PAKLAY HYDROPOWER PROJECT

5th MRC Regional Stakeholder Forum

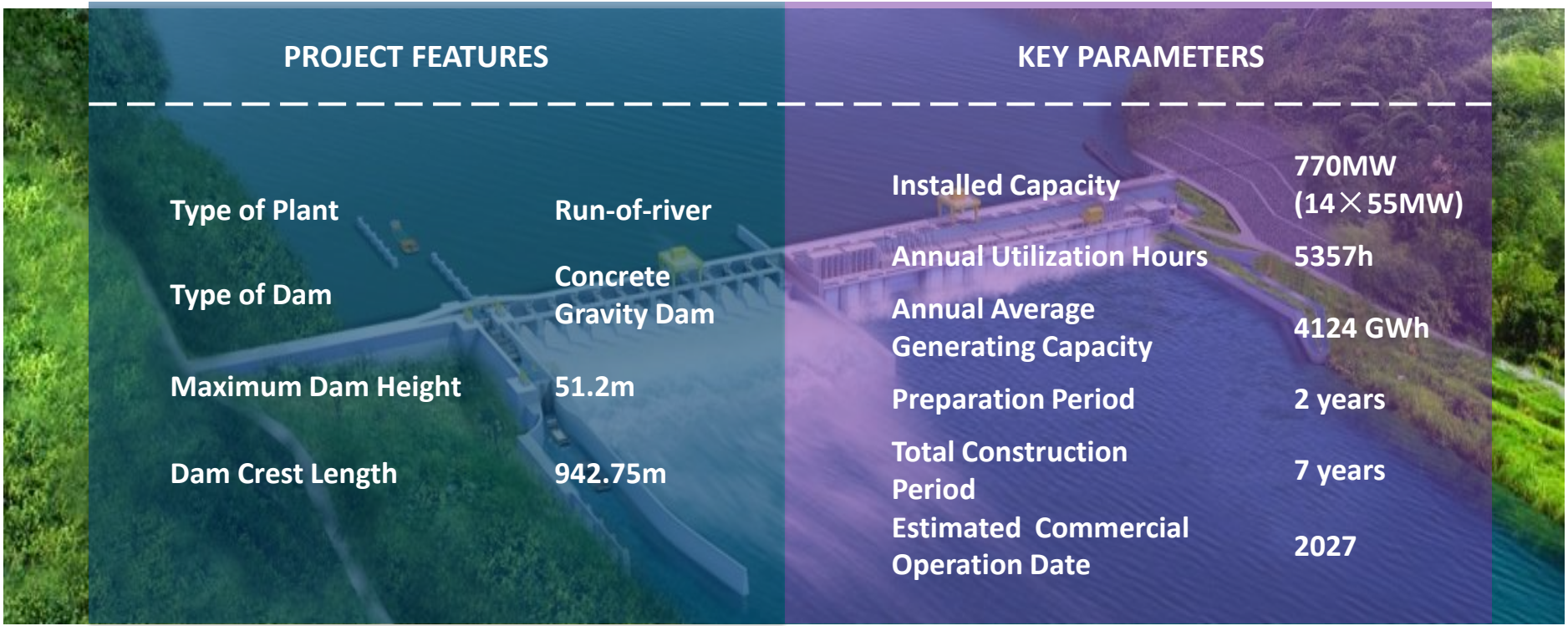
20 September 2018

Mekong Mainstream Project

4th of the 7 hydropower projects along the Mekong mainstream in Lao PDR

Project Location

- 240km from Vientiane Capital
- Straight-line distance to Lao-Thai border approx. 60km

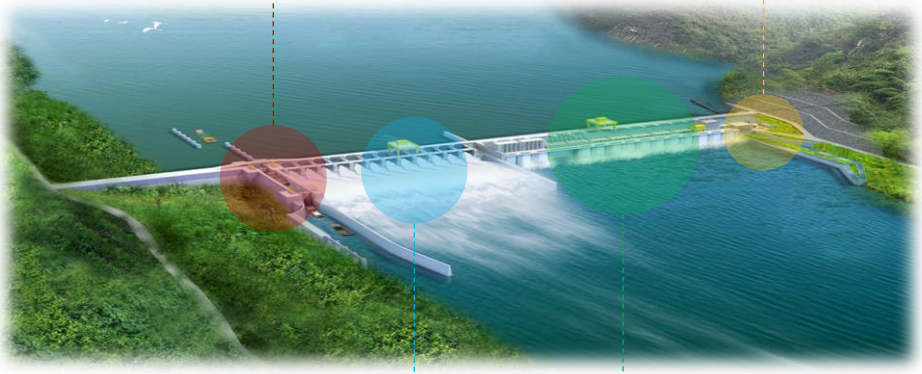


PROJECT FEATURES		KEY PARAMETERS	
Type of Plant	Run-of-river	Installed Capacity	770MW (14×55MW)
Type of Dam	Concrete Gravity Dam	Annual Utilization Hours	5357h
Maximum Dam Height	51.2m	Annual Average Generating Capacity	4124 GWh
Dam Crest Length	942.75m	Preparation Period	2 years
		Total Construction Period	7 years
		Estimated Commercial Operation Date	2027

Project Structures

Navigation Locks

- Single-Stage ship lock
- Capacity for passing 500t ships
- Size of navigation lock: 120m*12m*4m



Fish Passage

- 1017m length, 6m width, 3m depth
- A large resting pool considered

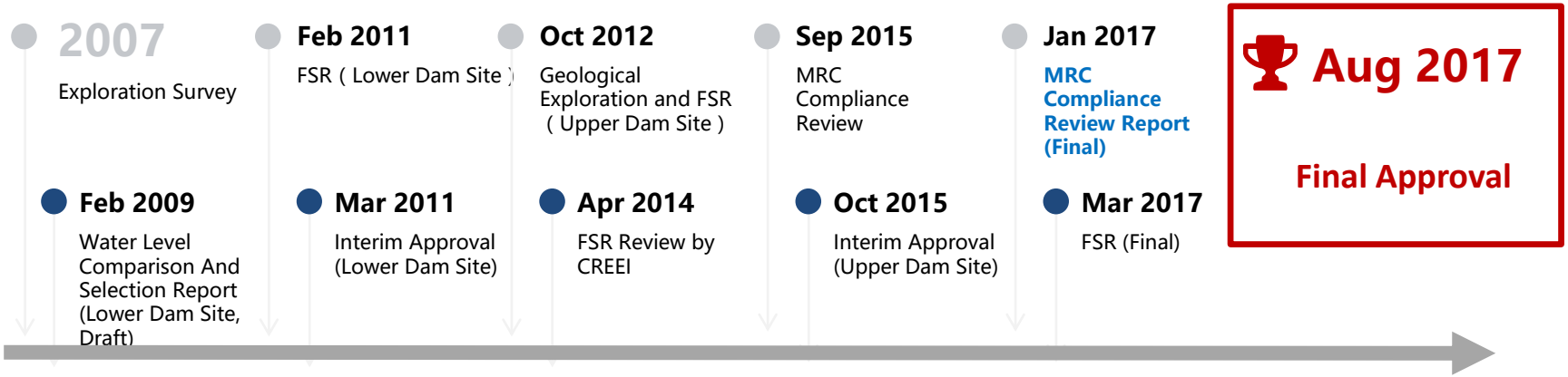
Spillway

- EL 220m: 11 open-type high-level surface bays (16m*20m)
- EL 212m: 3 open-type low-level surface bays(16m*28m)
- EL 205m: 2 sediment flushing bottom outlets(10m*10m)

Power House

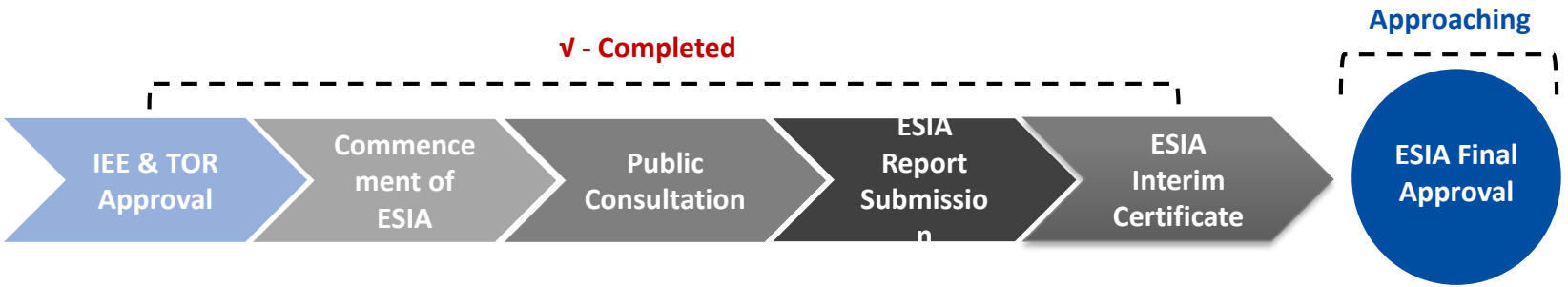
- Capacity: 770 MW
- 55 MW of bulb generating unit
- 14 Units

1.2.1 Feasibility Study



11 years of profound study with involvement of excellent designing firm and international consultants, laying a solid foundation for the project implementation and operation.

1.2.2 Environment & Social Impact Assessment (ESIA)



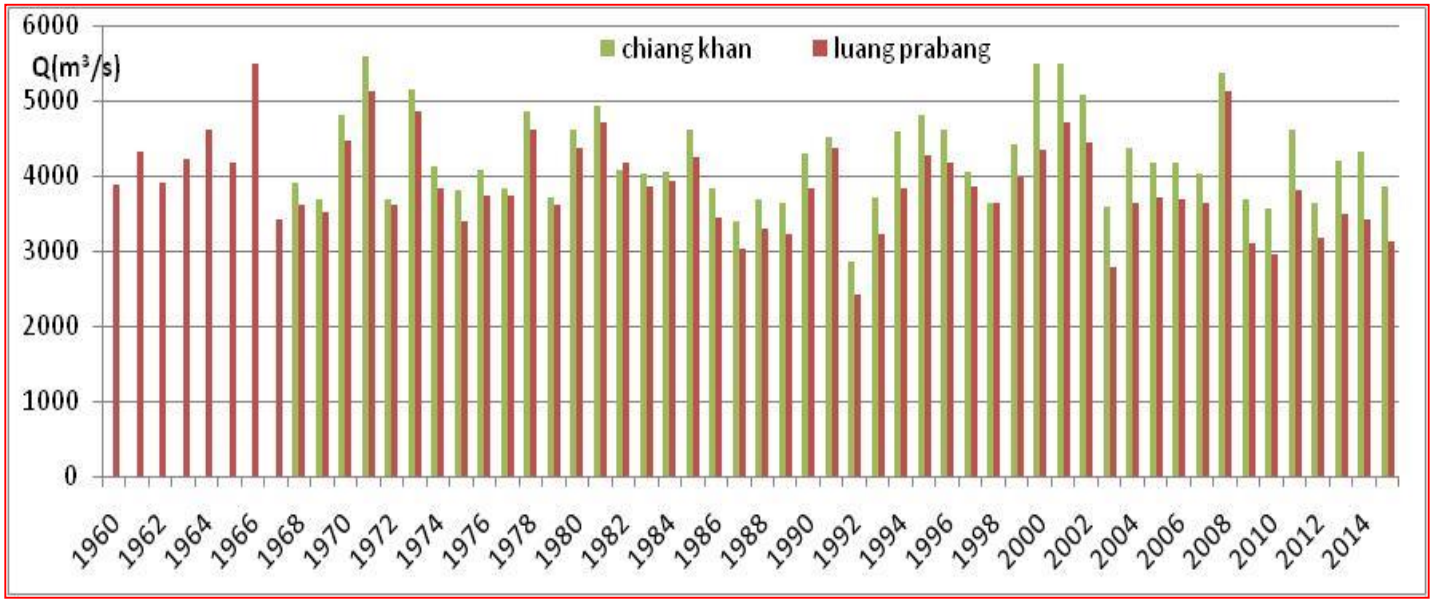
Completed and updated 8 ESIA related reports:

- Transboundary Environmental and Social Impact Assessment (TBESIA)
- Cumulative Impact Assessment (CIA)
- Environmental Impact Assessment (EIA)
- Environmental Management and Monitoring Plan (EMMP)
- Social Impact Assessment (SIA)
- Social Management and Monitoring Plan (SMMP)
- Resettlement Action Plan (RAP)
- Health Impact Assessment (HIA)

1.2 Hydrology

1.2.1 Runoff

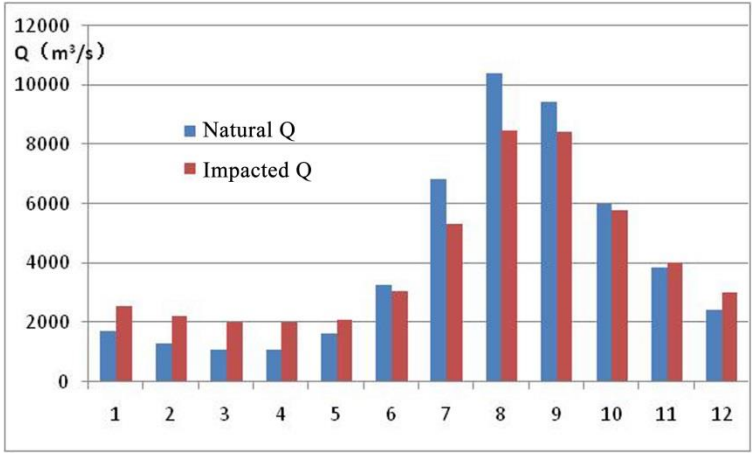
a) By extending the data series of the Luang Prabang Hydrological Station and the Chiang Khan Hydrological Station to 2015, it can be obtained that the average annual discharges at the two stations are 3,820 m3/s and 4,240 m3/s respectively through statistical analysis.



1.2.1 Runoff

b) it can be obtained that the average annual discharge at the dam site is 4,060 m3/s

c) the runoff at the dam site under the impacts of upstream cascades has been analyzed and calculated;

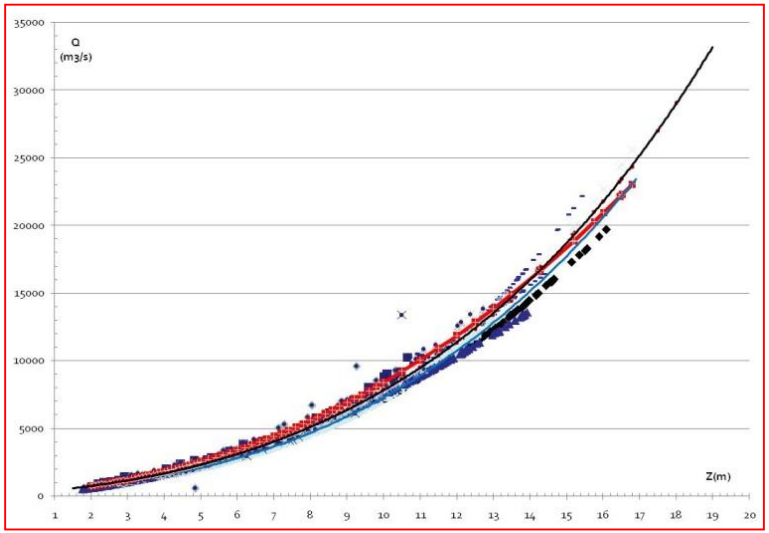


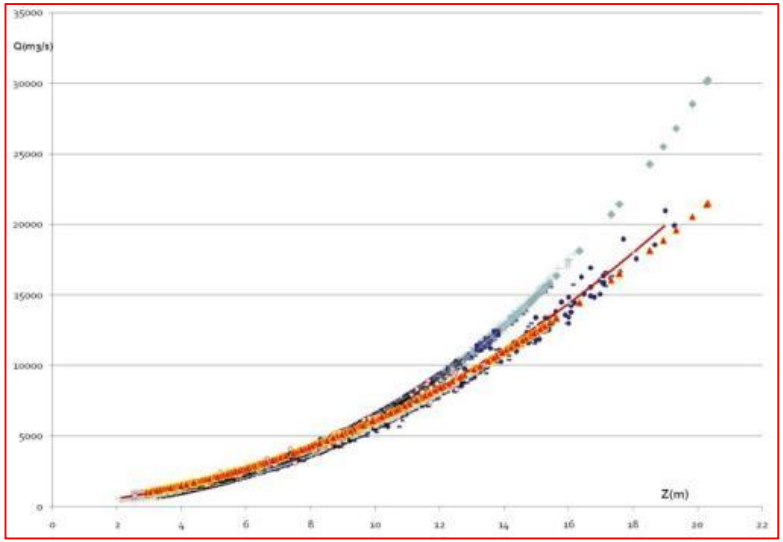
Monthly Average Discharge Over Years at the Dam Site
Unit: m^3/s

Month	January	February	March	April	May	June	July	August	September	October	November	December	Annual
Q	1740	1310	1120	1150	1690	3210	6610	10250	9280	5880	3810	2440	4060
%	3.59	2.70	2.31	2.37	3.49	6.62	13.63	21.14	19.14	12.13	7.86	5.03	100

1.2.2 Stage-Discharge Relationship

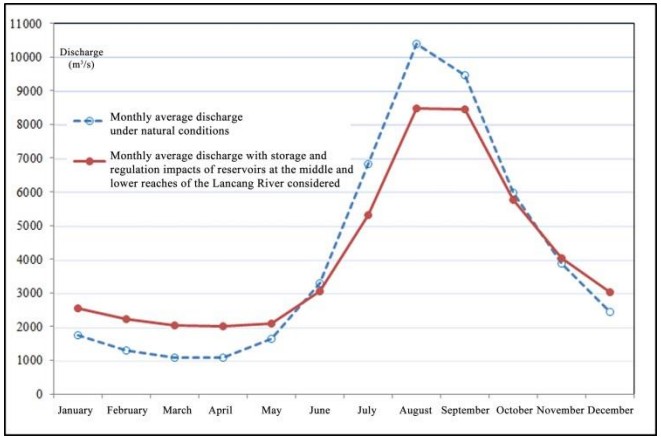
the stage - discharge relationship at the dam site calculated at this stage is basically proper;

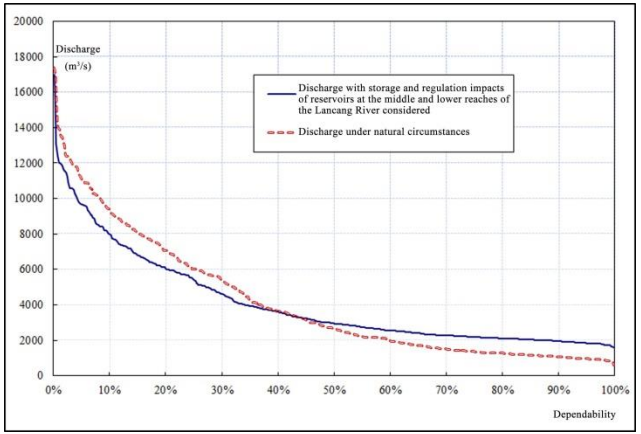




1.2.3 Analysis on Impacts of Upstream Reservoirs on Runoff at Paklay Dam Site

Analysis on impacts of reservoirs on the main stream of the Lancang River on runoff at Paklay Dam Site





Considering regulation and storage impacts of reservoirs at the middle-lower reaches of the Lancang River, the average annual discharge at the Paklay Dam Site is consistent with that under natural conditions. However, with a relatively large variation in annual distribution of discharge, the average discharge in flood season (June ~ October) will decrease by about 14%, and that in dry season (December ~ next May) will increase by about 50%.

1.2.4 Sediment

- The analysis and calculation results indicate that there is average annual suspended load discharge and average annual suspended load sediment content of 16.50x106 t and 0.129 kg/m³ respectively at the dam site;

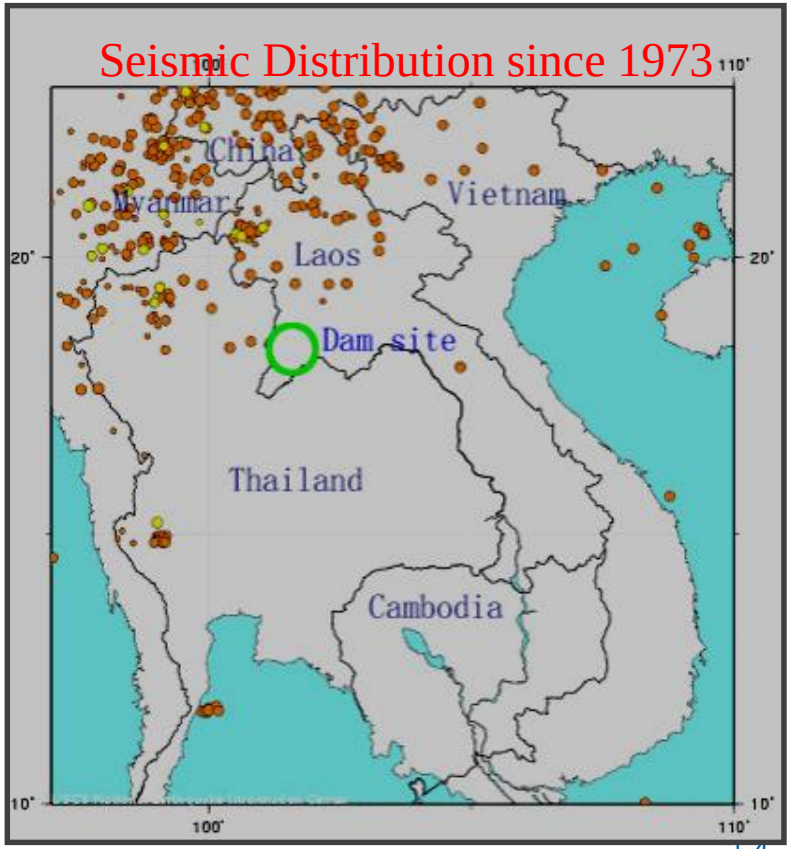
Monthly Average Sediment Discharge Over Years at the Dam Site Unit: 10,000 t

Month	1	2	3	4	5	6	7	8	9	10	11	12	Annual
Sediment discharge	21	9	7	7	20	74	254	499	412	206	99	44	1650
%	1.26	0.56	0.42	0.42	1.22	4.46	15.36	30.21	24.97	12.50	5.97	2.64	100

1.3 Geology

1.3.1 Regional Geology

According to USGS information, no major earthquake has occurred within a radius of 150km since 2150 BC ; 4 earthquakes has occurred within a radius of 150 km since 1973 (M4.7 as the maximum) and no earthquake has occurred within a radius of 30 km.



