Review of the Ch. Karnchang Public Company Limited Environmental Impact Assessment (EIA)

Xayaburi Hydroelectric Power Project, Lao PDR

Prepared by Team Consulting Engineering and Management Company, Limited

August 2010

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April, 2011

Summary Finding: The Xayaburi Hydroelectric Power Project Environmental Impact Assessment (EIA) fails to address many important aspects of the proposed modification of the natural flow regime of the Mekong River and the consequences of the modified flow on the river at three locations: upstream, at the dam site, and downstream from the proposed site. The EIA is punctuated by a lack of clarity, includes many contradictory statements, and is not acceptable from a technical standpoint. In my experience an EIA of this quality would not be considered acceptable in the US or many other jurisdictions. The EIA is of such poor quality that it seems highly irresponsible that it is being offered to support the first dam proposed for the lower Mekong mainstream.

There are two major flaws in the EIA that need to be addressed. First, the EIA is incomplete and oversimplifies the dam's impacts on ecological resources, including water quality, aquatic ecology, fisheries and public health. The EIA is notable for the essential information *not* included in the report and the important environmental questions *not* addressed.

Second, the EIA is based on the assumption that changing the natural flow regime of the Mekong River with a *run of the river barrage* will not seriously damage the river's ecological integrity as long as some flow is allowed. The EIA further suggests the *run of the river barrage* will enhance the natural flow by changing the residency time and velocity of water flowing during the dry season. However, current ecological knowledge on the Mekong River clearly indicates that the opposite is true. The EIA does not demonstrate an understanding of how rivers function and is focused on the amount of water flowing as a single dimension of the Mekong River ecology.

Hydrobiology

Two important factors that are certain about river discharge and flow that are not addressed in the EIA follow: 1. Rivers are naturally irregular, 2. Any regularity of flow pattern is largely a statistical phenomenon (Hynes, 1970). Regulating flow with a *run of the river barrage* as proposed in the Xayaburi project will change the flow velocity and the natural diurnal variations in flow and seriously damage critical biological habitat, water quality, sedimentation dynamics, and the biological food web that is the foundation of the Mekong River's ecological resources and ecosystem services. One major concern is the alteration of flows that can negatively impact the rapids and pools that provide essential habitat for fish, macroinvertebrates, and other important organisms in the Mekong River food web. Many species of fish and macroinvertebrates that are a major source of food for fish are adapted to the differences in discharge and flow velocity naturally occurring during different periods of the year.

Both unaddressed factors are significantly magnified by the fact that the EIA fails to address the proposed project in the context of increasing global concern about climate change and its effects on weather patterns, the hydrologic cycle, diminishing ecosystem services, and the increasing scarcity of sustainable water resources.

Section 4.1.2.1 Introduction (pg 4-11) of the EIA clearly acknowledges the fact that "The development of the Xayaburi Hydroelectric Power Project by storing and regulating its flows for electric generating will inevitably cause significant change in the original surface water flow condition." The proposed alteration/elimination of the natural dry season low flow conditions is of particular concern and will result in negative impacts to the ecosystem's natural annual dry-rainy season dynamics. Although the increased volume of flow (approximately 1,000-1,200 m^3/s) arriving at the proposed Xayaburi dam site is the result of the regulation of upstream Chinese dams (i.e. the Xiaowan and Nuozhadu projects), the operation of the Xayaburi project will substantially reduce the velocity of that water from about 0.9 m/s to 0.1m/s and negatively impact the river ecology. The reduction of the natural fast flows in the river resulting from the Xayaburi dam operation should be carefully considered and added as an essential part of the EIA.

The "significant change" in the natural flow regime proposed in the project EIA will most certainly cause a cascade of negative environmental impacts including water quality degradation, loss of biodiversity, diminished ecosystem services and a degradation of public health. Given the importance of a proposal for the first dam on the Mekong mainstream, it would seem prudent to require that the EIA include appropriate Environmental Flow Assessments (EFA) as part of the study protocol.

