



Sustainable Hydropower Development in the Xe Kong Basin of Lao PDR: Crafting a “Master Plan”

Scope of Work

Revised November 15, 2016

Executive Summary

Lao PDR is the nation with the most experience in hydropower development in Southeast Asia, with even larger future potential and intensions. For the future facilities, the choices regarding the siting, design and operation will be governed by the new Policy on Sustainable Hydropower Development that was decreed by the Prime Minister on January 12, 2015.

In consultation with the Ministry of Energy and Mines and other relevant agencies of the Government of Lao, the Natural Heritage Institute will produce a sustainable hydropower development “master plan” to assist and guide the Government of Lao PDR in that Policy, without sacrificing its development goals. This work is undertaken under an Operations Permit issued by the Ministry of Foreign Affairs and will be conducted under a Memorandum of Understanding with the National University of Lao and in ongoing consultation with all of the agencies of the government of Lao PDR that exercise authority over hydropower, river basin development, and fisheries administration.

In the Mekong River Basin, the principal sustainability consideration in hydropower development is the avoidance of impairment of the exceptional productivity of the Mekong fishery. Therefore, the “master plan” will take account of, but greatly improve on, the several previous hydropower development plans that have been promulgated by JICA, among others, by presenting the opportunities for:

- **siting** future hydropower dams in locations that do not inundate or block fish passage into the habitats that are most valuable for migratory fish breeding and rearing;
- **designing** the dams to efficiently pass sediments and nutrients; and
- **operating** the dams to maintain a semblance of the natural flow patterns, including the seasonal variability of flows, to enable the fish to access and use the high-value riverine and floodplain habitats.

In this way, the sustainable hydropower development “master plan” will position the Government of Lao to take a proactive role in deciding in advance the locations, designs and

operations of projects for which it will accept competitive applications from investors to conduct feasibility studies, environmental impact assessments, and proposals for concession agreements. That plan can then also serve as an exemplar and template for sustainable development that can be applied in the rest of the country, throughout the Mekong Basin, and in the rest of the world.

Today, the mainstream of the Xe Kong tributary is the last undeveloped major tributary in the Mekong River Basin, and its natural function remain unimpaired down the mainstream Mekong, through the Cambodian floodplains and the Tonle Sap Great Lake, through the Vietnam Delta, to the South China Sea. The lower reach of the Xe Kong River is characterized by a high level of fish biodiversity, amounting to 175 species, including 64 migratory fish species. Fifteen species are exclusive to the Xe Kong River; they are neither found in any other Mekong River tributary nor anywhere else in the world. Many of these species must migrate upstream to spawning areas. Completing these migrations require unobstructed passage upstream, as well as the capacity for adults, larvae and juveniles to migrate or drift downstream.

The 3-S portion of the basin is the most important for migratory fish propagation and sediment and nutrient contributions. The Xe Kong migration corridor is utilized by a great diversity of fish species, many of high commercial importance. This fishery is important for food security and livelihoods of many people, often the rural poor, living in Lao PDR and the downstream riparian nations. This fishery is also a major source of income and a significant economic driver in these nations. Any significant declines in catch because of loss of connectivity to upstream refuge and breeding sites will have major social and economic impacts. Between 40 and 70% of the catch is dependent on fish species that migrate long distances along the Mekong River mainstream and into its tributaries (Barlow et al. 2008). The livelihood benefit of the resource, in terms of nutrition, income and employment, is crucial, particularly for rural poor, who have few other livelihood options.

If fish passage in all three of the 3-S tributaries were obstructed by dams, this would potentially lead to a reduction of catches of around 13-14%. The Se San and Sre Pok Rivers have already been intensively developed in Vietnam, and Lower Se San 2 dam is also under construction at the confluence of Se San and Sre Pok Rivers in Cambodia. Only the main stream of the Xe Kong River remains in a natural flow condition. Maintaining its extraordinary natural values while accommodating hydropower production goals is therefore the most important challenge that the Government of Lao PDR faces today in implementing its Policy on Sustainable Hydropower Development.

There are currently 7 hydropower dam sites on the mainstream Xe Kong that are being actively studied for feasibility under current Memoranda of Understanding issued by the Ministry of Planning and Investment. The degree of impact that these dams and reservoirs would cause to migratory fish, due to both the barrier they pose to fish migration and to the inundation of riverine spawning habitats, depends on their size and, most important, their location. The further downstream the dam, the more impactful it would be. But all of the lowest six are located right in the prime migratory fish spawning habitat of the mainstream river. These would provide an absolute barrier to fish migration as it is not feasible to engineer fish by-passes around these large dams, and each would create impoundments that would inundate these habitats. The combined effect would be to turn what is now a river ecosystem into a series of lakes which would not sustain the hundreds of migratory species that require these habitats to survive. The lowermost dam in the cascade is the most imminent to receive a construction authorization. It would block off the entire Xe Kong basin within Lao, including some of the prime tributaries for migratory fish. It would generate only 76 MW of power but

would be highly impactful. Fish passes around the dam would not mitigate these impacts as it is the reservoir itself that would cause the most damage to fish passage and reproduction.

There is little doubt that these dams cannot satisfy the Policy on Sustainable Hydropower Development as sustainability as the environmental impact assessments that have already been prepared for two of these dams make indisputable. The benefit of the “master plan” for developers and government regulators alike will be to deflect time, money and efforts away from these unsustainable dams to more suitable sites located in the areas of the watershed that are not accessible to migratory fish. A sustainable hydropower “master plan” for the Xe Kong will locate the dams at sites that do not inundate or block fish passage into the habitats that are most valuable for migratory fish breeding and rearing; design the dams to efficiently pass sediments and nutrients; and operate the dams to maintain enough natural variability of flow patterns to enable the fish to access the high-value habitats. A major accomplishment of this study is to identify those sites, and show how hydropower dams at those sites can be designed and operated to be sustainable. In sum, this is a project to demonstrate what sustainable hydropower development means and how to implement it.

The logic of the “master plan” is that future hydropower dams should be built above natural or artificial barriers to upstream fish migration. Those are the areas of the Xe Kong watershed that are upstream of existing dams. The hydropower site suitability survey that the NHI team has conducted so far has reached the following tentative conclusions:

- 1) The suitable additional sites are on tributaries rather than on the mainstream of the Xe Kong.
- 2) These sites must not be located within National Biodiversity Conservation Areas. There are three such areas in the basin that pose limitations on eligible sites: (i) The Xe Xap NBCA on the north side of the Xe Kong mainstream above the # 5 dam site and running to the Vietnam border, (ii) the Dong Ampham on the south side of the Xe Kaman tributary, and (iii) the Xe Pian NBCA on the north side of the Cambodian border reach of the Xe Kong.
- 3) The Houay Axam is a substantial tributary to the upper Xe Kong, above the # 5 dam site, flowing south to north with the confluence near the village of Amoy Kong. There is one promising new dam site on this tributary that could substitute for Xe Kong # 5.
- 4) In the reach of the Xe Kaman tributary above its lowermost dam, there are four potential dam new dam sites that are not already under study by developers that also have potential. The watershed of the Xe Kaman tributary above the Xekaman Sanxay dam, currently under construction, is also inaccessible to migratory fish. This dam and Xekaman #1 are much too high for fish by-pass facilities to be feasible. Therefore, the reaches of the Xe Kaman tributary 56 kilometers upstream of the confluence with the Xe Kong River will be blocked to upstream migration.
- 5) In the Nam Kong tributary, there is an additional site that is already under investigation above the existing dam, Nam Kong # 2. That additional site (Nam Kong # 3) likely can satisfy sustainability criteria. However, there are no additional or new sites that seem promising above Nam Kong # 2.
- 6) Aggregating the power potential of the 5 potential new sites that have been identified, roughly 460 MW of new power sites could be developed. This compares to

approximately 1000 MW of power from the 7 mainstream dams that are not sustainable and would not be included in the Master Plan.

It now appears unlikely that there is enough potential for new and sustainable hydropower within the Xe Kong basin alone to substitute for the entire power potential from the 7 sites on the mainstream Xe Kong. (On the other hand, it seems unlikely that all 7 of these sites will emerge from the ongoing feasibility studies). Therefore, NHI has expanded the scope of the analysis to also assess the potential for sustainable hydropower sites in nine other major river basins of Lao (not including the mainstream Mekong) above existing or under-construction dams. These are portions of the catchments which are already inaccessible to migratory fish, due to the existence of these dams.

These watersheds are as follows:

- 1) Nam Kading (Nam Theun 1 being built by Phonesack Group—33 km from confluence, 600MW)
- 2) Nam Gniep (two dams already constructed, one under construction, 3 more with MoUs)
- 3) Nam Leuk (one dam already constructed)
- 4) Nam Ngum (two large dams already constructed, 2 more being built)
- 5) Nam Lik (one dam already constructed)
- 6) Nam Khan (one dam already constructed, one under construction)
- 7) Nam Ou (#2 already constructed, # 6 and #7 under construction, 4 more planned)
- 8) Nam Nga (one under construction)
- 9) Nam Tha (one built, one under construction)

As there are a substantial number of hydropower projects already being investigated in these watersheds, these will be examined to determine whether the project is viable, whether it is being actively pursued, whether it is indeed “sustainable” with respect to avoidance of impacts on critical habitat for resident (non-migratory) endemic species, whether it can be designed to flush sediments and nutrients, and whether it can be operated (in conjunction with the rest of the dams in the cascade) to avoid flow alterations into the downstream river system. Projects that are deemed to satisfy the sustainability criteria will be included in the master plan. In a subsequent task, the team will investigate potential additional sites in the same catchment areas, looking at topographic, hydrologic and geologic characteristics.

