure 3.69 shows the potential 25 relocation sites and the habitat types in the resettlement area. The predominant natural habitats in this area are mixed broadleaf and coniferous (55%), upper dry evergreen (22%) and upper mixed deciduous (18%).

In total, only 750-1,000 ha will be degraded through conversion to agricultural land and house plots. The proposed sites for the agricultural land and house plots have already been cleared or degraded to varying degrees by past agricultural and logging activities. The majority of the remaining area indicated in the resettlement area is allocated to forest management, and as such the impact from the Project should be positive.

Nakai Dam

Approximately 1,325 ha has been allocated for the construction of the Nakai Dam and its access road. The main single natural habitat to be impacted for this construction will be in upper dry evergreen forest (35%). However, much of the habitats directly adjacent to the Nakai Dam consist of unstocked or disturbed/regenerating forest (51%). The construction of the Nakai Dam itself will only require 10-15 ha of clearance, much of which will be in the inundation area after the dam is closed.

Upgrade & Construction of Road 8B

On the Plateau, the upgrading of existing portions of Road 8B together with the construction of the new alignment will impact approximately 2,700 ha of habitats. Upper mixed deciduous, mixed broadleaf and coniferous, and upper dry evergreen natural habitats represent 70% of this area.

Power Station & Regulating Pond/Dam

Potentially, the construction of the Power Station and regulating pond/dam will impact a total of 900 ha. Much of the forest directly adjacent to the Power Station and regulating pond/dam construction areas is already degraded from past road construction and agriculture activities. This is reflected by the fact that over 60% of the area to be affected by the Power Station and regulating pond/dam comprises of either unstocked or disturbed/regenerating forest.

Downstream Channel

In the Gnommalat area, the construction of the Downstream Channel will affect over 1,650 ha of land, which, because of the greater presence of human population, predominately consists of rice paddy and agricultural land (48%). In terms of forested natural habitats, 550 ha of dry dipterocarp will be affected. Direct impact on forest in this area is therefore negligible. This

impact includes the spoil areas as currently indicated.

115/500 kV Transmission Lines

Initially, the clearance of vegetation for the construction of both 115/500 kV Transmission Lines and their associated access tracks may affect up to 4,650 ha of land. This includes the section of the 115 kV Transmission Line from Mahaxai to Thakhek, under the responsibility of EDL. The Transmission Line alignments traverse rice paddy and agriculture land for 26% of the total area. These agricultural areas will not require clearing, other than the area occupied for the construction of the tower footprints. Other habitat types that will be affected by the construction of the Transmission Lines include dry dipterocarp (24%), disturbed/regenerating forest (19%) and unstocked forest (19%), which will require some degree of vegetation clearing. There is a degree of flexibility in the precise final alignment, and where possible the final route of the Transmission Lines will avoid areas of major vegetation.

During the operational phase, the Transmission Lines will impact a substantially smaller area than indicated above. The impact will be limited to the actual tower footprints themselves and routine clearing of vegetation within the easements. An estimated 782 ha of habitat will be cleared for the Transmission Line tower footprints and easement, over half of which will consist of lowland dry dipterocarp forest (Table I.8). These calculations are based on the assumption that no clearing would be required in rice paddy and agricultural land, and minimal clearing would occur in unstocked and disturbed/regenerating forests.

Buffer Zones

No direct construction is planned to take place in the buffer zones surrounding the Nam Kading and Xe Bang Fai. The primary impact associated with the Project will be the modification of hydrological regime.

Nam Kading

The buffer zone extends 270 m on either side of the Nam Kading and encompasses 11,377 ha of terrain. The major natural habitats present in the buffer zone include upper dry evergreen (25%) and upper mixed deciduous (11%) habitat, but the lesser valuable habitat types of unstocked and disturbed/regenerated forest together

represent almost 40% of the total buffer zone. The main concern in this zone is the reduction in flow attributed not only to the Project but also to the operation of the Theun Hinboun Hydroelectric Project. Whilst severe impact on the vegetation is not considered likely, the dependence of key and threatened species of mammals on the aquatic ecosystem is an important element.

