SFG2575 REV

WB-Funded Project

Han River Inland Waterway Improvement Project in Hubei (Yakou Navigation Complex Project) Supplemental Environmental and Social Impact Assessment Report

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1 Introduction

1.1 Introduction to Early EIA Preparation

Entrusted by Port and Waterway Administration of Hubei Provincial Department of Transportation, HydroChina ZhongNan Engineering Corporation (subordinate to Power Construction Corporation of China) (hereinafter referred to as the company) undertakes the environmental impact assessment of Han River Yakou Navigation Complex Project.

The company has set up a project team to implement field surveys and data collection; entrusted Wuhan Imagination Technology Development Co., Ltd. to carry out survey and assessment on terrestrial organism; entrusted Centre Testing International Group Co., Ltd.(CTI) to monitor the surface water, ground water and soil of the project located river section and atmospheric and noise environment of the project construction areas, monitor the pollutant contents in sediments of the project located river section, carry out leaching toxicity tests on the sediments of the project located river section and collect the routine monitoring data of part of the built reservoirs at Han River and water quality in lower reach of Han River; has submitted special report on terrestrial ecosystem survey and assessment and environmental monitoring report.

In December 2013, entrusted by the Port and Waterway Administration of Hubei Provincial Department of Transportation, Hubei Provincial Water resources and Hydropower Planning, Survey and Design Institute prepared *Report on Water & Soil Conservation Plan of Han River Yakou Navigation Complex Project* which was approved by the Ministry of Water Resource of PRC in March 2015. Port and Waterway Administration of Department of Transportation of Hubei Province entrusted Institute of Hydroecology of Ministry of Water Resource and Chinese Academy of Science (the Institute of Hydroecology) to implement schematic design on fish pass and process design of fish breeding and releasing station of Yakou Navigation Complex; the company and the Institute of Hydroecology jointly implemented analysis and studies on joint ecological operation of complexes along Han River mainstream below Danjiangkou complex and brought up *Joint Ecological Operation Plan of Complexes Along Han River Mainstream below Danjiangkou* (trial) and the demonstration report.

On the basis of the above mentioned works, the company prepared *Environmental Impact Assessment Report of Han River Yakou Navigation Complex Project* (hereinafter referred to as the EIA) in November 2015 which has passed the evaluation of Environmental Impact Assessment Center of the Ministry of Environment Protection of PRC in December 2015. The full text of the report was disclosed in websites of Port and Waterway Administration of Hubei Provincial Department of Transportation and the Ministry of Environmental Protection in January 2016. Ministry of Environmental Protection approved the EIA report with document numbered H.S.[2016] No. 13 on February 17, 2016

1.2 Purpose and Contents of Supplemental ESIA Report

1.2.1 Assessment Purpose

The World Bank has carried out identification on Han River Yakou Navigation Complex Project in February 2016. According to the requirements of World Bank, the company further expanded the scope of the environmental impact assessment and social

assessment in accordance with safeguard policies of World Bank, prepared environmental and social management plan and supplemented cumulative effect assessment on development planning of complexes at Han River. In addition, since the original EIA Report was prepared in the feasibility study phase of the project and the preliminary design report of the project has been completed, in this supplemental ESIA Report, the contents of the original EIA Report were updated according to the preliminary design and the conclusion and feasibility and validity of the environmental protection measures were also reviewed.

The World Bank and Hubei Province have established long-term cooperation relationship and, so far, the World Bank has supported five highway projects and one inland navigation project in Hubei Province. Meanwhile, the World Bank has financially aided environmental improvement projects and urban development projects of cities along Han River in Hubei Province. These projects have brought about significant effects on poverty alleviation and economic development benefits and many good practices have been implemented in the field of environmental protection and social development. Han River Yakou Navigation Complex Project is the second cooperation between the World Bank and Hubei Province in the field of inland navigation and it is possible that such project will become a demonstration project with good development benefits and practices in safeguards.

1.2.2 Assessment scope and contents

According to the safeguard policies of the World Bank and environmental and social impacts screening of the project, this project is classified as Category A project which requires full assessment. Safeguard policies applicable to this project are OP4.01, OP4.04, OP4.11, OP4.12 and OP4.37.

Scope of the supplemental environmental and social impact assessment is: Navigation complex, upstream reservoir embankment reinforcement, transmission line, auxiliary works (such as borrow pits and disposal sites, construction roads and construction camps) and other activities related to the project construction and operation. What's more, scope of impact assessment on natural habitats, the social impacts and physical cultural resources are covered and mitigation measures were also developed. In particular, screening and assessment on cumulative impacts that may be imposed by the development of complexes along Han River on ecological environment of the river basin was also conducted after taking into account the planning and implementation status of complexes at Han River. Contents of the supplemental assessment are shown in Table 1-1.

Table 1-1 Comparison between this supplemental ESIA and the original domestic EIA

Key Issues	Contents of the Original EIA	Gap filling to meet WB requirements
Assessment scope	Yakou Navigation Complex Project area, the inundated areas and the resettlement areas	Added the assessment on upstream reservoir embankment reinforcement and transmission line; detail the contents of environmental impact assessment of resettlement according to the latest RAP.
Alternative analysis	Compare the dam site, select the normal water level and design the fishway from the perspective of environmental protection.	Comprehensively compare the dam sites, select the normal water level and design the fishway from the perspective of project conditions,

Key Issues	Contents of the Original EIA	Gap filling to meet WB requirements
		economic indicators and environmental protection.
Natural habitats—aquatic ecosystem	Baseline survey of aquatic ecosystem (including the fish type, fish resources and important habitats), prediction and assessment of impacts on fish, protective measures (including protection of habitats, bionic fishway, fish breeding and releasing station and joint ecological operation and so on)	Systemic sort out the current conditions of aquatic ecosystem and prediction and assessment of impacts, further detail the ecological operation plan, formulate the experimental study plan of ecological operation and bring up assessment and improvement plan on fish pass effects of the fish pass at different complex of the basin.
Environmentally sensitive areas—Wanyangzhou Wetland Park	Current conditions assessment, impact assessment, and consultation with responsible authority (forestry department).	Further baseline survey on Wanyangzhou Wetland Park and formulate a detailed plan of Wanyangzhou Wetland Park in collaboration with responsible authority (forestry department)
Physical cultural resources	PCR baseline survey and preliminary protection plan	Further detail the current conditions of physical cultural resources and prepare the physical cultural resources management plan
Social impacts	Current conditions of social and economic environment, analysis of environmental impacts of resettlement, impacts on human health and the mitigation measures	Detail the description on current social impacts according to the social impact report and supplement the contents of social disturbance, assessment and measures
Public consultation and information disclosure	Three rounds of public consultation and information disclosure on yichengnews.com and website of Port and Waterway Administration of Hubei Provincial Department of Transportation in August 2014, on website of Environmental Protection Bureau of Xiangyang City in December 2014 and on Xiangyang Daily on January 20, 2015. The full text of EIA Report was disclosed on website of Port and Waterway Administration of Hubei Provincial Department of Transportation and website of the Ministry of Environmental Protection of PRC in January 2016.	Carry out another two rounds of public consultation and include more people into the activities (non-governmental organizations, potentially affected people and relevant departments) and the full EIA Report was disclosed on website of Port and Waterway Administration of Hubei Provincial Department of Transportation in June 2016
Cumulative impacts	Retrospective assessment on Wangfuzhou and Cuijiaying complexes built in middle and lower reaches of Han River and taken the	Develop a systemic cumulative EIA, determine the assessment scope and time boundary, main impact issues and valuable ecological components

Key Issues	Contents of the Original EIA	Gap filling to meet WB requirements
	cumulative impact of development of the complexes into consideration in light of impact on aquatic ecosystem	(VECs) through screening and selection, analyze and assess the cumulative effects, put forward environmental protection measures and plan of the basin and formulate the next study plan
Report form	EIA Report (including environmental monitoring and management plan)	Supplemental ESIA Report, the Cumulative Environmental Impact Assessment report, environmental management plan of the complex, environmental management plan for embankment reinforcement and executive summary of EIA report.

