Lao Mekong Sanakham Hydropower Project
PNPCA Consulting & Opening Workshop
2018/10/30
1 Project Brief
1 Project Brief

<table>
<thead>
<tr>
<th>CHARACTERISTIC OF PROJECT</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>INSTALLED CAPACITY</td>
<td>684MW</td>
</tr>
<tr>
<td>NUMBER OF UNITS</td>
<td>12</td>
</tr>
<tr>
<td>AVERAGE ANNUAL OUTPUT</td>
<td>38.08x10^8 KWh</td>
</tr>
<tr>
<td>ANNUAL OPERATING HOURS</td>
<td>5567h</td>
</tr>
<tr>
<td>TONNAGE OF SHIP LOCK</td>
<td>500t</td>
</tr>
</tbody>
</table>
1 Project Brief

- In August 2010, the Pre-feasibility Study Report was approved by China Renewable Energy Engineering Institute.

- In May 2011, the Feasibility Study Report was approved by China Renewable Energy Engineering Institute.

- On December 21, 2011, the Feasibility Study Report was finally approved by the Electricity Department of the Ministry of Energy and Mines, Lao PDR.

- In May 2011, the Feasibility Study Report was approved by China Renewable Energy Engineering Institute.
1 Project Brief

- Independent Review of the Sanakham Hydropower Project was conducted by CNR from October 2014 to June 2015. The final report of independent review was submitted by CNR on the basis of site investigation, technical discussion and written reply of the Developer, etc.

- The updated feasibility study report was completed in September 2015 in accordance with the comments of the Independent Review. On November 13, 2015, the Updated Feasibility Study Report was finally approved by the Electricity Department of the Ministry of Energy and Mines, Lao PDR.
On June 16, 2014, the Ministry of Natural Resources and Environment, Lao PDR granted the Environmental Permit for Sanakham Hydropower Project.

ESIA Consultation Meeting

ESIA Statement Review Meeting
2 Hydrology
2 Hydrology

Hydrological Analysis

- Analysis of natural geography
- Data collect
- Meteorological data
- Hydrological data
- Hydrology survey
- Data assessment

- Meteorological elements
- Runoff
- Design Flood
- Rating curve
- Climate condition
- Runoff characteristic
- Flood characteristic
- Analysis
- ......
Hydrology

Hydrological data

There are a number of hydrologic stations along the main stream of the Mekong River. Luang Prabang station and Vientiane station are selected as the design basis for hydrology design of Sanakham Project.
2 Hydrology

✓ Hydrological data series: 1923~2012;
✓ During 2009~2012, 4 sets of water gauges had been established at the damsite, mainly to measure water levels;
✓ Level & discharge were measured in 2015
2 Hydrology

Runoff

Interzone method for modeling the runoff Data, whose formula as:

\[ Q_{p,ps} = Q_{p,ws} + \frac{F_{ps} - F_{u/s}}{F_{d/s} - F_{u/s}} \times (Q_{p,d/s} - Q_{p,u/s}) \]

Area ratio method for modeling the runoff Data, whose formula as:

\[ Q_{p,ps} = Q_{p,rep,s} \times \left( \frac{F_{ps}}{F_{rep,s}} \right) \]

<table>
<thead>
<tr>
<th></th>
<th></th>
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<th></th>
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<tr>
<td>1690</td>
<td>1340</td>
<td>1150</td>
<td>1160</td>
<td>1650</td>
<td>3420</td>
<td>6920</td>
<td>11800</td>
<td>10900</td>
<td>6570</td>
<td>3840</td>
<td>2350</td>
<td>4410</td>
</tr>
</tbody>
</table>
2 Hydrology

- Flood
  - Analysis of storm
  - Flood statics
  - Analysis of catastrophic flood
  - Flood Frequency Analysis
    - Design Flood at Dam Site
    - Availability Analysis
    - Construction Duration Flow Analysis

Curve-Fitting Method:

\[
\bar{x} = \frac{1}{n} \sum_{i=1}^{n} x_i \\
S = \sqrt{\frac{1}{n-1} \sum_{i=1}^{n} x_i^2 - \frac{1}{n} \left( \sum_{i=1}^{n} x_i \right)^2} \\
C_1 = \frac{S}{\bar{x}} \\
C_2 = \frac{n \sum (x_i - \bar{x})^2}{n(n-1)(n-2) \bar{x}^2 C_1} \\
f(p; \bar{x}, C_1, C_2) = \bar{x}[1 + C_2 \phi(p; C_1)]
\]
It can be seen that the flood calculation method adopted by HXEC is similar to the calculation method adopted by MRC-CNR and the difference between the developer estimations and MRC-CNR estimations is very small, the maximum of which is less than 3.87%, the minimum is only 0.86%.