Xe Bang Fai

The Xe Bang Fai will experience almost a doubling of the annual discharge. The subsequent increases in erosion will, to some degree, impact the habitats surrounding the Xe Bang Fai. The buffer zone is similar in size to that of the Nam Kading, at 11,753 ha. However, due to the greater densities of human population in the area, the

habitat types in the Xe Bang Fai buffer zone are predominantly rice paddy and agricultural land (44%). Dry dipterocarp (21%) is a prominent natural habitat that could be affected in this zone.

Significance of Natural Habitats to be Degraded or Converted

National Level of Significance

At a national level of significance, the Project footprint will impact only 0.6% of the national area. In terms of natural habitats, the Project footprint will encompass 10% of the national area of swamps, 0.8% of lower mixed deciduous area, and 0.5% of dry evergreen and coniferous forest (Table 5). Therefore from a national perspective the degradation of natural habitat is insignificant, with the exception of swamps.

The comparison on a national level requires cautious interpretation due to discrepancies in data. The national level assessment was limited to using the 1992 FIPD data for the whole country.

Table 5: Habitat occurrence and degradation for Bolikhamxay, Khammouane and Savannaket Provinces

Habitat Type	Total Area in Provinces FIPD 2002 (ha)	Total National Area FIPD 1992 (ha)	NT2 Project Area (ha)	NT2 ProjectArea + Fragmented Areas (ha)	% of NT2 Footprint + Local Provinces	% of NT2 Footprint + Nation	Habitat Degradation Rank in the 3 Provinces
Mixed broadleaved & coniferous	100,838	0	26,972	27,217	27.0	na	1
Swamp	45,955	46,934	4,596	4,682	10.2	10.0	2
Gallery/riverine forest	4,091	0	254	254	6.2	na	3
Coniferous forest	1,849	12,333	59	59	3.2	0.5	4
Dry evergreen	459,383	2,566,847	9,508	13,596	3.0	0.5	5
Water	89,694	181,654	2,535	2,535	2.8	na	6
Rice paddy	544,133	923,020	8,617	11,908	2.2	1.3	7
Dry dipterocarp	716,417	1,444,411	5,225	14,429	2.0	1.0	8
Urban	10,788	20,064	194	194	1.8	1.0	9
Lower mixed deciduous	182,666	383,056	441	3,140	1.7	0.8	10
Ray	92,486	457,031	1,365	1,460	1.6	0.3	11
Upper mixed deciduous	1,480,886	7,203,863	18,450	21,689	1.5	0.3	12
Agricultural	6,128	113,204	88	88	1.4	0.1	13
Non-forest	2,056,982	8,643,727	19,657	28,619	1.4	0.3	14
Barren land & rock	211,072	217,082	63	716	0.3	0.3	15
Bamboo	20,111	835,979	0	0	na	na	16
Forest plantation	0	1,230	0	0	na	na	
Unclassed or cloud	1,547	0	0	0	na	na	
Total	**6,025,024**	**23,050,433**	**98,020**	**130,586**	**2.2**	**0.6**	

Sub-National Level of Significance

Terrestrial Natural Habitats

To minimise speculative accounting, details of the significance of the natural habitats to be degraded or converted at a sub-national level were generated for Bolikhamxay, Khammouane and Savannaket Provinces (Table 5). The total area of 130,586 ha that will be degraded or fragmented by the Project represents only 2.2% of the total area of these three provinces. The greatest impact will be on mixed broadleaved and coniferous forest, with a total of 27,217 ha being potentially affected. This represents 27% of the total habitat found in the three provinces. Swamp habitat degradation represents a 10% loss of the original provincial extent. Other important natural habitats that will register significant degradation at a sub-national level are gallery/riverine forest (6.2%), dry evergreen forest (3%) and coniferous forest (3.2%). Approximately 21,689 ha and 14,429 ha of upper mixed deciduous and dry dipterocarp will be lost respectively, but this represents only 1.5-2% of their total area in the three provinces, and should not be considered as a significant degradation. The degradation of already altered land such as rice paddy, agriculture and urban habitat types will affect between 1.4 and 2.2% of the provincial area but these are social rather than biodiversity conservation issues, and are covered in the RAP.

In summary, in terms of significance of the natural habitat lost the natural habitats ranked 1-6 are those of concern for offset measures.

