

An overview of the Luang Prabang Hydropower Project and its submitted documents



This document provides an overview on the Luang Prabang Hydropower Project (LPHPP) and the submitted documents of the proposed project from Lao PDR. It presents key information extracted from the submitted documents, except where stated otherwise. It is intended to provide a summary of the LPHPP, to facilitate discussions with stakeholders, who may be interested in the PNPCA process. It will enable stakeholders to find essential information with respect to the project design, as well as potential negative impacts and proposed mitigation measures, monitoring programmes, social and environmental impact assessments.

1. Introduction

On 31 July 2019, the Mekong River Commission (MRC) Secretariat received notification from the National Mekong Committee of the Lao PDR submitting the Luang Prabang Hydropower Project (LPHPP) for Prior Consultation (PC) under the Procedures for Notification, Prior Consultation and Agreement (PNPCA).

The proposed LPHPP is the fifth proposed use of the waters of the Mekong River System submitted for the Prior Consultation process under the MRC's PNPCA. The earlier four PC processes are for the Xayaburi, the Don Sahong, the Pak Beng, and the Pak Lay Hydropower Projects conducted in 2010-2011, 2014-2015, 2016-2017, and 2018-2019, respectively.

The PNPCA PC process requires the three notified Member Countries (Cambodia, Thailand and Viet Nam) to acknowledge and review the documents submitted for prior consultation and submit their replies (through a Reply Form) to the MRC Joint Committee. The MRC Joint Committee may direct the MRC Secretariat to assist in the evaluation of the proposed use by undertaking a technical review of the submitted documents. This may include an assessment of possible impacts on other water uses; the ecological functioning of the river system; and any possible impingement on the rights of the Member Countries.

2. Purpose of this document

This document provides a summary of the documents submitted by Lao PDR. It will enable stakeholders to access key information on the principles of the project design, likely social and environmental impacts, potential adverse impact mitigation measures, and the proposed monitoring and forecasting schemes. The document presents only that information extracted from the submitted documents, except where stated otherwise.

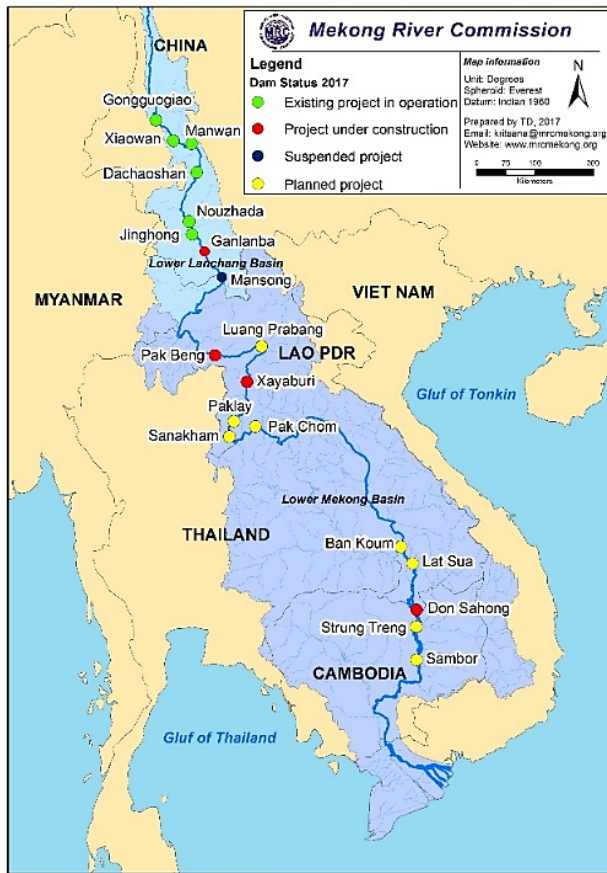
3. Summary of the Luang Prabang Hydropower Project

3.1 Background of the project

The Luang Prabang hydropower project is the 2nd in the cascade of run-of-river projects on the Mekong mainstream, from upstream to downstream, in the Lower Mekong Basin. It is located between the two previously consulted Mekong mainstream projects, the upstream Pak Beng project, and the downstream Xayaburi project.

The Project site is located on the Mekong River around 2,036 kilometres from the Delta in the Province of Luang Prabang. It lies approximately 25 km upstream of Luang Prabang town, at the village Ban Houaygno, and about 4 km upstream of confluence between Nam Ou and Mekong. The reservoir area is expected to cross the provinces of Oudomxay and Luang Prabang.

The Luang Prabang Power Company Limited (LPCL) has been established in the Lao PDR, and will undertake the development of the LPHPP under a Memorandum of Understanding (MoU) between the Government of the Lao PDR and PetroVietnam Power Corporation in October 2007. The latter established the LPCL for the purposes of developing the project.



The Luang Prabang Hydropower Project

- (1) Run-of-river project
- (2) 25 km upstream of Luang Prabang town
- (3) 130 km upstream of Xayaburi HPP
- (4) 2nd in the Cascade of hydropower projects in the lower mainstream Mekong River
- (5) Installed capacity: 1,460 MW (including the Auxiliary Unit of 60 MW)
- (6) Turbines: 7*200 MW
- (7) Expected construction start date: 2020
- (8) Expected operations start date: 2027
- (9) Mainly for export and local consumption

Figure 1: The location and key metrics of the proposed Luang Prabang Hydropower Project.

3.1 Engineering structures of the proposed project

The Luang Prabang HPP is a barrage type hydroelectric run-of-river scheme comprised of:

- A powerhouse equipped with seven Kaplan turbine/generator sets with total installed capacity of 1,400 MW, and a maximum gross head of 36.80 m;
- Auxiliary units using water to create an attraction flow for the fish migration facilities (approx. 180 m³/s), providing a further 60 MW capacity;
- A spillway structure with six radial surface gates (19 m width x 25 m height, and a sill level 288.0 m). Three low level outlets (12m width x 16 m height, and a sill level 275.0m);
- A two-step Navigation lock system for 2x500 DWT vessels;
- A fish pass system for upstream and downstream migration; and
- A 500-kV transmission line to Vietnam with an approximate length of 400 km to the Vietnamese border and 200 km to the next suitable substation. Alternatively, power could be transmitted to Thailand through a power line with an approximate length of 250 to 300 km.

The main structures of Luang Prabang HPP comprise the; navigation lock, spillway, powerhouse (including the right and left piers), and the closing structure. The Luang Prabang HPP is planned to be constructed from the right riverbank starting from the Navigation Lock then followed by Spillway which is located between the Navigation Lock and the Powerhouse. Then towards the left bank, the closing structure is located at the end. The dam crest elevation is 317 metres above sea-level (m asl), the maximum dam height is about 79 m over the deepest foundation. The fish pass system providing facilities for upstream and downstream migration with multiple entrances is located along the powerhouse, as well as in the left pier, right pier and on the right riverbank along the Navigation Lock.

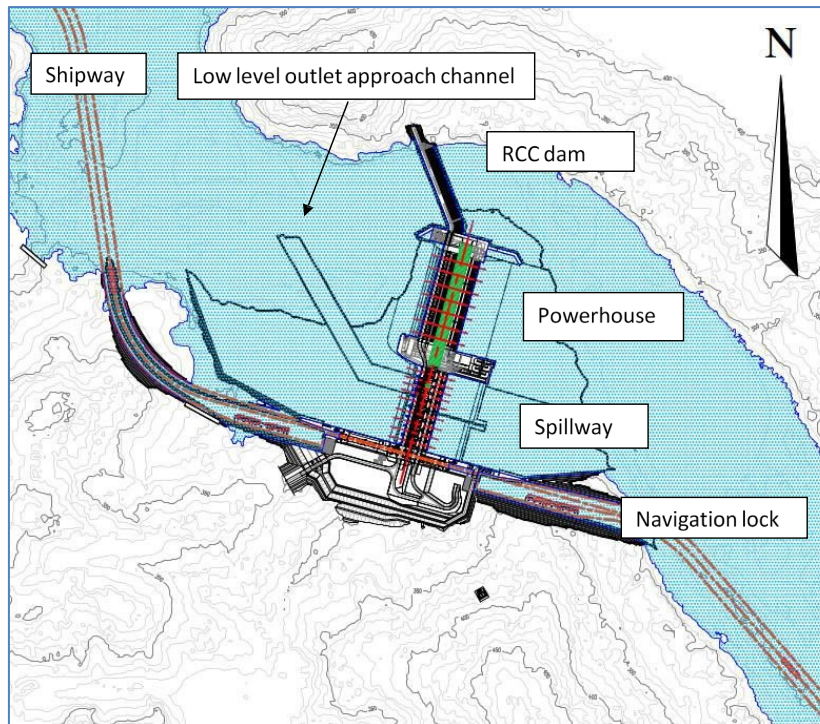


Figure 2: Main components and infrastructure of the Luang Prabang Hydropower Project

3.1.1. Navigation Lock

The navigation lock will be located at the right riverbank. It is designed to be operated for 95% of the time and will only be shut down in large floods. The navigation structure is a two-step navigation lock system for 2x500 DWT vessels. This has been proposed to keep the maximum lifting height below 30 mas as recommended in the Design Guidance. The locks are designed to divide the maximum lifting height of 35.5m into two equal parts.

The locks include three miter gates, an upstream, middle and downstream miter gate. CFD (Computational fluid dynamics) modelling of the water conduit system was carried out to demonstrate the hydraulic performance of the water feeding system. The filling of the chambers of the Navigation Lock is done via a gravity-based feeding system from the headwaters of the plant controlled by bonneted gates. The lockage time for the two-step ship lock is expected to be shorter than 50 minutes.

The navigation lock has also been designed to provide additional fish passage during migration periods.

3.1.2. Spillway

The spillway structure comprises six surface spillway bays and three low level outlet bays which are arranged in two main blocks. The first block comprises the three low level outlet bays and a surface spillway bay on each side. The second block includes the four surface spillway bays. The arrangement is required by the deeper foundation level of the low-level outlets and the stilling basin which is separated by a concrete wall. The dimension of the surface spillways is 19 m wide and 25 m high, at sill level of 288 m asl. This has a design discharge of 4,850 m³/s at FSL. Likewise, the low-level outlets are 12 m wide and 16 m high, at a sill level of 275 m asl, and a design discharge of 3,530 m³/s at FSL.

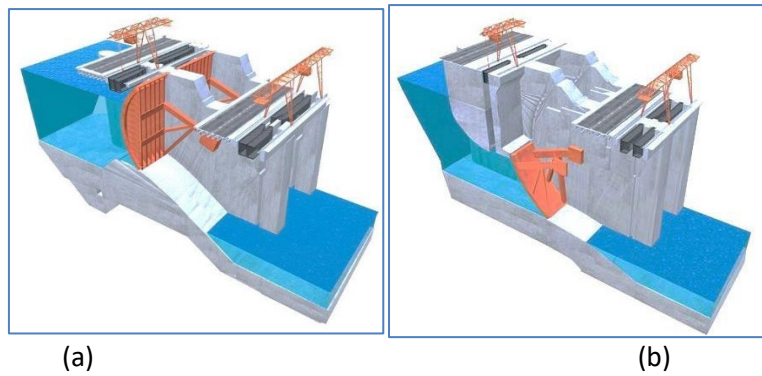


Figure 3: Sections of the surface spillway bay (a) and low-level outlet spillway bay (b)

3.1.3. Powerhouse

The Powerhouse is an integral structure of the barrage and is located in the centre of Mekong river. The powerhouse withstands the full upstream water pressure and is designed to act as a gravity dam. The powerhouse is equipped with seven vertical Kaplan units (main units), the auxiliaries and an erection bay at each end of the powerhouse. The upstream and downstream fish migration system is integrated into the powerhouse structure, intake channel and tailrace channel. The total length of the powerhouse is 275 m, 97 m wide and 80 m high. The total length of the machine hall is 195.2 m and the total length of erection bays is 130 m (80 m and 50 m on each side). The unit spacing between turbine the axis's is 32 m and the deepest foundation level (drainage sump) is at 237.5 m asl.