<table>
<thead>
<tr>
<th>Exceedance Probability(%)</th>
<th>T(years)</th>
<th>Flood Flows at Sanakham project</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>1994 Study Estimations</td>
</tr>
<tr>
<td>50</td>
<td>2</td>
<td>16300</td>
</tr>
<tr>
<td>20</td>
<td>5</td>
<td>19400</td>
</tr>
<tr>
<td>10</td>
<td>10</td>
<td>23580</td>
</tr>
<tr>
<td>5</td>
<td>20</td>
<td>22900</td>
</tr>
<tr>
<td>2</td>
<td>50</td>
<td>25000</td>
</tr>
<tr>
<td>1</td>
<td>100</td>
<td>28780</td>
</tr>
<tr>
<td>0.5</td>
<td>200</td>
<td>29900</td>
</tr>
<tr>
<td>0.2</td>
<td>500</td>
<td>31700</td>
</tr>
<tr>
<td>0.1</td>
<td>1000</td>
<td>33880</td>
</tr>
<tr>
<td></td>
<td></td>
<td>33000 (30900-34900)</td>
</tr>
<tr>
<td>0.05</td>
<td>2000</td>
<td>34400</td>
</tr>
<tr>
<td>0.02</td>
<td>5000</td>
<td>36100</td>
</tr>
<tr>
<td>0.01</td>
<td>10000</td>
<td>37300</td>
</tr>
</tbody>
</table>
2 Hydrology

 OSX  Rating Curve

Measure discharge and water level

Hydraulic formula

Rating curve

Hydraulic formula

Rating curve of dam site

- Data of 2015
- Data of 2010
- Flood data of 2008
- Review (adopted)
- Feasibility Study in 2011

Rating curve of dam site
3 Sediment
3 Sediment

✓ Sediment sampling, gradation of particles, mineral composition testing;
  ● In May 2015, sediment sampling and testing works was initiated.
  ● Taking sediment samples twice per month.
As for the proposal by CNR experts, the bottom elevation of the right five outlets has been lowered to 192.0, from 198.0m, which would improve sand flushing efficiency.
Calculation with mathematical model

- According to the flushing sluice arrangement adjustment as well as the operating modes, a mathematical model was established for sedimentation calculation;
  1. The outflow sediment content is basically consistent with the inflow value, and in the initial period, the sand discharge rate would surpass 70%;
  2. A 2-D water-sediment mathematical model is established to calculate the water flow regimes in the dam upstream and downstream, sedimentation distribution and erosion-deposition change in front of the dam, sedimentation distributions in the upstream navigation approach channel entrance, in front of the left and right sluice dam sections, and at the powerhouse dam section.
With the two flood sluices respectively arranged at left and right wings, the flood discharge and sand flushing efficiency is rather efficient; the right sluice is located at the thalweg of the original river channel, with small amount of deposits in front of the dam, the sand flushing efficiency is sound.
A sand barrier will be set in front of the power intake, each unit dam section will be arranged with one sand outlet which could timely flush fine sand accumulated at the intake front towards downstream, and coarse sand will be intercepted in front of the sand barrier.
Deposition at the upstream approach channel would be mainly affected by the backflow zone, mainly distributed at the inner side of the guide wall, deposition at the outer side can be basically flushed out during releasing flood. However, after 20-year operation, the minimum water depth at the upstream approach channel would still be deeper than 4.0m, which is satisfactory to the PDG’s demand. When navigation is affected, deposition could be artificially cleared off with the reservoir drawdown.
✓ Sedimentation monitoring plan

In order to monitor and analyze the impacts of reservoir sedimentation, the following items shall be observed in light of main reservoir sediment problems:

(1) Inflow and outflow sediment/water;
(2) Changes of the sedimentation before dam and in reservoir;
(3) Water surface profile of reservoir;
(4) Change of erosion & deposition and collapse of reservoir bank;
(5) Monitoring dam downstream erosion during the initial reservoir operation period;
(6) Monitoring deposition at upstream and downstream approach channels.
5.3.1 Inflow Sediment Analysis

(1) Suspend Load

Chiang Khan Station is applied as the representative station for sediment inflow. The mean annual amount of the suspended sediment to flow into Sanakham reservoir is 69.0 million t. The average sediment concentration during main flood season is 0.686 kg/m$^3$; and mean annual sediment content is 0.496 kg/m$^3$. 
(2) Grain size gradation of samples

6 groups of overburden samples were taken by geological engineers at damsite riverbed, the average grain size gradation is obtained in the sieving method, with the median grain size of 0.4mm, maximum grain size of 50mm.
(3) Bed Load

Using the Sharmov and Meyer-Peter formulas to calculate the bed load sediment runoff at dam site, the ratio of suspended load to bed load for the two is respectively 0.51% and 1.27%.