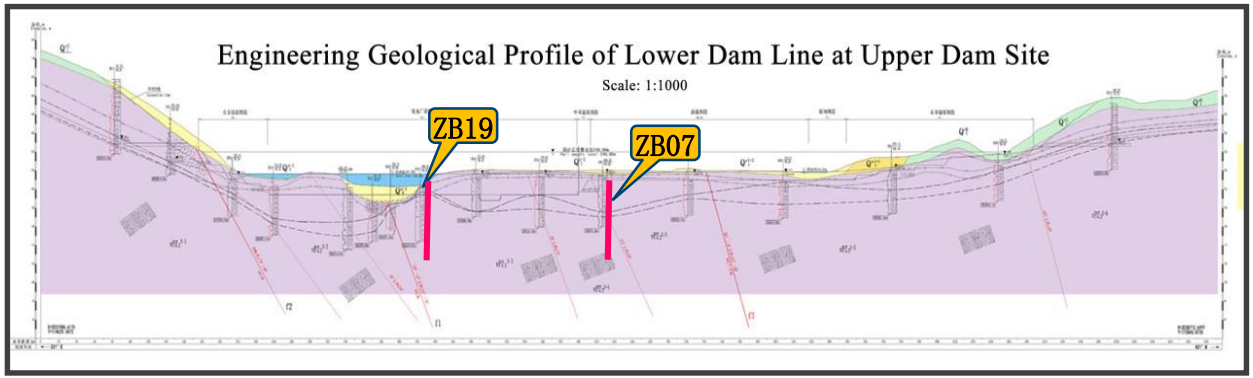
1.3.1 Regional Geology

According to the seismic safety evaluation and research results, it is recommended that the peak ground acceleration be 0.384 g (SEE and MCE) for that with an exceedance probability of 2% in 100 years.

Ground Motion Parameters of Bedrock at the Recommended Dam Site

Designed seismic dynamic parameter	50-year exceedance probability	100-year exceedance probability		
	10%	50%	4%	2%
Return years	475	145	2475	5000
Amax (gal)	130.0	64.9	284.3	376.8
βmax	2.38	2.32	2.44	2.49
Tg (sec)	0.26	0.25	0.27	0.28
Ah(g) (= Amax/980)	0.133	0.066	0.290	0.384
γ	1	1	1	1

1.3.2 Geological Conditions of the Upper Dam Site



The strata outcropping at the upper dam site are of mica quartz schist and blastopsammite. The schist has low strength and weak weathering resistance; the blastopsammite has high strength. Bedrock weathering is shallow in the riverbed and relatively deep in bank slopes.

1.4 Project Planning

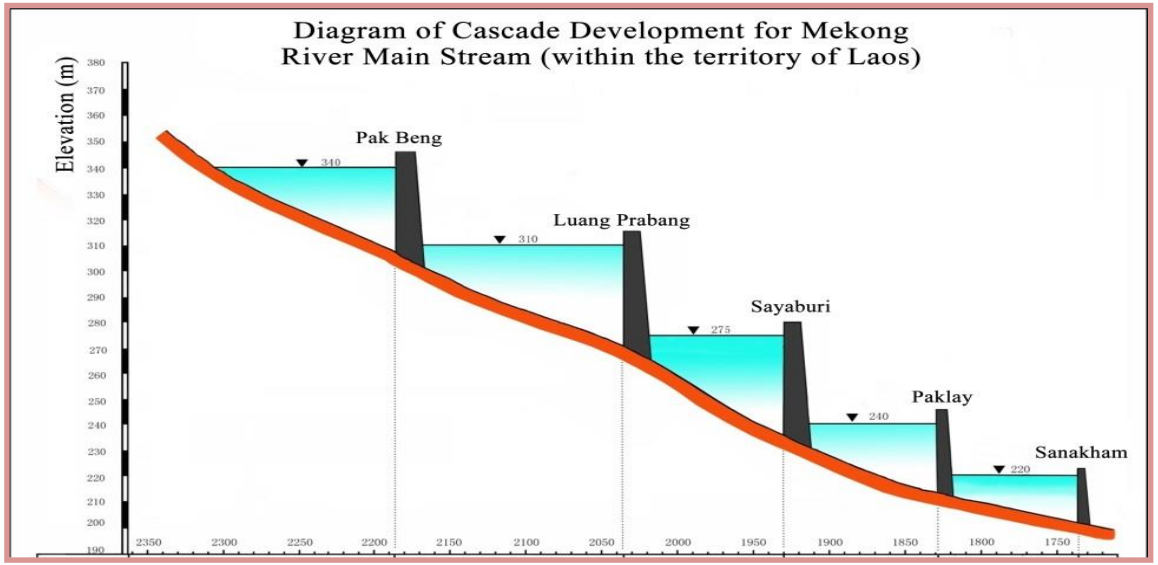
1.4.1 Power Market Analysis

Paklay HPP will mainly supply power to Thailand.

1.4.2 Full Supply Level

In the feasibility study, the full supply level of Paklay HPP is considered as 240.00 m. It have a min. operating level of 239 m and a live storage of 54.8 million m^3.

Cascade HPP Development on the Main Stream of Mekong River (within Laos)

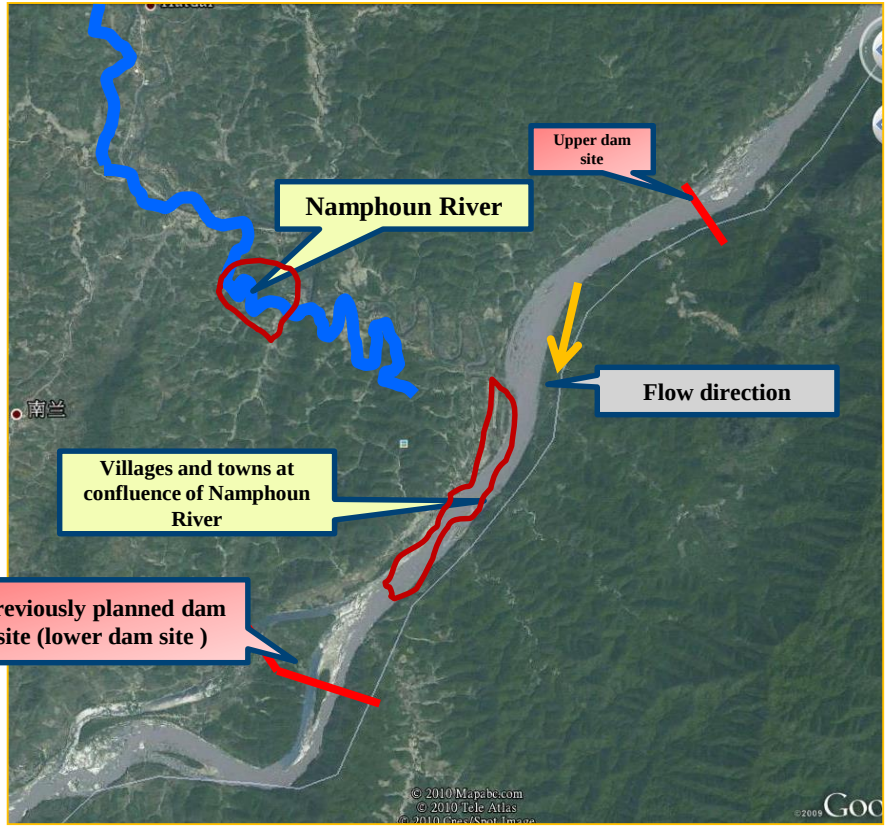


1.5 Project Layout and Main Structures

1.5.1 Dam Site Comparison

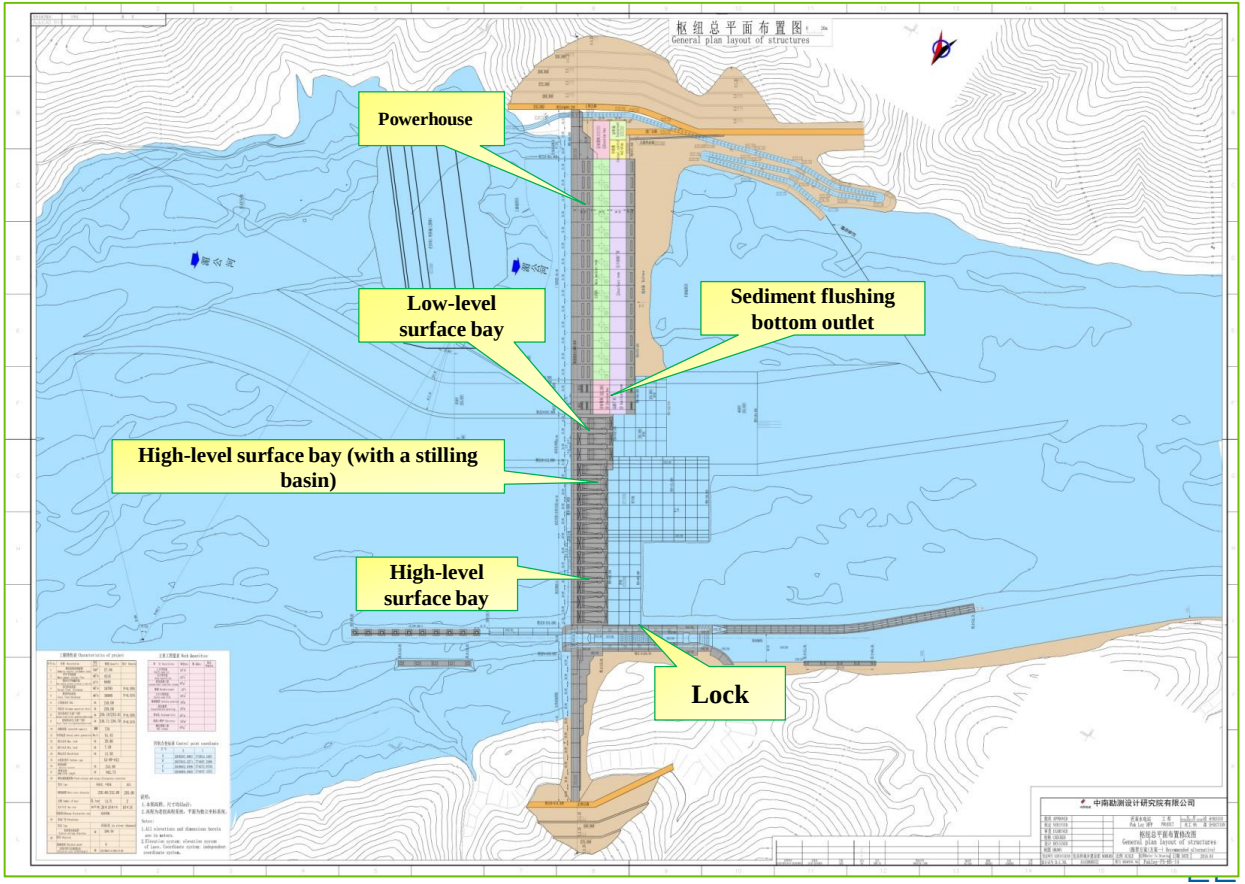
The upper dam site and lower dam site are proposed for comparison.

After an overall comparison, the upper dam site is recommended in this stage.