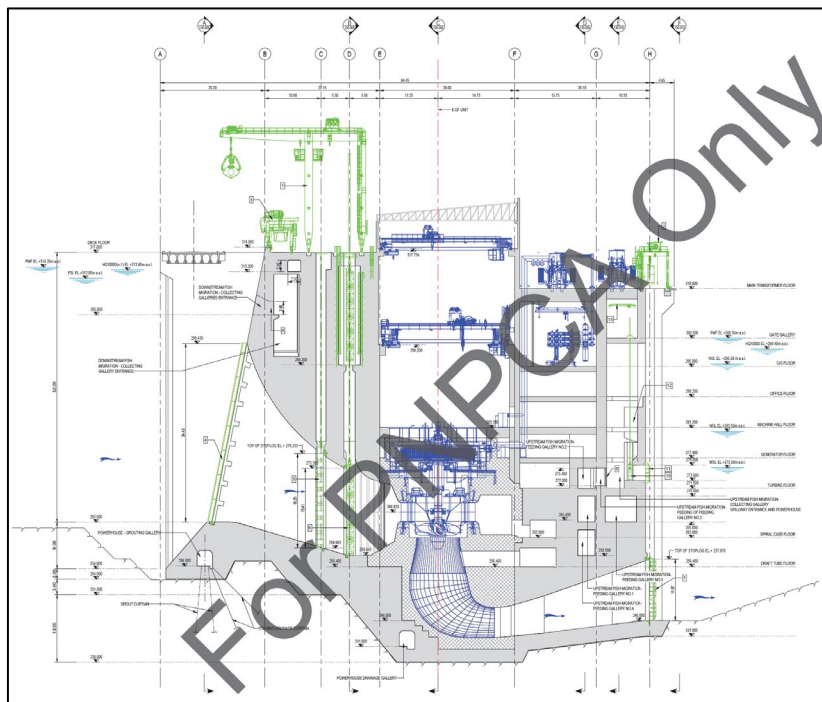


Figure 4: Cross section of Powerhouse

3.1.4. Closing structure

The left bank closing structure will be constructed to close the original main river channel at the left bank. It is designed as a Roller Compacted Concrete (RCC) gravity dam, with a maximum height of 53 m above foundation level and an overall length of 281.23 m. The elevation of the dam crest is 317 m asl and the foundation level is at 264 m asl. The width of the crest is 12 m.

3.2 Water and flood release structures

The overflow and the sediment-flushing sections are composed of six high-level surface bays or surface spillways, three low level outlets, and the powerhouse/turbines. During flood operations the excess water (that is not used for generation of electricity and/or operation of the Navigation Lock and Fish Migration Facilities) will be discharged through the spillways.

When the capacity of the low-level outlets is reached, the surface spillways will start operations. All gates of the surface spillway will be equipped with flap gates to allow the spill of floating debris in front of the spillway into the tailwater area.

3.3 Fish Mitigation Facilities

The fish migration facilities are intended to sustain the life cycle and populations of the long distance migratory white fish species found in the part of the river where the LPHPP is located. The developer has included facilities for upstream and downstream migration, and has aimed to meet the requirements of the MRC PDG 2009, and to provide similar functionality as the Xayaburi HPP fishpass¹.

3.4 Dam safety

The Luang Prabang HPP barrage and impoundment area are classified as a storage project (in regard with the reservoir volume and dam height, but not in regard with its operation). There is consequently a potential for significant damage should it fail, particularly given the proximity of Luang Prabang town just downstream. The structures have, therefore, been designed to withstand extreme seismic and flood events. The design parameters are:

- **Flood standard**

The spillway design accommodates a design floods equivalent to a 10,000-year flood), and a check flood based on the Probable Maximum Flood (PMF) if all gates are in operation. The discharges associated with these floods are outlined in Table 1².

Table 1: Design Floods for Luang Prabang Spillway

	Discharge	Comment
10,000-year flood	33,500 m ³ /s	(n-1)
PMF	41,400m ³ /s	Safety Check Flood

The spillway capacity has been determined by a physical hydraulic model test. Based on the rating curves for the spillway, the resulting upstream water levels are 314.20 m asl for the PMF and 313.60 m asl for the 10,000-year design flood (with one surface spillway gate not in operation – to provide for a safety margin). These parameters align with the recommendations of the PDG 2019, and the Xayaburi Dam.

¹ Please refer to Section 4.1.10 for more detailed information on fish mitigation facilities

² The design flood is that flood that can pass the structure without causing any damage. The Safety Check Flood may cause some damage to the structures, but not complete failure of the dam.

- **Seismic standards**

All the dam and safety-relevant elements have to be designed for the worst earthquake ground motion to be expected at the dam site, called Safety Evaluation Earthquake (SEE) ground motion. The SEE ground motion parameters will be determined probabilistically considering a return period of 10,000 years based on all available earthquake catalogues and seismotectonic data (faults in greater project region). The site-specific Peak Ground Acceleration values (horizontal and vertical components) for the SEE design Earthquake for the Luang Prabang HPP site are outlined in Table 2.

Table 2: Site-Specific Peak Ground Acceleration (PGA) for the SEE earthquakes

Design Earthquake	Analysis Method	Return Period (year)	Peak Ground Horizontal	Acceleration (g) Vertical
SEE	Probabilistic	10,000	0.56	0.43

A detailed safety monitoring system is proposed for the LPHPP during construction, reservoir impounding and long-term operations. This consists of sensors and instruments to monitor; 1) Displacement, movement and settlement, 2) Water level, water pressure, 3) Leakage/seepage, 4) Climate and 5) Dynamic response (Seismicity).

3.5 Operations

Since the LPHPP is a Run-of-River type hydropower plant, the Full Supply Level will be maintained steady for most of the time during operation, and will only vary during spillway operations or other exceptional operating cases. The FSL operating range will consequently be between 312.00 and 312.50 m asl to accommodate the practicalities imposed by the control system.

During flood operations, the three low level outlets and six surface spillway bays will discharge the excess water (water not used for generation of electricity and/or operation of the Navigation Lock and Fish Migration Facilities), starting with the former in order to route “turbidity currents” through the spillway and to minimise sedimentation close to the dam structure. When the capacity of the low-level outlets is reached, the surface spillway will start operation. All gates of the Surface Spillway will be equipped with flap gates to allow spill of floating debris in front of the Spillway into the tailwater area.

4. Overview of the submitted documents

The Final Feasibility Study Assessment, dated 10 May 2019, was submitted, including six volumes, namely: 1) Executive Summary Report, 2) Main Report, 3) Drawings, 4) Environmental and Social Impact Assessment, 5) Cumulative and Transboundary Environmental Impact Assessment, and 6) Annexes.

These reports have been prepared by Pöyry Energy Ltd. for the Luang Prabang Power Company Limited, and are summarised in the following sections.

4.1 Main Feasibility Study Report

4.1.1 Access to the project site

There are currently several options to access the project site from Luang Prabang town (25km). Luang Prabang town is accessible by air, and road including from Thailand, Viet Nam, and China. Railway access will be possible by 2021 when the 427km long railway section Laos section of the 925km long Sino-Laos Railway Link from Kunming to Vientiane is completed.

4.1.2 Hydropower Development Plan

Hydropower development in Lao PDR is central to understanding the economics of electricity production, as well as domestic and export use, and hence any opportunities for internalising the external environmental costs of generation across all 4 Member Countries. This is also central to an evaluation of the reasonable and equitable use of the Mekong River System for power generation.

Hydropower development in Lao PDR is summarised into the Feasibility Assessment from the following studies; “Mekong Mainstream Run-Of-River Hydropower” (1995) that identified a total of twelve projects with a total capacity of 13,000 MW, and the 2009 GoL study “Optimization Study of Mekong Mainstream Hydropower” to optimize the upstream 5 projects in Lao PDR (Table 3).

Table 3: The 5 upstream Mekong mainstream HPP Projects outlined in the GOL Optimization Study

Project name	Kilometrage	Capacity [MW]	FSL [m asl]
Pak Beng	2,188	1,230	345
Luang Prabang	2,036	1,410	310
Xayaburi	1,930	1,260	275
Pak Lay	1,818	1,320	240
Sanakham	1,772	570	215

4.1.3 Power Markets

The regional power market is similarly important to any assessment of reasonable and equitable use.

In Lao PDR, the Electricite du Laos (EDL) acts as the single buyer and operates all transmission and distribution assets. The market is characterized by significant cross shareholding among the major players and the states, with EDL being engaged in both generating and buying from Independent Power Producers (IPP). Generation, mainly from hydropower, grew by 16.7% per year from 2005-2015, with a bump from the added production from Nam Ngum 2 in 2010. Capacity growth rate is higher at 23.91% per year, with peak demand growing by 9.28% for the same period. Currently more than 60% of the installed capacity is for export. The future outlook shows peak demand growing at a Compound Annual Growth Rate (CAGR) of 12.1% while capacity at 18.4% domestically only.

In Thailand, EGAT, wholly owned by the state, is a single buyer, and generator and owner of the transmission network and two of the largest IPP. EGAT holds 40% of installed capacity while larger IPPs produce 38% of the demand and small and very small producers the rest. Generation in Thailand reached 201,166 GWh in 2017 from natural gas and coal, while renewables are taking up a growing share. Installed capacity reached 42,433 MW in 2017 and has grown at 4.18% per year from 2001-2017. Thailand has started to import, from Lao hydropower plants and the Hongsa coal fired power plant. The revised Power Development Plan of 2018 foresees a slight downward adjustment in both peak demand and generation from 2019, and recovering and surpassing the forecast levels in the 2015 version of the Plan. The goals outlined in the revised plan are stated as energy security, economy and ecology. The Plan also gives space for imported power purchase.

Vietnam also operates under the single buyer modality, with a slow reform towards a wholesale generation market. Generation has been dominated by state-owned enterprises however more recently the private sector has been increasing its share. Sector reforms foresee a competitive wholesale market establishing from 2017 – with slow progress, and a fully competitive retail market from 2023. Power consumption in Vietnam has been growing at twice the rate of its GDP, and the

Government is aiming at reducing this coefficient to 1.0 by 2020. Installed capacity increased to 45,000 MW by end of 2016, and capacity addition has grown at a similar rate to the rise in peak demand. Plans for the sector show an expected growth in generation at CAGR of 10.48% from 2015-2020, and a slower rate of 8.2% from 2020-2035.

Cambodia's market structure is similar to that in the neighbouring countries, with the single buyer being Electricity du Cambodge, also in charge of generation and owning the transmission network and part of the distribution lines. Generating capacity reached 1,681 MW in 2016, with a CAGR of 20.47% from 2007. Coal and hydropower plants contribute mostly to that growth with hydropower accounting for 55%, coal 26%, Heavy Fuel Oil (HFO) and diesel 18%, and biomass 1%. Imports play an increasingly important role in electricity supply, most of which is imported from the other MRC Member Countries. The future outlook is shown in the Power Development Master Plan published in 2014. This foresees peak demand growing from 620 MW in 2012 to 3,255 MW in 2030, with a CAGR for the period 2012-2030 at 10.12%.