For the sake of safety, the ratio of bed load to suspended load of 2% is adopted for estimation of the bed load sediment runoff at dam site with the result of mean annual bed load sediment runoff at dam site being 1.38 million t.
According to the suspended load particle gradation provided by CNR in May 2015, the sedimentation in the reservoir has been reviewed:

After 10-year operation of the reservoir in the proposed mode, the sediment accumulation in the reservoir area would amount to 127 million m³, with an average sediment discharge ratio of 77.8%, the average sediment content in the outflow water after sediment settling in the reservoir is 0.386kg/m³, only about 22.2% lower than the natural scenario.

After 50-year operation, the average sediment accumulation at the dam front is about 3m deep, averagely up to the elevation of 197.2m. The sedimentation in the reservoir area would not bring about threat to the operation safety of the power plant and the ship lock.
5.3.3 Impact on Pak Lay hydropower station

Longitudinal Profiles of Backwater & Sediment in Sanakham Reservoir

- When the water level in front of the dam is at EL. 220m, the backwater level at Pak Lay Power Station would be raised by 0.0~4.16m;
- under the annual average discharge of 4410 m$^3$/s, the POOL level incremental due to backwater would be 0.07m;
- when the discharge exceeds 5801 m$^3$/s (design discharge of Sanakham), backwater level would have no impact on Pak Lay Power Station.

Backwater – Discharge Relation at Pak Lay Station
4 Geology and exploration
4 Geology and exploration

- Earthquake safety

Epicenter Distribution Map of Historical Strong Earthquakes Occurred in 553 Years (1446-1999) at the Project Site and Peripheral Area
4 Geology and exploration

- **Earthquake safety**

### Seismic Dynamic Parameter
Values of Bedrock in the Project Area

<table>
<thead>
<tr>
<th>Designed seismic dynamic parameter</th>
<th>50-year exceeding probability</th>
<th>100-year exceeding probability</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>10%</td>
<td>5%</td>
</tr>
<tr>
<td>Amax (gal)</td>
<td>62</td>
<td>88</td>
</tr>
<tr>
<td>β</td>
<td>2.25</td>
<td>2.25</td>
</tr>
<tr>
<td>Tg (sec)</td>
<td>0.35</td>
<td>0.35</td>
</tr>
<tr>
<td>ah (g)</td>
<td>0.063</td>
<td>0.09</td>
</tr>
</tbody>
</table>

Sanakham
## Quantity of completed investigation works

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
<th>Unit</th>
<th>Qty.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Exploration</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Borehole drilling</td>
<td>m/no.</td>
<td>7510/153</td>
</tr>
<tr>
<td></td>
<td>Adit</td>
<td>m/no.</td>
<td>797/11</td>
</tr>
<tr>
<td></td>
<td>Test pit</td>
<td>m³</td>
<td>28450</td>
</tr>
<tr>
<td></td>
<td>Packer test</td>
<td>Section/no.</td>
<td>417/53</td>
</tr>
<tr>
<td><strong>Geophysical survey</strong></td>
<td>Acoustic wave in borehole</td>
<td>m/no.</td>
<td>322/9</td>
</tr>
<tr>
<td></td>
<td>Overburden</td>
<td>m/strip</td>
<td>32571/234</td>
</tr>
<tr>
<td></td>
<td>Adit wall test</td>
<td>Section /no.</td>
<td>34/5</td>
</tr>
<tr>
<td><strong>Tests</strong></td>
<td>(including rock property test, rock mechanics test, aggregate alkali activity test, impervious soil test and aggregate test, etc.)</td>
<td>set</td>
<td>174</td>
</tr>
</tbody>
</table>
Drilling machine at work on MEKONG river