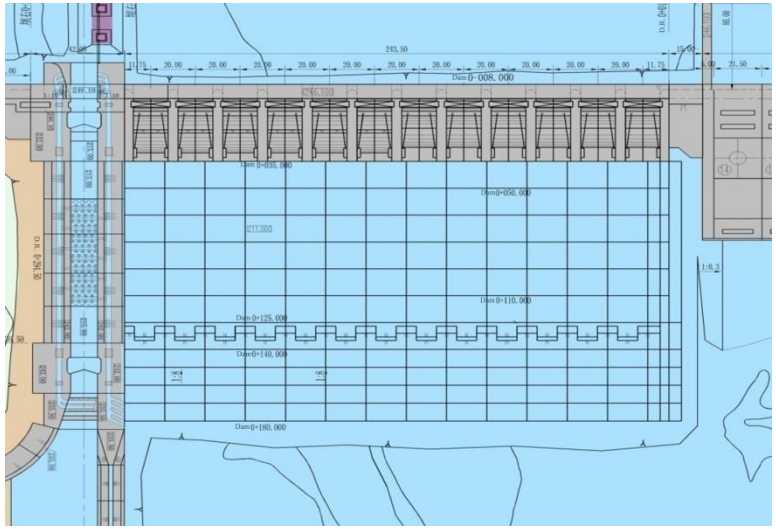


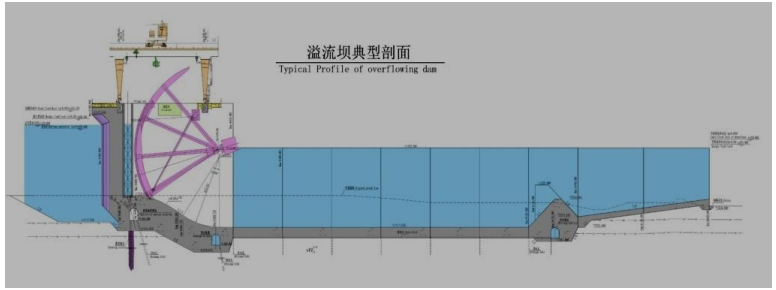
1.5.2 Project Layout

The project consists of the water-release and energy dissipation structures, water–retaining structure, powerhouse, shiplock and fishway. From left to right along the dam, the structures are fishway, left non-overflow section, retaining-type powerhouse section, overflow section (energy dissipator by hydraulic jump), shiplock section, and right non-overflow section.

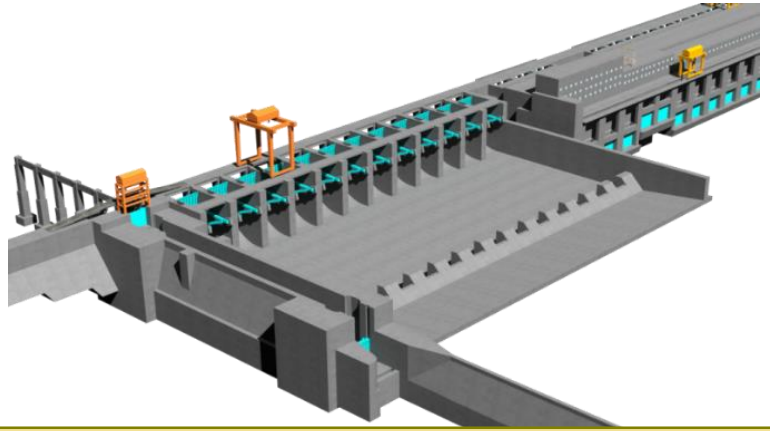


1.5.3 Main Structures





The overflow section consists of 11 open-type high-level surface bays, 3 open-type low-level surface bays and 2 sand flushing outlets.



open-type high-level surface bays:16.0m×20.0m.

open-type low-level surface bays:16.0m×28.0m.

sand flushing outlets:10.0m×10.0m.

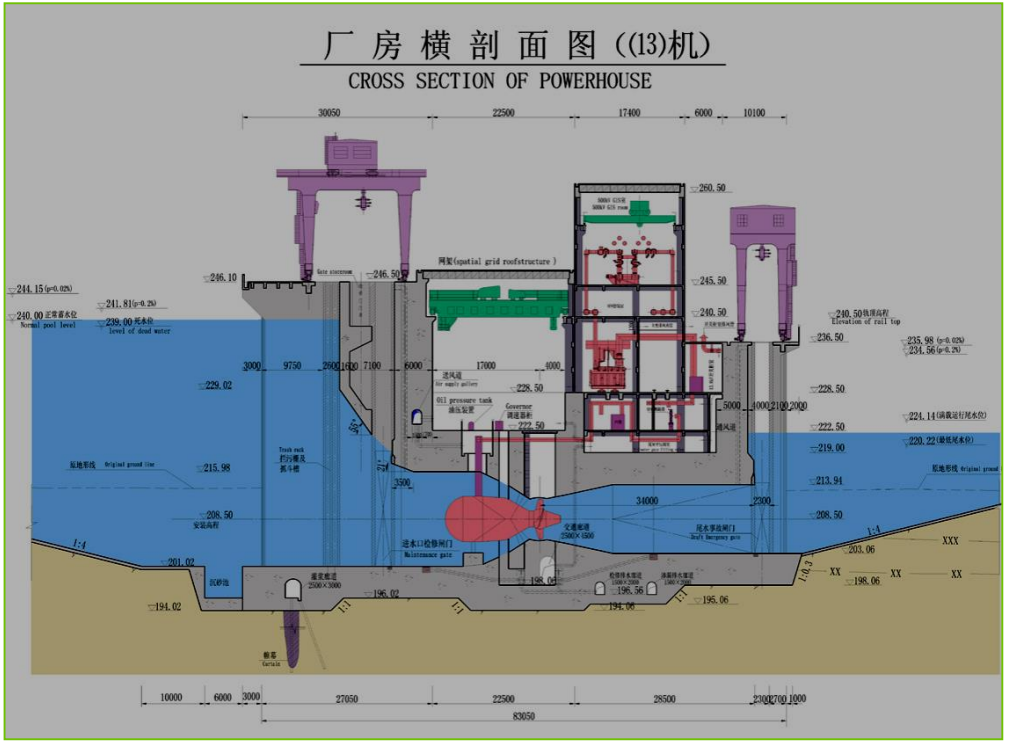
1.5.3 Main Structures

The hydraulic jump energy dissipator is proposed.

1.5.3 Main Structures

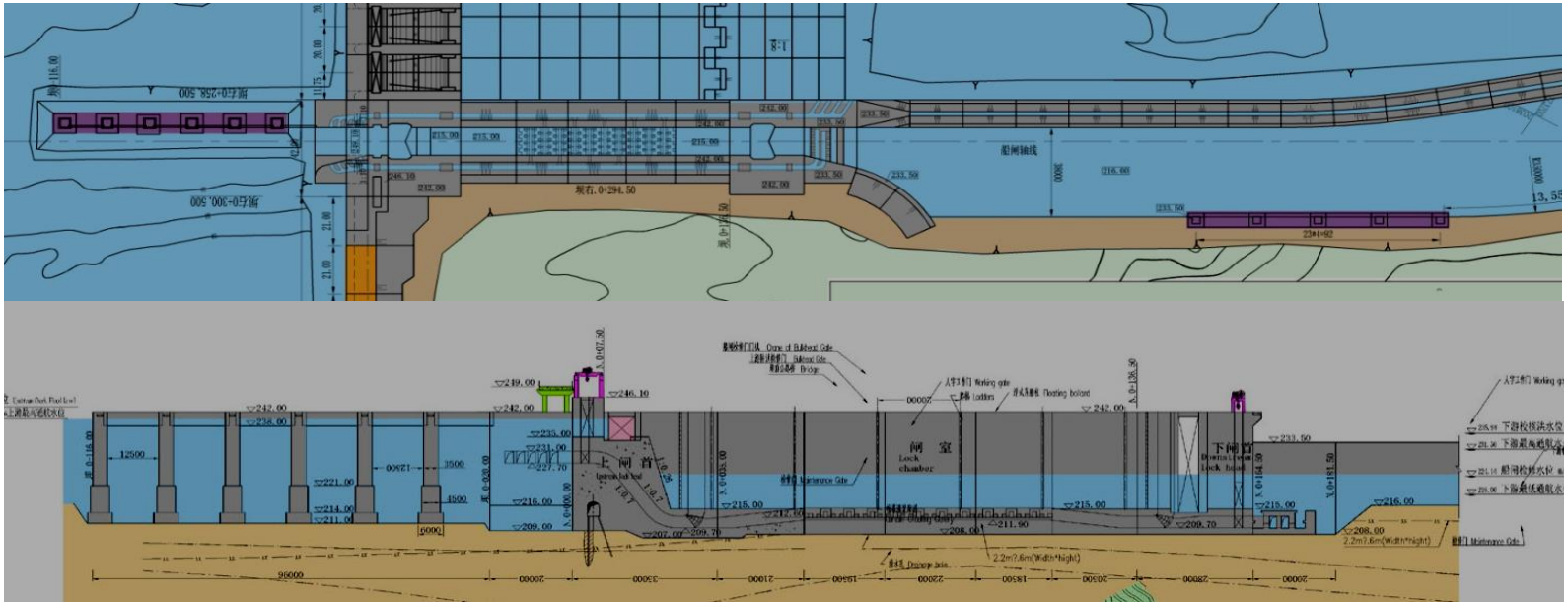
The main powerhouse consists of the machine hall and erection bay.

The machine hall has a net width of 21.00m, and consists of three floors from top down, namely operation floor, busbar floor and passage floor. The setting elevation of unit is 208.50m.



1.5.3 Main Structures

Navigation structure: In this stage, the single-stage ship lock alternative is recommended. The effective size of the ship lock is 120.0m×12.0m×4m（L×W×water depth） as per MRC. The ship lock system consists of the upper approach, ship lock and lower approach.

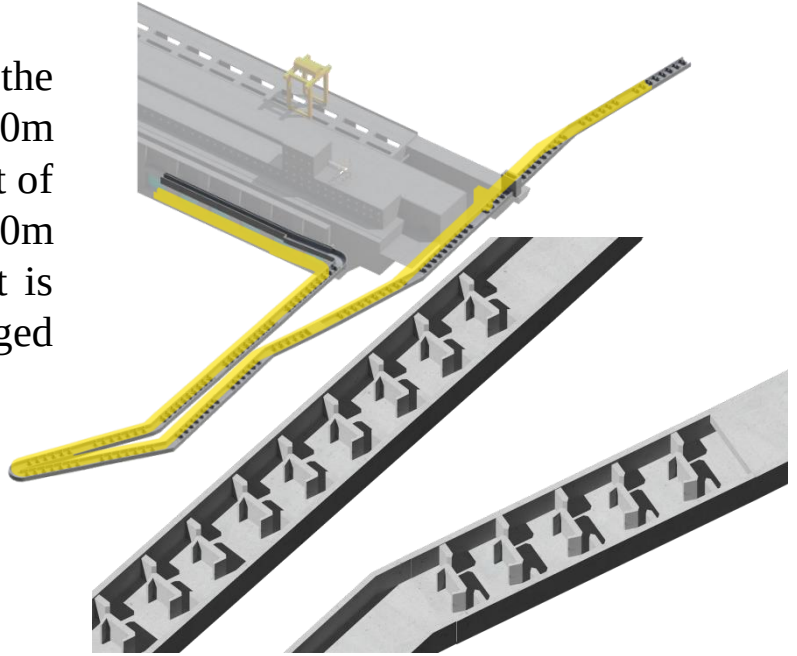


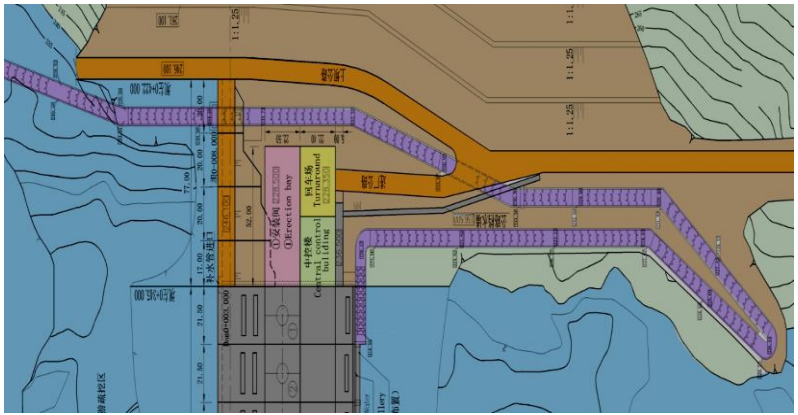
1.5.3 Main Structures

Fishway structure: The two-side vertical-slot fishway is recommended.