However, the following should be considered when interpreting the significance of the natural habitat degradation:

• The majority of the impact on the dry evergreen forest will not be land-take. This concerns the buffer area of the Nam Kading as it flows through the Nam Kading NBCA. Though inside

the Project footprint area, the buffer is not expected to experience significant impacts as a direct result of the Project;
• The majority of gallery/riverine forest is located in the lower reaches of the Xe Bang Fai. This is a dynamic area changing shape over time, and so communities are able to adapt to periodic changes in river flow and exploit new habitat as it is made available. Increased dry season flow and erosion created by the Project may favour early colonizers of the gallery/riverine forest community;
• Swamp conditions may develop on the sandy soils of the Plateau's flooded valleys, currently covered by mixed broadleaved and coniferous forest; and
• The degradation of the lowland dry dipterocarp, lowland dry evergreen and lowland mixed deciduous forests may not be significant in terms of conservation value. These lowland forests exist in relatively densely populated areas and have been subject to much disturbance and exploitation. These forests have long been used for timber and firewood collection, hunting, and gathering of NTFPs – activities which have subsequently reduced the complexity, diversity and density of the forests. The clearing of the forest for agriculture has left fragmented remnants that do not have the habitat values associated with similar vegetation communities in less populated areas. Taking these factors into consideration, the proposed clearing in the lowland areas (for Power Station, Downstream Channel and Transmission Lines) will not pose a significant threat to natural habitats.
Therefore, at the sub-national level of significance the major natural habitat degradation will be in the mixed broadleaf and coniferous forest. This natural habitat class can be considered as a fire climax that has created a mosaic of broadleaf and conifers, with conifers dominating in areas that have been recently burnt, but unable to
regenerate under their own canopy. In time they are replaced by broadleaf species. The conifers on the Plateau appear to be selectively logged, which would leave organic matter in the soils of the logged areas, and thus favour broadleaf regeneration. The species of this community are expected to be relatively quick to exploit the opportunity. As a result of the Project land-take however, the areas with the necessary environmental conditions that favour development will be reduced and these cannot be recreated or substituted elsewhere.

Aquatic Habitats

A total length of 673,135 m of river will be inundated by the reservoir out of a total length of 2,340,919 m found on the Nam Theun catchment above the Nakai Dam. This represents 29% of the total length and should be considered as a significant degradation. Outside the inundation area, the change in hydrology will alter the environmental equilibrium of river habitat. It is not possible at this stage to quantify the degradation of river habitats that might occur through sluggish river sections, rapids, pools, sand banks, etc.

Impacts on Protected Area

It is anticipated that the Project will directly impact approximately 1,181 ha of land within the PHP – NNT Corridor. This represents only a 2.6% impact on a total corridor area of 45,123 ha. Figure I.5 illustrates the areas of impact within the PHP – NNT corridor. It should be pointed out that the Project will not directly impact the NNT NBCA through construction activities: the only protected area to be directly impacted will be the PHP – NNT Corridor. Overall an estimated 10,567 ha of protected area will affected by Project activities. The majority of this area is not subject to physical land-take. Over 85% of this total area will experience only indirect impacts, which include:
• The areas surrounded by fragmentation caused by Project roads and facilities in the PHP – NNT corridor on the Plateau – 4,317 ha or 40.9%; and
• River buffer around the Nam Theun and Nam Kading as it flows through the Nam Kading NBCA and the PHP – NNT corridor – 5,062 ha or 47.9%.
The significance of impacts on the protected areas needs to go beyond quantifying immediate land-take alone. The issues of concern for the NNT NBCA and neighbouring protected areas include the effect on function at a regional level, and at the local level the impact on biological functioning and movement of wildlife between the NNT NBCA and the PHP NBCA. Therefore the size of the fragmented area in the PHP – NNT corridor may be less important than its location in a critical area between the NNT and PHP NBCAs. The biological function of the corridor area is difficult to quantify, and it is hard to assign biological indicators to assess any changes in function. Concerns have been raised over the movement of elephants and the

remnant populations of White-winged ducks in the corridor.
In addition to direct land-take, the effects of reduced river flow on aquatic communities needs also to be considered. The proposed reduction in flow in the Nam Theun below the dam site to a minimum flow of 2 m3/s will have a significant impact on the aquatic community, especially in the 12 km section of the Nam Theun between the dam site and the confluence with the Nam Phao. Further downstream, the effect on the flows of the Nam Kading in the Nam Kading NBCA will also be influenced by the management of the Theun-Hinboun dam.