Drilling machine at working on land

Adit of PD01 at DAM site

Adit of PD31 at quarry
5 Design Layout
Dam type: Concrete dam
Water retaining structure: Left auxiliary dam, ship lock, left flood sluice, powerhouse, right flood sluice, fish pass, right auxiliary dam
Dam crest length: 909.9m
Max. dam height: 56.2m
Number of Units: 12
Type of unit: bulb
Unit capacity: 57MW
Total capacity: 684MW
Height of plant: 58.4m
Length of plant: 350.2m
### Discharge Sluices

<table>
<thead>
<tr>
<th>Description</th>
<th>Left Bank Sluices</th>
<th>Right Bank Sluices</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of sluices</td>
<td>13</td>
<td>5</td>
</tr>
<tr>
<td>Type of weir</td>
<td>broad-crested</td>
<td>broad-crested</td>
</tr>
<tr>
<td>Size of gates</td>
<td>$15\text{m} \times 22\text{m}$</td>
<td>$12.5\text{m} \times 16\text{m}$</td>
</tr>
<tr>
<td>Elevation of weir</td>
<td>198m</td>
<td>192m</td>
</tr>
<tr>
<td>Energy dissipation</td>
<td>hydraulic jump</td>
<td>hydraulic jump</td>
</tr>
<tr>
<td>Operation</td>
<td>opened and closed in dynamic water</td>
<td>opened and closed in dynamic water</td>
</tr>
</tbody>
</table>
- **Ship Lock**

- Number of steps: 1
- Max. tonnage: 500t
- Max. working head: 20.38m
- Size of chamber: $120m \times 12m \times 4m$
- Total tonnage: $2.178 \times 10^6$ t/year
Fish Way

- Length: 2.39km
- Slope: 0.075%
- Width: 5m
Dam Safety
6 Dam Safety
Dam Safety

Project Management Plan

- Prepared in FS stage

- Construction supervision plan
- Quality assurance plan
- Instrument plan
- Operation and maintenance plan
- Emergency preparedness plan

Improved in construction stage

Dam Safety Management System
Design Standard

- The Lao Electric Power Technical Standard (LEPTS)
- The International Commission on Large Dams (ICOLD)
- World Bank, Operational Policy 4.37
- International standard: ACI, ASTM, US Army Corps of Engineers, United States Bureau of Reclamation, etc.
- Chinese Standard
• No earthquake above 5 magnitude has ever occurred within 100km of the dam site in 553 years;
• Seismic safety evaluation had been completed by the Earthquake engineering research institute of Yunnan (China);
• The horizontal seismic peak ground acceleration for standard of design and check is 0.063g ($a_h$) and 0.1g ($a_h$), respectively.
### Flood Standard and Characteristic Discharge

<table>
<thead>
<tr>
<th>Dam type</th>
<th>Work condition</th>
<th>Return period (year)</th>
<th>Flood discharge (m³/s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gravity dam</td>
<td>Design flood</td>
<td>2000</td>
<td>34700</td>
</tr>
<tr>
<td></td>
<td>Check flood</td>
<td>10000</td>
<td>38800</td>
</tr>
</tbody>
</table>

The proposed maximum navigable water level for navigation structures is based on 3-year frequency floods.
The calculated results indicate that all structures satisfy relevant requirements.
Safe passage of flood

- 13-Left Bank sluices, Size 15mx22m
- 5-Right Bank sluices, Size 12.5mx16m

Check flood: 38800m³/s
Design flood: 34700m³/s

Max. flood level upstream of the dam is 6.2m lower than the dam crest elevation.

10000-year flood with two outlets closed during flood discharge. Max. flood level upstream of the dam is 4.9m lower than the dam crest elevation.
Discharge equipment reliability

Electromechanical safety design consideration

- Enough strength and rigidity
- Backup power
- Spare parts for convenient maintenance
- Spare hoisting capacity
First-Stage Diversion Structures include dry season cofferdam, longitudinal concrete guide wall and upstream and downstream all-year-round cofferdams.

- The dry season cofferdam is capable of retaining a 10-year flood with discharge of 5450 m³/s.
- The all-year-round cofferdams are capable of retaining a 20-year flood with discharge of 23,000 m³/s.

Construction in dry season will last from December, 1st year to May, 2nd year and December, 2nd year to May, 3rd year.

Construction in flood season will last from June, 3rd year to December, 4th year.