1.5.3 Main Structures

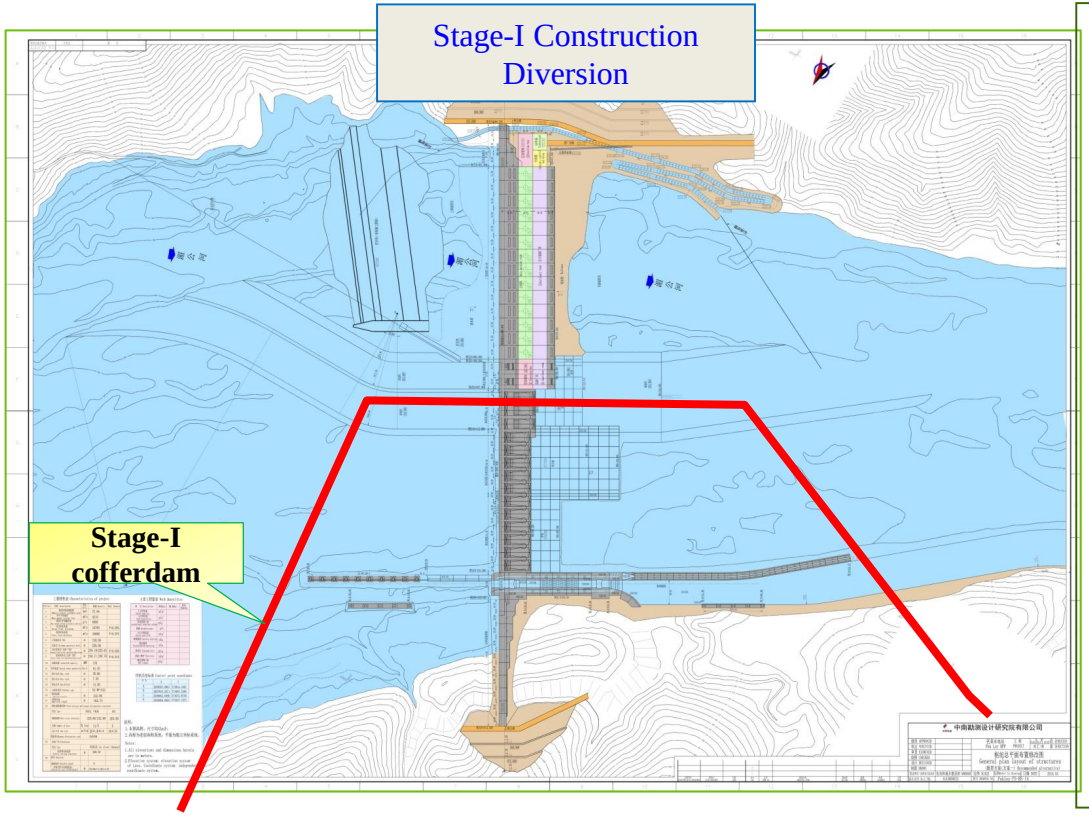
Fishway structure: The fishway is arranged on the slope on the left side of powerhouse, with a total length of 830.00m (including 25m-long Denil section at the inlet), and a gradient of 7.68%. The two-side vertical-slot fishway section is 805.00m long, with an average gradient of 2.12%. The fishway inlet is connected to the fish collection system, and its outlet is arranged 150m upstream of the power intake, with one bulkhead gate.





1.6 Construction Planning

1.6.1 Construction Diversion



The stage-I cofferdam is used for closing the water release structure, navigation lock and right-bank non-overflow dam, while the left river bed is used for overflowing and navigation.

Diversion standard: 20-year flood with a discharge of 23,500 m^3/s.

1.6.1 Construction Diversion

枢纽总平面布置图
General plan layout of structures

Stage-II cofferdam

Stage-II Construction Diversion

The stage-II cofferdam is used to close the main powerhouse, fishway and left-bank non-overflow dam, while the water release structure is used for overflowing and the lock is used for navigation.

Diversion standard: 20-year flood with a discharge of 23,500 m^3/s before power generation and 50-year flood with a discharge of 26,100 m^3/s after power generation.

Hydrologic Survey at Damsite Section

CNR Review Comment: The hydrologic survey at the dam site section should be supplemented.

Modification:

a) the temporary water level, discharge and sediment measurement at the damsite section was carried out.

b) the bed material sampling and grading analysis was conducted.

2.1.2 Hydrologic Survey at Damsite Section

Modification:

c) the water level gauging station at the dam site was restored and manual water level observation started.

d) manual staff gauge and automatic gauging station for Paklay hydrological station were built.

2.1.2 Hydrologic Survey at Damsite Section

Modification:

e) the flow measurement with ADCP and conventional velocity meters as well as sediment sampling and analysis was started.

Sediment Sampling and Gradation Analysis

Runoff and Flood

CNR Review Comment: The runoff and flood should be checked.

Modification:

b) The runoff at the damsite has been analyzed and checked based on the damsite measurements and the processed data and the collected data;

Mean Monthly Discharges at Damsite from 1960 to 2015

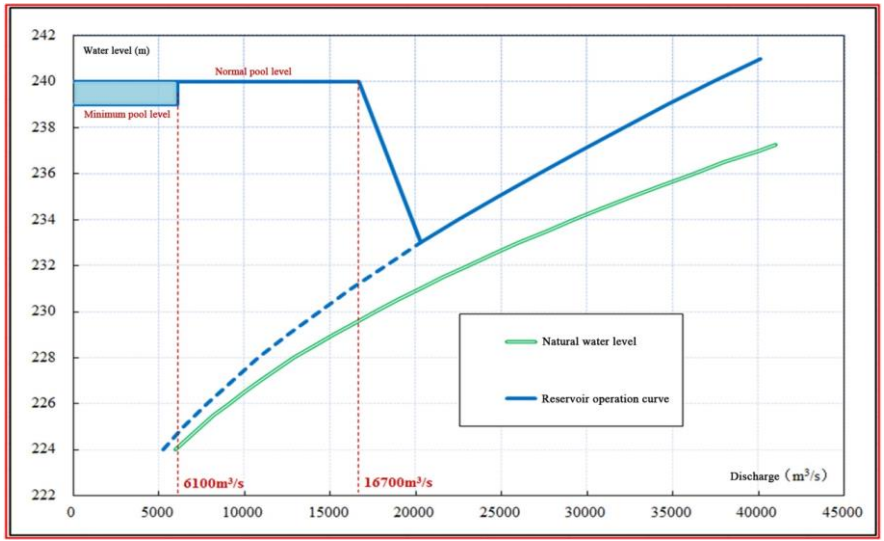
Q：m^3/s

Month	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
Q	1,740	1,310	1,120	1,150	1,690	3,210	6,610	10,250	9,280	5,880	3,810	2,440	**4,060**
%	3.59	2.70	2.31	2.37	3.49	6.62	13.63	21.14	19.14	12.13	7.86	5.03	**100**

Paklay Reservoir Operation Mode

CNR Review Comment: The reservoir operation mode should follow the operation principles of run-of-river hydropower stations.

Modification: The reservoir operation mode has been adjusted following the operation principles of run-of-river hydropower stations. For details, see the figure below:



2.2.1 Basic Information and the Suspended Load Sediment at the Dam site

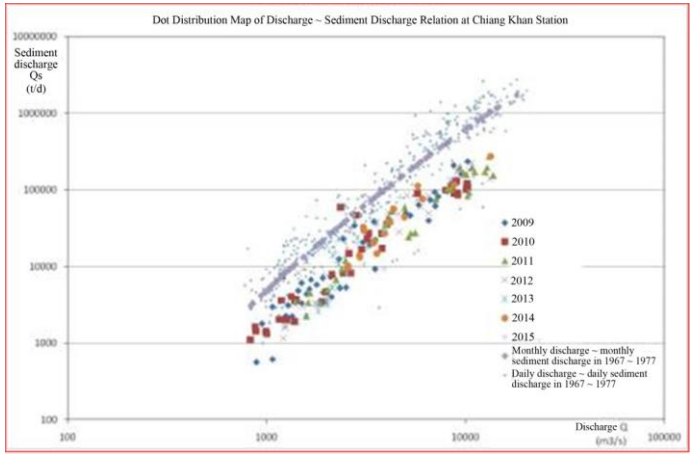
CNR Review Comment: Additional basic information should be collected and the suspended load sediment results should be checked at the dam site.

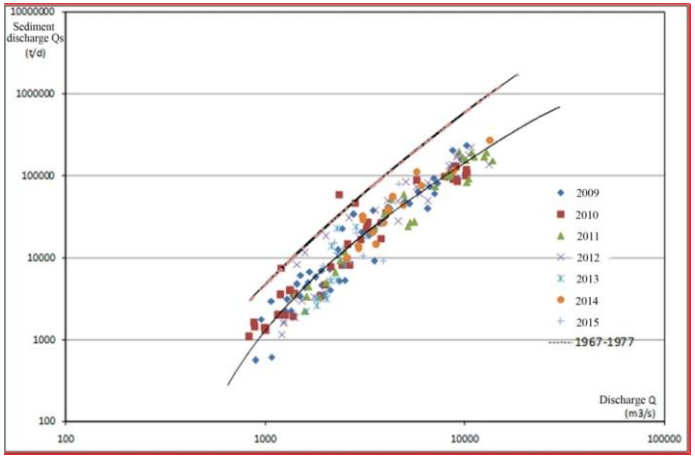
Modification:

a) The sediment data were additionally collected.

b) The suspended load sediment results at the dam site were analyzed and calculated;

c) The sediment results were checked and reviewed.





Suspended Load Sediment Gradation

CNR Review Comment: The suspended load sediment gradation should be analyzed.

Modification:

a) Analysis and collation were conducted for sediment gradation sampling results, as well as the bedload sediment gradation sampling results;
b) Comparison and analysis were conducted for the suspended load sediment grain gradation results obtained in different periods;

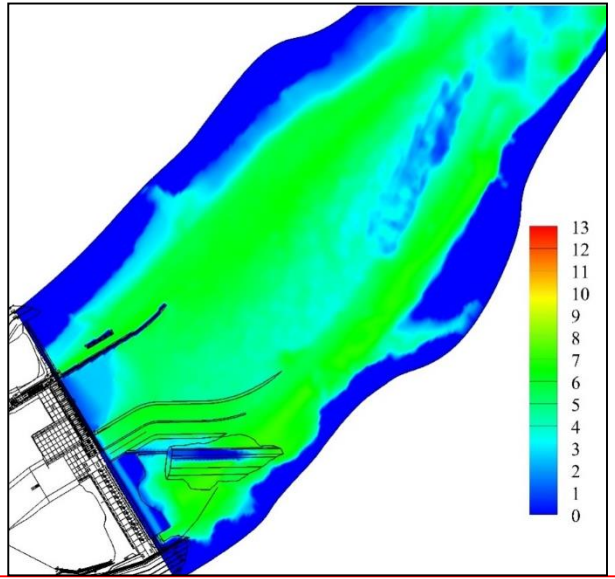
Flood Water Surface Profile Measurement and Channel Roughness Coefficient Calibration

In August 2016, we conducted flood water surface profile measurement at the river reaches of the Paklay reservoir area.