4.1.4 Topography

There have been several topographical and bathymetric surveys of the riverbank, the area to be impounded and cross sections of the reservoir area. The bathymetry was measured by echo sounder with the area of about 2km from dam site, 1 km downstream in Mekong River from confluence with Nam Ou river, and 1km upstream in Nam Ou river from the confluence with Mekong River. These surveys have been based on the same elevation datum as the immediately upstream, downstream hydropower dams (Pak Beng and Xayaburi). This provides a more accurate assessment of water levels and backwater effects.

The high accuracy levelling control network points DGPS were established with total of 9 control points across cover the Xayaburi, Pak Beng, and Luang Prabang dam sites.

4.1.5 Hydrology

Hydrological Data

Daily manual water level and discharge data were collected at 2 locations on Mekong mainstream at Chiang Saen Station (upstream of the site) and at Luang Prabang Station (downstream of the site), at 5 locations on Mekong mainstream using automatic water level. Additional readings were taken at 3 locations on the Mekong tributaries (Nam Ou, Nam Khan, and Nam Suang) based daily manual water level readings, and at 3 automatic gauged data on the Nam Ou and Nam Khan Rivers. The locations of these gauges are displayed in the Figure 7 below.

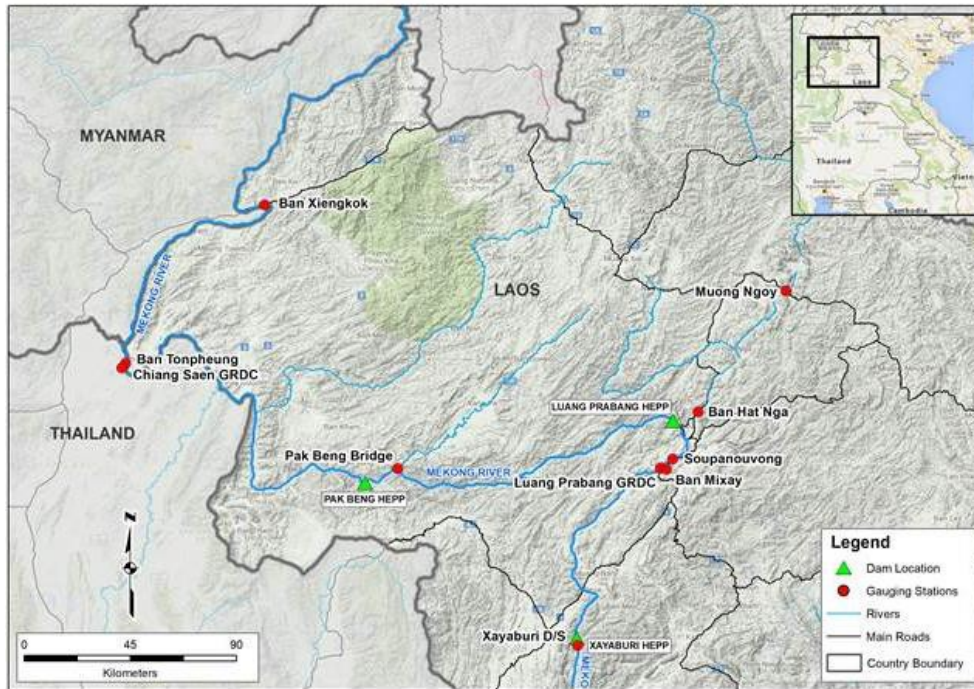


Figure 5: Location of hydrological stations collected for the study

The manual daily data at Chiang Saen and Luang Prabang are available from 1960 till 2018. While at those 3 automatic stations are available from 1987 to 2014 (Nam Suang at Ban Sibounhom) and 1988 to 2017 (Nam Ou at Muang Ngoy and Nam Khan at Bang Mixay). The higher frequency data at 4 automatic gauges on Mekong (Ban Xiengkok, Ban Tonpheung, Pakbeng Bridge, and Soupanouvong) are available for part of 2016 until October 2018. The Xayaburi station on the mainstream has 15-min data from April to November 2016 as does the Ban Tonpheung station. The 15-min data on tributaries are available from August 2015 to November 2016 at 3 locations (Nam Ou at Muang Ngoy and Ban Hat Nga and Nam Khan at Ban Mixay).

Table 4: Overview of the flow data of Mekong River and tributaries used in the feasibility assessment.

Gauging Station	River	Daily Data	Hourly Data	15 min Data
Luang Prabang	Mekong	05/60–10/18		
Chiang Saen	Mekong	05/60-10/18		
Ban Xiengkok	Mekong		05/16-10/18	
Ban Tonpheung	Mekong		04/16-10/18	04/16-11/16
Pakbeng Bridge	Mekong		09/16-10/18	
Soupanouvong	Mekong		07/16-10/18	
Xayaburi d/s	Mekong			04/16-11/16
Muang Ngoy	Nam Ou	01/88-12/17		08/15-11/16
Ban Hat Nga	Nam Ou			08/15-11/16
Ban Mixay	Nam Khan	01/88-12/17		08/15-11/16
Ban Sibounhom	Nam Suang	01/87-12/14		

Inflow Hydrology

A water balance model was applied to simulate runoff timeseries dataset and to analyze the impacts of the upstream hydropower development in China (Lancang River). Runoff was generated from combination of the rainfall datasets as mentioned above. The simulated annual average inflow from 1951-2018 to Laung Prabang HPP was estimated at 3,293 m³/s, assuming that the upstream dams were operating during this period. This is intended to approximate the future hydrology for assessing the economic viability of the LPHPP.

Flood Hydrology

The discharge data used for the flood peak analysis was taken from the Luang Prabang station (1960-2009) and from the Chiang Saen station (1960-2018). An approach developed by Sangal (1983) was adopted to determine peak discharge from daily readings as instantaneous discharge data are not available. Then the Creager formula was applied to estimate the floods for different recurrence intervals. The 10,000-year design flood was estimated at 33,500 m³/s.

The dry season peak flows were also estimated for January to May using the same approach. The design dry season flood at a 1,000-year return period was estimated at 7,800 m³/s. The Probable Maximum Flood (PMF) was estimated by applying a Probable Maximum Precipitation (PMP) storm as input into the hydrological model developed for flow generation as described previously. The PMP was selected from a 1970 US Weather Bureau PMP isohyets map for Main Mekong. The model simulated the PMF discharge for Luang Prabang HPP by using the preceding rainfall (suggested by the U.S. Weather Bureau) and the PMP storm as input data. The resulting PMF discharge peak (check flood) was computed at 41,400 m³/s.

4.1.6 Geology

The dam site is located on a stable block between two branches of the Dien Bien Fu Fault Zone. That fault line lies 9.75 km from the dam site as shown in the Figure 8.

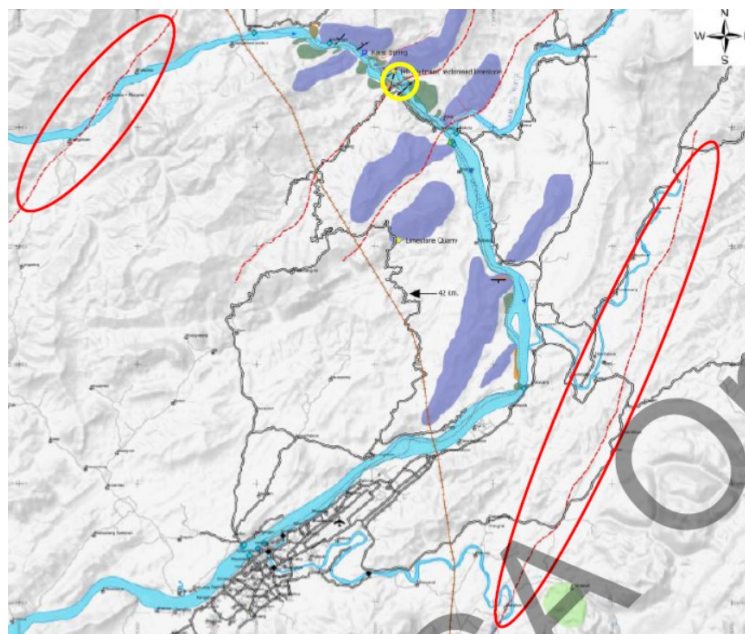


Figure 6: Tentative geological overview map showing the assumed location of the Dien Bien Fu Fault

In addition, site and laboratory investigations were performed in 2019 to re-assess the number, extent

and properties of the faults in the wider project area, and especially close to the selected dam axis. As there are a considerable number of faults identified, their seismic behaviour must be verified and more thoroughly investigated. The detailed results of these studies are documented in the Geotechnical Contractor’s Factual Report and its Annexes.

The main bedrock units consist of dark green-grey andesitic basalts, volcano-clastics and subvolcanic intrusions, as well as thinly bedded calcareous clastic sediments. The contacts between the two different main units are mainly of stratigraphic and not of tectonic origin. The foundation conditions for the civil structures are moderate to favourable. No karst-features are expected, which may have led to the dam leaking. Suitable construction material (massive limestone) for concrete aggregates were identified close to the dam site on the right upstream riverbank; massy basaltic bedrock, which has to be excavated, can be used for purposes with lower quality demand, i.e. embankment fillings. The current dam location (Alternative 1 at kilometer 2036 of the Mekong River) is feasible from the geological-geotechnical point of view.

Given the seismicity of South-East Asia, the occurrence of several destructive earthquakes in this part of the world and the lack of a reliable site-specific seismic hazard study for the project site, a site-specific seismic hazard analysis has been performed. The proposed PGA values are of preliminary nature and may be revised in the following project phases based on further investigation and modelling. From the FS report, the site-specific Peak Ground Acceleration values (horizontal and vertical components) for the different design earthquakes are given in Table 5.

Table 5: Site-Specific Peak Ground Accelerations (PGA) for different earthquake return periods

Design Earthquake	Analysis Method	Return Period (year)	Peak Ground	Acceleration (g) Vertical
CE	Probabilistic	50	0.06	0.04
OBE	Probabilistic	145	0.13	0.09
DBE	Probabilistic	475	0.24	0.18
MDE	Probabilistic	2,475	0.41	0.31
SEE	Probabilistic	10,000	0.56	0.43
SEE	Deterministic	0.54	0.40

4.1.7 Social and Natural Environment

Social environment

The project is expected to have a direct impact on 26 villages in three provinces: Luang Prabang, Oudomxay and Xayaburi, with an estimated 840 households³ and 9,974 people, out of which 5,540 are female. These villages would be in the submerged area and/or the backwater area and their inhabitants would have to be relocated, either to new resettlement sites or higher ground in the same villages. The impacts foreseen are loss of agricultural and forestry land, houses and public infrastructure. The report notes that lost land cannot be replaced as all the productive land is already being used. However, the report also suggests that the affected people would be compensated and supported with livelihood restoration activities according to international standards.

³ It seems that it is not consistent as in the SIA the number of households is 2113.

Some of the social impacts during project construction include working camps and follower camps impacting on the local economy, increased traffic, disrupted navigation, and a reduction in fisheries. Nonetheless, the FS suggests that the overall social impacts during both construction and operation would be at medium or low levels after the mitigation.