According to the above requirements, the company collected more data, further analyzed the data and prepared supplemental ESIA Report according to policies and requirements of World Bank, including : 1) Physical cultural resources within the scope of construction and house demolition; 2) Cumulative effect assessment of development of complexes at Han River; 3) Information disclosure and public consultation related to the supplemental ESIA and cumulative effect assessment.

Operation of all complexes in middle and lower reaches of Han River will exert cumulative impacts on ecological environment of the basin. Therefore, in this supplemental ESIA Report, cumulative effect assessment is an important part, prediction and assessment on cumulative effects after operation of all planned complexes is described and the environmental issues after operation of these complexes are defined, providing basis for further development of the planned river sections and comprehensive decision-making on environmental development of mainstream in middle and lower reaches of Han River.

Therefore, in accordance with mission Aide Memoire of World Bank, the documents on environmental safeguards include: The original EIA Report, supplemental ESIA Report, the CEA report, the ESMP (or EMP) of the complex, the ESMP (or EMP) for embankment reinforcement of reservoir area and an EIA executive summary.

1.3 Environmental safeguard policies of World Bank

Requirements of the World Bank consist of ten basic safeguard policies. The project's compliance with environmental safeguard policies of World Bank is summarized in the following table:

Table 1-2 Analysis on compliance of this project with safeguard policies of World Bank

Safeguard policy	Applicable or not	Compliance
Environmental assessment (OP / BP4.01)	Yes	• Category A , environmental and social impact assessment has been carried out; • EA documents include: 1) the original EIA Report; 2) supplemental ESIA report; 3) the ESMP of the complex and other auxiliary works; 4) the ESMP for embankment reinforcement of reservoir area; 5) ESIA executive summary;

		• Multiple activities of public consultation have been carried out according to OP4.01 and the full text of EA Reports have been disclosed.
Natural habitats (OP/BP4.04)	Yes	• Survey on aquatic and terrestrial ecosystem has been implemented and potentially affected natural habitats and targets of ecological protection have been identified; • Potential impacts of the project on natural habitats and ecological sensitive areas and fish have been assessed; • Protective measures on the habitats, including protection on fish habitats, fish pass and ecological operation and so on; • The project will not cause remarkable degradation or conversion of key habitats.
Pest Management (OP4.09)	No	No procurement and use of pesticides is involved in this project.
Physical cultural resources (OP/BP4.11)	Yes	• Survey on cultural relics has been done and ancient tombs were identified in the project affected area. These ancient tombs will not be affected by the project construction but be subject to the inundation or erosion of impoundment of reservoir; • Physical cultural resources protection plan has been formulated • "Chance-find" measures of cultural relics have been included into environmental management plan
Dam safety (OP/BP4.37)	Yes	• Dam safety plan has been prepared
Forestry (OP/BP4.36)	No	No forest in the project affected areas, so this policy is not applicable.
Involuntary resettlement (OP/BP4.12)	Yes	Resettlement Action Plan has been prepared.
Indigenous peoples (OP/BP4.10)	No	No ethnic minorities in the project affected areas and this policy is not applicable.
Project in controversial areas (OP/BP7.60)	No	No controversial areas in the project affected areas and this policy is not applicable.
Projects on International Waterways (OP/BP7.50)	No	No international waterway projects in the project affected areas and this policy is not applicable.

In addition, the report is also prepared with reference to Environment, Health, and Safety Guidelines of World Bank (EHS Guidelines).

2 Project Description and Impact Screening

2.1 Background

2.1.1 Han River basin overview

Han River is the largest tributary of Yangtze River in the middle reach of Yangtze River, originates from south piedmont of Qinling Mountains of Shaanxi Province and runs through Shaanxi and Hubei Provinces before flowing into Yangtze River in Wuhan. The total length is 1567km, the drop height is 1964m and the basin area is 159,000km^2. Han River basin is located at East Longitude106 ° 12 ' to 114 ° 14' and North Latitude 30 ° 08 ' to 34 ° 11', including southern part of Shaanxi Province, western part of Henan Province, northern and middle parts of Hubei Province, northeastern part of Sichuan Province and Southeastern part of Gansu Province. The border between Han River Basin and Yellow River Basin is Qinling Mountains, Waifang Mountain and Funiu Mountain; the border between Han River Basin and Huai River Basin is Funiu Mountain and Tongbai Mountain; and the border between Han River Basin and Jialing River and Juzhang River is Micang Mountain, Daba Mountain and Jing Mountain. The southeastern part of Han River Basin is Jianghan Plain and no obvious natural border between Han River Basin and mainstream of Yangtze River exists.

The whole basin is divided into three typical sections: The section above Danjiangkou is **upper reach** with a length of 920km and basin area of 95,200km^2. In upper reach, the terrain is alternating valley and basin with many bottomland; the current is swift and the longitudinal grade is great; most of the riverbed materials are pebbles and some of them are stone; and the mean gradient is above 0.6 ‰. The main tributaries in upper reach are Bao River, Xun River, Jia River and Danjiang River on the left bank and Ren River and Du River on the right bank. In terms of topography, middle-low mountainous areas account for 79%, hills account for 18% and valley and basin only accounts for 3%.

The section from Danjiangkou to Zhongxiang is **middle reach** with a length of 270km and controlled basin area of 46,800km^2. The reach run through hilly land and the river section is wandering, wide and shallow. During the low flow years, the river width is 300m to 400m and the river width in high flow years is up to 2km to 3km. There are many sandy beaches and instable riverbed scouring and deposition here; the drop height is 52.6m and the mean gradient is 0.19‰. The main tributaries in middle reach are Xiaoqing River and Tangbai River on the left bank and Nan River, Man River and Bei River on the right bank. The major topography is plain, accounting for 51.6%; the mountainous areas account for 25.4% and hilly land accounts for 23%. The Yakou project is located in the middle reach.

The section from Zhongxiang to Hankou is **lower reach** of Han River with a length of 379km and catchment area of 17,000km^2. The river section runs through Jianghan Plain with embankment built at both sides. The riverbed materials are sand and the river gradually narrows until it is only about 200m in estuary. The river section is meandering; the drop height is 41.8m and the mean gradient is 0.06‰. Hanbei River flows into Han River from the left bank and Dongjing River diffluence pass on the right bank diverts the water into Yangtze River. Plain accounts for 51%, mountainous areas account for 22% and hilly land accounts for 27% in the low reach plain. Refer to Figure 2-1 for water system of Han River Basin.

On the whole, the northwestern part of Han River Basin is higher whereas the

southeastern part is lower. The terrain of upper reach is alternating hilly land, mountainous areas, valley and plain and the terrain of middle and lower reach is plain protected by embankment. The mountainous areas account for 55%, hilly land accounts for 21% and plain accounts for 23% of the whole basin. The basin is in subtropical monsoon zone and the climate is mild and humid. The average annual temperature is 12 ℃ to 16 ℃ and the average annual precipitation is 873mm. The precipitation gradually increases from upper reach down and the rainfall mainly occurs in May to October. The rainfall in this period accounts for 70% to 80% of the rainfall of the whole year. The runoff is mainly supplied by rainfall which is abundant. However, the runoff is unevenly distributed during the year and mainly distributed in May to October.