For each of the alternative dams identified in the siting analysis, the study will assess how these dams might be designed to facilitate the passage of sediments and nutrients. This is often referred to as a policy of “transparent dams”. The incorporation of low level gates to permit flushing and/or sluicing of sediment is one essential factor. The size, shape and geometry of the reservoir are the others.

Hydropower dams in the “master plan” will be sited upstream of the high value habitats for migratory fish reproduction. Yet they can still have a deleterious effect if they distort the flow pattern in a manner that makes that habitat inaccessible or unusable. The most serious concern is that these dams may reduce the peak flows that inundate the floodplains and spawning gravels and vegetation in the river channel, or eliminate the riffles that occur at the lower flow levels under natural conditions. Some distortion is probably inevitable. The study will ascertain the thresholds of tolerance of flow distortion for the migratory species. The study will assess alternative scenarios for coordinated operations of these dams to maintain a downstream flow pattern that will enable the migratory fish to access and use the prime spawning and rearing habitats. The desired pattern will resemble the natural flow regime in

terms of timing, duration and magnitude of high and low flows as closely as possible. The analysis that must be conducted to determine operational parameters is often referred to as “environmental flow requirements”.

Work Plan

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| TASK 1: | Summarize and advance the current state of knowledge on fish migration behavior in the Xe Kong Basin |
| TASK 2: | Conduct a Workshop of Xe Kong Migratory Fish Experts to Vet Results of Task 1 Research |
| TASK 3: | Conduct Hydropower Site Suitability Analysis in the Areas of the Xe Kong Watershed above Barriers to Migration |
| Task 4: | Investigate the Status of Hydropower Dam Sites in Other Lao River Basins |
| Task 5: | Survey Potential Additional Hydropower Sites Above Existing or Under-Construction Dams in the Other Mekong Tributary Watersheds |
| TASK 6: | Assessment of Impacts on Critical Habitat for Endemic Non-Migratory (Resident) Fish Species from Potential Dam Sites |
| Task 7: | Design and Operational Analysis for Sediment Discharge for the Dams in the Master Plan (Currently Planned and Potential additional Dams) |
| TASK 8: | Setting Environmental Flow Targets To Afford Access To Prime Migratory Fish Spawning And Rearing Habitats |
| TASK 9: | Cost/Benefit Analysis |
| TASK 10: | Outreach to Hydropower Developers, Investors, and Customers |
| Task 11: | Draft a Hydropower Development “Master Plan” for the Xe Kong Basin |
| TASK 12: | Draft a Cumulative and Transboundary Environmental Impact Assessment of the “Master Plan” and of the current development plans and compare the two |
| TASK 13: | Draft an Implementation Plan for the Hydropower Development “Master Plan” |
| TASK 14: | Conduct Public Workshop to Vet Hydropower Development Master Plan and Implementation Plan |
| TASK 15: | Present Hydropower Development Master Plan and Implementation Plan to Ministry of Energy and Mines and Other Responsible Ministries and Agencies of the Government of Lao PDR |

Purpose and Approach: To Assist the Government of Lao PDR to Implement its Policy on Sustainable Hydropower

Lao PDR is now the most experienced nation in Southeast Asia in hydropower development. At present, 21 hydropower dams larger than 15 MW are operating, and 26 more are under construction. For these facilities, irreversible choices regarding siting and design have already been made; only the operations can be altered. Yet there are about 85 additional hydropower facilities larger than 15 MW that have been approved or are being planned and studied (www.poweringprogress.org/new/power-projects, updated June 9, 2015). As to all of the potential future facilities, the choices regarding the siting, design and operation are not final and remain open for further review by the Government of Lao PDR (GoL).

In consultation with the Ministry of Energy and Mines (MEM), the Ministry of Planning and Investment (MPI), and other relevant ministries and agencies of the Government of Lao, the Natural Heritage Institute (NHI) is undertaking to produce a “master plan” for future hydropower development to assist and guide the Government of Lao PDR in implementing the Policy on Sustainable Hydropower Development that was decreed by the Prime Minister on January 12, 2015. NHI has been charged by these agencies to create for their consideration a hydropower development “master plan” based on the core principles of sustainable hydropower development. This work is undertaken under an Operations Permit issued by the Ministry of Foreign Affairs and will be conducted under a Memorandum of Understanding with the National University of Lao (NUoL) and in ongoing consultation with all of the agencies of the government of Lao PDR that exercise authority over hydropower, river basin development, and fisheries administration.

Implementing the Policy on Sustainable Hydropower Development of Lao PDR

The 12 January 2015 Decree of the Prime Minister, promulgating the Policy on Sustainable Hydropower Development in Lao PDR, commands the several Ministries with authority over hydropower development to:

- Ensure that potential negative impacts on the environment and social system are prevented or mitigated (Article 4);
- Require hydropower project developers to prevent and mitigate any potential risks to natural resources and the environment in the design, construction and operation stages (Article 6, page 4);
- Require all hydropower projects to undertake a comprehensive Environmental and Social Impact Assessment. For any project with large transboundary impacts, the EIA shall include a cumulative and transboundary impact assessment (Article 7, page 4);
- Avoid and mitigate as much as possible losses to natural conserved habitat areas (Article 11, page 5).

This policy builds on the National Policy on Environmental and Social Sustainability of the Hydropower Sector in Lao PDR (June 7, 2005), in which the government of Lao PDR proclaims that hydropower development must be sustainable if its potential to deliver lasting benefits is to be fully realized and that ecological sustainability depends upon the avoidance of irreversible environmental impacts such as the loss of biodiversity or disruption of ecological cycles.

In the Mekong River Basin, the principal sustainability consideration in hydropower development is the avoidance of impairment of the exceptional productivity of the Mekong fishery, which is at risk when dams are built unless they are **sited, designed and operated** to maintain:

- (1) The passage of migratory fish both upstream and downstream, and the free-flowing conditions of their spawning and rearing habitats, so that they can complete their life-cycle;
- (2) The natural variability in the flow patterns that connect the river to its floodplains and provide the cues for fish migrations;
- (3) The flows of the sediment and associated nutrients that sustain the morphology and habitats downstream of the dams.

What Does “Sustainable” Hydropower Mean Functionally?

In sum, the functional definition of sustainable hydropower is simply the siting, design and operation of hydropower dams to avoid or counteract the three principle physical impairments that dams cause to the natural processes of rivers that sustain its living elements. This can be illustrated by the following chart:

Primary Considerations for Sustainable Hydropower:

Counteract impacts→→ Aspects of project ↓↓↓	Barrier to migratory fish & Innundation of habitat	Trapping of sediments and nutrients	Alteration of natural flows
Siting	Above existing barriers to migration Avoid inundation of critical habitat for endemic native species	Deeper canyons in headwaters	Re-regulation of altered flows for hydropeaking at or below terminal dam
Design	Fish pass facilities, low-impact turbines, fish screens	Low level or radial gates for discharge	Low capacity factors of powerplant to accommodate variable discharges; Pumped storage
Operation	Maintain minimum velocities through reservoirs to maintain larval drift	Flushing, sluicing, density current discharges	Run of River operations

The study will assess opportunities for:

- **siting** future hydropower dams in locations that do not inundate or block fish passage into the habitats that are most valuable for migratory fish breeding and rearing;
- **designing** the dams to efficiently pass sediments and nutrients; and
- **operating** the dams to maintain a semblance of the natural flow patterns, including the seasonal variability of flows, to enable the fish to access and use the high-value riverine and floodplain habitats.

The resulting sustainable hydropower development “master plan” will approximate the hydropower production of the current proposals while still maintaining the social and environmental benefits of a healthy fishery, and will do so with financial costs attractive to potential investors and power customers.

How the Master Plan Improves Upon Previous Development Plans

There have been a series of hydropower development plan prepared for the Mekong River basin by outside experts over the years, starting as long ago as 1955 by the US Bureau of Reclamation, and soon thereafter, the UN sponsored “Wheeler Report” carried out by the U.S. Army Corps of Engineers and then the 1962 Ford Foundation Report. More recently, each of the successive Mekong River Basin organs (the Mekong River Committee, then the Interim Mekong Committee, followed by the Mekong River Commission) have issued several “indicative studies” and “basin development plans”, all of which targeted the portion of the river basin within Lao PDR for the most intensive development due to its conducive topography and abundant and well-watered river basins.