The slope Stability and seepage stability of the first-stage cofferdam have been calculated. The results show that they can meet the specification requirements.
Cofferdam safety

- Second-Stage Diversion Structures include longitudinal concrete guide wall, upstream and downstream all-year-round cofferdams.
- The all-year-round cofferdams are capable of retaining a 20-year flood with discharge of 23,000 m$^3$/s.
- The second-stage cofferdams will retain water from January, 5th year to July, 7th year.
- Permanent structure will retain the water in the completion period of the project from August, 7th year to December, 8th year.

The slope Stability and seepage stability of the second stage cofferdam have been calculated. The results show that they can meet the specification requirements.
Monitoring

- Perfect monitoring program
- Installation of advanced instruments
- Monitoring data collection
- Data analysis and feedback
7 Ship Lock
Design standards for ship lock

Ship lock scale: 500t level
Effective dimension of the lock chamber: $120 \times 12 \times 4$ m
Max. flotilla: $1+2 \times 500t$ (two row in-line) compoundable ship
Max. overhead clearance for navigation: 8 m
Number of ship lock lines: single-line ship lock is designed; second-line ship lock is reserved in appropriate place.
Guarantee rate of navigable stage: 95% for lowest navigable stage

The effect depth of riverbed incision is 1.0 m
Navigable stage

Upstream highest navigable stage: 220.00m
Upstream lowest navigable stage: 219.00m
Downstream highest navigable stage: 212.55m (downstream level in 3-year flood)
Downstream lowest navigable stage: 199.62m (95% guarantee rate)
Difference between upstream and downstream highest navigable stages: 20.38m
Ship lock stage: single stage
Navigation structure is a one-lane single stage ship lock which is arranged at left bank floodplain, consisting of upstream approach channel, upper lock head, lock chamber, lower lock head, downstream approach channel and upstream and downstream mooring dolphins, etc.
The opening time (tv) of filling and emptying valves is 6 min, respectively; 

- Filling and emptying time of the lock chamber is 9.62 min and 9.98 min, respectively;
- Water flows smoothly in the lock chamber; the designed mooring force of the ship (fleet) is smaller than the allowable mooring force.
Overall Hydraulic Physical Model Investigation

The flow conditions at the inlet and outlet of the ship locks are good; there is no vortex, local drop, uprise or other unfavorable hydraulic phenomenon.

The upstream and downstream approach channels feature small flow velocity and uniform flow distribution, meeting relevant codes and design requirements.
The second-line shiplock is located in the geologically favorable gully on the left bank. The second-line shiplock has the entrance and exit far away from the first-line shiplock. Both shiplocks are seated on the left bank and not far apart for the convenience of unified management. Such layout will not pose effect on the safety of the first-line shiplock during construction of the second-line shiplock and the construction of the second-line shiplock has no influence on the completed headworks.
8 Fish Pass Facility
Main fish migration system in the Mekong River basin

Spawning sites on the mainstream of Mekong River
Fish Investigation

Net hauling

6 stations for survey, sampling and observation

Market survey by Thailand's fish experts
Design Principle

1. Fish investigation
2. Determine target fish
3. Fish habits investigation
4. Upstream and downstream migration design
5. Monitoring
 Design Consideration (Upstream migration)
➤ Design Consideration (Downstream migration)
With reference to the latest investigation on fish and historical data, we studied the kinds, quantity of fish resource, and living habit. And referring to the experience on the world, a natural-like fishway is selected.

Passages for fish passing through Sanakham dam: fishway, turbine, sluice. Turbine generators for Sanakham are bulb type units, which are environmental friendly. With 18 flat-bottom flood sluices arranged for Sanakham, the upstream-downstream level difference during the flood release period would be not much.
Design Consideration

- Flood sluice gate section
- Powerhouse section
- Fish pass
  - Width: 5m
  - Length: 2.39km
  - Slope: 0.075%
- Monitoring room
- Switchyard
- Entrance 1
- Entrance 2
- Blocking fish with electric screen
- MEKONG
- Lure fish facility
- Namhueng
Built bypass channel fish way on the world
9 Water Quality
Survey, sampling and observation was conducted at 6 stations

The surface water quality from the six sampling sites in the project area shows a good quality of class three for fresh surface water.
Mitigation Measures for water quality of Construction and Operation

（1）Measures to mitigate impacts on water environment of construction and living campsites.

➢ regular waste collection will be part of the camp requirements

➢ Wastewater setting pond will be provided for aggregate processing system, concrete mixing system, machine processing plant and other plants for construction use

➢ Domestic sewage treatment system will be supplied in the campsites of the Employer and the Contractor.