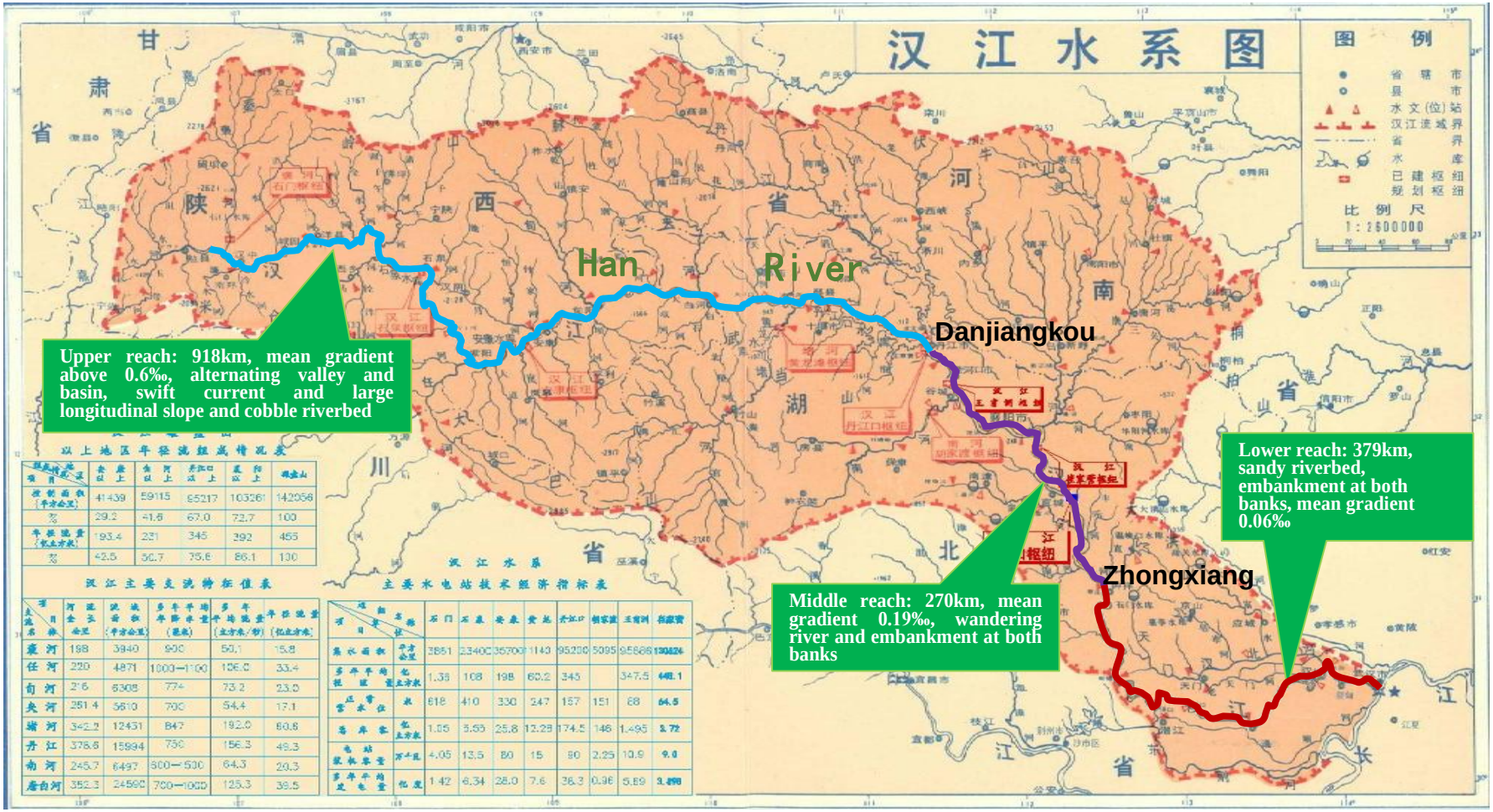


Figure 2-1 Map of Han River System

2.1.2 Han river basin planning and development

2.1.2.1 Planning of the basin

a) Integrated planning

In order to reasonably develop the water energy resources of mainstream of Han River, Changjiang (i.e. Yangtze River) Water Resources Commission and other relevant authorities have carried out flood control planning, water supply planning, planning on water resources and aquatic ecological environment protection, power generation planning, navigation planning and water & soil conservation planning and so on since 1950s. Such as, *Report on Key Points of Han River Basin Planning* in 1956, *Report on Development Plan of Han River Mainstream in Upper Reach* in 1966, *Comprehensive Utilization and Planning Report of Han River Mainstream below Jia River* in 1993, *Construction Plan of Pilot Modernized Hydraulic Complexes in Middle and Lower Reaches of Han River in Hubei Province* in 2004 and *Amended Comprehensive Utilization and Planning Report of Han River Mainstream below Jia River* in 2009.

In June 2009, Changjiang Water Resources Commission has prepared *Overall Planning Report of the Han River Mainstream* which has passed the evaluation of Water Conservancy and Hydropower Planning and Design Institute of the Ministry of Water Resources in December 2010 and put forward the revised *Overall Planning Report of the Han River Mainstream* in May 2011. The revised edition has been submitted to the State Council for approval. It is recommended in the report that the complexes mainstream of Han River consist of 15 projects: Huangjinxia, Shiquan, Xihe, Ankang, Xunyang, Shuhe, Baihe, Gushan, Danjiangkou, Wangfuzhou, Xinji, Cuijiaying, Yakou, Nianpanshan and Xinglong. Among them, the proposed 8 complexes are in Hubei. They are Gushan, Danjiangkou, Wangfuzhou, Xinji, Cuijiaying, Nianpanshan and Xinglong complexes. Refer to Figure 2-2 for plan position of complexes in mainstream of Han River.

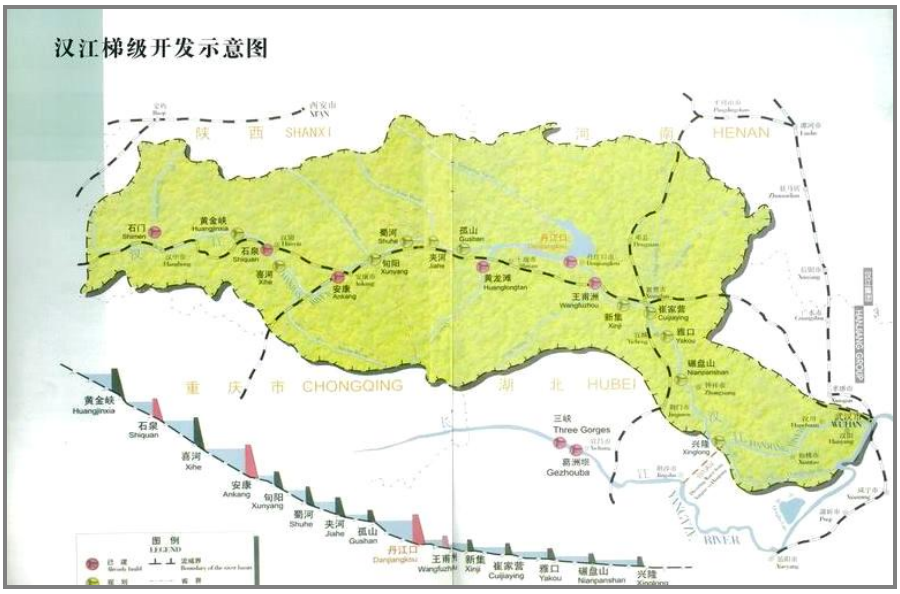


Figure 2-2 Plan map of cascade development along Han River

b) Navigation planning

Han River is the main waterway trunk in Hubei Province and Shaanxi Province and is in

the important position in integrated transport system of Hubei Province and Shaanxi Province. The transport authorities have been paying attention to the navigation development of Han River and have prepared Navigation Planning Report of Han River Basin as early as in 1958. In 1984, the transport authorities of Hubei Province and Shaanxi Province jointly prepared *Navigation Planning Report of Han River*. Department of Transportation of Hubei Province has successively proposed *Navigation Planning Report of Yangtze River System in Hubei Province* and *Navigation Planning Report of Han River in Yangtze River System* in 1992 and also completed the supplementation and revision of *Inland Navigation Development Planning of Hubei Province* and *Navigation Planning Report of Han River* in 2003 to 2004 and in 2008 respectively. In the above reports, engineering measures are put forward to improve the waterway conditions and make the waterways in the section from Hankou to Danjiangkou, the section from Danjiangkou to Yunxian and the section from Yunxian to Baihe meet standards of Grade IV, Grade V and Grade VI waterway; channelization and the Yangtze River-Han River Water Transfer Project are to be implemented in the future to make the waterways in the section from Hankou to Danjiangkou, the section from Danjiangkou to Ankang and the section from Ankang to Yangxian meet standards of Grade III, Grade IV and Grade V waterway.