Specific findings are as follows:

Under Construction Period it is stated that "Increasing amount of water for living of aquatic organism causing positive impact to aquatic ecology." This statement is a recurring theme in the EIA (see also pg 5-11 5.2.1 Fisheries, Aquaculture, and Aquatic Ecology) and identifies a very serious lack of understanding of basic river ecology and fisheries biology on the part of the EIA authors.

Changing the natural flow regime of the Mekong River by artificially increasing the amount of water during the dry season and, therefore, disturbing normal sedimentation patterns can be an ecological tipping point that will have very serious effects on the aquatic food web and the environmental stability of the river ecosystem (Sabo, et al., 2010; Lanza, 2010; Taylor et al., 2006; Poff et al., 1997). Many species of fish and other aquatic organisms are dependent on diurnal and seasonal flow patterns for their migrations, reproduction, and food supply.

Artificially increasing the amount of water during the dry season will subject fish and other aquatic organisms to longer periods of exposure to toxic chemicals including pesticides (e.g. DDT residuals from malaria control, PCB's from industrial wastes), and metal contaminants (e.g. lead and zinc) arriving from riparian zone mines along the Mekong (Lancang) in China (CIIS, 2002; Monirith, 1999). Toxicity can be strongly influenced by both the total amount of potentially harmful chemicals and the exposure time of organisms to the chemicals. Increasing the amount of chemically contaminated water for longer time periods due to decreased flow velocity could increase toxicity to fish and other aquatic biota.

The hydrological and climatological data provided (pg 4-12 and 4-13 Table 4.1.2.1; Figures 4.1.2-3 and 4.1.2-4) are inadequate and limited to records ending in 2008. The EIA does not address potential climate change events that could have major hydrological and climatological impacts on the proposed project. The hydrological and climatological data in the EIA should be updated and reflect current conditions.

For example, changing the flow patterns will alter the distribution of the natural sediment particle size array along the river. That change will then produce a cascade of negative impacts on the sediment architecture that provides the physical and chemical habitat essential for the survival of all major components of the aquatic food web from microorganisms to fish.

Changes in sediment particle size distribution affect both nutrient and contaminant availability from suspended materials and sediments and can result in negative impacts on river chemistry and ecology. For example, the normal stoichiometry of the primary nutrients that regulate phytoplankton growth at the base of the food web (i.e. ratios of nitrogen and phosphorus) are influenced by nutrient exchanges between sediment particles and water.

Changes that produce nitrogen to phosphorus ratios below 29:1 can be associated with toxic blooms of cyanobacteria referred to as Harmful Algal Blooms (HABs). The potential for water quality degradation and biological toxicity from HABs during the altered flow regime (including periods of artificially increased dry season flow) is not considered in the EIA in spite of the fact that survey data of planktonic organisms in the report (pgs 4-83 and 4-92 Tables 4.2.1-3 and 4.2.1-7) list the cyanobacteria *Spirulina, Schizothrix, Oscillatoria, and Raphidiopsis* as part of the river phytoplankton community.

In addition to nutrient ratios, the ecological conditions favoring cyanobacteria include low light conditions and increased temperature. Data for transparency (Secchi disc), turbidity (NTU), and ratios of nitrogen to phosphorus provided on pg 4-51 (Table 4.1.3-2) and pg 4-54 (Table 4.1.3-3) of the EIA document reduced light conditions and nitrogen to phosphorus ratios well below 29:1 indicating a high probability, frequency, and duration of HABs.

HABs are known to produce toxicity that negatively affects human health, and have resulted in the loss of important livestock, fish and waterfowl (Chorus and Bartram, 1999; Dixon, 2008). A recent report indicated that cyanobacteria produce environmental estrogens (i.e. endocrine disrupting chemicals) that cause serious impacts on fish and other aquatic organisms (Rogers et al., 2010).

Changes in sediment habitat from the project will diminish ecosystem services (e.g. food from river fisheries) through the loss of benthic organisms providing the essential food for fish feeding on algae and invertebrate prey, and organisms involved in nutrient cycling (Wall, D. H., 2004).