The first hydropower development study to focus specifically on in the Xe Kong basin in Lao PDR was the 1995 “Master Plan Study on Hydroelectric Power Development in the Se Kong Basin”, prepared by the Japanese International Development Agency (JICA). The Xenamnoi dams, the Xekaman # 1, and Xe Kong #4 dams were specifically featured. Of these, the first is operating, the second has just been constructed, and the third is still being planned. Notably, this study did not consider any of the sustainability considerations for hydropower described above. It devotes just sentence to the impacts on migratory fish, less than a page to sediment disruption, and actually concludes that the flow alterations will be beneficial. In 1999, the Asian Development Bank produced a hydropower development study that included the Xe Kong basin that ranked potential projects on factors that included social and environmental impacts. But this study also made no attempt to describe sustainable alternatives.

The “master plan” that NHI has been charged to produce will take account of, but greatly improve on, these earlier efforts. Specifically, it will explicate how the hydropower development goals for the Xe Kong basin can be met through alternatives that implement the government’s policy on sustainable hydropower development, as defined above.

How the Master Plan Will Reposition the Government of Lao PDR in the Hydropower Development Process

The general trajectory for hydropower development in Lao PDR is that the projects are initiated by foreign investors, sometimes with a Lao public or private equity stake, and proposed to the Lao Government for its consent. Application is made to the Ministry of Planning and Investment for a Memorandum of Understanding conferring exclusive rights to conduct a feasibility study, which is then submitted to the Ministry of Energy and Mines for review of the technical and financial merits. Importantly, these MoU’s do not commit the Government of Lao PDR to permit the construction of the facility or to any of its siting, design or operational details. The MoUs require the developer to conduct an environmental impact assessment, which is submitted to the Ministry of Natural Resources and Environment (MONRE) for review. If MoNRE determines that the assessment complies with the procedural requirements, it issues a Certificate of Compliance. The developer then applies to MEM for a concession agreement to build, own and operate the hydropower plant. These agreements last for approximately 25 years, at which point the projects may be transferred to the government of Lao PDR. In the main, the projects will export the power to foreign power companies in Thailand and Vietnam,

subject to power purchase agreements that provide a revenue stream that guarantees a rate of return to the investors. Notably, the role of the Lao Government in this process is entirely reactive. The siting, design and operations are proposed by the developers, who perform the feasibility analysis, the financial analysis, and the environmental impact assessments, all with little or no substantive oversight by the government agencies, which generally lack the technical expertise to perform an independent review.

This project to create a “master plan” for sustainable hydropower development will reverse that trajectory, starting with the Xe Kong basin. It will position the Government of Lao to take a proactive role in deciding in advance the locations, designs and operations of projects for which it will accept competitive applications from investors to conduct feasibility studies, environmental impact assessments, and proposals for concession agreements. The “master plan” can advertise to potential investors the type of hydropower projects that the Government of Lao wishes to consider and can guide the terms of the concession agreements to outside investors and power purchasers. This will position Lao PDR to be the master of its own house in the economic development of its portion of the Mekong River System. That plan can then also serve as an exemplar and template for sustainable development that can be applied in the rest of the country, throughout the Mekong Basin, and in the rest of the world.

Why Focus on the Xe Kong Sub-Basin?

Today, the mainstream of the Xe Kong tributary is the last undeveloped major tributary in the Mekong River Basin, and its natural function remain intact all the way from the headwaters at the Vietnam border through southern Laos to the confluence with the mainstream Mekong.¹ From there the River flows unimpaired down the mainstream Mekong, through the Cambodian floodplains and the Tonle Sap Great Lake, through the Vietnam Delta, to the South China Sea.² The rest of the basin has already been fundamentally altered by the seven mainstream dams in the Lancang headwaters in China, with two mainstream dams to be commissioned by Lao PDR above the Khone Falls; and by the pervasive siting of dams on all the other major tributaries. The Lower Se San 2 dam in Cambodia will block passage of migratory fish into the Sre Pok and Se San tributaries, leaving only the main stem of the Xe Kong River unimpeded.

In the context of the development that has already occurred, the Xe Kong River is by far the most important portion of the Mekong River system for unimpaired flow, sediment and nutrient contributions³, and sustaining migratory fish. Indeed, it is accurate to state that the Xe

¹ The Xe Kong River originates on the Vietnam side of the border, where it is called the A Sap. A diversion dam was constructed for hydropower generation in this reach that diverts most of the flow to a powerhouse located in the Bo River basin. However, this facility is so high in the catchment that it does not significantly affect the flows in the Lao portion of the river.

² The only downstream obstruction in prospect is the Sambor hydropower dam on the mainstream Mekong in Cambodia. This dam would be built in a migratory fish corridor that carries the greatest density of adult fish and larvae on the planet. As originally proposed, the dam would destroy the Mekong migratory fishery. Fortunately, an alternative that would leave channels of the river unobstructed is being assessed by NHI under an agreement with the Royal Government of Cambodia that is likely to be adopted instead. That will keep the river free-flowing from the Xe Kong headwaters to the South China Sea.

³ By one estimate, nearly 10% of the sediment and nutrient load of the entire system comes from the Xe Kong. Sediment and nutrient passage in this tributary will have the greatest benefit for the continued productivity of

Kong is the most productive portion of the river that produces the most fish for human consumption in the entire world. Maintaining its extraordinary natural values in the face of impending hydropower development is therefore the most important challenge that the Government of Lao PDR faces today in implementing its Policy on Sustainable Hydropower Development.

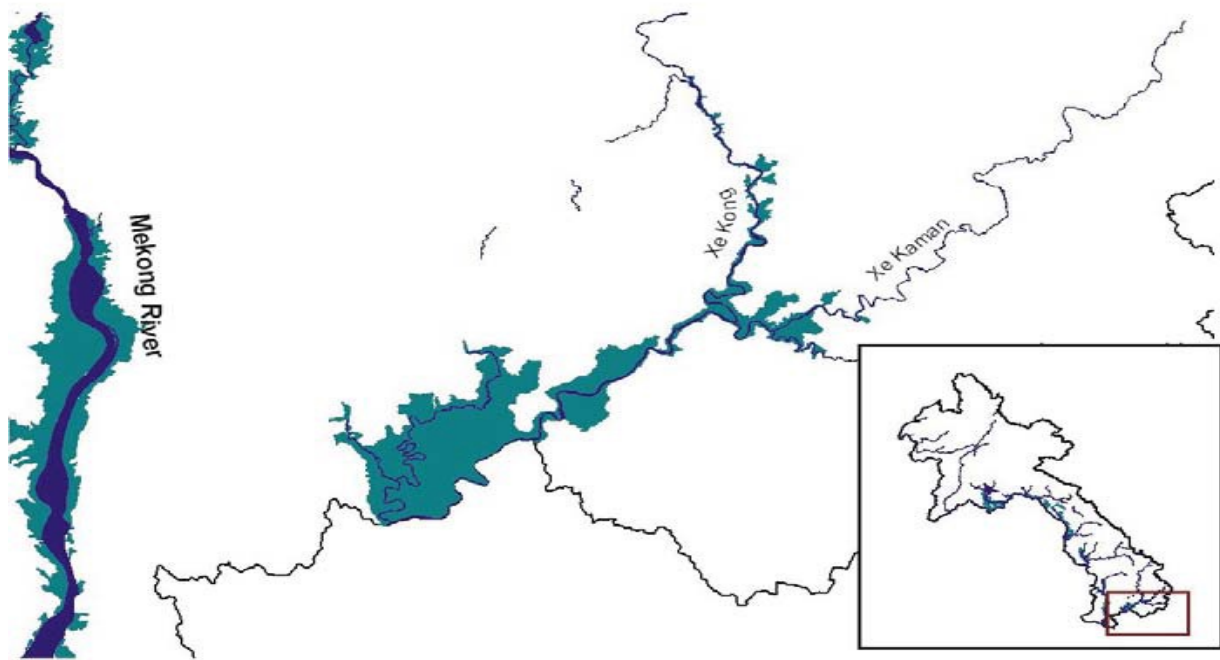
Topographical Characteristics of the Xe Kong River Basin

The Xe Kong River basin is characterised by a diverse range of topographical features ranging from mountainous to flat terrain. The fast flowing streams in the north are characterised by rocky reaches creating rapids interspersed by deep pools. In the reach downstream of the proposed Xe Kong 5 dam site there are 14 sets of rapids and 18 deep pools. The southern lower reaches (Attapeu Region) are broad floodplain areas (134 km downstream of Xe Kong 5 Dam site) characterized by slower flowing water, sandy substrate, few rapids and deep pools. Below the confluence with the Xe Kaman River, the river flows through a wide floodplain with few rapids and 8 deep pools.