In September 2012, National Development and Reform Commission of PRC approved *Scheme for Construction of High Grade Waterway in Han River and Jianghan Canal* (2011-2015) submitted by Hubei Provincial Development and Reform Commission and Shaanxi Provincial Development and Reform Commission. In accordance with such navigation planning, channelization of complexes along Han River should be completed till 2020 and all waterways should meet the planned waterway standard. Namely, the waterway in section from Hanzhong to Yangxian should meet standard of Grade VII waterway, the waterway in section from Yangxian to Ankang should meet standard of Grade V waterway, the waterway in section from Ankang to Danjiangkou should meet standard of Grade IV waterway and the waterway in section from Danjiangkou to Hankou should meet standard of Grade III waterway. It should be noted that the transport authorities and the water conservancy authorities basically have the same opinion on complexes development plan along mainstream of Han River in Hubei Province, i.e. the development plan of Gushan complex, Danjiangkou complex, Wangfuzhou complex, Xinji complex, Cuijiaying complex, Yakou complex, Nianpanshan complex and Xinglong complex. Refer to Figure 2-3 for navigation planning and complex arrangement along mainstream of Han River in Hubei Province.

Table 2-1 shows the engineering characteristics of complexes along Han River below Danjiangkou complex. The following characteristics can be seen: Danjiangkou reservoir has annual regulation capacity and when the water level is lower than the normal water level, Danjiangkou reservoir has capacity of 29.05 Billion cubic meters. The capacity of reservoirs in the downstream of Danjiangkou reservoir have capacity of far less than that of Danjiangkou reservoir when the water level is lower than the normal water level and their capacities are only 0.51% to 3.02% of that of Danjiangkou reservoir. Those reservoirs are runoff-model reservoirs and only have daily regulation capacity or do not have any regulation capacity. Hence, hydrological regime, the most important factor affecting the ecological environment in middle and lower reaches of Han River, is mainly controlled by Danjiangkou reservoir and interval runoff of the basin.

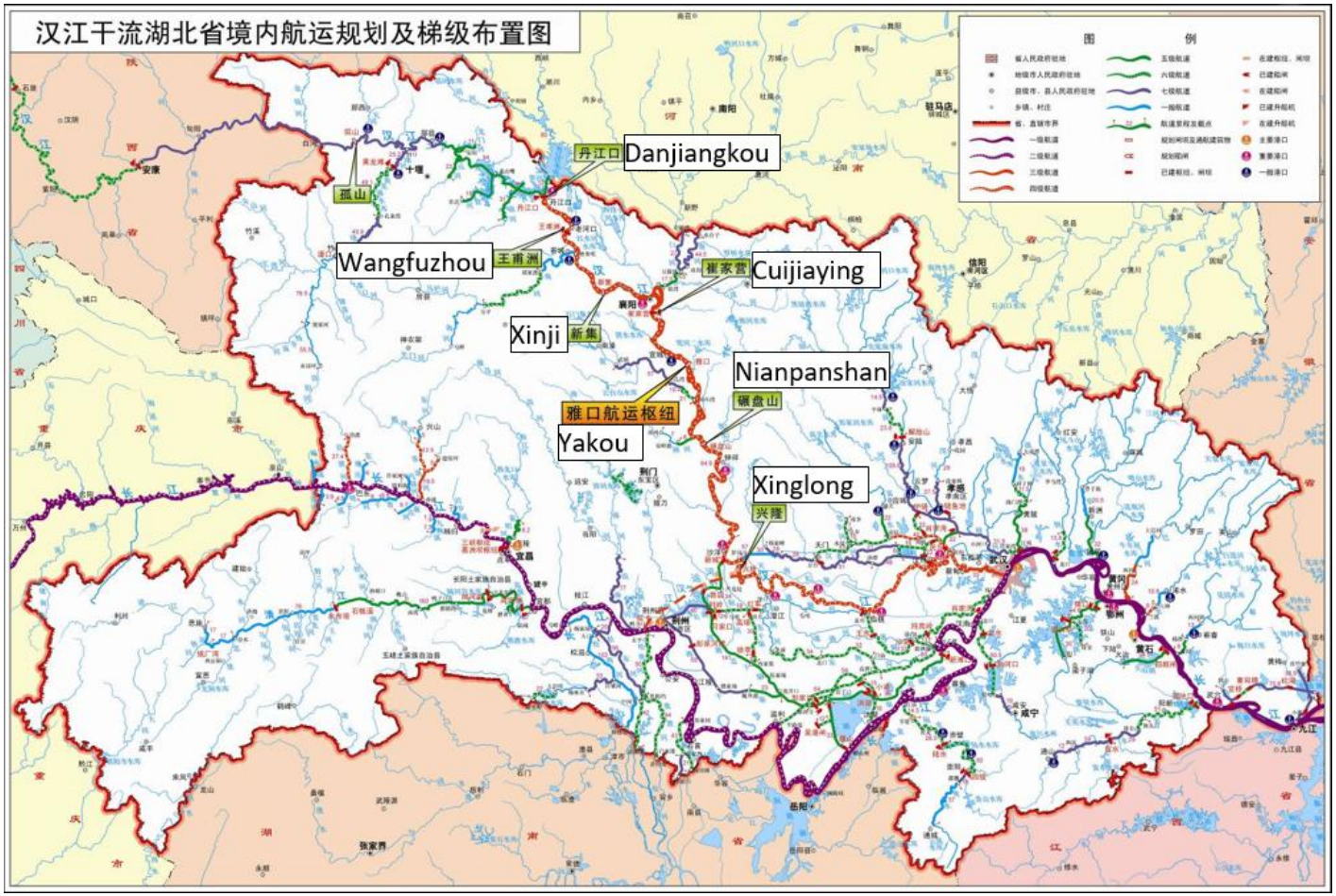


Figure 2-3 Navigation planning and complex construction along mainstream of Han River in Hubei Province

Table 2-1 Characteristics of complexes along mainstream in middle and lower reaches of Han River

Item	Unit	Danjiangkou (initial)	Danjiangkou (late)	Wangfuzhou	Xinji	Cuijiaying	Yakou	Nianpanshan	Xinglong
Basin area	10^4 km^2	9.52	9.52	9.53	10.3	13.06	13.31	14.03	14.42
Average discharge	m^3/s	1230	1230	1215	1282	1470	1520	1569	1569
Annual runoff	100 million m^3/s	387.8	387.8	383.1	404.3	463.6	479.3	494.8	494.8
Normal water level	m	157	170	86.23	76.23	62.73	55.22	50.72	36.23
Dead pool level	m	140	150	85.48	75.93	62.23	54.72	50.32	/
Drawdown depth	m	17	20	0.75	0.3	0.5	0.5	0.4	/
Capacity of reservoir under normal water level	100 million m^3	174.5	290.5	1.495	3.012	2.45	6.08	8.77	2.73
Dead storage	100 million m^3	76.5	126.9	1.207	2.806	2.05	5.41	7.94	/
Regulating storage	100 million m^3	98	163.6	0.288	0.206	0.40	0.67	0.83	None
Type of regulation		Annual	Incomplete overyear regulation reservoir	Anti-regulating reservoir of Danjiangkou	Daily	Daily	Daily		None
Installed capacity	MW	900	900	109	120	96	80	200	37
Annual electricity generation capacity	100 million kW·h	38.3	33.78	5.81	5.03	4.3	3.72	6.5	2.18
Function		Flood control, power generation, Irrigation, navigation	Flood control, water supply, power generation, navigation	Power generation, navigation, irrigation, breeding, tourism	Power generation, navigation	Power generation, navigation	Power generation, navigation, irrigation	Power generation, navigation, irrigation	Power generation, navigation, irrigation
Progress		Completed	Under	Completed	Feasibility study	Completed	Feasibility study	Feasibility study	Built

			construction		stage (under preparation)		stage	stage	
Completion time		1973		2000		2010			
Construction site		Danjiangkou	Danjiangkou	Laohekou	Xiangyang	Xiangyang	Yicheng	Zhongxiang	Qianjiang
project owner or potential project owner		Han River Water Conservancy and Hydropower Group Co., Ltd.	Han River Water Conservancy and Hydropower Group Co., Ltd.	Hubei Han River Wangfuzhou Hydropower Co., Ltd.	Han River Water Conservancy and Hydropower Group Co., Ltd.	Hubei Han River Cuijiaying Navigation and Hydropower Complex Project Management Office	Preparation Group of Yakou Navigation Complex Project	Hubei Hanjiang Modern Water Conservancy Co., Ltd.	Hubei Provincial South-to-North Water Diversion Project Management Bureau