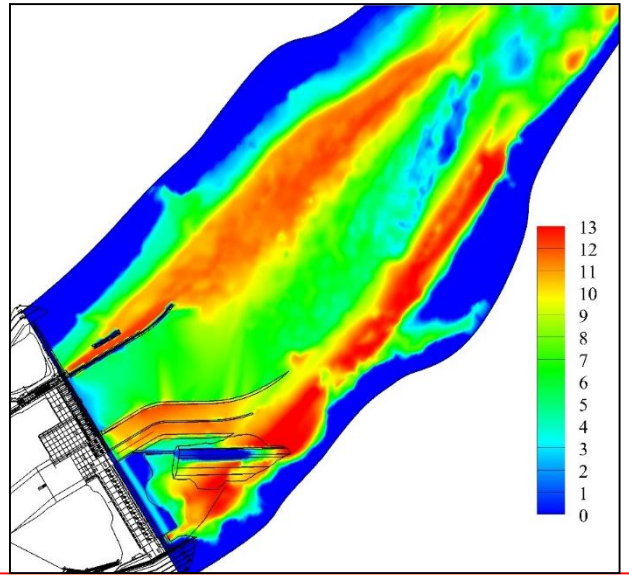
2D Sediment Numerical Simulation for Project Area — River Reaches Upstream of the Dam

a) Overall analysis on sediment scouring and deposition for river reaches upstream of the dam area

Sedimentation is seldom seen at the main stream of the river course and frequently at the river bays. The reservoir has a maximum sedimentation thickness of about 13 m after 40-year operation.



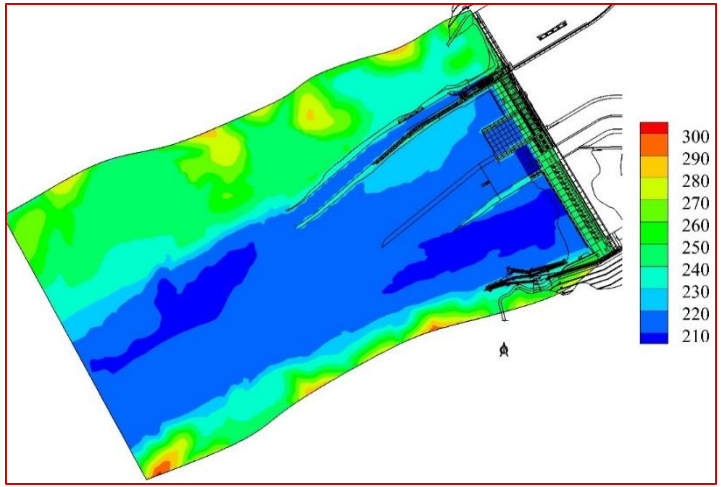
Distribution of Sediment Scouring and Deposition Thickness of River Reaches Upstream of the Dam Area (20-year Operation of Reservoir)



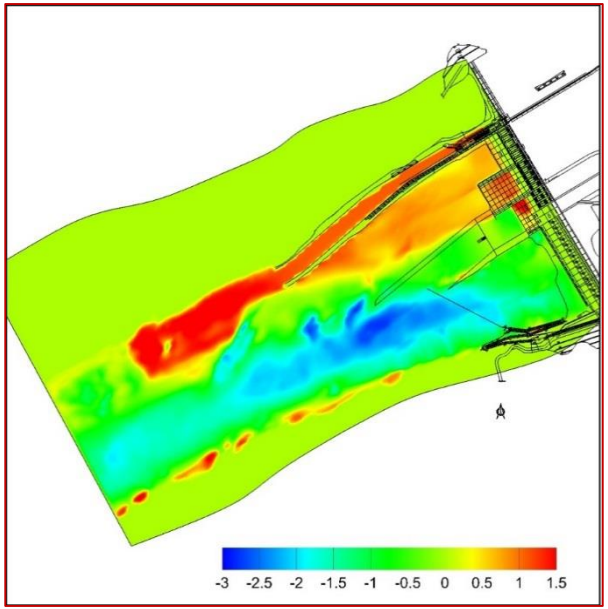
Distribution of Sediment Scouring and Deposition Thickness of River Reaches Upstream of the Dam Area (40-year Operation of Reservoir)

2D Sediment Numerical Simulation for Project Area — River Reaches Downstream of the Dam

a) Analysis of sediment scouring and deposition landform for river reaches downstream of the dam



Landform Elevation Downstream of the Dam After 5 Years of Reservoir Operation

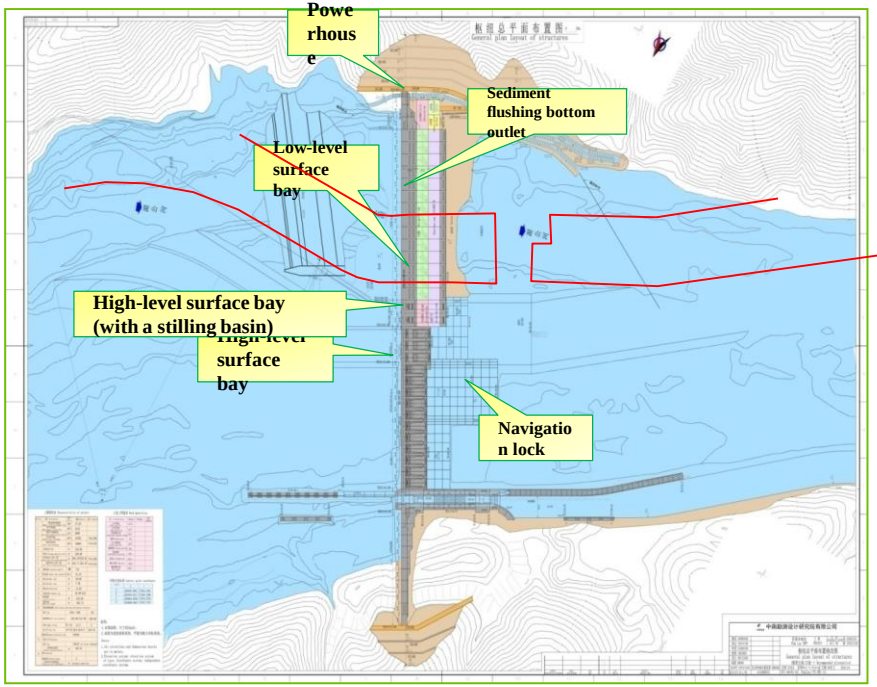


Distribution of Sediment Scouring and Deposition Thickness Downstream of the Dam After 5 years of Reservoir Operation

2.3 Dam Safety

2.3.1 Project Layout

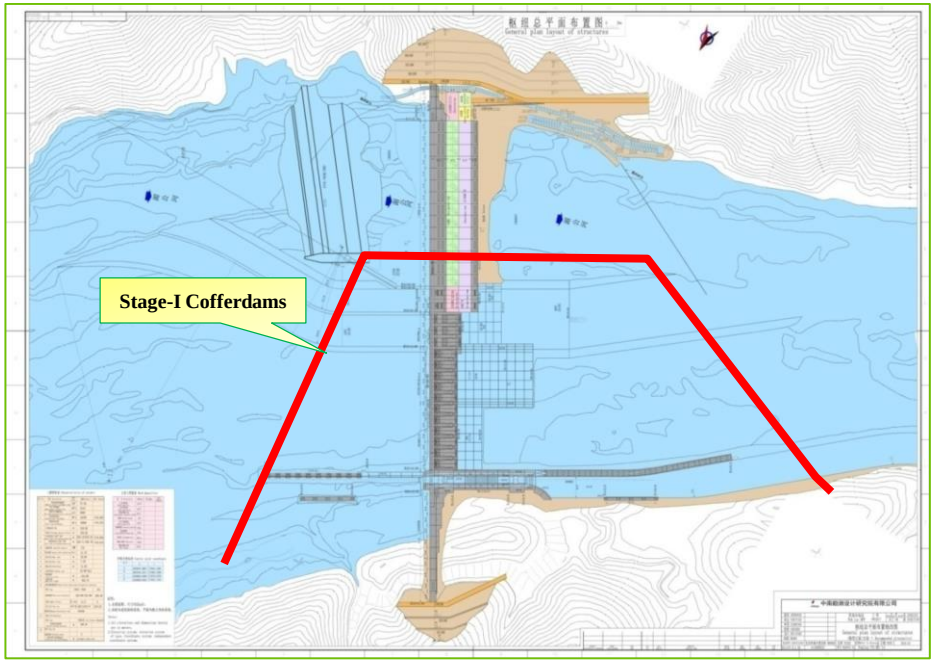
Layout Plan



Based on the original recommended scheme, the erection bay ② is moved to the right end of the powerhouse and two sediment flushing bottom outlets are arranged below the erection bay ②. Three low-level surface bays for flood releasing & sediment flushing are arranged between the erection bay ② and the original flood releasing surface bays. The twelve surface bays in the original scheme is reduced to eleven. Deep grooves are excavated both upstream and downstream of the low-level and high-level surface bays, and connected with the upstream and downstream thawing channels.

2.3.1 Project Layout

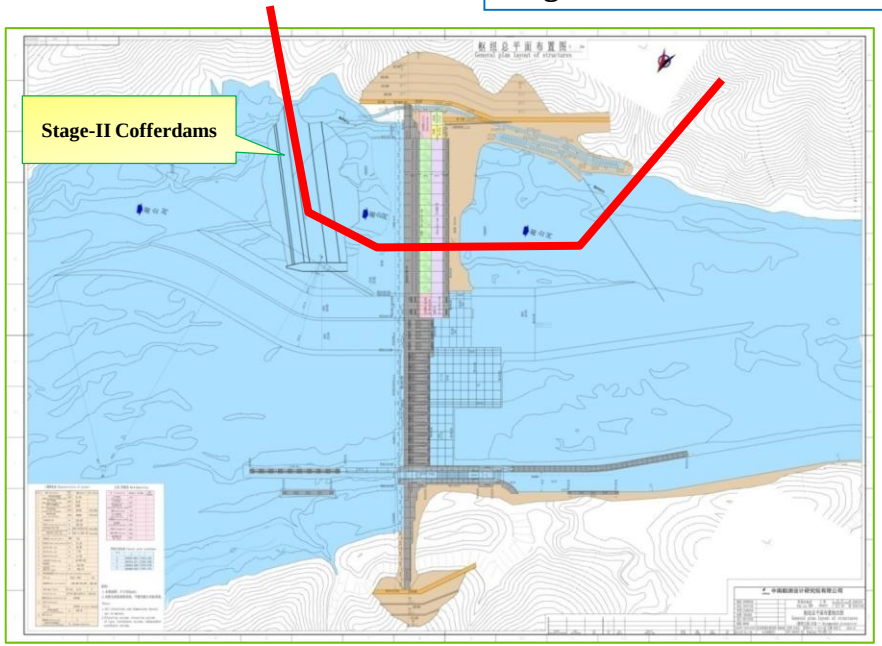
Stage-I Construction Diversion



The stage-I cofferdams are used for closing the area of the water release structure, navigation lock and right-bank non-overflow dam section, while the left river bed is used for the river flow and navigation.
Diversion standard: a 20-year flood.