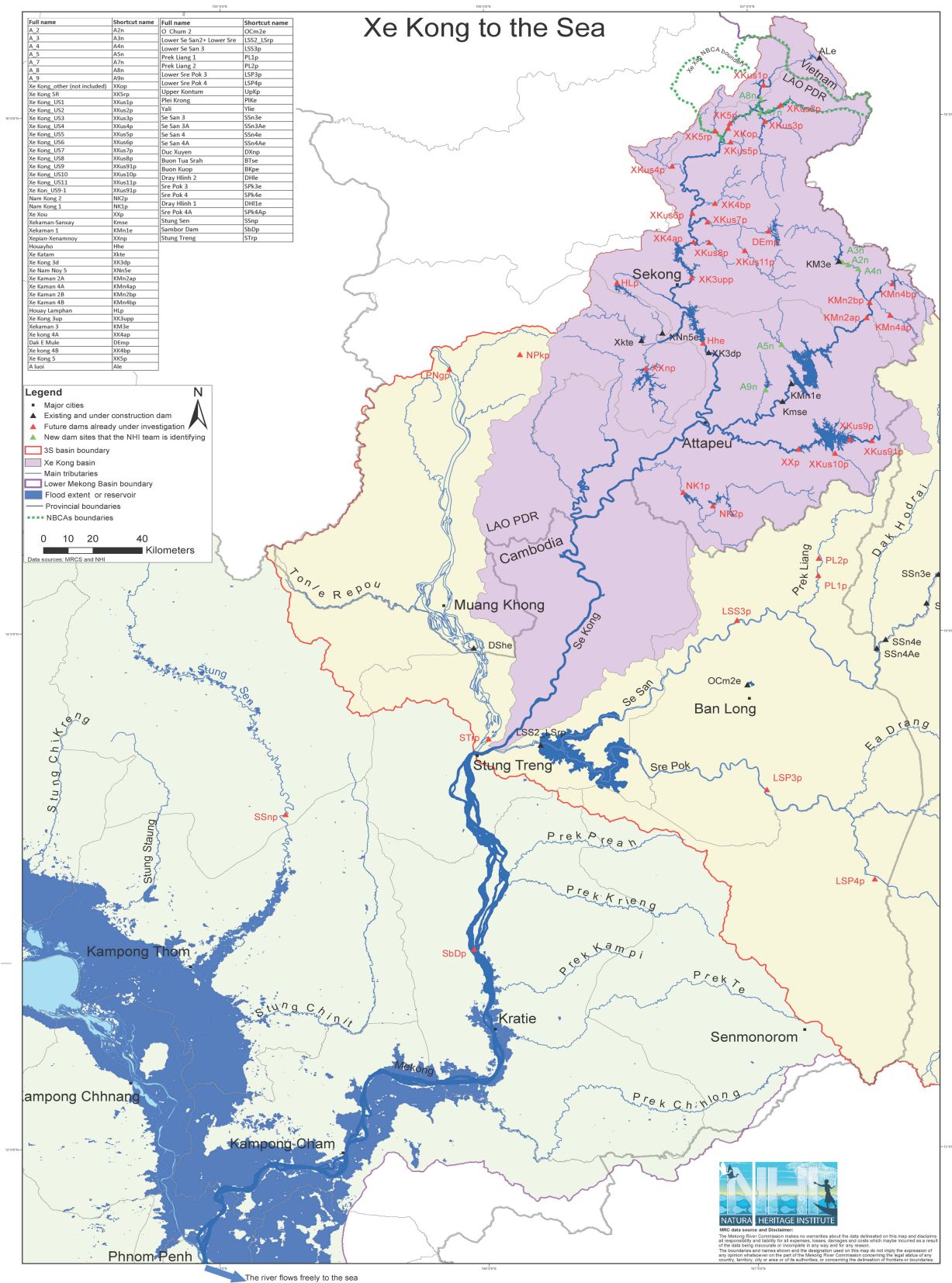
The Xe Kong River's floodplain habitat is believed to be one of the key factors contributing to its impressive fish productivity and diversity (Welcomme 1995). Conserving this habitat is essential for protecting biodiversity and providing food security for rural households. Floodplains are unquestionably the engine of high fish production and rich biodiversity, and serve important ecological roles for the entire river basin.

The floodplain area of the Xe Kong River is substantial (see **Error! Reference source not found.** for extent in Xe Kong and Xe Kaman River, Attapeu Province) and likely a major contributor to fish production. It consists of seasonal and permanent wetlands, streams, forests, grasslands and rice paddies. High water levels during the rainy season provide a food-rich environment for spawning fish as well as productive soil for the cultivation of rice and other cash crops. Many fish species that spawn on the floodplain migrate seasonally over long distances into the headwaters of the river system (Poulsen and Viravong 2001), suggesting that vigorous floodplain habitat has biological and socio-economic benefits for both upstream and downstream communities. These floodplains support a significant fishery for both local and national demand.

the Tonle Sap in Cambodia and the delta in Vietnam because there are no downstream dams to capture these materials. The habitats that are nourished by these materials from the Xe Kong produce the fish that migrate back up into this system to the great benefit of everyone, including the people of Lao PDR.



Extent of floodplains of the Xe Kong and Xe Kaman rivers - Attapeu Province (Source Mollot et al. 2003)



Importance of the Xe Kong for Production of Migratory Fish

The lower reach of the Xe Kong River is characterized by a high level of fish biodiversity, amounting to 175 species, including 64 migratory fish species. Fifteen species are exclusive to the Xe Kong River; they are neither found in any other Mekong River tributary nor anywhere else in the world. Many of these species exhibit complex life cycles that involve migration between different areas of the river, particularly upstream migration to spawning areas. Completing these migrations require unobstructed passage upstream, as well as the capacity for adults, larvae and juveniles to migrate or drift downstream.

At least one third of Mekong fish species migrate between downstream floodplains where they feed and upstream tributaries where they breed. The Se San and Sre Pok Rivers have already been intensively developed in Vietnam, and Lower Se San 2 dam is also under construction at the confluence of Se San and Sre Pok Rivers in Cambodia. Only the main stream of the Xe Kong River remains free flowing. If fish passage in all three of the 3-S tributaries were obstructed by dams, this would potentially lead to a reduction of catches of around 13-14%. Importantly, it will restrict access of migratory fishes to the tributaries of 3-S, which are known to be essential to the recruitment in the Cambodian floodplain and delta region. Therefore, Xe Kong River is the most important remaining habitat for migratory fish species in the Mekong River system as a whole.

The timing of the upstream and downstream migrations varies depending on fish life cycles with the various species utilising different components of the hydrograph for both upstream and downstream migration. Studies indicate continuous spawning, peaking during the spring (February-March) and the onset of the flood (June-July) and, finally, when the water recedes (November). Many of the abundant species found in the lowlands of the Mekong River system spawn around the beginning of the flood season. Flood-related spawning results in the fish larvae and fry growing at a favorable time, when aquatic habitat expands and zooplankton (the essential food for most fish larvae) is plentiful. Eggs and larval life stages drift downstream to recolonize/restock the lower Cambodian floodplain and delta at all times of the year. Therefore, upstream and downstream migration must be maintained throughout the year if the fisheries are not to be compromised.

There has been no ichthyologic work conducted in the drainage until recently and little has been published on the specific fish fauna of the Xe Kong River or their spawning requirements. As one work element in the joint study plan, the existing state of knowledge will be summarized, the critical knowledge gaps identified, and a program of research to address these gaps will be launched.

The economic value of the Mekong fishery in Lao PDR, Cambodia and Vietnam is the highest in the world and would be substantially compromised if all of the 3-S (Se San, Sre Pok and Xe Kong Rivers) tributaries are developed for hydropower (WFC). Overall, consumption of fish and other aquatic animals (OAAs) in the Lower Mekong Basin is estimated at about 2.8-3.2 million tons per year, and about one million tons of aquatic products are exported from the basin each year. At the current price (i.e., USD \$ 1-1.80/kg) the total value of the fishery is about US\$ 3.7 to 7.0 billion per year. Additionally, its value should be judged by its replacement cost, profitability, contribution to food security and to nutrition (MRC, 2010). Fisheries supply 49-82% of the animal protein consumed in the Lower Mekong Basin. Average per capita consumption of fish products in Lao PDR is estimated to be 43 kg/capita/year.

The importance of fisheries to livelihoods in the Xe Kong River is documented by rural appraisal studies carried out on the floodplain (Mollott *et al.* 2005). The Xe Kong migration corridor is utilized by a great diversity of fish species, many of high commercial importance.

This fishery is important for food security and livelihoods of many people, often the rural poor, living in Lao PDR and the downstream riparian nations. This fishery is also a major source of income and a significant economic driver in these nations. Any significant declines in catch because of loss of connectivity to upstream refuge and breeding sites will have major social and economic impacts. Between 40 and 70% of the catch is dependent on fish species that migrate long distances along the Mekong River mainstream and into its tributaries (Barlow et al. 2008). The livelihood benefit of the resource, in terms of nutrition, income and employment, is crucial, particularly for rural poor, who have few other livelihood options.