2.1.2.2 Middle and Lower Han River Mainstem Cascade Implementation Progress

The middle and lower Han River extends Danjiangkou to the river mouth of Han River (where Han River flows into Yangtze River). The total length of the river section is 652km, and the catchment area is 6.4×10^4 km^2. Seven complexes are planned for the middle and lower Han River mainstem, of which four have been constructed, namely Danjiangkou (built in 1973 and upgraded in 2014), Wangfuzhou (2000), Cuijiaying (2010) and Xinglong (2015); the remaining three are have not started construction yet.

Figure 2-4 provides description of each dam. ***For easy reference, the 7 dams are numbered from Stage 1 to Stage 7, with Danjiangkou dam being River Mile 0 km.***

1) Danjiangkou complex is located 800m downstream of the confluence of the mainstem of Han River and Dan River in Danjiangkou City, Hubei Province. The controlled drainage area is 9.52×10^4 km^2, and the average discharge at the dam site is 1,230 m^3/s.

Stage 1 – Danjiangkou Complex, MLH River Mile 0 km

- Danjiang complex was put into operation in 1973; normal pool level 157m; normal storage capacity 17.45 billion m3; annual average flow (at dam site) 1230 m3/s; installed capacity 900MW; navigable by ship elevator;
- South-to-North Diversion Project intends to move water from Danjiangkou reservoir to north China to alleviate its severe water scarcity issue. To meet the objective, the dam was heightened to allow normal water level of 170m and reservoir storage capacity increased to 29.05 billion m3. The project was put into operation on December 12, 2014. Annual diversion water amounted to 2-3 billion m3.
- No fish pass built.

2) Wangfuzhou complex is located at about 3km downstream from Laohekou City in Hubei Province, and 30km downstream of Danjiangkou Complex. Wangfuzhou Hydropower Complex is the first power and navigation complex below Danjiangkou Reservoir. The controlled drainage area is 9.53×10^4 km^2, and the average discharge at the dam site is 1,215 m^3 /s.

Stage 2 - Wangfuzhou Complex, MLH River Mile 30km

- Built in 2000; upstream drainage area 95,300 km2; 30km downstram of Danjiangkou dam; normal pool level 86.23m; storage capacity 150 million m3; annual average flow (at dam site) 1215 m3/s; installed capacity 109 MW; navigable by ship lock;
- Main structure consists of dam, sluice gate, power house, and ship lock;
- No fish pass.

3) Xinji complex is located in the territories of Xiangcheng District and Fancheng District in Xiangyang City, Hubei Province, and the dam site is located at Baimadong, 47.5km downstream of Wangfuzhou Complex, 63.5km upstream of Cuijiaying Complex, and 28km upstream of of Xiangyang City. The controlled drainage area is10.3×10^4 km^2, and the average discharge at the dam site is 1,290 m^3 /s.

Stage 3 – Xinji complex design drawings, MLH River Mile 77.5km

- Under preparation; upstream drainage area 10,300 km2; 47.5 km downstream of Wangfuzhou dam; normal pool level 76.23m; storage capacity 301 million m3; annual average flow (at dam site) 1282 m3/s; installed capacity 120 MW; navigable by ship lock;
- Main structure consists of dam, sluice gate, power house, shiplift and fish pass;

4) Cuijiaying Complex is located in Panggong Sub-district of Xiangyang City, 17km downstream from Xiangyang City, and the controlled drainage area is13.06×10^4 km^2. This complex is the fourth complex among the seven complexes along mainstem of Han River in Hubei Province, which is 142km away from Danjiangkou Complex, 109km away from Wangfuzhou Complex, and 515km away from the river mouth (where Han River flows into Yangtze River). The average discharge at the dam site is

1,470 m^3 /s.

Stage 4 - Cuijiaying complex, MLH River Mile 142km

- Built in 2010; upstream drainage area 13,060 km2; 142 km downstream of Danjaingkou dam; normal pool level 62.73m; storage capacity 301 million m3; annual average flow (at dam site) 1470 m3/s; installed capacity 96 MW; navigable by ship lock;
- Main structure consists of dam, sluice gate, power house, shiplift and fish pass;

5) Yakou Complex is located in the middle reach of Han River and in the territory of Yicheng City in Hubei Province, which is 81.58km away from Xiangyang City, 56.14km away from Cuijiaying Navigation and Hydropower Complex, 15.74km away from the downtown of Yicheng City. The controlled drainage area is13.31×10^4 km^2, and the average discharge at the dam site is 1,487 m^3 /s.

Stage 5 – Yakou complex, dam site, MLH River Mile 196 km

- Under preparation; upstream drainage area 13,310 km2; 56.14 km downstream of Cuijiaying dam; normal pool level 55.22m; storage capacity 608 million m3; annual average flow (at dam site) 1520m3/s; installed capacity 75 MW; navigable by ship lock;
- Main structure consists of dam, sluice gate, power house, shiplift and fish pass;

6) Nianpanshan complex is located in the territory of Zhongxiang City at middle and lower reaches of Han River, and the dam site is located at Yanshantou in Wenji Town, and 63.95km downstream of Yakou complex. The controlled drainage area is14.03×10^4 km^2, and the average discharge at the dam site is 1,630 m^3 /s.

Stage 6 – Nianpanshan complex, dam site, MLH River Mile 260 km

- Under preparation; upstream drainage area 14,030 km2; normal pool level 50.72m; storage capacity 877 million m3; annual average flow (at dam site) 1569m3/s; installed capacity 200 MW; navigable by ship lock;
- Main structure consists of dam, sluice gate, power house, shiplift and fish pass;

7) Xinglong Complex is the last complex at middle and lower reaches of Han River, and

it is located in Duobao Township in Tianmen City and Gaoshibei Township in Qianjiang City at the lower reach of Han River in Hubei Province, 378.3km away from Danjiangkou Complex and 273.7km away from the river mouth. The controlled drainage area is14.42×10^4 km^2, and the average discharge at the dam site is 1,569 m^3 /s.

Stage 7 – Xinglong complex, MLH River Mile 378.3 km

- Built in 2015; upstream drainage area 14,420 km2; normal pool level 36.23m; storage capacity 273 million m3; annual average flow (at dam site) 1569m3/s; installed capacity 37 MW; navigable by ship lock;
- Main structure consists of dam, sluice gate, power house, shiplift and fish pass;

Figure 2-4 Description of Middle and lower Han River Dams/Reservoirs

2.2 Project objectives

Yakou Navigation Complex is a low-head runoff power station and is mainly developed for navigation purpose, with power generation, irrigation and tourism as the secondary development objectives. Normal water level of the reservoir is 55.22m, corresponding to the storage capacity of 337 Million Cubic Meter. The reservoir has daily regulation capacity. The power station has rated head of 4.0m, installed capacity of 75MW and uses base load power generation regulation. The waterway is Grade III waterway and the design shipping tonnage is 1000t. The project grade is Grade II and the scale is of Great (2) type.