Importance of Natural Habitat Degradation to Species
As the water level in the reservoir rises or the vegetation is cleared for construction, terrestrial animals will either be forced out of their natural habitat or trapped in isolated pockets. Natural habitat degradation will have an impact on biodiversity at the community, species and genetic levels.
Using the habitat criteria for species whose niche has a river type component, the following species will be affected:
• The White-winged duck will experience fundamental niche degradation across 51% of its range on the Nakai Plateau; and
• The fish eagles, the Crested and Blythe's Kingfisher, and the River lapwing, have ranges that cover higher elevations. Degradation of their fundamental niches through inundation will be 28.8%.

Inundated Areas & Wildlife Movements
The inundation area of the Nakai Reservoir will impact both natural habitats and wildlife. Some species that habitually cross the Plateau may continue to do so after inundation. During periods when the reservoir water level is at FSL, movement will be limited to flying and swimming species. The banks are steep in this area, and there will be little change to the surface area of the islands as the water changes depth. Species able to swim, such as elephants, will be able to island hop and swim across the corridor. In periods when the reservoir water level is low, constraints on movement may possibly be similar to those experienced before the Project.
In general, the terrestrial species that use the river corridor to travel will likely find the reservoir an impediment to their movements. However, the relatively shallow slopes of the dividing hills adjacent to the reservoir are not xpected to be a major constraint to north-west/south-east movement.

White-winged Duck
The reported five to ten remaining pairs of White-winged duck select natural habitats below 600m (WCS, 1995). The length of river degradation below 600 m due to inundation totals 664,542 m. Comparing this degradation to that remaining in the NNT NBCA shows a shortfall of 27,216 m. Comparing the same degradation to just the area within the NNT NBCA, the shortfall rises to 370,535 m. This implies that the available natural habitat for the White-winged duck will decline to 30.7% of the current area when the reservoir is inundated, leaving only suitable habitat in a band between El 538 to 600m.
Considering the low population numbers of the White-winged duck, this local degradation of its fundamental niche area may not be significant. In terms of resource needs, the reduced area may be sufficient to support the current population. The issue is the viability of the remaining population and preservation of the genetic diversity they contribute to the world population. Hence, attempts should be made to increase the suitable habitats available to them.

Elephants
The Asian elephant has been identified as a species of special interest to the Project, as natural habitat degradation will be extensive for the species, and there exists a potential for increased conflict with the human population. It is the key large mammal on the Plateau, and hence the conservation of this species can ensure the conservation of other species using the same natural habitats. Current threats are from hunting and natural habitat degradation. The main Project impacts on the elephant population include further degradation of natural habitats (including critical resources such as mineral licks), increased access for poachers, disruption of movement patterns, and increased conflicts with the resident human population (which can lead to injury and death to both humans and elephants). Elephants in the northern

end of the Plateau range into the NNT NBCA and the PHP NBCA. Past experience with elephants in reservoir areas indicates that inundation may not alter habitual movements significantly, but the risk still remains that new routes may be adopted.

Creation of Habitats

The Project will create a host of habitats, primarily in the inundation zone of the Nakai Reservoir. Potentially, the habitats that will be created include:

- Lacustrine habitat of the reservoir;
- Island habitats with various forest types formed by the inundation;
- Ephemeral and permanent swamps adjacent to the reservoir;
- Smaller lakes, pools and sluggish streams created by the back water of the reservoir; and
- Mudflats and seasonal grasslands created by the annual reservoir drawdown.