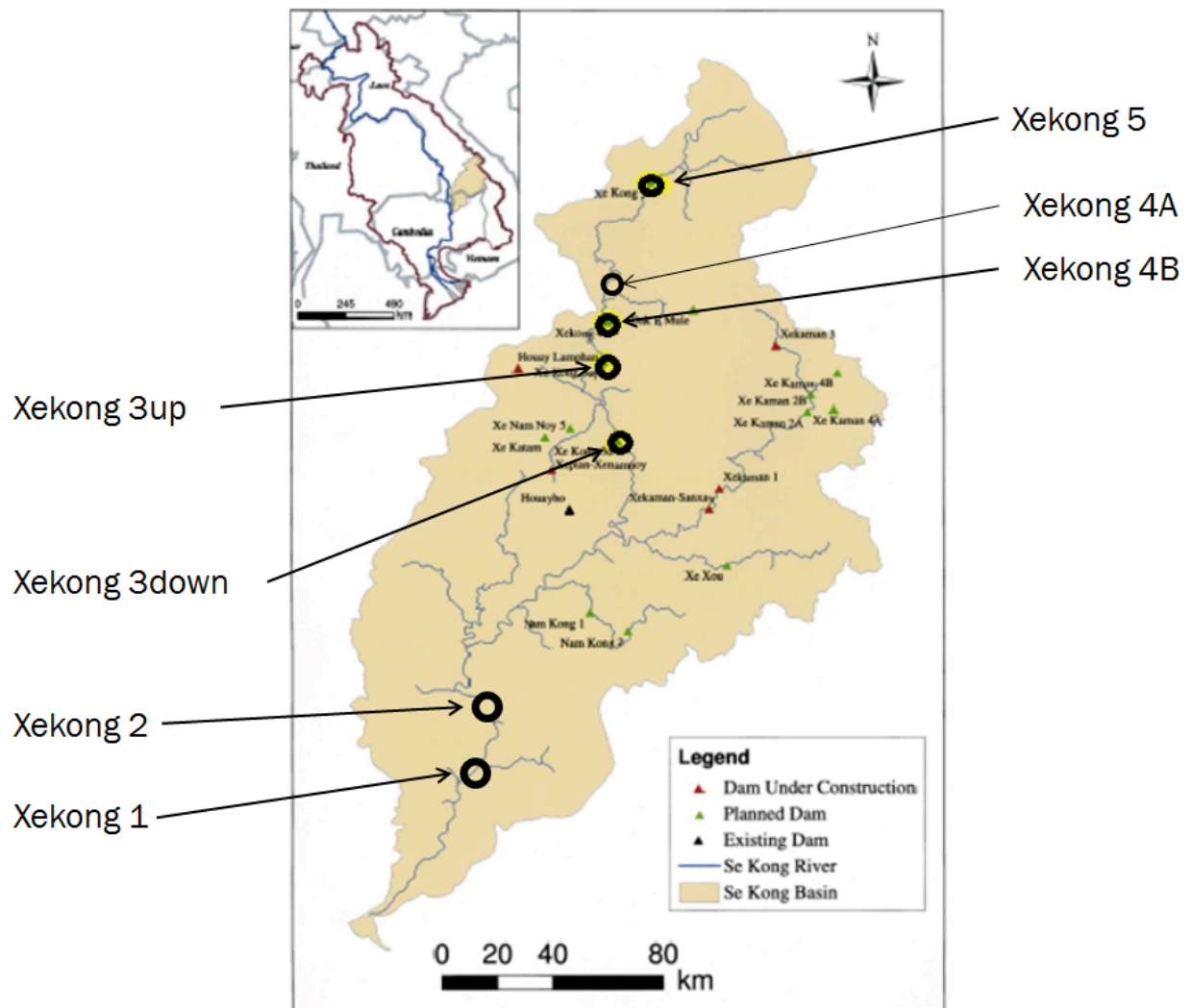
On September 26 and 27, 2016, this project convened a technical workshop of the international and Laotian experts on the migratory fishery of the Xe Kong basin. The findings and conclusions from the workshop will constitute the scientific foundation on which the sustainable hydropower master plan will be erected. The major findings and conclusions that will shape that master plan are as follows:

- The Xe Kong tributary and mainstream Mekong downstream from the confluence constitutes the most productive portion of the Mekong freshwater fishery. Because the Xe Kong is the last major tributary of the Mekong that provides free passage of fish from headwaters to the sea, this corridor constitutes a valuable and irreplaceable element of the Mekong river for migratory fish populations.
- The upper catchment of the Xe Kong is more important for biodiversity; the lower catchment is more important for biomass. Management strategies may vary depending on the desired balance between conserving biomass and biodiversity.
- Many species migrate upstream to spawn and feed at the beginning of the wet season, with intense spawning from this time to the peak of the wet season. Fish migrate to refuges in deep pools toward the end of the wet season. Most of the Xe Kong species which are important for human consumption follow this pattern.
- Even if all seven dams proposed for the Xe Kong mainstream were to be built to the MRC standard of “providing safe passage for 95% of the target species under all flow conditions.” which represents best global practice, the cumulative effect would still be a major reduction in both biomass and species diversity.
- The reservoir impacts cannot be avoided or mitigated to a significant extent. These are of five types:
 - I. The reduction in flowing water habitats for spawning.
 - II. The inundation of rearing habitats.
 - III. The mortality of eggs and larvae in the static waters of the reservoirs.
 - IV. Water quality changes, caused by seasonal stratification and consequent anoxia of lower water levels.
 - V. Changes in species composition and effects on the food chain.

- In theory, it is possible to operate the reservoir to maintain a sufficient velocity of flow to maintain hydraulics and to transport the larvae all the way to the point of discharge through the spillways and turbines before they perish from lack of nutrition. However, these operations will affect power generation and revenues, posing a direct trade-off between fishery maintenance and hydropower objectives.
- The most critical time when larval drift through the reservoirs may be problematic is during the early wet season when a large volume of spawning takes place but the river flows are not yet high enough to provide the needed reservoir velocities.
- Artificial propagation of fish by means of aquaculture in the reservoir does not replace the species, productivity, or livelihoods that are lost when the natural capture fishery is impaired by the construction of dams.
- Fish farming generally entails different and generally lower value species; substantial reduction in fish diversity; different capital, ownership and marketing structures; and different skills requirement than those possessed by the natural capture fishers.
- Any mainstream dams in the Xe Kong should be operated to discharge a flow pattern that is conducive to the requirements of migratory and resident fish, often referred to as **“environmental flow requirements”**. The objective is to maintain much of the natural seasonal variability of flows and temperature, especially avoiding large hourly or daily fluctuations in flow. This may require discharge buffering and re-regulation of flows below the reservoir.

Impact of Hydropower Schemes on Migratory Fish in the Xe Kong Basin

There are currently 7 hydropower dam sites on the mainstream Xe Kong that are being actively studied for feasibility under current Memoranda of Understanding issued by the Ministry of Planning and Investment. The approximate locations are shown on the map below:



The degree of impact that these dams and reservoirs would cause to migratory fish, due to both the barrier they pose to fish migration and to the inundation of riverine spawning habitats, depends on their size and, most important, their location. The further downstream the dam, the more impactful it would be. Thus, Xe Kong 1 and 2 would be the least sustainable. But all of the lowest six are located right in the prime migratory fish spawning habitat of the mainstream river. These would provide an absolute barrier to fish migration as it is not feasible to engineer fish by-passes around these large dams, and each would create impoundments that would inundate these habitats. The combined effect would be to turn what is now a river ecosystem into a series of lakes which would not sustain the hundreds of migratory species that require these habitats to survive. The lowermost dam in the cascade is the most imminent to receive a construction authorization. It would block off the entire Xe Kong basin within Lao, including some of the prime tributaries for migratory fish. It would generate only 76 MW of power but would be highly impactful. Fish passes around the dam would not mitigate these impacts as it is the reservoir itself that would cause the most damage to fish passage and reproduction.

Xe Kong # 5 is also problematic. Until the NHI migratory fish experts made an epic journey to the reach of the river just below the dam site, it was not known for certain whether the site was accessible to migratory fish, due to a reputed waterfall (Tat Kalang). This is now

unambiguously resolved. The reputed waterfall is just a series of rapids that drop only about 6 meters in total. The NHI team clearly ascertained that this reach is navigable by migratory fish and discovered at least 10 migratory species above the rapids in the catch of the local fishers. What is not known definitively is the abundance of and total number of migratory species that access the reaches above dam site # 5 for spawning and rearing. Because the reach above the dam site all the way to the Vietnam border is essentially inaccessible by either road or river, and is devoid of fishing activity, it is not feasible to ascertain the extent of degree of fish migration above the # 5 dam site.

The Xe Kong migratory fish experts workshop found that the Xe Kong #5 dam will inundate much longer reaches of the river and will also back water up into Xe Xet NBCA. Given these considerations, the precautionary principle suggests that it would be prudent to investigate alternative dam sites. NHI's site suitability analyses suggest that the Houay Axam site may constitute a feasible alternative site off of the mainstream. Yet, given the paucity of information regarding endemic fish species in the upper Xe Kong, there is not a sufficient basis at this time for determining which of these sites would cause the least impact on biodiversity.

There is little doubt that the lower six dams, and also likely #, cannot satisfy the Policy on Sustainable Hydropower Development as sustainability is defined in this study. Indeed, the two environmental impact assessments that have already been prepared for two of these dams make that indisputable.