Navigation: Construction of the complex can effectively connect it with the upstream Cuijiaying Navigation and Hydropower Complex and six shoals in the inundated reservoir area like Longmentan, Shuifomiao, Bajiazhou, Niulukou, Quejiatao and Guohaiying improve the grade of the waterway of 52.67km in the reservoir area from Grade IV to Grade III and make the shipping tonnage of ship lock to 1000t. No dredging is needed. Combination of the complex with other complexes and waterway regulation projects which have been built, under construction or are to be constructed in middle and lower reaches of Han River can realize the high-end connection between the waterway of downstream reaches of Xiangyang and Yangtze River waterway.

Power generation: The power station has installed capacity of 75.0MW and is equipped with altogether 6 tubular water turbines with unit capacity of 12.5MW. The unit rated flow is 372.4m3/s and the full-load flow rate of these 6 turbines is 2234.4m3/s. The annual utilization hour is 3361h and the average annual energy output is 252 Million KWH. The power station is adjacent to load center of Xiangyang and Yicheng and will improve the power supply of such region upon its completion.

Irrigation: Regular water level of the reservoir area will be raised upon completion of the complex and farmland of 80,000 mu in Liushui Town, Zhengji Town, Yancheng and Nanying under administration of Yicheng will be irrigated. Meanwhile, probability of irrigation of Changshan pump station planned by Xiangyang city on the left bank of the reservoir area (with water intake in Yingshanzui and irrigation area of 300,500mu) will be improved with saved cost for water intake, providing conditions for development of high efficient and economic agriculture.

Tourism: Water surface width of the waterway in reservoir area will be up to 2km to 5km and water surface of 12,700 hectare will be formed upon completion of the complex and water surface, providing good development opportunity for tourism. This will play a good role in improving the landscape, image and investment environment of Yicheng city.

2.3 Project components and impact screening

2.3.1 Project location

The proposed Yakou Navigation Complex is located in river section from Xiangyang to Zhongxiang and the dam site is located in Yakou village, Liushui Township which is in downstream of Yicheng of Xiangyang, and is 15.7km away from Yicheng city and about 80km away from Xiangyang City.

Refer to Figure 2-5 for location of Yakou Navigation Complex Project

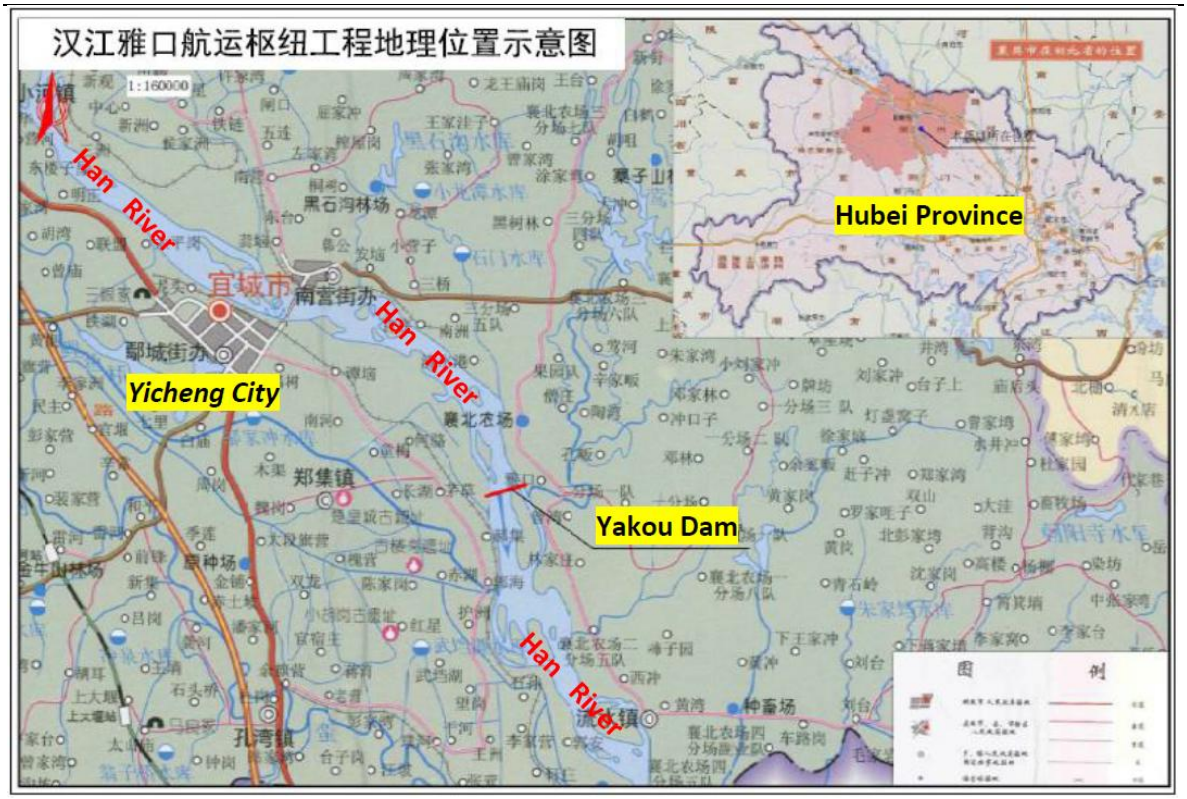


Figure 2-5 Location of Yakou Navigation Complex Project

2.3.2 Project components

The project components covered by the environmental assessment includes Yakou Navigation Complex Project, water diversion works (during construction) and the auxiliary works; and resettlement work, embankment reinforcement work of the reservoir area, transmission line and other works related to construction and operation of the Yakou dam and reservoir. The project components are shown in Table 2-2.

Table 2-2 Overview of Project Components and Implementation Agencies

No.	Subproject	Description
I	**The complex**	**Implementing agency: Port and Waterway Administration of Hubei Provincial Department of Transportation/Yakou PMO**
1	Main work of the complex	● For buildings of the complex, it is recommended the plan of building ship lock on the right bank and building power house on the left bank. The total length of dam axis is 3179.9m and the maximum height is 14.0m. Altogether 44 drain holes are arranged in the sluice gates. ● Water diversion works ● Waterway regulation works (limited to the shiplock immediate upstream and downstream)
2	Material sites	● Two earth borrow areas: Yakou earth borrow area on the left bank and Luojiazhuang earth borrow area on the right bank; ● One sand-gravel quarry: Longmentan quarry; ● Block stone purchased from Matoushan and Jinniushan commercial quarries.
3	Disposal sites	● Two disposal sites and all spoils will be used to form the construction

No.	Subproject	Description
		site: ne located in Class I terrace in downstream of left bank dam line and the other one is located in Class I terrace near right bank dam site. ● Part of the construction site will be used for dam management area; the remaining that is not occupied permanently will be rehabilitated upon completion of construction.
4	Transportation works, access roads	● Roads to outside of the construction site: Newly built access road with pavement elevation of 59.0m and total length of 1.3km on the left bank to connect with provincial road S218. Materials transport is mainly realized via the existing local roads. ● Roads in construction sites at left and right bank: 8 temporary construction roads with total length of 10.2km and a temporary road with length of 2.0km for other temporary works are required to be newly built or rebuilt.
5	Work camps	The total number of workers in the peak period is 2100 and two construction camps occupying 0.83hm^2, including working camps and office building.
6	Fish protection facilities	Total length of fish pass is 951.08m. The length of bionic fishway is 560.58m and that of the project fishway is 390.5m. Build new fish stock enhancement station and release fishes of 4 million every year.
7	Reservoir bottom cleanup	Clean the reservoir area, including the buildings, structures and vegetation and so on before the impoundment to ensure the navigation safety and water quality after impoundment.
II	**Land acquisition and resettlement work**	**Implementing agency: Port and Waterway Administration of Hubei Provincial Department of Transportation and People's Government of Xiangyang City**
8	Resettlement	Altogether 35 households (91 people) are to be displaced. 18 households which are scattered in the reservoir area will be resettled in a decentralized way and most of 17 households in fisherman's cooperative of Yakou Village, Liushui Town where the dam is located will purchase the house by themselves and only 2 of them will be resettled in a centralized way. The resettlement area is located in the region with existing roads.
9	Faciliities rehabilitation of the reservoir area	● Reconstruct roads for farm machinery of 7.5km, 3 cargo terminals and 4 ferries; ● Protect or upgrade the telecommunication lines of 3.0km affected by the reservoir inundation; ● Measures of seepage interception, drainage and waterlogging: Change direction of gradient of Huangjia Ditch and deepen Huangjia Ditch on the right bank; reform Guohai Sluice and build Yejicheng pump station; build two waterlogging pump station at Guanzhuang Culvert and Sluice and Guhekou Culvert and Sluice on the left bank; heighten 10 small pump stations; rebuild, or seal and compensate, or upgrade 12 culverts and sluices.
10	Cultivated land protection work	Lift land in the reservoir area to form 12 lifted land areas to protect cultivated land of 13,413.79mu.