Natural Environmental Condition

The natural environment condition is summarized as follows:

- **Climate:** the wet season in the Luang Prabang area is from April to October, with a mean monthly precipitation in the range of 100 to 300 mm.
- **Water Quality:** The field sampling conducted during February 2019 at 5 stations on Mekong River and the Nam Ou suggests that the water quality of the Mekong River at this point is typical for natural surface water with limited pollution contamination, and is suitable for domestic consumption and use with customary water treatment and disinfection for irrigation and livestock use.
- **Hydrology:** The mean monthly flow at the Luang Prabang station varies from 872 m³/s to 8,724 m³/s, with August flows being typically the highest, and March the lowest flows. The mean monthly water level at same station varies from 3.4 m to 12.3 m.
- **Sediment Transport:** Historical data from the 1980s and 1990s were used to estimate that the Mekong mainstream in the area has an average suspended sediment load of 80-100 Mt/year.
- **Biological Environment:** The Mekong River section upstream and downstream of the LPHPP is characterized as a perennial River with rapids (before impoundment by the Xayaburi and Luang Prabang HPPs), with riverine banks of beach and sand bars. The results from field investigation along the Mekong from Luang Prabang to Pak Beng reveal that there are neither marshes nor swamps around the confluences of tributaries and the Mekong mainstream due to the steep riverbanks and that there is no reed or other swamp type vegetation along the river. The ecosystems along this stretch of river will change due to the change in the hydraulic conditions and reduced fish migration. Moreover, the flora and fauna on the riverbanks will be lost due impoundment behind the HPPs. The submerged area mainly includes agricultural land, teak plantations and forest. No national protected area or national park will be directly impacted by the project. The Feasibility Report assumes that the same 161 species identified at the Xayaburi HPP will also be present in the LPHPP area.

4.1.8 Alternative Study and Optimization

Alternatives for the siting and infrastructure of the Luang Prabang HPP have been proposed. These include:

- **Different Project Sites:** Two alternative sites have been assessed and compared, one at km 2036 and a second further downstream at km 2035 as shown in the Figure 9.



Figure 7: Overview of the two Sites for the Barrage

- Arrangement of the main structures:** Two arrangements for the main structures, i.e. the spillway and the powerhouse have been assessed. The safety of navigation requires that Locks have to be located at the right abutment. This then dictates the siting of the spillway and powerhouse. The arrangement (from the right bank) of Navigation Lock - Spillway – Powerhouse was found to be preferable mainly due to a lower construction risk and slightly lower construction costs. The disadvantage of this arrangement would potentially be a negative impact of spillway operation on the downstream entrance into the Navigation Lock. This will have to be made subject to a detailed hydraulic optimization.
- Fish Migration concept:** The Luang Prabang HPP will be similar to that developed for Xayaburi HPP, but without a separate fish pass system. The upstream migration system comprises multiple entrances along the powerhouse, a collecting system, and two fish locks at the left pier with outlets into the headwater. The downstream migration facility provides entrances above the power intakes, the fish are spilled via a stepped downstream chute at the right pier into the tailwater. The water from the attraction flow is used for electricity generation at the auxiliary units. When the spillway is in operation additional upstream migration facilities are provided at the right riverbank along the Navigation Lock.
- Optimization of Installed Capacity:** The installed capacity was optimised based on an incremental benefit/cost analysis. In order to minimise the total number of units, a design discharge of 765 m³/s per unit was assumed, and arrangement with 6, 7 and 8 units has been assessed. The optimum arrangement was found to be 7 units, resulting in a total design discharge of 5,355 m³/s for the main turbine units.

4.1.9 Energy Production

An energy model has been built up for the Luang Prabang HPP reflecting the layout of the planned power plant, and is based on the 67 years daily inflow series for the years 1951 to 2017 (taking into account the changes due to the Lancang Cascade), the tailwater rating curve, electricity tariffs, water losses (due to operation of the Navigation Lock and Fish Migration Facilities) and technical parameters and losses (e.g. transmission line, own consumption, availability) in order to determine average annual electricity output and average revenues.

The calculation of the average annual energy generation and revenues figure shows that the sellable electricity for the simulated time series from 1951 to 2017, is 6,424 GWh/year, with the maximum and minimum values are 7,258 GWh/a and 5,465 GWh/a respectively.

In order to assess the impact of the hydrological variation on the energy output the percentiles P50, P75, P90 and P95 are given in Table 5. The 90% percentile (P90) is the generation which will be reached for 90% of the years.

Table 5: Impact of hydrological variation on energy output

Percentile	Energy Output [GWh/a]
P50	6,408
P75	6,174
P90	5,986
P95	5,927

4.1.10 Operational Aspects

Four types of operation are outlined:

- **Normal Operation**

Since the Luang Prabang HPP is a Run-of-River type hydropower plant, the Full Supply Level will be maintained relatively constant during operations. During Normal Operation, the FSL operating range for the FSL will vary between 312.00 and 312.50 m asl. (This assumes that there will be no hydropeaking operations.)

- **Spillway Operation**

During flood operations, the spillways will discharge the excess water (water not used for generation of electricity and/or operation of the Navigation Lock and Fish Migration Facilities). The operation of the spillway will start with the low-level outlets in order to route “turbidity currents” through the spillway and to minimise sedimentation near to the dam structure. When the capacity of the low-level outlets is reached the surface spillway will start operation. All the gates of the Surface Spillway will be equipped with flap gates to allow spill of floating debris in front of the Spillway into the tailwater area.

- **Operation of the Navigation Lock**

The Navigation Lock is designed to be operated between a 30 years flood and 95% flow duration of the river in natural conditions. The maximum head difference between upstream and downstream is about 35.5 m. The navigation lock needs to be operational across the full range of possible water levels. The minimum upstream water level for the operation of the Navigation Lock is 294.25 m asl (Lowest Operating Level, LOL).

The filling of the chambers of the Navigation Lock is done via a gravity-based feeding system from the headwater of the plant, controlled by bonneted gates. The lockage time for a two-step ship lock is expected to be shorter than the required 50 minutes.

- **Operation of the Fish Migration Facilities**

The LPHPP feasibility level design includes fish migration facilities to sustain the life cycle and populations of long distance migratory white fish species found in the upper Zone of the LMB.

Upstream fish migration

The upstream fish pass facilities include: Fish locks at powerhouse, multiple entrances along the downstream face of the powerhouse, and at the left pier. The fish in these collection galleries are guided by attraction currents to two parallel fish locks, including a fish crowder and movable screen floor, where the fish are lifted up into the headwater of the reservoir. A feeding pond is included at the right pier, with feeders along the collecting gallery and at the back of the fish locks, also to attract fish throughout the collecting gallery and through the various entrances of the facility. The exact type and technology for these systems will be decided at the later stage.

Right bank: For fishes migrating along the right riverbank, a possible upstream migration facility will be provided near the navigation lock. This will comprise the following structures: a fish lock downstream of the stilling basin next to the navigation lock; a culvert crossing the downstream approach channel, providing sufficient clearance for the moving ships and vessels at the downstream approach channel; and an open channel at the left bank leading to the upstream approach channel. The fish entering the fish lock will be lifted up to the headwater level and will be released into the upstream culvert and channel leading to the upstream approach channel of the navigation lock.

Downstream fish migration

Fish migration through the powerhouse: a collecting gallery installed above the powerhouse intakes and a downstream stepped chute (exit chute) to the tailrace channel will be built to support fish migrating downstream.

Mortality for smaller fish through the turbines will be minimised due to the turbine design, while larger fish will be diverted by the trash racks to the collecting gallery.

Fish migration will also occur through the spillways when these are in operation.

4.1.11 Hydraulic Design

Tailwater Rating Curve

The tail water rating curve for the LPHPP was calculated based on a 1D hydrodynamic model (FLORIS²⁰⁰⁰) which covered the 25 km reach from the Soupanouvong gauging station to several kilometres upstream of the dam site. The rating curve at Soupanouvong station was extrapolated for high flood discharges (approx. over 22,000 m³/s). The model was parametrized based on the information taken from the Optimization study of Mekong Mainstream Hydropower, CNR 2009. The tailwater rating curve was derived using simulated inflow as described above. The report mentions that the discharge values higher than 20,000 m³/s are less accurate due to the extrapolated rating curve at Soupanouvong.

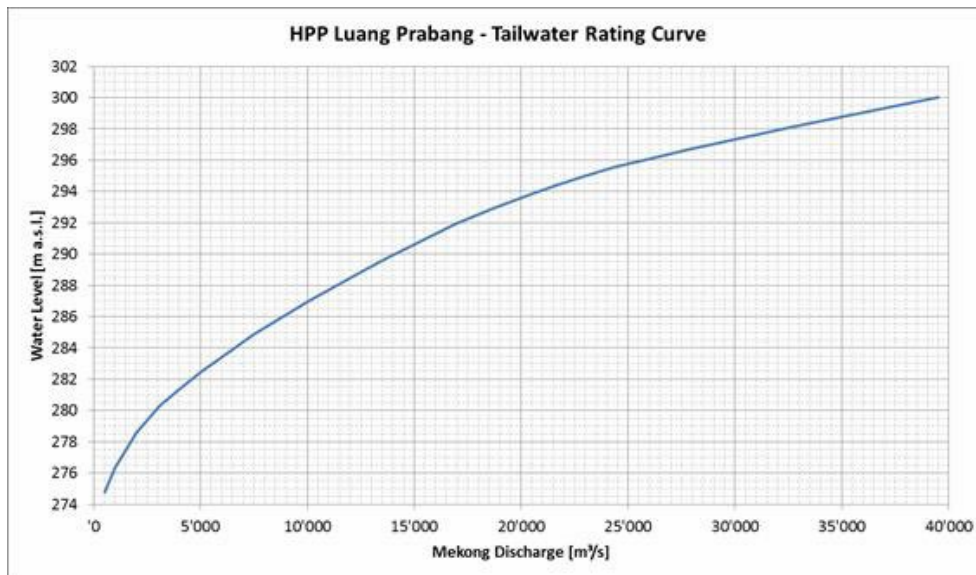


Figure 8: Tailwater Rating Curver of Luang Prabang Dam Site

Backwater Calculation

The backwater was simulated by the 1-D HEC-RAS software and the calibration was done based on the CNR study of 2009. A constant headwater level up to the PMF of the spillways was applied in the simulations. At the FSL (312 m asl) the backwater extends approximately 75 km upstream of the barrage. The backwater curve is almost horizontal at 312 m asl at lower discharges and closer to natural conditions during flood events.

The impacts on the tailwater of Pak Beng HPP due to the LPHPP was studied by the hydraulic model for natural conditions and for FSL ranging from 310 m asl to 314 m asl at 1 m intervals. Given these assumptions in the Feasibility Report, it was found that electricity production at the Pak Beng HPP decreases with increases in tailwater levels (or FSL).

Sediment Transport Model

The 1-D numerical model GSTARS 2.1 was applied to model water flow and sediment transport through the impounded reach, after a 1-D hydrodynamic model was set up to model flow. A similar calibration method to the backwater model was applied (based on CNR 2009 results). The model covered a total length of 148 km on the Mekong mainstream with a total of 38 river cross-sections (average distance of each section is approximately 4 km), thus covering the anticipated future reservoir area. The sediment module was applied for 21-year period from 1997-2017.

Grain size distribution of the riverbed material was analyzed from 10 riverbank samples taken from various locations along the backwater area of the dam on 12 April 2019. It was found that the sediment samples range from silt to sand with specific gravity ranges from 2.4 to 2.6 g/ml (average of 2.51 g/ml).

Suspended sediment loads were analyzed from 6 samples taken from the Supanuvong station, Luang Prabang station and Houa Yo which found that total suspended solids were between 10 and 60 ppm (average of 38.3 ppm). The study extended their estimation of sediment load by adopting a sediment rating curve for Luang Prabang developed by the MRCS (Final Report, Discharge Sediment Monitoring Project (DSMP) 2009-2013: Summary & Analysis of Results (2014). The sediment load was then estimated at 22Mt/year from the discharge timeseries of 1997-2017.

Sediment transport was modelled for natural flow conditions and for a FSL of 312 m asl. The model

results showed a tendency for deposition in a narrow river stretch (from km 2,084 to 2,036). A higher potential for deposition was found between km 2,052 to 2,164. Sediment is consequently mostly deposited in the upper part of the impounded section, decreasing towards the dam structure. It was found coarse silt material is transported out of the reach while most of the fine sand material is deposited.