The extent and connectivity of these permanent and ephemeral habitats will depend on both seasonal variations in rainfall and seasonal dynamics of inundation resulting from the operation of the Project. On an annual basis, these habitats will undergo both increases and decreases in size. There is a degree of scientific uncertainty attached to the creation and characterisation of these habitats as they have a broad possibility of becoming functional habitats supporting a wide array of both plant and animal diversity. The habitats created by the Project will take time to stabilize and support communities. Fluctuations in niche volume created by seasonal changes in reservoir level could cause a decrease in the population of some species that attempt to adapt to the new conditions. It would therefore be premature to speculate on the possible contribution of these habitats created by the Project in supporting certain communities or populations of conservation importance. The enclaves that will be created on the northeast side of the reservoir have the potential to form important habitats, such as wetlands and small lakes, for fish spawning and feeding and for other important species associated with these types of habitat. Likewise,
the suitability of the northern part of the reservoir and the northern embayments as potentially appropriate/acceptable habitats for the ducks will require investigation. The feasibility of creating slow-flowing artificial wetlands close to the existing White-winged duck habitats but above the inundation zone, is also worthy of investigation.

Area to be Protected by the Project

The principle offset for degradation of natural habitat by the Project is the financial assistance and management support for the conservation of the 338,718 ha NNT NBCA and surrounding protected areas. This management is under the control of the Nam Theun 2 Watershed Management and Protection Authority. To assist the operations of the WMPA, a management framework and detailed operational plan, the SEMFOP, has been developed. The framework and plan should ensure the long term sustainable management of the area. The Project will provide initial funding of US$ 6.6 million for activities prior to the start of Project operations, and US$ 1 million for each year of the operating phase thereafter. GOL currently has few resources to devote to the conservation and management of conservation areas.

Adequacy of Offsets

Regional & Global Significance of the NNT NBCA

The northern Annamite Mountains are of outstanding importance in terms of global and regional biodiversity. In recent years, two endemic species of ungulates have been discovered – the saola (*Pseudoryx nghetinhensis*) and the large-antlered muntjac (*Muntiacus vuquangensis*), and Heude's pig (*Sus bucculentus*), long thought to be extinct, has been rediscovered in the area (Duckworth et al., 1999). Several species of fish, mostly new to science, were considered to be endemic to the Nakai Plateau – e.g. *Scaphognathops theunensis* and *Tor ater* – but now are known to inhabit headwaters of the Nam Theun catchment outside the zone of direct impact.

The NNT NBCA, within these northern Annamite Mountains, is the largest protected area in Lao PDR and is considered one of the most important protected areas in Asia (Robichaud, 2002) and of global significance (MacKinnon, 1997). On a regional level, the NNT NBCA has the country's most important forest cover in terms of extent and quality (Berkmuller et al., 1995), and is ranked the highest overall in terms of threatened bird and mammal species (Ling,

1999).

The NNT NBCA is contiguous with the Vu Quang Nature Reserve in Vietnam. The PHP – NNT and NNT – HNN corridors link NNT NBCA with Hin Nam Nor NBCA and Phou Hin Poun NBCA respectively (Figure I.7). The proposed northern extension of the NNT would link it with the proposed Pu Mat Reserve in Vietnam. As a result of its central location, the NNT NBCA is considered a linchpin for protected area systems in the region. The NNT NBCA acts as a core through which genetic material is transported between the surrounding protected areas. Apart from the value of the varied natural habitats for species richness, the biological functions of the NNT area are assumed to regulate populations and species distribution. From a management point of view, these biological functions provide a regulating mechanism to sustain biological diversity, and in the short term prevent local extinction. Without some form of management presence to protect the NNT NBCA from unsustainable human use and natural habitat degradation, biological diversity in all the region's protected areas will experience decline.

The current threats to the NNT NBCA, highlighted earlier in this annex, will continue unless adequate resources can be made available for its management and protection. Figure I.8 shows that northern and central parts of the NNT NBCA have been disturbed, while the southern parts appear to have experienced relatively little human activity. Therefore it is imperative that successful management is implemented to prevent any further degradation of this globally significant area.

Adequacy on a Habitat Level

As Table 6 shows, with few exceptions, the areas of analogous forest and habitat type offset in the NNT NBCA significantly exceed those that will be lost as a result of the Project. In particular, the natural habitat types of dry evergreen, upper mixed deciduous, coniferous and gallery/riverine forest are fully offset by the conservation of the NNT NBCA. However, not all natural habitat types will be represented in the offset area, and of those that are,
their representation may not be equivalent to the area of impact in the Project footprint. These exceptions include swamp habitats, mixed broadleaf & coniferous, lower mixed deciduous and dry dipterocarp forest.