The EIA for # 4 states:

- "Most of the 201 species of fish recorded in the Mekong mainstream at Khone Falls will be present in the Se Kong, and some estimates put the fish diversity at between 300 and 500 species" P. 0-8
- "In Se Kong Province almost every household is engaged in fishing activities both for subsistence and for income generation...All villages in the reservoir flooding area have robust fisheries primarily for subsistence, contributing a large part of the protein in their diet. . . . Migratory fish make up over 70% of the fish caught in the Mekong river basin." P. 0-8
- "There will be a major impact upon migratory fish species, both by blocking upstream migrations, but also by delaying migration triggers such as early flood events." P. 0-13.
- "Initial estimates put the current production of fish and OAAs at about 10,000 tons per year, of which migratory fish make up 71%. With the Se Kong 4 dam in place . . . the reduction in catch may be as much as 3,300 tons a year, with a value of USD 6.25 million." P. 0-14
- Changes in the flow regime will have a major negative impact on migratory fish species." P. 4-9

The EIA for Xe Kong # 5 is equally unambiguous:

- “The fish fauna will become significantly impoverished, perhaps losing as much as 2/3 of the fish species currently found there, and all fish migration from downstream will cease.” P. 0-8

If anything, the 5 dams proposed for the lower sites would be even more impactful. If the standard of “sustainability” is implemented in a meaningful way, these dams clearly do not qualify.

The benefit of the “master plan” for developers and government regulators alike will be to deflect time, money and efforts away from these unsustainable dams to more suitable sites located in the areas of the watershed that are not accessible to migratory fish. A sustainable hydropower “master plan” for the Xe Kong will locate the dams at sites that do not inundate or block fish passage into the habitats that are most valuable for migratory fish breeding and rearing; design the dams to efficiently pass sediments and nutrients; and operate the dams to maintain enough natural variability of flow patterns to enable the fish to access the high-value habitats. A major accomplishment of this study is to identify those sites, and show how hydropower dams at those sites can be designed and operated to be sustainable. In sum, this is a project to demonstrate what sustainable hydropower development means and how to implement it.

Siting Opportunities for Sustainable Hydropower:

The logic of the “master plan” is that future hydropower dams should be built above natural or artificial barriers to upstream fish migration. Those are the areas of the Xe Kong watershed that are upstream of water falls or existing dams. Now that we know that the Tat Kalang “waterfall” on the mainstream Xe Kong is nothing of the sort, the “master plan” will concentrate the sustainable hydropower dams off of the mainstream Xe Kong.

The hydropower site suitability survey that the NHI team has conducted so far has reached the following tentative conclusions:

- 1) The suitable additional sites are on tributaries rather than on the mainstream of the Xe Kong.
- 2) These sites must not be located within National Biodiversity Conservation Areas (NBCAs). There are three such areas in the basin that pose limitations on eligible sites: (i) The Xe Xap NBCA on the north side of the Xe Kong mainstream above the # 5 dam site and running to the Vietnam border, (ii) the Dong Ampham on the south side of the Xe Kaman tributary, and (iii) the Xe Pian NBCA on the north side of the Cambodian border reach of the Xe Kong.
- 3) The Houay Axam is a substantial tributary to the upper Xe Kong, above the # 5 dam site, flowing south to north with the confluence near the village of Amoy Kong. There is one promising new dam site on this tributary that could substitute for Xe Kong # 5.
- 4) In the reach of the Xe Kaman tributary above its lowermost dam, there are four potential new dam sites that are not already under study by developers that also have potential. The watershed of the Xe Kaman tributary above the Xekaman Sanxay dam, currently under construction, is also inaccessible to migratory fish. This dam and Xekaman #1 are much too high for fish by-pass facilities to be feasible. Therefore, the reaches of the Xe

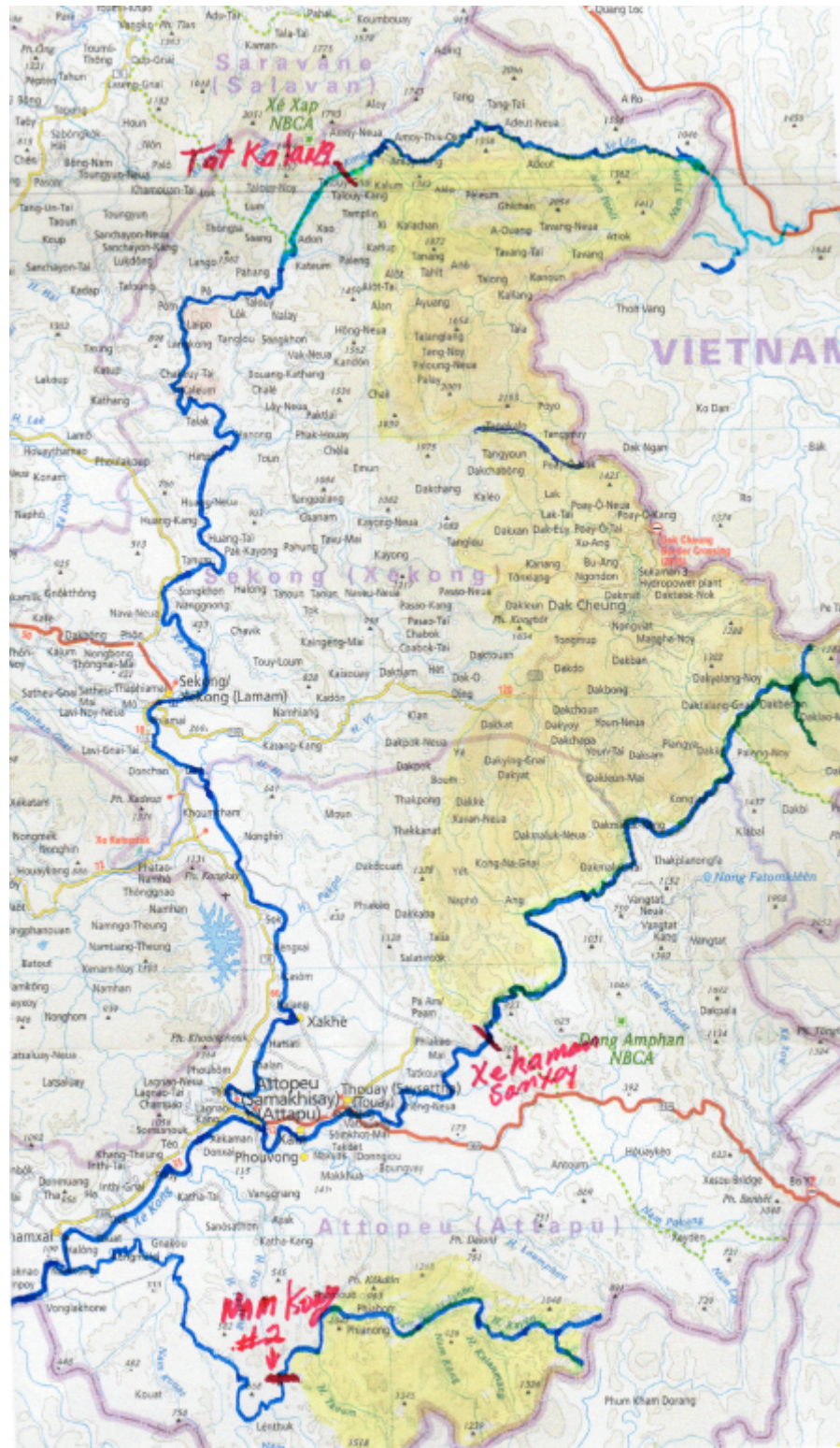
Kaman tributary 56 kilometers upstream of the confluence with the Xe Kong River will be blocked to upstream migration.

- 5) In the Nam Kong tributary, there is an additional site that is already under investigation above the existing dam, Nam Kong # 2. That additional site (Nam Kong # 3) likely can satisfy sustainability criteria. However, there are no additional or new sites that seem promising above Nam Kong # 2.
- 6) Aggregating the power potential of the 5 potential new sites that have been identified, roughly 460 MW of new power sites could be developed. This compares to approximately 1000 MW of power from the 7 mainstream dams that are not sustainable and would not be included in the Master Plan.

The eligible areas surveyed by the NHI team for suitable additions hydropower sites are shown on the map below:

Candidate Watersheds

- Upstream of Xe Kong #5
- North of Xe Kaman
- Upstream of Nam Kong 2



The results of the survey of sites warranting further investigation is presented in the table below:

	POTENTIALLY VIABLE				
Item	A_1	A_2	A_3	A_4	A_7*
Status	NEW	NEW	NEW	NEW	NEW
(Lat. /Long.)	15°26.17'N 107°20.2'E	15.422460N 107.371350E	15.432067N 107.349212E	15.406373N 107.408824E	16.014786N 107.044092E
Province	Xe Kong	Xe Kong	Xe Kong	Xe Kong	Xe Kong
River	Xe Kaman	Xe Kaman	Xe Kaman	Xe Kaman	Houay Axam
Installed capacity (MW)	250	10	10	12	177
Simulated power output (MWh/yr)	885980*	35521*	34724*	39521*	517846*
Rated head (m)	520	20	20	20	231
Design discharge (m3/s)	62.3	51.4	50.5	62.8	78.2
Full supply level (m)	960	760	860	420	566
Catchment area (km2)	712	686	673	841	784
Mean annual flow (m3/s)	26.6	34	34	42	39
Total reservoir volume (mill m3)	141.5				

*Subject to refinement through elevation-volume curves for the sites, optimization modeling of the sites as a network, accounting for storage operations, sequencing of reservoirs, and and cumulative hydrologic/sediment impacts.