Hydraulic Design Spillway

Two physical model tests are planned as part of the final design process. The first model will simulate overall hydraulic behaviour of the project structures and site topography and the second model will provide the detail for the surface spillway and low-level outlets. The LPHPP developer has adopted the spillway arrangement from Xayaburi HPP (the low-level outlet and surface spillway bays are identical).

The spillway facilities and the hydraulic performance were studied by using a physical model tests in Bangkok which applied the same physical hydraulic model developed for the Xayaburi HPP to LPHPP. The physical model (scaled at 1/60) was tested to determine the maximum capacity of the spillway facilities where the spillway gates are in the fully open position. Discharge rating curves for low level outlets, surface spillways, and for the entire spillway in operation have been obtained. The discharge capacity for the design flood (with one gate not operational) was determined based on the rating curves for each individual gate with a reduction factor due to unfavorable approach flow conditions. The resulting upstream water levels from the tests are 314.20 m asl for the PMF (41,400 m³/s) and 313.6 m asl for the 10,000-year design flood (33,500 m³/s) (one gate not in operation), respectively.

The physical hydraulic model tests of the overall hydraulic structures and site topography do not yet cover the entire LPHPP (including upstream and downstream approaches). These tests are planned for Quarter 3 of 2019, and will aim at optimizing the overall hydraulic performance of the plant including the overall spillway capacity.

Hydraulic Design of Navigation Lock

The feeding system was designed to be hydraulically optimized in order to eliminate as far as possible surface flow and translation waves, which might lead to unacceptable forces in the mooring ropes; and to reduce the filling velocities to limit cavitation in the system.

The developer has carried out CFD (Computational fluid dynamics) modelling of the water conduit system (intake, outlet, main conduit, diffuser and openings) to demonstrate the hydraulic performance of the water feeding system.

The “Hydraulic System” software package from EPFL (École Polytechnique Fédérale de Lausanne) has been used for the simulations of the filling/emptying. The reports indicate that the filling/emptying of the lock chambers met certain criteria such as:

- Maximum filling and emptying time of 10 minutes;
- Limitation of the discharge to 110 m³/s (10% above design discharge); and
- Control of the discharge using the service gates of the water feeding system.

Overall 2-Dimensional Mathematical Model

A 2D hydrodynamic numerical simulation software package called “BASEMENT” was applied to optimize the overall hydraulic design of the LPHPP by optimizing hydraulic flow conditions upstream and downstream of the plant. The model was applied to define hydraulic capacity of the planned river

diversion (during the construction) and construction pit (2- to 100-yr return periods); the upstream approach channel to the spillway (design flood at 10,000-yr return period and PMF); and upstream approach channel to the powerhouse (rated discharge of 5,355 m³/s when all seven units running at full capacity). The basic inputs were the 3D elevation model of Mekong riverbed from the bathymetric survey and the design drawings of the diversion wall and the upstream and downstream cofferdams.

Dam Break Analysis

The objective of the dam break analysis was to develop inundation maps for downstream areas, in the event of a dam break. These are then used for the Emergency Preparedness Plan or Emergency Action Plan. The analysis focused on 3 events: natural floods (100-yr to PMF flood discharges), mis-operation of the dam, and dam break flood assessment. The feasibility assessment assumed the failure of structure will occur at the 3 consecutive blocks of the closing structure (RCC concrete gravity dam). In that case, the breach outflow increases and reaches its maximum after 0.5 hours and returns to the initial 100-year flood level after roughly 36 hours.

The 1D HEC-RAS model developed for backwater calculations for Xayaburi HPP was adopted for dam break analysis. The study area included the Mekong reach 8 km upstream of the LPHPP to 8 km downstream of the Xayaburi HPP. This consisted of approximately 300 cross-section at 500 m intervals. The tributaries in Nam Khan, Nam Xeuang and Nam Rivers were included in the model, including river lengths of approximately 10 km upstream of confluence with the Mekong mainstream. A 12.5 m gridded map based on the ALOS Palsar DTM provided the terrain input to the model. Two inundation maps were produced; one covers the area 50 km downstream of LPHPP and another one focused on the City of Luang Prabang (the two maps are presented in Volume 3). The flood areas resulting from five scenarios i.e floods of 100-yr, 1,000-yr, 10,000-yr, PMF return period and dam break on a 100-yr flood, are displayed together on both maps. It was found that the flooding areas are similar for the three scenarios.

The peak outflow through the potential breach was approximately 45,900 m³/s (10% higher than PMF flood) which occurred about 30 minutes after starting of the breach.

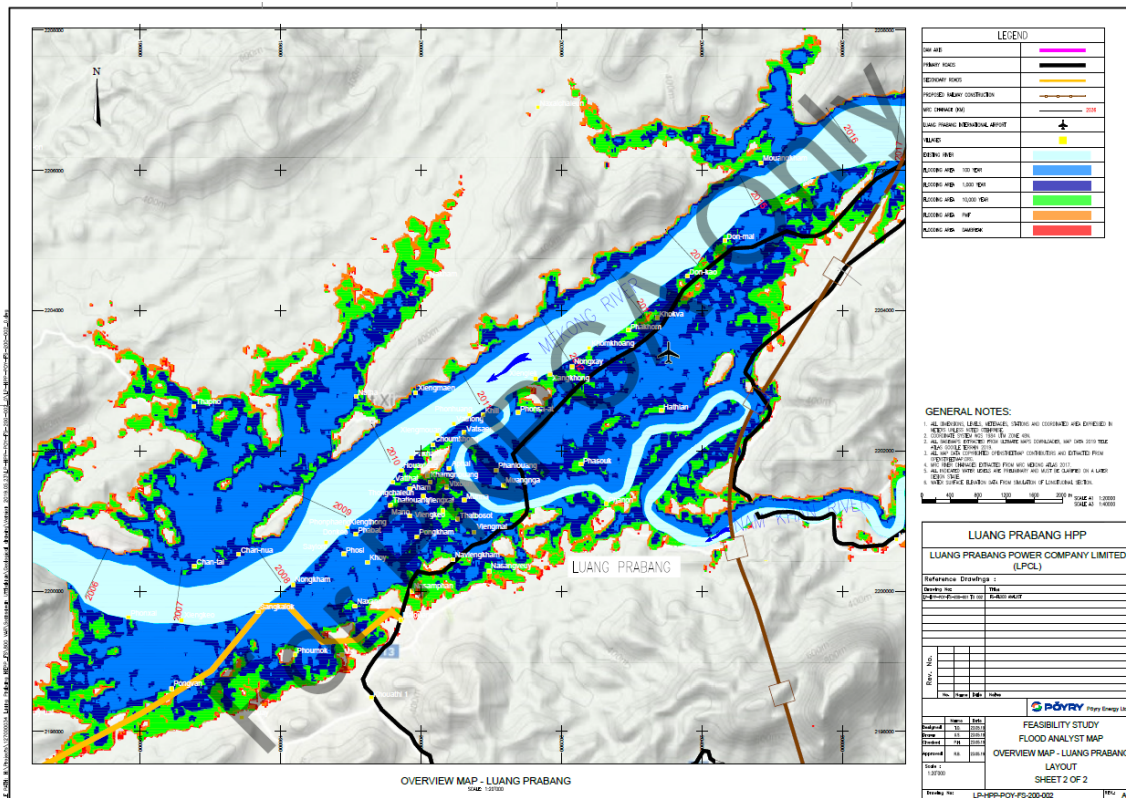


Figure 9: Simulated inundation areas at Luang Prabang City resulting from floods at 100-, 1,000-, 10,000-year, PMF and dam break assumption

4.1.12 Civil Design

Lao PDR Standards, Lao Electric Power Technical Standards (LEPTS), International Standards and International guidelines have been followed. The documentation indicates that both versions of MRC Preliminary Design Guidance have also been taken into account. The following civil design implications for the key structures include:

- **Navigation Lock:**

The design of the navigation lock needs to meet the navigational requirements of the Mekong River. The MRC Preliminary Design Guidance 2019 provides the detailed requirements for the design of locks for Mekong Mainstream projects. As the maximum head difference between the upstream and downstream water level of this project is 35.50 m, a two-step Navigation Lock is proposed in order to keep the maximum lifting height below 30 m. The locks are designed to divide the maximum lifting height into two equal parts.

- **Spillway:**

The following have been taken into consideration for the Spillway design:

- Safe passage of design floods with one spillway bay closed criterion and PMF floods with all gates in operation.
- Energy dissipation downstream of the spillway (avoidance of erosion, wave action and impact on navigation).
- Passage of sediments (gravity currents, arrangement of low-level outlets)
- Avoidance of cross-currents towards the navigation lock (downstream entrance area)

- **Powerhouse:**

The powerhouse is an integral structure of the barrage and is located in the centre of the Mekong

River. The powerhouse must withstand the full upstream water pressure and is designed to act as “gravity dam”. The following has been taken into consideration for the design of the powerhouse:

- Access to the powerhouse (during construction and operation).
- Adequate space for assembly and service of plant equipment, incl. unloading bay(s).
- Lifting requirements (crane) for unloading, assembly, installation and maintenance.
- Adequate space around equipment for service and maintenance, as well as safety clearance.
- Firefighting system, emergency exit and health and safety requirements.
- Energy evacuation, switchgear and connection to transmission line.
- Drainage and dewatering system.
- Facilities and space for upstream and downstream fish migration system.

- **Fish Migration Facilities:**

To achieve effective attraction, the fish passage design was integrated into the earliest project concepts, as it influences the dam and powerhouse concept and alignment, abutment and training wall shapes, spillway and gate design, and stilling basin design. The most relevant criteria to be used for the design of the fish migration facilities are as follows:

- Fish passage facilities for both, upstream and downstream migration should be incorporated.
- The Navigation Lock could also be used as additional fish passage during migration periods.
- The fish migration facilities shall operate the whole year, and optimally between the lowest flow and the 1-year flood.
- Design of the upstream and downstream fish passage for fish between 5 cm and 300 cm, as well as downstream drifting eggs and larvae during the wet season.
- Fish migration system shall use a minimum of 10% of low flow (Q95) and 1% of the 1-year flood; two aspects should be incorporated into the design, attraction (locating the entrances for fish approaching the entrances) and passage (through the fishways).
- Maximum water velocity for short distances (< 0.2 m) is 1.4 m/s, maximum velocity in channels is 0.5 m/s.
- Minimum depth is 3.0 m under all flows
- Use of turbines that minimise fish mortality.

- **Left bank Closing Structure:**

The closing structure for the Luang Prabang HPP is designed as a concrete gravity dam constructed from roller compacted concrete (RCC).

- **River Diversion and Construction Pit Concept:**

The Luang Prabang HPP is planned to be constructed in a single construction stage. For this purpose, the construction pit is protected from the Mekong River by a diversion wall and coffer dams upstream and downstream of the construction pit. For the design of the river diversion and construction pit a 100-year design flood of 23,800 m³/s has been adopted.

- **Dam Safety:**

The Luang Prabang HPP barrage and impoundment area are classified as a storage project (in regard with the reservoir volume and dam height, but not in regard with its operation) with a large damage potential (consequence analysis). The key concepts of Dam Safety for this project are therefore summarized as follows:

- **Design:** Due to large damage potential, all the dam and safety-relevant element have been designed for the worst earthquake ground motion to be expected at the dam site, the so-called Safety Evaluation Earthquake (SEE) ground motion. A Plant Safety Concept

for the structural safety will be implemented based on international standards to ensure an earthquake resistance design based on these ground motion parameters. Additionally, a physical model will ensure the adequacy of the hydraulic design of the spillway and subsequent stilling basin and the safe spillage of floods during construction and operation.