In terms of aquatic habitats, the NNT NBCA will protect 859 km of river with slope < 5°, compared to the 622 km of degradation due to the inundation of the reservoir. This conservation of similar habitat can be considered as an adequate offset for the degradation of aquatic habitats due to the reservoir.

Table 6 Adequacy of the NNT NBCA as an offset for Project impacts (ha)

Habitat Type	**Project Footprint**	**Project Footprint + Fragmentation**	**NNT NBCA**	**% of Immediate Area Offset in NNT NBCA**	**% of Immediate & Fragmented Areas Offset in NNT NBCA**
Dry evergreen	9,508	13,596	189,219	100	100
Upper mixed deciduous	18,450	21,689	48,513	100	100
Gallery/riverine forest	254	254	934	100	100
Coniferous forest	59	59	51,262	100	100
Non-forest	19,657	28,619	43,813	100	100
Ray	1,365	1,460	2,124	100	100
Agricultural	88	88	1,052	100	100
Urban	194	194	63	32.5	32.5
Rice paddy	8,617	11,908	1,507	17.5	12.7
Swamp	4,596	4,682	181	3.9	3.9
Mixed broadleaved &	26,972	27,217	45	0.2	0.2

coniferous					
Lower mixed deciduous	441	3,140	0	0	0
Dry dipterocarp	5,225	14,429	0	0	0
Barren land & rock	63	716	0	0	0
Water	2,535	2,535	0	0	0
Total	**98,020**	**130,586**	**338,718**		

It has already been suggested above that using the uplands area of the NNT NBCA as an offset for impacts to lowland natural habitat types means that environmental impact at the regional and national levels shall be minimal. There is potentially a significant shortfall of mixed broadleaf and coniferous forest in the NNT NBCA offset compared to the area lost from inundation. However, despite concern about the potential loss of diversity of conifers at the genetic level, the degradation of the forest community and species population is not the main issue. The greater degradation will be the environmental conditions of the river in this area that constitutes a natural habitat for a number of species, including potentially the White-winged duck. This species, if its presence is confirmed on the Nakai Plateau, has restrictive habitat preferences, and any habitat degradation would be of global significance.

Neither lower mixed deciduous nor dry dipterocarp natural habitats are represented in the NNT NBCA, and therefore the offset cannot be seen as adequate for these habitat types. However, at a national and provincial level the impact on both these natural habitats is not perceived as significant.

The decision on whether the degradation of one natural habitat area can be compensated by the conservation management of another is subjective and depends on the values assigned to the natural habitat degraded or protected. The fact that the security of the NNT NBCA has been made dependant on the Project is not
a relevant issue. What is relevant is the possible loss of biological diversity through non-effective management of the NNT NBCA in a no-Project scenario. The security of the NNT NBCA is of critical importance for regional as well as global conservation. Thus any degradation of individual natural habitat elsewhere could be outweighed by the potential gains in improved regionally and globally important biological communities in the NNT NBCA, with their endemic species. To use the White-winged duck as an example, the degradation of its fundamental niche may be potentially severe, but as it is believed that there is currently a small population, this may not be significant. All remaining individuals could be accommodated in the area available and if hunting and habitat disturbance (for this and other species) can be minimised, then it is possible that the area of realised niche can be increased even though the absolute size of the fundamental niche declines. In this way, effective land resource management can more than offset degradation.

Conclusion

Natural habitats in the Project area are currently being converted as a result of human activities. From 1973-2003, forest cover within the area of the Nakai Plateau decreased by 11% to 60% cover, and forest cover within the inundation zone decreased by 13% to 48%.

Of 130,589 ha of Project footprint that could potentially be affected, 62% will be natural habitat and the remaining 38% will be either non-forest habitat, disturbed/regenerating or unstocked forest. The major habitat degradation will be in mixed broadleaved and coniferous (20.8%), disturbed/regenerating and unstocked (20.7%) and upper mixed deciduous (16.6%) natural habitats. Other habitats that will be significantly impacted are dry dipterocarp, upper dry evergreen and rice paddy, representing 9-11% of the Project footprint.

An estimated 10,567 ha of protected area will be affected by Project activities. The majority (85%) of this area is not subject to physical land-take but indirect impacts of fragmentation or river buffer.