Changing the normal flow and the natural patterns of discharge disturbance can also cause increases in predator-resistant grazing insects which would divert energy away from the food chain leading to predatory fish negatively impacting fisheries (Wooten et al., 1996).

The loss of fish species in tropical rivers has been shown to negatively impact carbon flow and cause a disruption of normal patterns of primary production and respiration which are key processes in maintaining the water quality and ecological integrity of the river (Taylor et al, 2006). Decreased fish diversity resulting from reduced flow velocity and other activities at the Xayaburi Hydroelectric Project will cause water quality problems and ecological damage to the Mekong River.

Changing discharge patterns as proposed in the EIA can lead to negative impacts on food chain length, a major factor regulating healthy ecosystem function. Recent studies have demonstrated that normal hydrological variability (discharge) is the mechanism underlying the correlation between ecosystem size and food chain length in rivers (Sabo et al., 2010).

Water Quality

The EIA vaguely describes a plan to collect data, monitor selected water quality parameters, and "assess expected impacts on aquatic ecology and fisheries resources." The EIA lists the multiple parameters used or planned for use in its assessment, monitoring, and mitigation activities throughout the report but fails to explain *how* data was applied to compile the "Summary of Environmental Impacts and Mitigation Measures" outlined on pg 6-22-6-35 in Table 6.5-1).

Most importantly, the EIA does not explain *how* data collected will be used to assure protection to the Mekong River ecosystem using the planned monitoring and mitigation efforts listed throughout the EIA.

The EIA lacks sufficient current data describing the water quality and sediment characteristics in the Mekong River. Changing the natural flow regime by adding water during the normal dry season cycle can cause water quality degradation due to changes in normal sedimentation patterns and in the key physical, chemical, and biological parameters that provide good water quality.

The methods and data provided for existing surface water quality in Chapter 4 (see pg 4-41- 4-54 and Tables 4.1.3-1, 4.1.3-2, 4.1.3-3) are limited to 6 sampling stations and 16 parameters taken from one wet season survey done in 2007 and one dry season survey completed in 2008. The surveys are clearly not adequate to characterize the water quality occurring over a typical monsoon cycle in the Mekong River.

The limited data in the EIA has very low predictive reliability because of the very high statistical variation inherent in water quality parameters, a fact clearly acknowledged by the statement on pg. 4-46 of the EIA, " the water quality indicators are all subject to considerable variation, with typical relative standard deviations (RSD) ranging from 20-30 % for conductivity to over 100% for TSS. This variability has major implications for the number of samples required to detect statistically valid changes between locations with time."

The protocol used to sample parameters to measure water clarity is inconsistent. Secchi disc transparency was used in the 2007 wet season survey to describe the water as "relative turbid" (pg 4-50 photo 4.1.3-1) while turbidity (NTU) was used in the 2008 dry season.

Turbidity is the standard parameter used in river water quality surveys because it correlates well with other standard water quality parameters. Turbidity should be included in the monitoring protocol because it also provides very important monitoring information with predictive value in regard to the overall health of the river chemistry and biology. Turbidity can negatively impact fish reproduction and diversity by constraining the color vision essential to normal mate choice and is a very important parameter for consideration in surface water quality monitoring (Seelhausen et al., 1997).

Turbidity correlates with the biological fraction of the total suspended and dissolved materials (TSS, TDS) in the river and can be used to estimate how much of that material is being broken down and recycled to support phytoplankton, benthic invertebrates, fish, and other essential components of the aquatic food web.

The correlation between turbidity and the breakdown of organic materials also reflects the rate of oxygen removed from the river typically measured as biochemical oxygen demand (BOD). Although BOD is listed as an environmental impact in Table 6.5-1 (see pg 6-23 Environmental Aspect, Surface Water Quality, Summary of Impacts, Construction Period, Barrage) it is not listed as a water quality parameter to be measured on pg 4-46 Table 4.1.3-1; pg 4-51 Table 4.1.3-2.