- **Monitoring System:** The behaviour of the water retaining structures that are relevant to dam safety will be monitored and measured by specific instruments. Monitoring instruments are installed to measure the performance during construction, reservoir impounding and long-term operation.
- **Operational Safety and Maintenance:** Since the effective operation and maintenance procedures are essential to ensure the viability and safety of the Luang Prabang HPP and its relevant structures, the scope of operating and maintenance procedures will be set out in an operations and maintenance manual appropriate for the Luang Prabang HPP.
- **Emergency planning including Dam Break Analysis:** The concept of an Emergency Action Plan (EAP) is described (but has not yet been elaborated). A dam break analysis has been carried out, and flood inundation maps in the downstream area have been prepared, to support the development of an EAP.

4.1.13 Electro-Mechanical Equipment

The LPHPP will be equipped with seven Main units and three Auxiliary units with the technical parameters as shown in Table 6.

Table 6: Generating units for the Luang Prabang HPP

Parameter	Main Units	Auxiliary Units
Rated Head	29.56 m	27.00 m
Number of units	7	3
Unit Discharge	765 m ³ /s	60 m ³ /s
Design Discharge	5,355 m ³ /s	180 m ³ /s
Installed Capacity	1,400 MW	60MW

The key characteristics of Electro-Mechanical Equipment for main units are summarized in the Table 7.

Table 7: The key characteristics of Electro-Mechanical Equipment for main units

Main Equipment		
<i>Kaplan Turbine</i>		
	Type	Vertical Kaplan turbine
	Rated unit capacity	200 MW
	Rated discharge per unit	765.0 m ³ /s
	Rated head	29.56 m
	Speed (normal/runaway)	83.3 / 235 rpm
<i>Generator</i>		
	Type	Three phase synchronous generator
	Rated output	220 MVA
	Power factor	0.90 overexcited
	Frequency	50 Hz
<i>Transformer</i>		
	Type	Three phase, two windings, oil immersed
	Numbers	7 + 1(spare unit)
	Rating	240 MVA
	Voltage reduction	16 / 550 kv
	Frequency	50 Hz
	Transport weight	650 ton
	Transport dimensions (length/width/height)	7.0 x 3.0 x 4.0 m
<i>Switchgear equipment</i>		
	Type	550 kV SF6 gas-insulated metal-enclosed switchgear
	Voltage level	550 kV
	Max. operating voltage	550 kV

4.1.14 Hydro-Mechanical Equipment

This section gives a general description of the hydro-mechanical equipment of the Luang Prabang HPP installed in the following structures:

- **Navigation Lock:** The hydro-mechanical equipment required for the Navigation Lock are for the Lock Chamber (three miter gates (upper, middle and lower) and stoplogs for maintenance works) and the feeding system.
- **Spillway:** The spillway is divided into a total of nine bays, six Surface Spillway bays and three Low Level Outlets. Each of these bays is equipped with a service gate (radial gate) operated by hydraulic cylinders. Gantry Cranes are also equipped in this area.
- **Powerhouse:** The Hydro-Mechanical equipment for the Powerhouse cover the Intake area and the Draft Tubes.
- **Auxiliary Powerhouse:** The two hydro-mechanical equipment is foreseen at the auxiliary powerhouse; (1) Intake: Intake maintenance gates, trash rack and trash rack cleaning machine and (2) Draft tube gate.
- **Fish Migration Facilities:** The hydro-mechanical equipment for the fish migration facilities is provided for the upstream fish migration system at the Powerhouse, the downstream fish migration system and the upstream fish migration system at the navigation Lock.

4.1.15 Transmission Line

The generated electricity is foreseen to be exported to neighboring countries. Due to the geographic location of the Luang Prabang HPP, possible off-taker would be Thailand or Vietnam.

The potential power export options and possible Transmission Line corridors have been compared and analyzed as shown in the Table 10. One important consideration is the cost to build transmission facility to the nearest interconnection point. The main criteria are the expected length of the transmission line, as this determines the costs for the construction as well as the transmission losses.

Table 8: Comparison of potential power export options between Thailand and Vietnam

Parameter	Thailand	Vietnam
Length of Transmission Line	300 km	620 km
Construction Costs of Transmission Line	USD 225 million	USD 465 million
Intermediate Substation	N/A	USD 72 million
Transmission losses	3%	6%

Based on this assessment, only the power export option to Thailand is taken into consideration in the Feasibility Study.

The proposed route of the 500 kV double circuit line starts at the GIS inside the Powerhouse at the Luang Prabang HPP and leads to the 500 kV Substation in Thailand (Nan or Tha Li which will be defined by EGAT later). The distance from the Luang Prabang HPP towards the Thai/Lao border is about 250 to 300 km.

Taking into account transmission line losses of about 3% and own consumption of about 1% the maximum capacity at the Thai border is not more than 1,400 MW.

4.1.16 Implementation Schedule and Construction Planning

A project implementation schedule has been prepared to establish the timeline for the implementation of the Luang Prabang HPP which can be briefly divided into the two main phases as follows:

- **Pre-award activities:** These cover all activities until financial close, e.g. preparation of the tender documents, tendering and procurement, permitting process, conclusion of the prior consultation process, financial set-up, preparation of Power Purchase Agreements. The overall time required for these activities is estimated to be 12 months.
- **Construction and commissioning:** The construction activities start with the Notice to Proceed (NTP), and end with the commissioning and take-over of the project. The actual schedule indicates that the first unit of the run-of-river plant will be ready for commercial operation 72 months from the decision to commence construction. The full capacity will be available within 84 months.

The overall Project Development Schedule is shown in Figure 10.

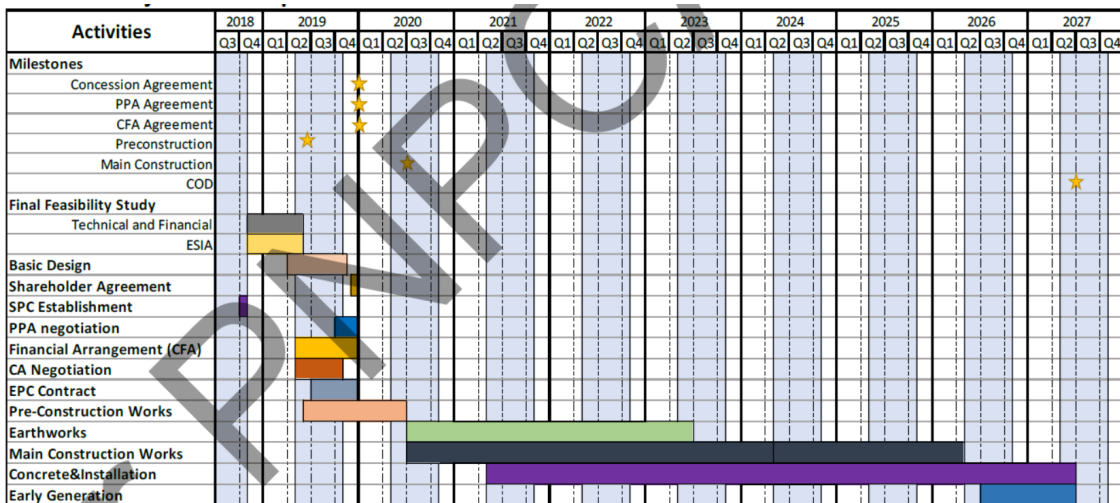


Figure 10: Overall Project Development Schedule

4.1.17 Risk Analysis

The key objectives of the development of a hydropower project is to develop the project within a reasonable time, to construct the project in time and within the budget, and to generate revenues during the operation phase sufficient to service all loans and to meet the forecasted profitability within the agreed concession period. In general, all aspects that have the potential to negatively impact these objectives are perceived as a risk.

A risk assessment for the Luang Prabang HPP Project has been carried out covering the main risks during construction and operation of the scheme. The identified risks have been assessed and adequate measures to control and manage these risks have been determined and proposed in the risk register.

Overall the risk assessment and the control and management measures result in an acceptable risk profile for the Luang Prabang HPP Project. However, this does not include any risks that may result from the additional costs and lost energy production that may result from the implementation of any measures to avoid, minimise and mitigate potential impacts. The Owner will consequently need to continue this process with the development of an appropriate mitigation strategy and re-assessment of the residual risks during the upcoming project phases.

The feasibility assessment also indicates that to enhance the success of the project further, risk reviews and workshops should be conducted on a frequent basis, involving a multidisciplinary sub-set of the project team, chaired by the Client’s project manager who is able to make decisions on the disposition of risks and their control and management activities. This may provide opportunities to align this process with any post prior consultation Joint Action Plan.

4.1.18 Compliance with MRC Preliminary Design Guidance

The Mekong River Commission Preliminary Design Guidance for mainstream dams has been available since 2009. A revised version has been available in draft form since 2018 from MRC’s website. These provide an overview of the issues the MRC will be considering during the prior consultation process and make recommendations for developers in this regard. The Preliminary Design Guidance of 2018 outline “performance standards” rather than prescriptive designs, so developers can innovate and propose alternative mitigation and operational measures to meet the stated objectives. They are built on experiences and knowledge within the Mekong basin and internationally good practice standards.

The documentation provided suggests that the Feasibility Design developed to be in compliance with the MRC Preliminary Design Guidance (draft version, June 2018). The extent to which this has been achieved will be evaluated in the Technical Review Report.

4.2 Environment and Social Impact Assessment Reports

4.2.1 Environmental Impact Assessment

The key environmental impacts during **the construction phase** are summarized in the feasibility assessment as follows:

- **Increased sediment loads and higher flow velocities** due to the construction of LPHPP and cofferdams;
- **Impacts from the increase of TSS** (total suspended solids) as a result of site clearance and earthwork activities, including quarry, borrow and dumping areas, construction of cofferdam structure in Mekong River, and the increase of BOD (biological oxygen demand) due to additional organic matter in sewage water from the construction camps.
- **The long-term loss of vegetation** in construction area.
- **Increased turbidity and siltation** caused by earthwork activities which will subsequently reduce sunlight penetration to deeper layers of the Mekong River. This has an impact on the phytoplankton population, leading to a decrease of oxygen, affecting benthic organisms and fish biomass.
- **Water pollution** and soluble nutrients from constructing activities which might cause eutrophication in downstream aquatic ecosystems.
- **Impaired fish migration** during construction activities due to hydraulic changes of the natural flow, especially increased water velocity due to decreased river channel width. It affects upstream migration since some migratory fishes will not cope with faster flowing water. This rapid flowing water also affects downstream migration since faster flow could transport egg and larvae to an unsuitable downstream habitat.
- **The loss of aquatic habitats.** There are two rapids just downstream of the project area, namely Kaeng Oi and Kaeng Thanu (approx. 0.5 and 1 kilometers downstream from the dam site). Kaeng Oi probably will be lost during construction, whereas Kaeng Thanu will experience alteration of flow conditions due to the cofferdam.

These impacts, and potentially others, will be explored further in the TRR.

The key environmental impacts during **the operation phase** are summarized in the EIA as follows:

- **Changes in the boundary conditions;** flow velocities, gradients and water depth due to the operation of dam system;
- **Impaired migratory fish species.** The reduced upstream migration limits the number of fish that can access of refuge habitats, spawning grounds, nursery grounds and feeding areas. There are no significant floodplain areas upstream of the proposed LPHPP. The EIA notes that the predominance of migratory fish in the catches of local fishermen above the Project site indicate that there are presently no short or mid-distance barriers to migration, and that many species currently move upstream into the tributaries and small stream to breed. The dam would therefore be a significant barrier to fish reproduction. The species most likely to be impacted will be those that undertake significant (passive and active) migration between critical (spawning, feeding, and refuge) habitats to complete their life cycle or to exploit seasonal variations in habitat quality and availability.
- **Loss of aquatic habitat.** Since the LPHPP has a backwater effect of approx. 157 km with aquatic habitats including rapids, sand bars, tributaries, which are important as

spawning/production areas, and dry season habitats/refugia, these will result in considerable reduction in spawning / production areas and dry season habitats/refugia for rheophilic Mekong species (i.e. those that require fast flowing, oxygen rich water) and probably an increase of more limnophilic fish species (i.e. those more adapted to slow flowing water).