2.3.1 Project Layout

Stage-II Construction Diversion



The stage-II cofferdams are used to enclose the area of main powerhouse, fish way and left-bank non-overflow dam section, while the water release structure is used for flow pass and the navigation lock is used for navigation.

Diversion standard: a 20-year before power generation; and a 50-year flood after power generation.

Integral Hydraulic Model Test

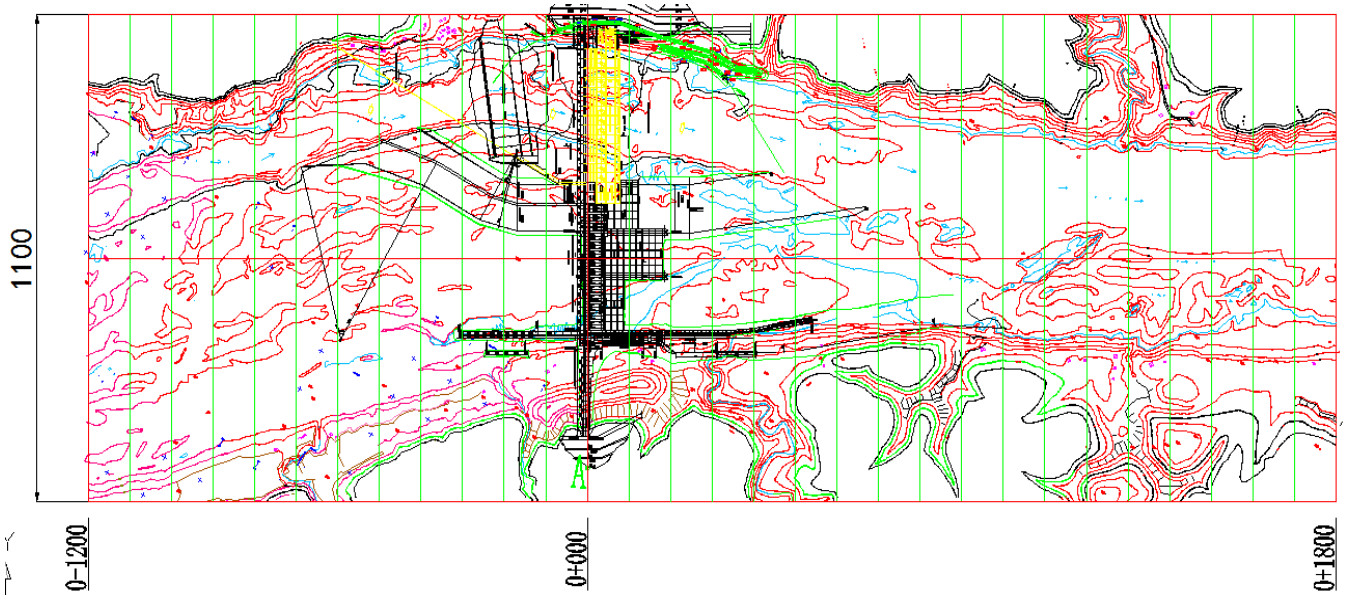
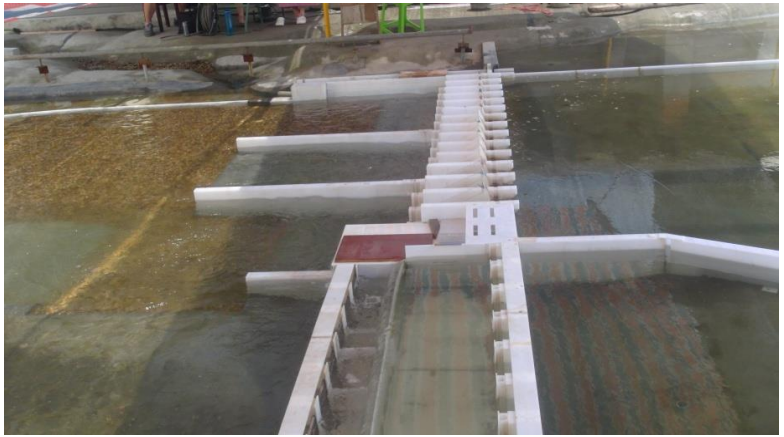


Fig. 1.1 Simulation Range by Integral Hydraulic Model of PakLay HPP

Integral Hydraulic Model Test

Pictures of the Integral Hydraulic Model Test.

Flow pattern Chart for Q= 34,895 m³/s (Full Opening of Gates at 2 Bottom outlets and 14 Surface Bays)



Flow pattern Chart for Q= 16,700 m³/s (Units operating at rated output+ 5 m-deep Opening of ①②③ Surface Bays + 7 m-deep Opening of ④⑥⑧ Surface Bays + 6 m-deep Opening of ⑤⑦ Surface Bays + 1 m-deep Opening of ⑨⑩⑪⑫⑬⑭ Surface Bays)

Integral Hydraulic Model Test

Pictures of the Integral Hydraulic Model Test.

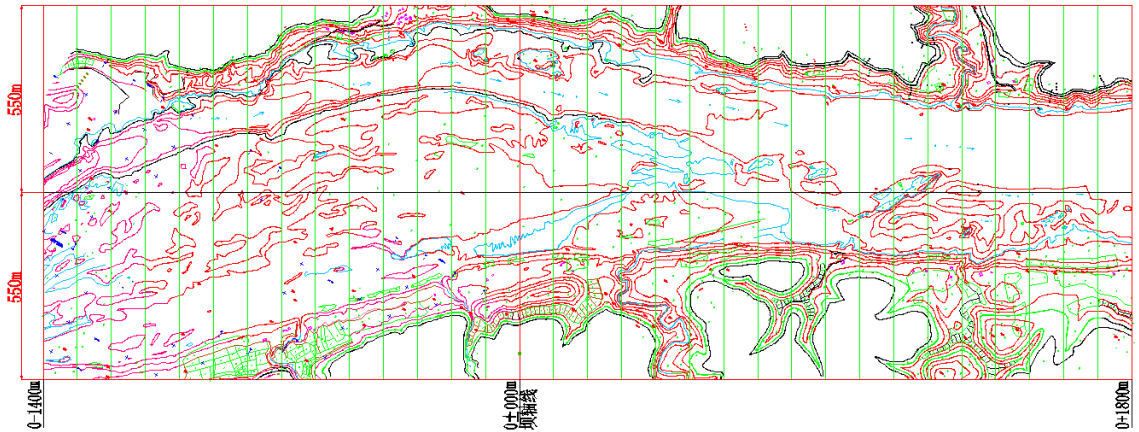
Scour Pit at Q = 39,040 m³/s
(Full Opening of 2 Bottom Outlets + 14 Surface Bays)

Scour Pit at Q = 16,700 m³/s
(8.33 m-ddep Opening of ①②③ Surface Bays
+ 11 m-deep Opening of ④⑤⑥⑦⑧ Surface Bays
+ 2 m-deep Opening of ⑨⑩⑪⑫⑬ ⑭ Surface Bays)

Integral Model Test for Construction Diversion

CNR Review Comment: It is suggested to add integral model test for construction diversion.

Modification: The model test shows that the construction diversion layout can meet the design requirements and the navigation during construction .

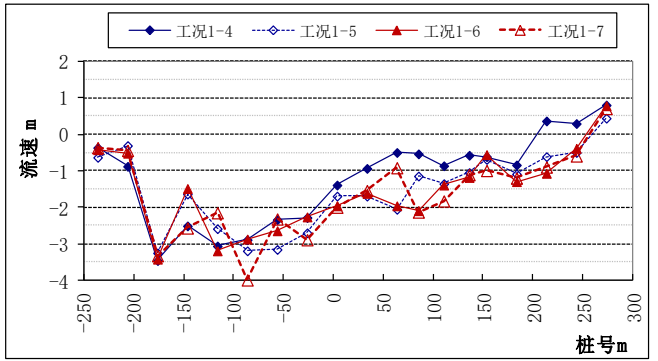


Simulation Range of Integral Model for Construction Diversion at Paklay HPP

2.3.4 Integral Model Test for Construction Diversion

Pictures and Results of Model Test for Stage I Construction Diversion:

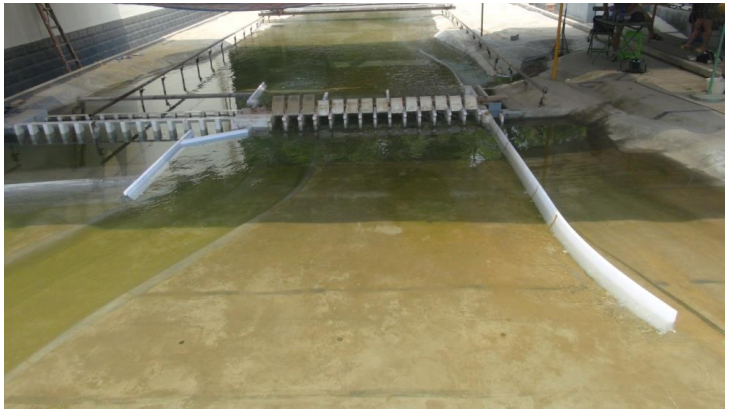
Flow pattern at a 20-year Flood (Q=23174m3/s)



Flow Velocity along the Left Side of Longitudinal Cofferdam

2.3.4 Integral Model Test for Construction Diversion

Pictures and Results of Model Test for Stage II Construction Diversion:



Flow pattern at a 20-year Flood (Q= 23,158 m^3/s)

2.3.5 Adjustment in Seismic Design Standard

CNR Review Comment: Considered earthquakes should be clarified and unified throughout feasibility study (MCE, OBE, SEE). No table of seismic parameters is given.

Modification: The seismic hazard assessment of Paklay HPP is conducted by a third party, the peak ground acceleration is 0.384 g for 100-year exceeding probability of 2%.

Designed seismic dynamic parameter	50-year exceeding probability	100-year exceeding probability		
	10%	50%	4%	2%
Return years	475	145	2475	5000
A_{max}(gal)	130.0	64.9	284.3	376.8
βmax	2.38	2.32	2.44	2.49
T_g(sec)	0.26	0.25	0.27	0.28
a_h(g)(= A_{max}/980)	0.133	0.066	0.290	0. 384
γ	1	1	1	1

OBE SEE

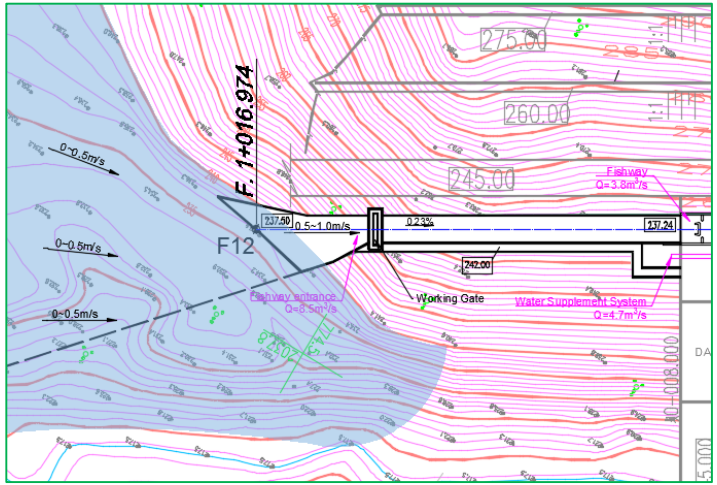
2.5 Fish Way

2.5.1 Connection of the Downstream Entrance of the Fish Way with the Bottom of the Riverbed

Brazilian Experts' Review Comment: The downstream entrance of the fish way should be connected with the bottom of the riverbed.