The EIA sampling protocol also fails to include another important standard parameter, orthophosphate (PO_4). Orthophosphate is the standard measure of the chemical form of the essential nutrient phosphorus that is readily available for algae, bacteria, and plants in the river food web. Standard water quality procedures used by most water quality monitoring programs including the Mekong River Commission Water Quality Monitoring Network (WQMN) that provides the main source of data used in the EIA include Turbidity, BOD, and orthophosphate. The EIA should contain a provision to provide comparative data.

Item 4. Aquatic Ecology, Fisheries, and Aquaculture, pg 6-27 Table 6.5-1 Construction Period states, "Reduction of plankton and benthic fauna during construction will be temporary and aquatic ecology will recover in short time." No explanation is provided to document *why* the impacts will be temporary and *how* and *why* the recovery will occur in a short time.

For the most part, the EIA relies on a very selective use of historical water quality monitoring data from the Mekong River Commission (MRC) Water Quality Monitoring Network (WQMN). The WQMN data cited in the EIA (e.g. pg. 4-47-4-49, Figures 4.1.3-3) are more than a decade old while the sediment data is more than 15 years old (e.g. pg.4-47, Figure 4.1.3-2).

Climate Change

Other areas of concern not considered in the EIA are the impacts of land use and climate change on water resources, water allocation, and aquatic and riparian environments (Kite, 2001), and the loss of water from altered flow patterns and evapotranspiration from impoundments in the tropics as predicted by the GRACE Project (Ramillien et al., 2005).

Three specific concerns about global water resource sustainability with regard to climate change are changes in precipitation as shifts in rainfall patterns, increased water loss from increased potential evapotranspiration (PET), and increased water withdrawal from river ecosystems. Recent drought events including the unexpected 2010 drought that occurred in the Chang Saen area causing a halt in river transport in the Mekong River highlight the uncertainty and serious risks of the proposed Xayaburi project that are totally ignored in the EIA.

Public Health

Summary Finding: The Public Health sections of the EIA are totally inadequate and very insensitive to the need to project human health and prevent negative quality of life impacts. It is irresponsible for the EIA authors to dismiss or oversimplify human health protection during the construction and operation phases of the first mainstream barrage on the lower Mekong River. In my experience, the EIA offers the worst example of a study of potential public health impacts of any EIA I have reviewed during my more than thirty years of experience with Mekong River research.

The EIA sections dealing with public health impacts lack detail and fail to provide adequate strategies to protect the health of people in the project areas. Although Table 4.4.1-8 lists Malaria and Diarrhea as leading causes of death in Lao PDR in 2006, they are dismissed in the EIA as "not so complicated" and "can be reduced when necessary care is available and accessible." (see pg 4-139). A very limited and vague description of the proposed "necessary care" is provided on pg 6-34 of Table 6.5-1 Summary of Environmental Impacts and Mitigation Measures for Xayaburi Hydroelectric Power Project.

Under infections, Table 4.4.1-8 on pg 4-139 lists malaria and Table 4.4.1-16 on pg 4-146 lists *Ascaris* and *Taenia* sp. as existing diseases in the project area. Table 4.4.1-8

“Leading Causes of Death in Hospitals of Lao PDR In 2006” ranks malaria as the number 4 and diarrhea as the number 9 cause of death. In spite of the presence of these diseases, the Mitigation Measures (iii) Environment sections of the EIA on pg 6-18 promise “Periodic mosquito survey and Periodic snail survey” but no well defined monitoring or mitigation plan to react to results of the surveys is provided. In addition, no public health protocol indicating monitoring frequency, intensity, or response to the presence of vectors and disease is included in Table 6.5-1 or elsewhere in the EIA.

The same inadequate detail is true for the discussions of snail vectored diseases in spite of the fact that the snail vector for the Mekong Schistosome, *Neotricula aperta* was found in the area along with many species of fish that carry the infective metacecaria that cause human opisthorchiasis. Recent research using Growing Degree Day (GDD) models of Schistosoma japonicum in China has demonstrated that climate change can contribute to the transmission of snail vectored disease by increasing the extent and level of disease transmission (Yang et al., 2006).

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