- **Alteration of natural flow** by dam operation. Reduction of flow velocity in the reservoir area influences the species composition. If the water velocity is too low the larvae may either sink to the bottom of the reservoir and die, starve from lack of suitable planktonic food, or are subject to greater predation in the static, less turbid water of the reservoir.

The key environmental **mitigation measures** are summarized in the EIA as follows:

- **The site preparation activities**, including land clearing and site filling and compaction, should be carried out during the dry season to avoid the problem of surface runoff with high turbidity discharging into the surrounding area or nearby drainage channels.
- The construction site should be surrounded by temporary ditches connected with **drainage system** in order to limit the amount of sediment that could be washed out to the surrounding area during the raining time.
- **A biomass clearance plan** has to be established and salvage logging and vegetation clearing has to be done in a way that fauna have ways to escape the areas (e.g. Block by block from the river going upwards).
- **Vegetation clearance** will be done before the nesting season of birds.
- **Field investigation and a biodiversity offset plan** will be done to evaluate and quantify the loss of biodiversity and check possible mitigation measures.
- **Sediments traps** should be installed along riverside of project construction area to prevent discharging of sediments into river.
- Limited fishing activities in the construction section in the river is recommended for both upstream and downstream areas, to ensure the protection of existing fish species and the safety of local fishermen. **Control measures on illegal fishing, prohibition of using explosive, hazard chemicals or electricity** should be strictly enforced.
- During the construction period, **a study of fish migration behaviour** would help to determine the high peak of migration and migrating stimuli factors for each species. Results from monitoring of fish migration through the Xayaburi HPP, which located downstream, shall be analyzed and taken into consideration for **the design of the fish passage facilities** for this project.
- **A study on natural flow and spawning season** of fish in Mekong River at the project area shall be undertaken before operation of the HPP. Dam operation shall mimic the natural water regime, as far as possible, to support persistence of pelagic spawning fish.
- **The aquatic habitat in the reservoir area** should be investigated both with respect to **biodiversity and economic value**. **Artificial fish habitats or reservation areas for spawning and nursing in parts of the reservoir and downstream** should be created for species which will not be able to use the fish migration facilities at the dam site. The artificial habitats and reserved spawning grounds together with fish pass can serve as spawning areas for the upstream migratory species and as a nursing area for downstream migratory species.
- **A permanent assessment of attraction factors for fish migration** should be employed to optimize the fish passage. The developer shall reserve **contingency funds** for modification/ improvements of the fish facilities.
- **Seasonal monitoring of fish species** needs to be performed upstream and downstream of the dam site. Results shall be analysed and summarized in yearly reports.
- **Target species that might be affected severely by the project additionally shall be cultured to release** later hatchlings/young specimens into the natural water body. Only natural species of Mekong River shall be released.

- **Establishment of fish sanctuaries** to maintain the natural spawning grounds of some species (upstream and downstream the LPHPP).
- Plans for training and extension programs for **river reservoir fishery management** shall be provided for local fishermen of the adjacent communities.
- To detect possible changes of the aquatic biocenosis, a proper management plan has to be installed. **Fish abundance, species composition of fish, benthos, and plankton shall be regularly observed at least twice a year** on upstream and downstream sites.

4.2.2 Social Impact Assessment

26 villages from immediately downstream of the dam site up to the end of the reservoir area, in three provinces Luang Prabang, Oudomxay and Xayaburi, will be directly affected by the LPHPP. An estimated of 2,113 households with 9,974 people, 5530 of whom are female, reside in these villages. These villages would either require complete or partial relocation or lose farm land or have their environment affected. Over 60% of the affected population are of working age. There is no information on the percentage of female headed households.

There is no information on the education levels of the working population but the percentages of people finishing different education levels and currently being in school are reported. Houses in the affected villages are either wooden cottage, brick houses or traditional Lao houses raised on wooden/concrete poles Land use and ownership in the area averages 3.3 Ha per household. The percentage of vulnerable households, simply classified mainly due to having an ageing household head, is 31%. Information on a support programme for these households is provided in the SMMP (Social Management and Monitoring Plan). The main ethnic groups are Lao Loum, Khmu and Hmong. There is an account of different roles for men and women in household decision making and work, with women mainly playing the key roles in housework and harvesting/gardening/handicraft and men in farming and husbandry.

Over 55% of the total population engage in productive labour with the main livelihoods being rice farming, slash and burn, vegetable gardening, livestock raising, local business, NTFP (Non-timber forest products) gathering and hunting. Household income levels range from 4,188 USD to 5,371 USD per year translating into average income of over 600,000 Kip to nearly 800,000 Kip per month per person, while the poverty line for 2018, adjusted for inflation from the official line in the Lao decree on Poverty and Development Criteria 2009 for rural areas, stands at 235,000 Kip per month per person.

Health facilities comprise health centers in some villages, a district hospital for every district and a provincial hospital for every province.

Navigation activities including from tourism are buoyant in the area with an estimated 2,367 trips of passenger boats (50-100 passengers) and 96 cargo ships passing the dam site in 2018. There is also information on UXO, cultural sites, landscape, and major tourism attractions. Special arrangements may be required for this shipping during the construction phase.

The social impacts are classified into pre-construction, construction, and operational phases. The levels of impact are based on the intensity, extent and duration of any adverse effects. Pre and during construction impacts are judged as high, and include land acquisition and relocation, changes in livelihoods affect food security, reduced fishery due to increased water turbidity. The mitigation measures proposed include compensation for the loss of land, riverbank gardens, private assets and livelihood restoration support; plus community and cultural facilities established at relocation sites. Employment for local labour and training are expected to be pursued as a main support mechanism

for the affected population.

4.2.3 Public consultation and disclosure

The public consultation and public disclosure of the Project has been conducted with the stakeholders and groups directly affected by the Project which have been identified as:

- (1) Project Affected Persons (PAPs), consisting of 2 districts of Luang Prabang Province namely Chomphet District, and Pak-Ou District, 1 district of Xayaburi Province, Hongsa District and 1 district of Oudomxay Provinces, Nga District;
- (2) Government Authorities;
- (3) Related Ministerial Offices; and
- (4) Other Civil Society Organizations.

The consultation process was implemented according to the Free, Prior and Informed Consent (FPIC) principles, which are generally regarded as a specific right that pertains to indigenous peoples and is recognized in the United Nations Declaration on the Rights of Indigenous Peoples (UNDRIP). Three methodologies and approaches were used in this regard: (i) Public Meetings; (ii) Focus Group Discussions (FGD); and (iii) Disclosures.

The key issues from the consultations are summarized as follows:

- The extent of backwater from the LPHPP: The exact increase of water level and inundation is a serious concern because it determines magnitude of the impact, and number of people affected.
- The pertinent information of the LPHPP: Location of dam site, type of dam, navigation lock, fish passage, increase of level of water upstream from the dam, potential impacts from project development is needed.
- Potential project impacts area may include villages, and agricultural area in lowlands, some paddy fields, forest areas and teak plantations along the Mekong River banks.
- The compensation and resettlement/ relocation plan: Villagers prefer cash compensation. They expect that the LPHPP developer will support them to improve quality of life. The major concerns of the female population were that the school, public health center and market should be provided in the resettlement site. The male population was concerned that that the resettlement site should be near project site, thus providing job opportunities, need for occupational training, and the establishment village credit lines to provide loans for the establishment of farmer groups.
- The project proponent should co-ordinate with the Administrative Offices in all the concerned Provinces, so that the Governors of the provinces could assign GoL staff at district and village levels to co-operate with the project study team.

4.2.4 Environmental Management and Monitoring Plan

The responsibilities for implementing the proposed EMMP during the pre-construction, construction and operation phases will be coordinated between Government of Lao PDR (GoL) and the project company under the Concession Agreement (CA) and will be governed by the relevant Lao law and legal framework. Also, the Project will establish and maintain an Environmental Management Office (EMO). The company's EMO shall commence operation from the start of the construction to end of the CA.

The authority overseeing the compliance of EMMP implementation will be delegated by the Ministry of Natural Resources and Environment (MONRE) by establishing an Environmental Management Unit (EMU) in accordance with the Environmental Protection Law. This competent authority will be mandated to monitor Project Company's performance and compliance with the environmental

measures, standards, and permits. Aligning this reporting to any post prior consultation Joint Action Plan will help keep the other Member Countries informed of both progress and compliance.

The proposed key environmental monitoring plans are summarized as follows:

- **Surface Water Quality Monitoring:** The Project will conduct **quarterly** monitoring during the construction and operation phases at a proposed seven monitoring stations along the Mekong River and any other stations that may be specified in the Concession Agreement.
- **Aquatic Ecology and Fish Migration Monitoring:** The Project will conduct these monitoring activities at five stations in Reservoir and the Mekong River and a monitoring station at the fish pass facilities and any other stations that may be specified in the Concession Agreement. Monitoring will be undertaken of 4 times/ year (or every 3 months).

Twenty-four sub-plans for EMMP are identified. These sub-plans will guide and support the developer during the construction and operation phases. The key sub-plans are summarized as follows:

- Erosion and Sediment Control;
- Water Availability and Pollution Control;
- Hazardous Substances Management;
- Unexploded Ordnance (UXO) Survey and Disposal;
- Vegetation Clearing;
- Biodiversity, Wildlife, and Aquatic Life Management;
- Capacity Building Plans and Programs; and
- Transmission Line Corridor Management Plan.

4.2.5 Social Management and Monitoring Plan

The Social Management and Monitoring Plan (SMMP) gives an overview of the potential impacts and a detailed description of measures the project developer plans to take in order to mitigate these impacts during the pre-construction, construction and operational phases.

The SMMP begins with listing the related policy and legal documents including Lao regulations and international treaties similar to those reviewed under the SIA. It then describes the organization, roles and responsibilities of the Government of Lao PDR, including the Provincial Resettlement Committee to oversee the implementation of the SMMP and REMDP (Resettlement and Ethnic Minority Development Plan). This body is supported by the RMU (Resettlement Management Unit) to coordinate with relevant parties, develop a workplan and budget and must report on implementation activities. The project developer is expected to establish a Social Management Office to act on behalf of the project to manage and monitor the implementation of mitigation measures, review and revise these when required, provide compensation as planned, undertake consultations with affected people, provide training and report on these activities to the Provincial Resettlement Committee. There will be an external independent monitoring agency of the SMMP and REMDP implementation.

The SMMP aims to ensure compensation for the affected people, enhancement or at least maintenance of well-being, adverse impact prevention and adaptation of people to new livelihoods. Mitigation measures, as noted in the SIA, comprise compensation for lost land, other assets, and income due to reduced fish cage production or reduced boat traffic, rehabilitation via income restoration, resettlement including provision of houses, cultural and other community facilities, allowance, restoration of livelihoods and consultation. There are also details of the livelihood restoration programme, including orchard tree plantations, rubber tree plantations, husbandry, handicraft and food processing.

A number of other programmes have been proposed. This includes Community/Social Development,

Land Tenure and Use, Public Health and Occupational Health and Safety, Transportation Management, Chance Find Management (for archaeological objects), Education Support, Cultural/Ethnic Development, Gender Development, Vulnerable Family Support and Public Awareness on Environment Protection.