From a national level perspective, the degradation of natural habitat is insignificant, with the exception of swamps. The Project will encompass 10% of the national swamp area.

From a sub-national perspective the greatest impact will be on mixed broadleaved and coniferous forest and swamps, with 27% and 10% of the total habitat found in the three provinces potentially impacted. Other natural habitats that will register significant degradation at a sub-national level are gallery/riverine forest (6.2%), dry evergreen forest (3%) and coniferous forest (3.2%).

The areas of habitat types offset in the NNT NBCA significantly exceed those that would be degraded as a result of the Project. Dry evergreen, upper mixed deciduous, coniferous and gallery, gallery/riverine forests are fully offset by the conservation of the NNT NBCA. Lower mixed deciduous and dry dipterocarp natural habitats are not adequately offset by the conservation of the NNT NBCA. However, the impact on these natural habitats is not perceived as significant at either the national or provincial level.

WILDLIFE PROGRAMME

This section comes as an addition to the Wildlife Programme presented in the EAMP, under **Chapter 7**.

Institutional Responsibilities for Wildlife Programme

Overall Coordination:
Coordination for the wildlife programme will be done through the RMA and WMPA board meetings as they are comprised of the implementers of the wildlife programme (WMPA, NTPC, RMA, district authorities).

Adaptive Management:
The wildlife programme will based on an adaptive management approach that encourages proactive testing of management options which are subsequently refined and reformulated based on monitoring results. This will be done by ensuring that management plans incorporate an experimental approach and robust monitoring. The programme will also be provided a discretionary budget (US$145,000) that can be used for incremental analytical and advisory support in developing experimental approaches for adaptive management. This could for example provide ecological modeling support or expert advice from wildlife managers worldwide. The budget would be provided by NTPC to specific programmes based on a predetermined set of criteria.

Fish Impacts in Upstream and Downstream Rivers:
NTPC will be responsible for assessing the project impacts on fish in the upstream and downstream rivers and reservoir pre and post impoundment. This includes species and habitat inventories, migrations and fish productivity. For the Nam Theun downstream of the dam NTPC is responsible for undertaking riparian flow assessments, modifying habitat and implementation of the adaptive management programme in the downstream Nam Theun.

The WMPA will take over responsibility for undertaking species and habitat monitoring in the NPA and Corridors from NTPC one year after COD[1]. They will also be a member of the committee advising the adaptive management programme in the downstream Nam Theun area. In addition, WMPA will also be responsible for incorporation of patrolling, fishing restrictions and other related measures as part of their planned activities under SEMFOP. XBF fisheries migration and species will be NTPCs responsibility.

Displacement of Terrestrial Animals in the Inundation Area:
NTPC will be responsible for assessing project impacts on terrestrial animals pre and post impoundment. This includes species and habitat inventories and monitoring populations and movements. NTPC is also responsible for developing and implementing a strategy for mitigation of impacts on terrestrial animals during impoundment and operation and training WMPA in its implementation ensuring they can take over the programme one year after COD. In terms of emergency response and enforcement (including animal rescue, human-animal conflict and enforcement of hunting rules) NTPC along with local authorities will establish an emergency response team and undertake a public awareness programme in conjunction with district and provincial authorities. NTPC will work with and train district and provincial authorities, allowing them take over the role after COD.

The GoL Authority in charge of salvage logging will be in charge of developing and implementing a wildlife protection strategy in relation to the salvage logging operations in coordination with NTPC, local authorities, and WMPA.

The district and provincial authorities will work with NTPC in the emergency response and enforcement team (for conflict situations and animal rescue for elephants and other wildlife) up until after COD when they will take sole responsibility for this program.

[1] WMPA can be involved in the activities at an earlier date. They also may be allowed by NTPC to take over implementation of the programme at an earlier date if they show the willingness and ability to do so.

The WMPA will take over the post-impoundment species management plan for the NPA and Corridors one year after COD[2].

Impacts due to reservoir formation including wetland conversion and formation:
NTPC will be responsible for assessing project impacts on terrestrial animals pre and post impoundment. This includes species and habitat inventory, monitoring of populations and distribution. NTPC will also coordinate with the WMPA to develop plans for post impoundment management of wetland species and fish spawning grounds in Special Conservation Areas.