No.	Subproject	Description
III	**Transmission line project**	**Implementing agency: Hubei Electric Power Company**
11	Supporting transmission lines	Build 110KV transmission lines of about 12km (Yakou power station to existing Zhengji substation)
IV	**Embankment reinforcement in the reservoir area**	**Implementing agency: Xiangyang Water Resources Bureau and Xiangyang Waterway Administration**
12	Embankment reinforcement in the reservoir area	Include Xiangcheng Oumiao section, Yicheng urban section and Yicheng Hedong section. The total length is 86.74km. 5km of Yicheng urban section was alrady completed in 2015 and the remaining will be completed before impoundment of the reservoir.

The specific contents, impact scope and screening results of the subprojects will be described in the following sections. Based on results of the original EIA, this supplemental ESIA will cover areas directly or indirectly affected by this project, including complex area, borrow sites, disposal site, access road, construction camp, bottom cleanup areas, resettlement area, cultivated land protection work, 110KV transmission lines, embankment project of the reservoir area and reservoir inundated area. In addition, the study will consider the potential impacts on reservoir inundated area (normal water level 55.22m), downstream areas of the dam and the surrounding ecological sensitive areas as well as natural habitats. The reasons for including the above areas into study scope and the potential environmental impact type of these areas will be presented in this chapter.

Meanwhile, given that the construction and operation of planned complexes of Han River will exert cumulative impacts on ecology and environment of the basin, cumulative effect assessment will be viewed as an important part of this supplemental ESIA Report. In this supplemental ESIA Report, impact of the operation of the built complexes in Han River on the environment will be studied from an overall perspective and prediction and assessment on cumulative effects of operation of the planned complexes will be provided. On such basis, the mitigation measures and suggestions will then be put forward.

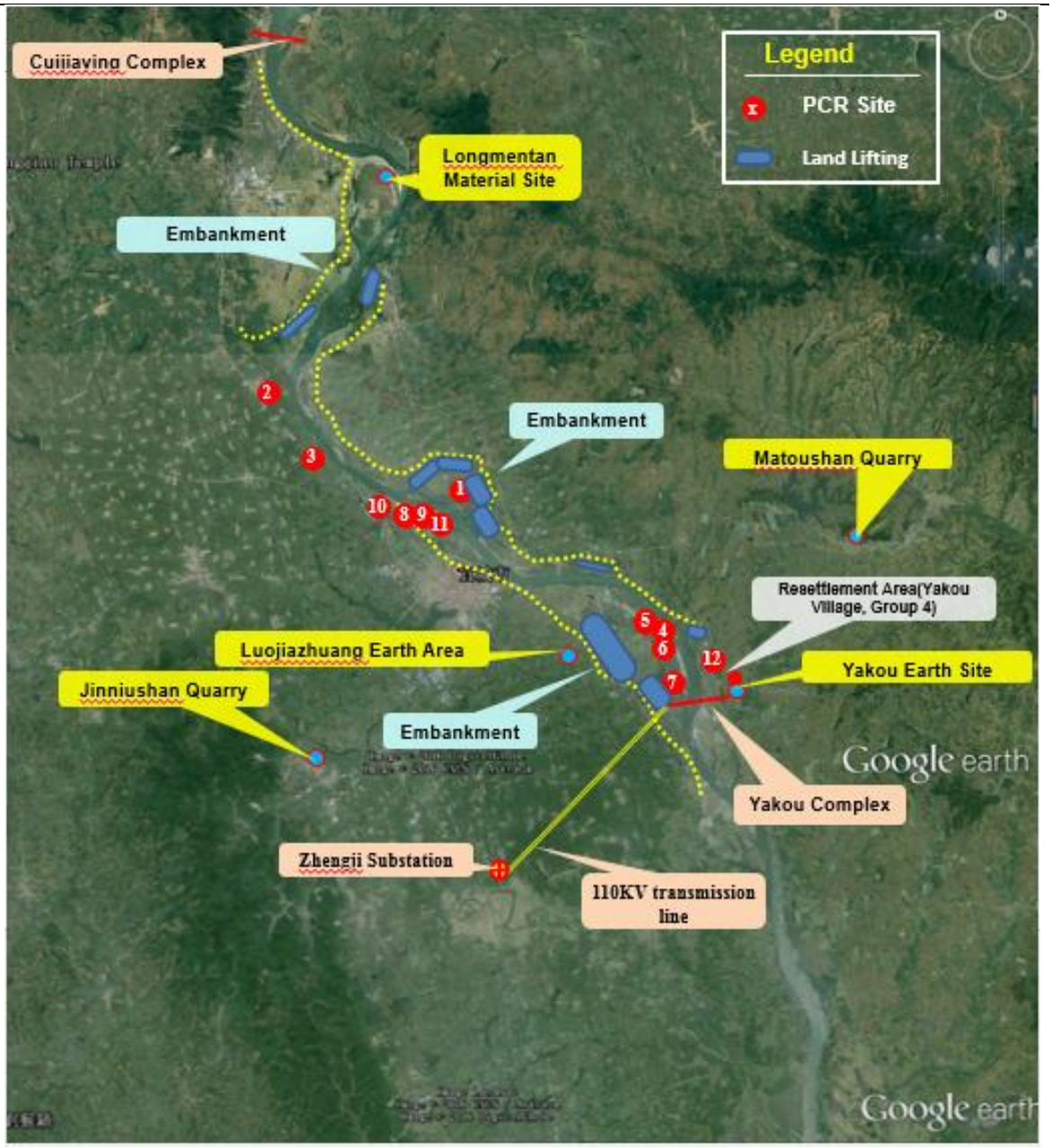


Figure 2-6 Yakou complex activites and locations

2.3.3 The hydro-navigation complex works

Construction of Yakou Navigation Complex dam will permanently occupy an area of 1152.3mu and temporarily use an area of 840.38mu. The permanently acquired land includes state-owned river flat of 411.23mu and collectively-owned land of 741.11mu. (note: 15 mu equal to 1ha.)

The hydro-navigation complex is comprised of permanent works and temporary works. The permanent work includes water retaining structures, sluice gates, navigation structures, power house and fish pass and so on. The temporary works consists of water diversion works and auxiliary works. Specific composition is shown in Table 2-3.