Implementation monitoring for these programmes would be through document verification, interviews with involved parties and affected people to check for activity completion and satisfaction of people. During project operation, the monitoring will focus on livelihood changes, health issues related to the livelihood and environment change induced stress, vulnerability level change, and boat service change.

A detailed process is outlined for addressing grievances as well as undertaking auditing and compliance assessment. The SMMP includes finally sub-plans for training and awareness, dam site and camp management, labour and personnel management, and health and safety.

4.2.6 Resettlement and Ethnic Minority Development Plan

The REMDP covers similar information as the SMMP and the SIA, such as the legal framework related to socio-economic issues in dam development, the roles and responsibilities of different parties, the project overview and consultation processes. The Plan then goes into detail on the project affected people, divided into four groups as in the SIA, and the respective mitigation measures and entitlements for each group. For example, groups with permanent loss of residential land would be entitled to 600 m² of land cleared from any unexploded ordinance for each household, or groups with permanent loss of agriculture land would be provided with comparable land or cash compensation. Loss of facilities such as houses and community centres would also be compensated for in the resettlement areas. Loss of livelihoods would be catered to through livelihood restoration programmes, cash compensation or other mechanisms.

The Plan requires a detailed property survey and valuation to be undertaken at the beginning of the resettlement programme, together with consultation with each of the affected villages on all aspects of the proposed resettlement plan. It also specifies the detailed design and construction requirements for any public infrastructure and community facilities. Livelihood restoration and training details are similar to those presented in the SMMP and SIA.

The Ethnic Minority Development Programme documents the ethnic groups and their respective lifestyles and livelihoods. The listing of ethnicity is gender disaggregated. It is claimed that the overall social development programme has been prepared in consideration of ethnic groups' characteristics. However, there is no specific information to verify this. The Plan also documents the activities of the cultural, community development, and education programmes.

The REMDP has the same organizational arrangements and grievance redress procedures as outlined in the SMMP. There is a section for implementation schedule and budget but there is no budget information provided.

4.3 Cumulative and Transboundary Environmental Impact Assessment

4.3.1 Hydrology

The cumulative and transboundary impacts on hydrology in the feasibility assessment comprise the impact of the Lancang Cascade, impact on the Tonle Sap Great Lake system and general hydrology impacts.

4.3.1.1. Impact of Lancang Cascade

The impacts due to the operation of Lancang Cascade were estimated by using a model that was developed for the period 1951 to 2018, assuming that the Lancang Cascade Dams were operating over the entire period. This is used to approximate the future inflow to the LPHPP. It was found that the dams in China would lower flood peaks (slightly) and increase dry season flows (significantly).

4.3.1.2 Impacts on the Tonle Sap Great Lake System

The impacts of hydropower development on the Tonle Sap system refers Arias *et al's* (2014) study on "Dam on Mekong Tributaries as significant contributors of hydrological alterations to the Tonle Sap floodplain in Cambodia". The study focused on the proposed 42 dams in the Sesan, Srepok and Sekong (3S) rivers and concludes that these dams could independently increase the great lakes 30-day minimum water level by 30 ± 5 cm and decrease annual water level fall rates by 0.30 ± 0.05 cm/day. The feasibility assessment, however, concludes that LPHPP will not cause any additional impact to the Tonle Sap system due to its run-of river nature.

4.3.1.3 General hydrological impacts from the LPHPP

The rising water level upstream of the LP HPP will create a reservoir area of 49 km² reaching back to the tailwater of the planned Pak Beng HPP. This will decrease flow velocities in this area, which will lead to local impacts such as reduction of downstream sediment transport, and changed habitat for aquatic life (further information is provided and discussed in the ESIA section).

The backwater from the LPHPP will affect the tailwaters of the Pak Beng HPP. It is estimated that reservoir impounding would take 15-20 days to reach FSL and then the dam would maintain this level with minor changes of approximately 1 m for minor floods, and up to a 2.2 m in the event of the PMF. Nevertheless, the developer suggests that the LPHPP will not affect the seasonal hydrograph and has no further hydrological effect to the downstream countries and Tonle Sap great Lake system.

4.3.2 Water Quality

Since the LPHPP is a run-of-the-river plant, the residence time of the water is rather short (approx. 3 to 9 days). When the low-level spillways are operating there will be no dead zone (zone below minimum operation level in a storage power plant) occurs. This should limit the potential to form a deep-water zone with deteriorating water quality. Moreover, clearing of the biomass and waste in the reservoir area before impoundment will further limit the change of anoxia in the deep waters. The report suggests that there will be no subsequent significant impact on water quality during normal operations.

4.3.3 Sediment Transport

The cumulative and transboundary impacts on sediment transport provided are based on the general literature review on the changing of sediment due to the Lancang Cascade.

The developer has undertaken a literature review based on recent studies on the sediment and morphology aspect and related topics. At Chiang Saen, due to the reduced sediment inflow coming from China, the sediment load was estimated at 84.7 Mt/y (pre-dams) and would decrease to 10.8 Mt/y (post-dams). The sediment load at Luang Prabang (post-dam) was estimated at 22.3 Mt/y. The total suspended sediment load within the Lower Mekong Basin is estimated to decreased from 160

Mt/y to 72.5 Mt/y due to the development of both tributary and mainstream hydropower (L. Koehnken, Mekong River Commission (MRC), July 2014).

The developer has used 40 years of sediment data from 1962-2012 provided by the Thai Department of Water Resources (with big gap data between 1976-1992), to determine the trend in sediment concentrations at Chiang Saen. This has been analysed considering “pre-Manwan dam” and “post-Manwan dam” periods. A significant reduction of suspended sediment concentration at Chiang Saen was found and was attributed to the Lancang Cascade hydropower dams. At Luang Prabang the impact of the Manwan Dam construction in 1993 was reported in the 1997 CNR study (CNR report, Dec-213).

Trends showing the reduction of suspended sediment loads in the Lower Mekong River due to the Lancang cascade were identified by all the studies, however, the estimated total sediment load changes differ between the studies. (Further information on the modelling of sediment losses is provided in the previous Chapter.)

4.3.4 Fish and Fisheries

The developer notes that according to the MRC Report (Hortle *et al*, 2013), fisheries are an integral part of the lives of the rural people, providing a major part of their animal protein intake in Lao PDR. The estimated consumption of inland fish is approximately 168,000 tons per year, while consumption of other aquatic animals is estimated at 40,600 tons per year, with the estimated total value of US\$150 million per year. The estimated fish and other aquatic animal consumption rates are about 29 kg/year/person (of which 24.5 kg from fish). The same report indicates that more than 481 fish species were found in Lao PDR and the average annual fish yield in Lao Mekong River and tributaries has been estimated at 70 kg/ha/year.

The above figures show the importance of fisheries resources in Lao PDR. The LPHPP will limit fish migration, which will in turn have negative impacts on fish and fisheries resources on which the Lao people depend. Data from the MRC suggests that with a surface area of 4,900 ha, (the area affected by the LPHPP impoundment), the affected reach currently produces around 343 tons of fish per year. These fish are consumed by some 14,000 Lao people (24.5 kg/capita/year). This is equal to 25% of the total population of Luang Prabang town.

The Mekong River reach from Chaing Saeng to Vientiane is about 800 km and consists of various habitats such as deep pools, rapids and riffles. The LBHPP, the second cascade below Pak Beng HPP, is located within this stretch of the Mekong River, and is home to 140 fish species (MRC, 2010). However, about 160 species were reported by the Pak Beng and Xayaburi HPPs developers. Among them, white fish species are the most vulnerable to the barrier effect of the LPHPP and this vulnerability will increase when habitats are lost due to the cascade of HPPs within this river stretch⁴.

The feasibility assessment suggests that the fish migration facilities are state of the art and provide several options for up and downstream migration. However, despite this it is unlikely that the facilities will be 100% effective, and some consequent loss of fish biomass is likely. The Xayaburi fish pass

⁴ The fish pass facilities proposed for the LP HPP are mainly based on those installed at Xayaburi HPP. *Please refer to Section 4.1.10 above for detailed information on operation of fish passage facility*

facilities are being monitored and this will be intensified when the entire migration system is operated. This monitoring programme will be extended to the LPHPP once it becomes operational. However, the individual impacts are expected to be quite similar to Xayaburi HPP as both use the same technology. However, these impacts will also be cumulative.

4.3.5 Food and Nutrition

Some loss of food production is expected due to the loss of land being inundated and to river condition changes. However, it stated that the cumulative impact of the project may not be significant outside of the project area.

The feasibility assessment, nevertheless, reports on work by the MRC in 2009, which highlighted that the environmental impacts of land-use change and irrigation development are of cumulative and transboundary nature, and that barriers to fish migration could reduce the livelihoods from fishing by 30% or more. Another study quoted, one conducted in Cambodia in 2012, (labelled IFRED) suggests that HPP developments could reduce fish and other aquatic animal supply by between 34,000 to 182,000 tons. This would in turn impact negatively to people with limited food alternative on their daily calorie intake, protein and micro-nutrient supplies posing a risk to public health.

4.3.6 Impacts on other development projects

Major related development projects that will be impacted by LPHPP or vice versa are listed as 1) China-Lao Railway Project; 2) Pak Beng HPP; 3) Xayaburi HPP; 4) Hongsa-Chiangman and the new Bridge across Mekong River Project; and 5) Development around Luang Prabang City and its World Heritage status.

China-Lao Railway Project

As part of its Kunming-Singapore line, a high-speed train line will stretch around 410 km from Boten on the Lao-China border to Vientiane. It is expected that the construction will be completed by the end of 2021 in the vicinity of the dam site. Thus, feasibility assessments suggests that reciprocal impacts would only occur for a short time of period.

Pak Beng Hydropower Project

It is expected that Pak Beng HPP will not change the flow pattern and no hydrological impact is expected on the LPHPP. However, the Pak Peng HPP has to use similar technology for fish migration and sediment transport, to ensure that any measures taken at LPHPP and Xayaburi HPP are effective. Close cooperation, and coordination of the full cascade is highly recommended.

Xayaburi Hydropower Project

The Xayaburi HPP is located on the downstream of the proposed LPHPP thus will be subject to any change of operations at the LPHPP. However, since Luang Prabang will not change the flow pattern and no hydrological impacts on the Xayaburi HPP are expected. However, close cooperation between the operators is highly recommended.

Hongsa-Chiangman Road and the new Bridge across Mekong River Project

The 114-kilometer Hongsa-Chiang Man Road (R4B) will be a shortcut providing access from Thailand to Luang Prabang. This road can be used as an alternative route for the transportation of heavy equipment and materials from Thailand to the LPHPP.

There is also a plan for construction of a new bridge across Mekong River about 10 km upstream of the ferry port in Luang Prabang Province. This bridge will connect Hongsa-Chiang Man Road (R4B) to

Highway No.13N thus providing a better connection between the two sides of the river to Luang Prabang City and the LPHPP.

Generally, the implementation of LPHPP is expected to affect the development around Luang Prabang City.

4.3.7 Social Issues

The documentation suggests that land prices could potentially go up due to both the China-Lao Railway and LPHPP projects. Consequent socio-economic impacts similarly expected to be positive due to the injection of capital from compensation and the economic activities linked to the construction of the dam.

Less positive impacts would be risks of social conflict, STDs (sexually transmitted disease), human trafficking and other behavioural issues. Furthermore, the expected increases in water velocity and changes in river course would impact negatively on navigation during construction, at least until the navigation locks are put in place and become functional.

Social issues further downstream or upstream were not mentioned.



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