WMPA will be responsible for patrolling the Special Conservation Areas of the Reservoir pre and post impoundment. WMPA will also implement a species management programme for wetland species and fish spawning in the Special Conservation Areas starting one year after COD[3].

RMA be responsible for implementing their licensing and permitting programme, some of which have conservation implications, in the area of the reservoir outside of the Special Conservation Areas.

The programme for the White winged duck will follow a similar institutional structure as described above.

A general schedule presenting the wildlife programme in terms of activities, budget and schedule is attached.

[2] WMPA can be involved in the activities at an earlier date. They also may be allowed by NTPC to take over implementation of the programme at an earlier date if they show the willingness and ability to do so.
[3] WMPA can be involved in the activities at an earlier date. They also may be allowed by NTPC to take over implementation of the programme at an earlier date if they show the willingness and ability to do so.

		Fish impacts in Upstream and Downstream Rivers
	177,000	
	127,000	Species and habitat inventory
-		*Development of the methodology, training of LARReC staff, 1st field survey, reporting*
-		*Recurrent field surveys and reporting*
Incorporated in the TORs fisheries monitoring		Monitoring of fish productivity
Incorporated in the TORs fisheries monitoring		Fish migration studies in Nam Theun and NPA
Incorporated in the TORs fisheries monitoring		Fish migration studies in XBF
Part of the above 127,000		Nam Theun habitat and flow studies
WMPA		Incorporating river protection into the management of NNT and Corridors
50,000 studies, and construction costs		Modification of downstream NT habitat
EMO cost		Implementation of flow adaptive management program
177,000 + EMO cost + construction costs		**TOTAL**
		Displacement of Terrestrial Animals in Inundation Area
	950,000	Programme for mammal species (including Sunda Pangolin, Sun Bear, Clouded leopard, Tiger).
310,000 survey budget		Pre-impoundment species and habitat inventory of the entire NP.
Part of the 310,000 survey budget		Post-impoundment species and habitat inventory (on the non-inundated part of the NP).
240,000 management budget		Pre-impoundment monitoring of movement and distribution.
Part of the 240,000 management budget		Post-impoundment monitoring of movement and distribution.
	50,000	Development of a strategy/measures targeting wildlife for salvage logging
GOL, and part of the above 50,000		Implementation of measures during salvage logging
	250,000	Development of a transitional strategy for reservoir impoundment
Part of the above 250,000		Implementation of transitional strategy for reservoir impoundment.
Part of the 240,000 management budget		Development of a post-impoundment species management programme
Part of the above 250,000 transitional strategy budget		Training of local authorities in wildlife rescue and emergency response
Part of the above 250,000 transitional strategy budget		Establishment and implementation of an emergency response team
Part of the 240,000 management budget		Implementation of a post impoundment species management programme
		Training of WMPA.
100,000 EMU budget		Public awareness programme
	198,500	Programme specific for Asian Elephant
		Pre-impoundment inventory and survey of habitats.
		Pre and post-impoundment monitoring of movements and distribution
		Implementation of a pre-impoundment elephant management programme
		Training of local authorities in elephant rescue and conflict response
		Establishment and implementation of an elephant conflict response team
		Development of a transitional strategy for reservoir impoundment
		Implementation of a reservoir impoundment elephant management programme
		Development of a post impoundment elephant strategy
		Implementation of post impoundment elephant programme
		Impacts due to reservoir formation including wetland conversion and formation
		Programme for wetland species (including fish, birds, reptiles and mammals)
Part of the 310,000 survey budget		Pre impoundment species and habitat inventory
Part of the 240,000 management budget		Pre and post impoundment monitoring of populations and distribution
part of 100,000 budget for RMA		Post-impoundment reservoir fish productivity and species monitoring
WMPA budget		Patrolling of special conservation areas
Part of the 240,000 management budget		Development of strategy for species and habitat management after impoundment
Part of the 240,000 management budget		Implementation of habitat and species management programme
Part of the 100,000 budget for RMA		Implementation of biodiversity aspects of reservoir management plan
	150,000	Programme specific for White winged duck
		Pre-impoundment population and habitat inventory
		Pre and post impoundment monitoring of populations and distribution
		Development of WWD management programme for post impoundment
		Implementation of WWD management programme