One objective of the “master plan” is to approximate the hydropower production of the current proposals while still maintaining the social and environmental benefits of a healthy fishery. It now appears unlikely that the NHI team can find enough potential for new and sustainable hydropower within the Xe Kong basin alone to substitute for the entire ~ 1000 MW potential from the 7 sites on the mainstream Xe Kong. (On the other hand, it seems unlikely that all 7 of these sites will emerge from the ongoing feasibility studies). Therefore, NHI has expanded the scope of the analysis to also assess the potential for sustainable hydropower sites in the other major river basins of Lao PDR (not including the mainstream Mekong) above existing or under-construction dams. These are portions of the catchments which are already

inaccessible to migratory fish, due to the existence of these dams.

Candidate Watersheds

→Nam Gniep	(3 existing, 3 MoU)
→Nam Leuk	(1 existing)
→Nam Ngum	(4 existing)
→Nam Lik	(1 existing)
→Nam Khan	(2 existing)
→Nam Ou	(3 existing, 4 planned)
→Nam Nga	(1 existing)
→Nam Tha	(2 existing)
→Nam Pha	1 MoU)

We note that there are already a large number of such projects that are already planned, approved, or being investigated in these watersheds. Therefore, the immediate task is to examine those sites to determine whether the project is viable, whether it is being actively pursued, whether it is indeed “sustainable” with respect to avoidance of impacts on critical habitat for resident (non-migratory) endemic species, whether it can be designed to flush sediments and nutrients, and whether it can be operated (in conjunction with the rest of the dams in the cascade) to avoid flow alterations into the downstream river system. Projects that are deemed to satisfy the sustainability criteria will be included in the master plan. In a subsequent task, the team will investigate potential additional sites in the same catchment areas, looking at topographic, hydrologic and geologic characteristics.

Nam Ngiap Basin

No.	Project Name	Basin	District	Province	Install Capacity (MW)	Annual Capacity (GWh)	Commence	Project Developer(s)	Supply
6	Nam Phouan	Nam Ngiap	Hoom	Xaisomboun	52.8	202.5	2019	Velcan Energy (France) / ECI	Signed PDA on 23/5/2014, on procedure of CA negotiation
7	Nam Pot	Nam Ngiap	Phaxay	Xiengkhuang	15	70.5		ACE Consultant	Signed PDA on 5/6/2012
8	Nam Ngaip-2C	Nam Ngaip	Khoun	Xiengkhuang	45	230	2021	Nonghai Group Co., Ltd	Signed SHOA on 23/4/2013, waiting for approval on electric current price

Nam Ngum Basin

No.	Project Name	Basin	District	Province	Install Capacity (MW)	Annual Capacity (GWh)	Commence	Project Developer(s)	Supply
14	Nam Bak-1	Nam Ngum	Xaisomboun	Vientiane	160	744	2019	Southeast Asia Energy Co., Ltd.	Signed MOU on 11/4/2007, 1 st extended until 3/6/2009

15	Nam Ngum-1 (ext, phase II)	Nam Ngum	Keoudom	Vientiane	40		2018	EDL (Japan govt loan)	EDL in procedure of selecting contractor
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Nam Ou Basin

No.	Project Name	Basin	District	Province	Install Capacity (MW)	Annual Capacity (GWh)	Commence	Project Developer(s)	Supply
6	Nam Phak-2	Nam Ou	Lar	Oudomxai	28	106.5	2020	Sahamit Phattana Company	Signed MOU on 23/5/2014, signed PDA on 10/09/2015
7	Nam Phak-3	Nam Ou	Lar	Oudomxai	40	152	2020	Sahamit Phattana Company	Signed MOU on 23/5/2014, signed PDA on 10/09/2015
8	Nam Nga- 1	Nam Ou	Nam Bak	Luangphabang	53.7	298	2020	Duangchaluen Construction	Signed MOU on 11/4/2012, 1 st extended until 10/10/2013
9	Nam Boun-2	Nam Ou	Bountai	Phongsali	15	85	2017	Hi-Engineering Company	

10	Nam Lang	Nam Ou	Phongsali	Phongsali	60	227		Venture Capital and Equipment Inc.,(Vietnam)	Signed PDA on 24/10/2014
11	Nam Ou-3	Nam Ou	Ngoi	Luangphabang	210	826	2020	Sinohydro Corporation Ltd and China National.	Master Agreement signed 11/04/2011
12	Nam Ou-4	Nam Ou	Kua	Phongsali	132	519	2020	Sinohydro Corporation Ltd and China National.	Master Agreement signed 11/04/2011
13	Nam Ou-7	Nam Ou	Phongsali	Phongsali	210	838	2020	Sinohydro Corporation Ltd and China National.	Master Agreement signed 11/04/2011
14	Nam Ou-1	Nam Ou	Pak Ou	Luangphabang	180	710	2021	Sinohydro Corporation Ltd and China National.	Master Agreement signed 11/04/2011

Proposed
Completed FS
Ongoing FS

Design Alternatives:

For each of the alternative dams identified in the siting analysis, the study will assess how these dams might be designed to facilitate the passage of sediments and nutrients. This is often referred to as a policy of “transparent dams”. The incorporation of low level gates to permit flushing and/or sluicing of sediment is one essential factor. The size, shape and geometry of the reservoir are the others.

Operational Alternatives:

Hydropower dams in the “master plan” will be sited upstream of the high value habitats for migratory fish reproduction. Yet they can still have a deleterious effect if they distort the flow pattern in a manner that makes that habitat inaccessible or unusable. The most serious concern is that these dams may reduce the peak flows that inundate the floodplains and spawning gravels and vegetation in the river channel, or eliminate the riffles that occur at the lower flow levels under natural conditions. Some distortion is probably inevitable. The study will ascertain the thresholds of tolerance of flow distortion for the migratory species. The study will assess alternative scenarios for coordinated operations of these dams to maintain a downstream flow pattern that will enable the migratory fish to access and use the prime spawning and rearing habitats. The desired pattern will resemble the natural flow regime in terms of timing, duration and magnitude of high and low flows as closely as possible. The analysis that must be conducted to determine operational parameters is often referred to as “environmental flow requirements”.

In assessing operational alternatives that will maintain the natural flood regime of the river, it is also imperative to consider how the flood events can be controlled to prevent property damage and loss of life from extreme events. The towns of Se Kong and Attapeu, as well as the smaller villages downstream from the Xe Kaman confluence, may be at risk. Therefore, the joint plan of study will model operational alternatives to determine the options that are most compatible with the needs of the migratory fish and that will also avoid flood damage risks.

Work Plan

TASK 1: Summarize and advance the current state of knowledge on fish migration behavior in the Xe Kong Basin

This task has been completed. The following reports have been produced:

- Summary of the data and findings on hydrology and fisheries in the Mekong system from data that has been collected over many years by the MRC Secretariat but not formerly compiled, processed and interpreted. Two reports have now been completed except for a distillation of the ramifications for of this analysis for migratory fish behavior in the Xe Kong basin.

- Synthesis of information in other reports on the Xe Kong fishery, including those from Kottelat, Baird and Meynell, and the information that can be gleaned from the Environmental Impact Assessments for the Xe Kong # 5 and # 4 dams.
- Table displaying results of exhaustive literature review and data mining of all sources in English and Lao of information on 50 of the most important commercially valuable migratory fish species that are found in the Xe Kong basin. Enter this information into a table that will afford easy access to the results. This is being conducted under contract with the National University of Lao and by NHI project experts.
- Report on field survey of fish catch at the villages between Kaleum Ferry and the village of Laipo. This is the reach of the river that is virtually unknown. Below this reach, the MRCS data is reasonably complete. Above this reach in the vicinity of the # 5 damsite, the project team has already gathered and reported on a field tour that resolves the issue of the passability of the headwaters for migratory fish and the existence of such species. Above the reach surveyed, the river is inaccessible and there is no fishing activity up to the Vietnam border. Interviews of fisherman were conducted at three villages to augment the information regarding what species are caught in what abundance in what parts of the river at what times. The tour included experts from the NHI team, the National University of Lao, the Provincial and Kaleum District Offices of Agriculture and Forestry.
- Report on zonation modeling to determine the sections of the river used by various species. The Statistical Package for Social Science will be used for this task.

TASK 2: Conduct a Workshop of Xe Kong Migratory Fish Experts to Vet Results of Task 1 Research

This task has been completed. The Findings and Conclusions are attached to this Scope of Work and are summarized in the section on Importance of the Xe Kong for Production of Migratory Fish. They will constitute the scientific basis on which the sustainable hydropower development master plan for the basin will be erected.