（2）Water quality monitoring program

➢ The water quality monitoring program has been revised completely. The monitoring will run through the construction period and the operation period of the project, and the monitoring objects include dirking water, construction and domestic sewage and the river water.
10 Trans-boundary Impact and Mitigation
Identification of Impacted Zones
• Fish Migration an
• Navigation
• Hydrology
• Sedimentation an
• Water Quality
• Dam Safety
• Social & Tourism

MAIN CONCERNED
11 Sustainable Operation and Management
Sustainable Operation and Management (Hydrology)

- Automatic system of hydrologic data collection and transmission

- Storm characteristic
- Flood characteristic
- Main tributaries distribution
- Hydropower characteristic
- Sensible factors

- Water Level
- Discharge

- Forecast Scheme in construction & operation
- Network
- Forecasting
Sustainable Operation and Management (Sedimentation)

- Sediment Monitoring System
  - Water and sediment in/out the reservoir
  - Water surface line of the front dam and tail section
  - Sedimentation in the reservoir area
    - Before the Dam
    - In approach channel
  - Sedimentation in the project area
  - Downstream river course
  - Bank deformation in the reservoir area
### Sustainable Operation and Management (Sedimentation)

- **Sediment Monitoring equipment**

<table>
<thead>
<tr>
<th>Equipment</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>LISST-100X</td>
<td>Observations of sediment particle size distribution and volume concentration</td>
</tr>
<tr>
<td>Trimble GPS</td>
<td>Global Positioning System</td>
</tr>
<tr>
<td>Total station</td>
<td>Land data acquisition</td>
</tr>
</tbody>
</table>
Sustainable Operation and Management (Sedimentation)

- Sediment Monitoring equipment

<table>
<thead>
<tr>
<th>Single beam sounding system</th>
<th>Multi beam sounding system</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1.png" alt="Single beam sounding system" /></td>
<td><img src="image2.png" alt="Multi beam sounding system" /></td>
</tr>
</tbody>
</table>

Underwater data acquisition
Sustainable Operation and Management (Sedimentation)

- Sediment management Brochure

  - Reservoir operating modes
    - Sediment releasing facilities of the power station
      - Control of the reservoir sedimentation
      - Sedimentation control before the dam
      - Sediment deposition in the approach channel
      - Downstream channel scouring
      - Bank erosion
      - Eco-friendly flushing
  - Monitoring and management
Sustainable Operation and Management (Monitoring)

- Monitoring system maintenance
- Automatic monitoring
- Data compilation
- Data analysis
- Working state evaluation
Sustainable Operation and Management (Environmental monitoring)

- The environmental management and monitoring Manual

Environmental Management → Environmental Monitoring

To minimize or prevent negative environmental and social impacts
Sustainable Operation and Management (Environmental management)

Organization chart
Sustainable Operation and Management (Environmental management)

The environmental monitoring plan

- Water Quality
- Hydrology
- Soil Conservation
- Biodiversity Conservation
- Cultural Properties
- Chemicals and Waste management
- Others
Environmental Integrated Design Report
Fish Pass Facilities Detailed Design Report
Detailed monitoring implementation plan
Water quality monitoring
Aquatic ecosystem monitoring
Vegetation restoration
Water treatment facilities building and operation

Sustainable Operation and Management

Environmental work plan

Designing

Implementation
Sustainable Operation and Management

- Tourism Care
- Documentary Management
- Neighboring Area
- Damage-Risk Pro-active Prevention
- Ecological flow
- Systematic Management
- Fish-friendly Operation
- Sediment Care
NWH and NCG company have identified and assessed the potential positive and negative impacts of the project, by field investigations with topographic maps and GPS. The more detailed information is in ESIA documents.
Sustainable Operation and Management (resettlement)

Construction land of this project involves 2 provinces (Vientiane, Xayaburi) and 3 districts. 267 families in 3 villages need resettlement and 354 families in 10 villages need relocation. According to the community participation survey, the affected people have the positive attitude for this project.
Mitigation measure for reducing negative influences to the regional socio-economic due to the construction land acquisition has been taken account into project development and SMMP. That is making use of the reasonable program of the development of fishery, livestock husbandry, public health treatment, communities and so on, to make the productivity and living standard be higher than or equivalent with original life at least.
The resettlement progress will be compatible with the project construction. The best time for moving people will be in the dry season in year 4 and 5.
Some pictures of project-affected community facilities

A school

Community Health Center

A temple

Village road
Thank you for your attention!