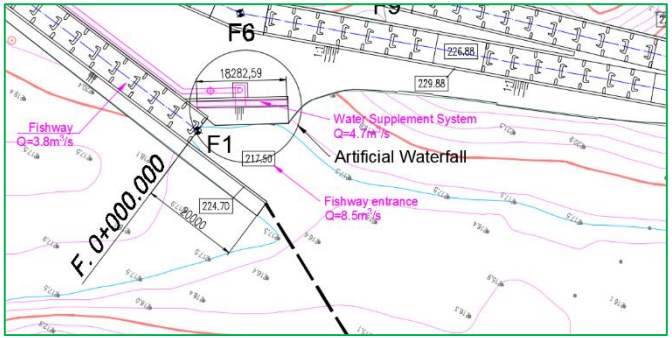
Modification: The layout of the upstream and downstream entrances of the fish way has been modified. The water flow at the upstream entrance is gentle, and the change of water flow at the fish way entrance can help the fishes find the entrance.

Layout of Upstream Entrance



The downstream entrance is arranged about 270m downstream of the powerhouse at the bank, where the riverbed is flat and the conditions for fish guiding are favorable.

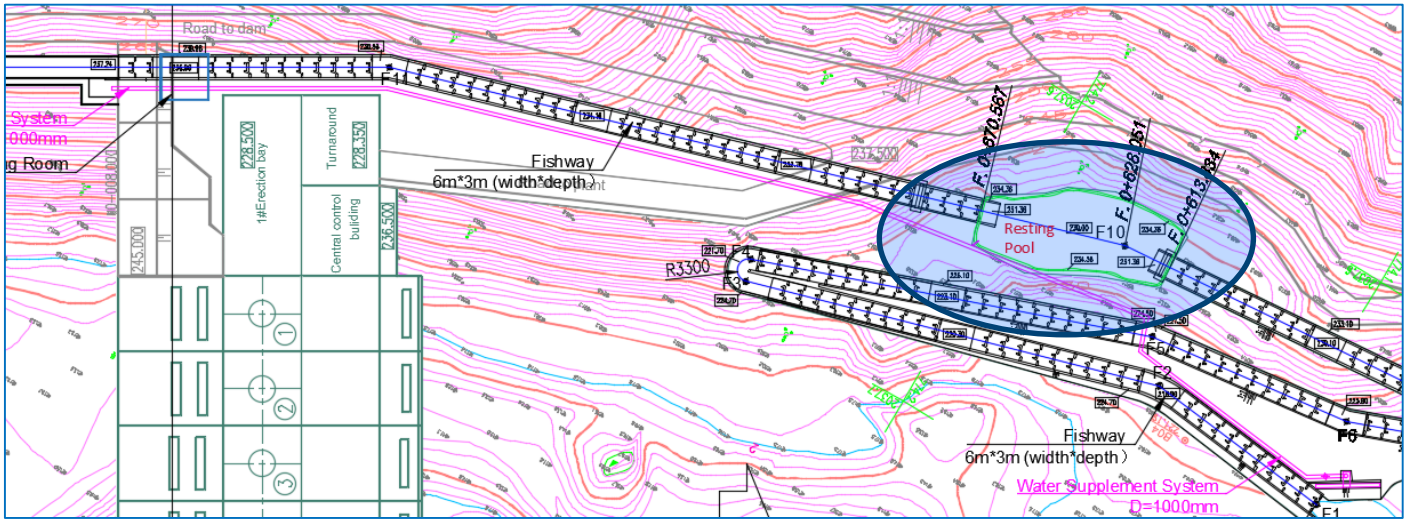
Layout of Downstream Entrance



2.5.2 Large Resting Pool

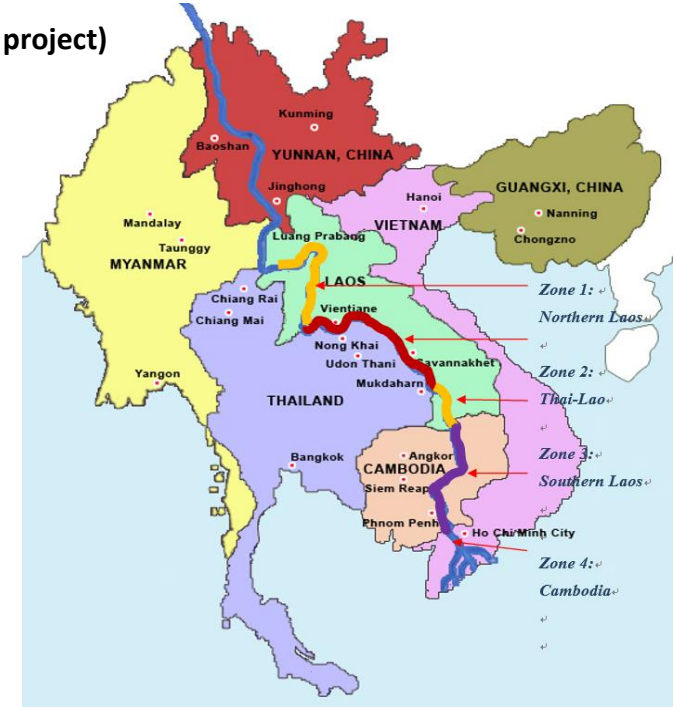
Brazilian Experts' Review Comment: A large resting pool should be added.

Modification: A large resting pool (about 56m long, 22m wide and 4.5m deep) has been added in the middle section of fishway, where the fishes can take a rest and find food so as to have energy to swim upstream.



➢Scope and study zone

- ✓ **Key biophysical and social condition (before the project)**
  - Hydrology and Mekong River Flows
  - Sedimentation
  - Fish Migration and Fisheries
  - Navigation
  - Water Quality
  - Dam Safety
  - Socio-Cultural and Economic
- ✓ **Transboundary and Cumulative Impacts Issues**
  - Hydrology
  - Sedimentation
  - Fish Migration and Fisheries
  - Navigation
  - Water Quality
  - Dam Safety
  - Socio-Cultural and Economic



- Zone 1: Northern Laos – Pak Tha (KM 2281) to Pak Heuang (KM 1736)
- Zone 2: Thai-Laos – Pak Heuang (KM 1736) to Ban Woenbuk (KM 904)
- Zone 3: Southern Laos – Ban Woenbuk (KM 904) to Cambodian border (KM 723)
- Zone 4: Cambodia – Cambodia border (KM 723) to Vietnam Border (KM218)
- Zone 5: Southern Vietnam – Vietnam border (KM 218) to Mekong Delta (KM 0)

Consultations

Data Collection

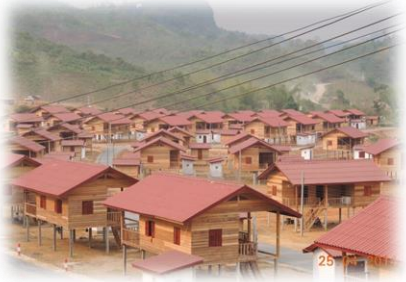
Field Surveys

➢Public Participation

- Public Consultation Conference
  - Village Level
  - District and Provincial Level
  - National Level
- International Regional Level
- Consultation with Other Stakeholders

➢Impacts

- Potential risks of domestic and irrigation water uses.
- Potential risks of downstream cropping.
- Potential risks of downstream health and nutrition.
- Potential risks of downstream tourism.
- Potential risks of Socio-political conflicts.

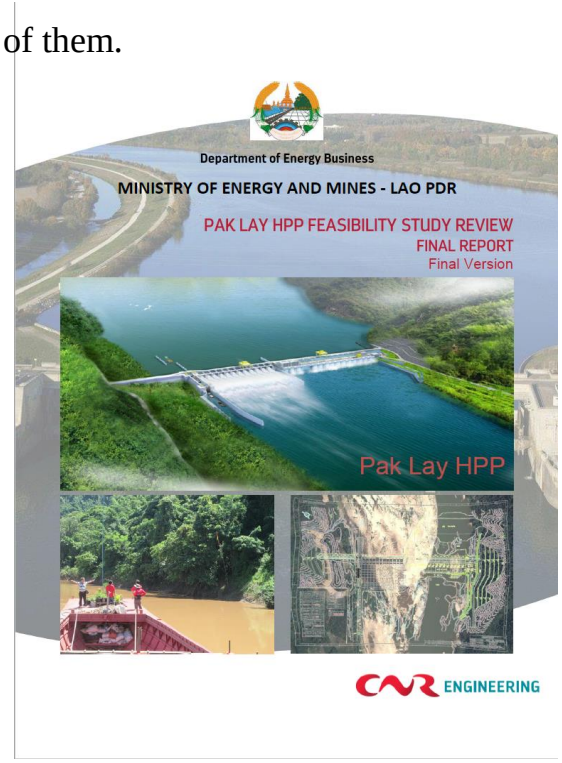


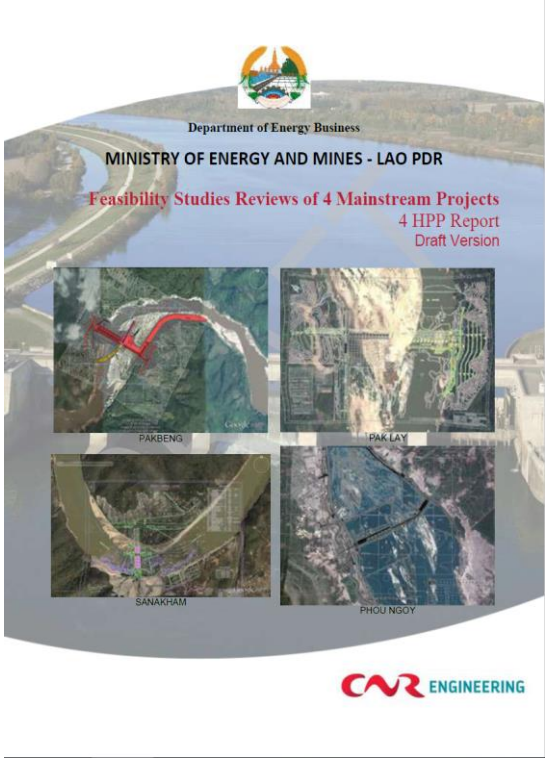
Proposed Resettlement village

➢Mitigating Measures

- provide alternatives for improved drinking water supplies for direct affected villages in downstream.
- Before moving resettlers to the resettlement sites, to check and analyze both water quantity and quality of the potential sources of water supply. In cases of insufficient water supplies, to prepare water storage such as reservoir or ponds to store water sufficiently for the resettlement sites.
- Select specific routes to transport construction material and equipment to avoid regular traffic.
- After the consultation, a village warning system will be installed as discussed in the consultation process during the early operation stage.
- To collaborate with EDL for rural electrification to be provided in the project affected villages.
- To carry out a public health education campaign on hygienic conditions, disease prevention and health promotion to ensure understanding and increase the awareness of the local population.
- To provide with sustainable agricultural alternative namely land for resettlers.
- Opening and closing time must be posted at the entrance of the Project site at all times.
- To pay full compensation, construct resettlement villages and provide livelihood restoration supporting.

CNR and IÁV released the final review report on the Pak Lay HPP in Jan 2017. At the same time, CNR completed an integrated report covering 4 mainstream projects (Pak Beng, Pak Lay, Sanakham and Phou Ngoy), where Pak Lay HPP is one of them.





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