TASK 3: Conduct Hydropower Site Suitability Analysis in the Areas of the Xe Kong Watershed above Barriers to Migration

Task 3.1: Consider all the currently proposed hydropower dam sites in the Xe Kong basin and identify those that are above barriers and will be included in the master plan.

This task has been completed

Task 3.2: Conduct a survey of site suitability for hydropower dams in the following areas (above the barriers to migration):

- The Houay Axam tributary in the headwaters above dam site # 5. Tributaries on the north side of the Xe Kong will not be considered as they are within the Xe Xap NBCA.

- Above Xe Kaman Sanxoy on the mainstream Xe Kaman and the tributaries flowing from the north and west (not within the Dong Amplian NBCA)
- The entire Nam Kong sub-basin above Nam Kong # 2 dam
- Streams flowing off of the Bolvean Plateau that are not already developed.

These sites will be identified based on suitable topography, geology and hydrology. This work has been completed for all of the bullets except the last one with respect to topography and geology, the hydrologic modeling using the fully calibrated SWAT model is now underway.

Complete by September 30, 2016

Task 3.3: Evaluate potential for redesign of Xe Kaman 2B and 4B projects for reconfiguration to increase hydropower production potential (a potential increase of 70 MW).

This task has been completed.

Task 4: Investigate the Status of Hydropower Dam Sites in Other Lao River Basins

This task will investigate sites that have been studied under MoUs issued by the Ministry of Planning and Investment, and that are above dams already existing or under construction, in the following river basins that are large enough for hydropower dams of substantial scale:

Nam Ngiap
Nam Ngum
Nam Ou

There are 10 dam sites in these basins that have been previously studied. In this Task, the team will determine which of these are likely feasible and should therefore be examined to see whether they meet sustainability criteria and should be included in the master plan.

This task will be completed by March 1, 2017

Task 5: Survey Potential Additional Hydropower Sites Above Existing or Under-Construction Dams in the Following Watersheds:

Nam Kading (Nam Theun # 1, under construction)
Nam Gniep (two dams already constructed, one under construction, 3 more with MoUs)
Nam Leuk (one dam already constructed)
Nam Ngum (two large dams already constructed, 2 more being built)
Nam Lik (one dam already constructed)
Nam Khan (one dam already constructed, one under construction)
Nam Ou (#2 already constructed, # 6 and #7 under construction, 4 more planned)

Nam Nga (one under construction)
Nam Tha (one built, one under construction)

Site suitability will be determined from data on topography (using the LiDAR generated maps from the Lao Department of Geography) hydrology and geology.

Complete by March 1, 2017

TASK 6: Assessment of Impacts on Critical Habitat for Endemic Non-Migratory (Resident) Fish Species from Potential Dam Sites

To be environmentally sustainable, hydropower dams should avoid impacts on not only on migratory species but also inundation of, and flow distortions through, critical habitats for endemic non-migratory species. The upper catchments of the already-developed watersheds in Lao PDR are known to be rich in biodiversity of aquatic species. Therefore, the NHI team will gather all available data regarding fish assemblages in the habitat areas that would be inundated by the reservoirs of the dam sites identified in Tasks 3, 4 & 5 to determine whether these include critical habitats for endemic species. We expect the data to come primarily from the environmental impact assessment for hydropower and other development projects, perhaps supplemented by fisher catch surveys conducted by the master plan study. However, the study does not have the time or resources to conduct original fish surveys.

Complete by March 1, 2017

Task 7: Design and Operational Analysis for Sediment Discharge for the Dams That Will Be Included In the Master Plan (Currently Planned and Potential Additional Dams)

Only future dams will be evaluated for design improvements to enable sediment management, including drawdown flushing or sluicing. The key considerations are installation of low- and mid-level gates, reservoir length and geometry, sediment and water inflow, and operational policies. The new RESCON2 software developed for the World Bank will be used to assess the sediment management options.

Proposed dams located upstream of existing dams may not require sediment passage because the existing dams do not have the capability to pass sediment (e.g., Xekaman Sanxoy, Xekaman # 1, Nam Kong # 2).

Complete by March 1, 2017

TASK 8: Setting Environmental Flow Targets To Afford Access To Prime Migratory Fish Spawning And Rearing Habitats.

All dam sites judged to be “sustainable” and therefore included in the Master Plan will be above existing dams. Therefore, their operation will not distort the flow regime in the river reaches accessible to migratory fish. Those flows will be controlled, and can be re-regulated by the terminal dam in each of the tributaries.

The Master Plan will assess the operational protocols for the dams it includes that are necessary to prevent impacts on critical habitats of endemic species identified in Task 6.

It will also prescribe operational protocols for the terminal dams necessary to prevent adverse impacts on spawning habitats for migratory fish in the downstream river. In effect, these dams may need to operate somewhat as re-regulation dams to counteract the flow distortions caused by the upstream dams. A team of migratory fish habitat experts will determine the tolerance for hydrologic change for a representative suite of migratory species. On this basis, environmental flow prescriptions will be developed for the floodplain areas of the mainstream Xe Kong below the confluence with the Xe Kaman, and for the mainstream Mekong below the terminal dams in the other watersheds, to the extent necessary. However, since the fraction of flow contributed to the mainstream Mekong from these tributaries is quite small, the distortions may not have an appreciable impact.

Environmental flow prescriptions will also be established for the 56 km of the Xe Kaman below Xekaman Sanxay and the Nam Kong below Nam Kong # 2.

Complete by March 31, 2017

TASK 9: Cost/Benefit Analysis

The cost per kilowatt hour for the Master Plan will be estimated and compared to the dams proposed for the mainstream Xe Kong

Complete by March 31, 2017

TASK 10: Conduct Process of Outreach to Hydropower Developers, Investors, and Customers

The Master Plan will make recommendations regarding which potential future hydropower projects should be judged to satisfy the Policy on Sustainable Hydropower, and should therefore be encouraged and invited, and those that do not. NHI wishes to enroll the developers themselves in this process and obtain their concurrence in the outcomes. The Master Plan will provide a rational, defensible and predictable roadmap for hydropower development that will take much of the risk out of the process for developers, investors and customers. It will, in effect, illuminate the best opportunities and also the undesirable options. The expectation is that the latter will be replaced by the former in a manner that meets the needs and expectation of all stakeholders.

To this end, NHI will engage in a process of outreach and communication with the developers, investors and customers that are already undertaking plans and studies, and others that may wish to do so. This process is already underway and will continue through the final preparation of the Master Plan and Implementation Plan.

Complete by May 31, 2017

Task 11: Draft a Hydropower Development “Master Plan” for the Xe Kong Basin

Complete by April 30, 2017

TASK 12: Draft a Cumulative and Transboundary Environmental Impact Assessment of the “Master Plan” and of the current development plans and compare the two.

Complete by May 31, 2017

TASK 13: Draft an Implementation Plan for the Hydropower Development “Master Plan”

Complete by May 31, 2017

TASK 14: Conduct Public Workshop to Vet Hydropower Development Master Plan and Implementation Plan

Complete by June 15, 2017

TASK 15: Present Hydropower Development Master Plan and Implementation Plan to Ministry of Energy and Mines and Other Responsible Ministries and Agencies of the Government of Lao PDR

Many agencies of the Government of Lao PDR have responsibilities for implementing various aspects of the Master Plan and Implementation Plan, including principally the Ministry of Energy and Mines and the Ministry of Planning and Investment. A table of the role these entities are playing in the development of these Plans is set forth below:

Role of Lao National Government Agencies:

Agency	Ministry	Role	Legal Status
Department of International Organizations	Ministry of Foreign Affairs	Permit issuance	Operations Permit has been issued
Department of Energy Policy and Planning	Ministry of Energy and Mines	Involved since inception—project designed in close consultation,	Draft MoU pending

Department of Investment Promotion	Ministry of Planning and Investment	Very supportive	Review and comment on products
National University of Lao	Ministry of Education	Lead role in literature review, organizing workshop of foreign and local experts on Xekong fishery	MoU and contract in process
Living Aquatic Resources Research Center	Ministry of Agriculture and Forestry	Field investigation and interviews of fishermen	Sub-grant agreement negotiated. Awaiting formal invitation from NUoL or MEM
Department of Livestock and Fisheries	Ministry of Agriculture and Forestry	Peer review, training in use of models	Consultative
Department of Environment Impact Assessment	Ministry of Environment and Natural Resources	Sustainability review, strategic environmental assessment, protected lands administration	Consultative
Department of Agriculture and Forestry	Sekong Province	Field investigation	Permissions from national parent agency obtained
Department of Planning and Investment	Sekong Province	Consultation and review, provide update information on small hydro schemes	Permissions from national parent agency not required

Department of Agriculture and Forestry	Attapeu Province	Field investigation; Very supportive	Permissions from national parent agency obtained
Department of Planning and Investment	Attapeu Province	Consultation and review , provide update information on small hydro schemes	Permissions from national parent agency not required

A final round of briefings will be provided for each of these institutions to present the findings and recommendations.

Complete by June 30, 2017