Table 2-3 Components of Yakou hydro-navigation complex

Project			Project composition at feasibility study stage	Changes of preliminary design
Permanent Works	The Complex Structures	Water retaining structures	The water retaining structures are of rolled earth-rock dam which consists of earth-rock on the right bank, earth-rock dam on the left bank and the linkage section and the total length is 1,322.5m. The earth-rock dam is non-earthy materials anti-seepage dam. Crest elevation is 59.0m, crest width is 8m and the maximum dam height is 14.0m.	The structure remains unchanged, the earth-rock dam is comprised of earth-rock dam on the left bank and earth-rock dam on the right bank and the linkage dam and the total length is 2,150.3m. The crest elevation remains unchanged and the crest width is 10m.
		Ship lock	The ship lock is comprised of upper approach channel, lower approach channel, upper ship lock head, lower ship lock head and lock chamber and the total length is about 150.5m.	The plan layout of ship lock remains unchanged and the total straight-line length from upper approach channel to lower approach channel is 1,361.8m.
		Sluice gates	The sluice gates are of reinforced concrete and open horizontal bottom sluice type and comprised of gravity pier, chamber type wall and steel tainter gate. Width of lock chamber at left side is 615.6m with 36 drain holes and width of lock chamber at right side is 205.2m with 12 drain holes. Net width of single hole is 14m.	Use open horizontal bottom sluice with 44 drain holes and the total net width of holes is 616m.
		Power house	7 tubular turbine and bulb power generators with unit capacity of 10.6MW and total installed capacity of 74.2MW will be installed in the power house located dam section and the wheel diameter of turbine runner is 7.06m. Buildings in the plant mainly include power plant and booster station.	Altogether 6 tubular turbine and bulk power generators with unit capacity of 12.5MW and total installed capacity of 75.0MW will be installed.
		Fishway	Combine staggered block type bionic fishway and project fishway. The total length of fish way is 951.08m and the length of bionic fishway is 560.58m. Longitudinal slope is 1/100 and the bionic fishway is of trapezoidal section type. Length of the project fishway is 390.5m and the longitudinal slope is 1/60.	Total length of fish pass is 921.82m. The length of bionic fishway is 560.22m and that of the project fishway is 361.60m.

Project			Project composition at feasibility study stage	Changes of preliminary design
	Auxiliary work	Waterway regulation projects	Not applicable	Dredge the area of entrance of the upper ship approach channel lock and the linkage section,
		Navigation marks project	Type I electric navigation marks are arranged along the river section. Build 78 new navigation-aids, including: 16 position indicating navigation aid (including small light tower), 58 side navigation aids, 2 whistle navigation aids and 2 limit navigation aids.	Not applicable
		Public works	Including road works and water supply and drainage works. The access road connects Yipukong county road and the ship lock management area and the pavement elevation is 59.0m. Total length of the road is 0.9km.	Include road works and water supply and drainage works and the length of access road is 1.3km.
		The complex management area	Arranged on the right bank of Han River and upstream of dam axis and is close to the complex. The complex management area occupies land of 7.5hm^2 and has construction area of 12,500m^2.	Office and production house, transport facilities, power supply and water supply facilities of the management units and greening of the project management area and the construction area is 8,140m^2.
		Dam crest road and bridge	Is comprised of cross-lock bridge, cross-sluice bridge and cross-power station bridge.	Consistent
		Other	Set on anchorage at 1.7km upstream and downstream of the ship lock respectively and temporarily, the pontoon will be purchased and used as the anchorage.	Consistent
Temporary Works	Water diversion works	Diversion by stage	Diversion by three stages: construct open water diversion channels and longitudinal cofferdam on the left bank and deflect through main riverbed at right side in the first stage; build earth dam, ship lock, sluice gates and powerhouse and deflect the water through open channel on the left bank in the second stage; construct earth dam on the left bank and discharge the water through the built sluice gates on the right bank and sluice gates on the right bank are ready for navigation.	Diversion by two stages: construct ship lock, power house and some sluice dam in the first stage and build the remaining sluice dam on the left bank
	Auxiliary works	Roads in the construction site	8.55km construction roads and 2 docks	10.20km construction roads and no dock
		Assistant enterprises for construction	Arrange concrete production system, construction plants, construction warehouses, water supply and power supply system and others at both banks. Aggregate processing system is set up in Matoushan quarry.	Those facilities are set up at both banks and the aggregate processing system is set up on the right bank.
		Living and office area	The number of people during the peak construction period is about 1500; the living area	The number of people during peak construction

Project			Project composition at feasibility study stage	Changes of preliminary design
			and the office area are set up at both banks and 2 living camps are set up.	period is 2100. The office camps and living camps are set up at both banks in a centralized way. 2 construction and living camps are set up.
		Earth-rock quarry	Purchase gravels from quarry at Tangbai River estuary and purchase stones from Matoushan dimension stones quarry and set up one earth borrow area, i.e. Yakou earth borrow area	Get natural gravels from Longmentan quarry; purchase dimension stones from Matoushan quarry and Jinniushan quarry; set up 2 earth borrow areas, i.e. Yakou earth borrow area and Luojiazhuang earth borrow area.
		Waste dump site	Set up three waste dump sites: waste dump site in upstream bund of left embankment of Han River; waste dump site in upstream bund of right embankment of Han River; Han River bund on the left bank of Ying River estuary.	Two waste dump sites: one waste dump site is located in Class I terrace in downstream of left bank dam line and the other one is located in Class I terrace near right bank dam site.
		Temporary storage site	Two temporary storage sites which are located under dam of left and right bank respectively and No. ② temporary storage site in downstream of the sluice gate upon completion will be submerged.	Cancel the temporary storage site

Key environmental issues include potential impacts on ecological environment, water quality, air quality and noise environment and so on. The soil erosion brought by and impacts on the ecology imposed by the earth borrow area and disposal site and the relevant mitigation measures are also one of the key aspects of environmental impact assessment.

2.3.3.1 Main works of the complex

(1) Structures of the complex

According to the recommended plan of setting up ship lock on the right bank and setting up power house on the right bank of upper dam line, the layout of the complex from right to left is: right bank: earth-rock dam of 1,820.3m, ship lock of 44.0m, the linkage section 145.9m, fish pass and power house (including the installation section of 50.5m) of 185.6m, sluice gate dam of 800.0m; left bank: earth-rock dam of 184.1m with dam axis of 3,179.9m. Refer to Figure 2-5 for plan layout of Yakou Navigation Complex Project.

Water retaining structures: Total length of the earth-rock dam is 2,150.3m and the dam is comprised of earth-rock dam on the left bank, earth-rock dam on the right bank and earth-rock dam in the linkage section. The earth-rock dam on the left bank connects with the bank slope at the left side and connects with the sluice gates at the right side and the length along the axis is 184.1m. The earth-rock dam on the right bank connects with the ship lock at the left side and connects with the flood control embankment at the right side and the length along the axis is 1,820.3m. The earth-rock dam in the linkage section is

located between the power house and the ship lock and the length is 145.9m. The earth-rock dam is plastic concrete gravel dam with anti-seepage wall, the crest elevation is 59.0m and the crest width is 10.0m. The ratio of upstream dam slope is 1:3.0 and the ratio of downstream dam slope is 1:2.5. The slope surface is protected with hexagonal concrete blocks with thickness of 12cm and sand-gravel cushion of 15cm.

Sluice gates: The sluice gates are set up at left side of power station and the sluice gates are located in main riverbed with 760m wide leading edge. The sluice gates are of horizontal bottom type and consist of lock chamber, upstream anti-scour trench, upstream bottom protection, upstream blanket, downstream stilling basin apron, downstream apron and downstream anti-scour trench. Elevation of base slab of sluice is Ñ44.0m and the lock chamber is of one-piece with two holes structure and the width of the lockage chamber of one-piece with two holes is 34.4m and the diameter of hole is 14m. Altogether 44 14*11.22m (W*H) drain holes were set in the sluice gates and bottom-flow energy dissipation is used. The length of energy dissipation apron and other aprons in the flow direction is 38m. Width of bottom of sluice gates is 30.0m and components arranged from the upstream to downstream are upstream pier head, gate slot, pier, corbel of arc sluice and downstream cantilever. Width of top of sluice gates is 35.0m and components arranged from the upstream to downstream are gantry crane, oil-line cable box girder and dam crest road and bridge and the elevation of sluice top is ∇59.0m.Total width of dam crest road and bridge is 10m and the center line is the dam axis.

Ship lock: Axis of ship lock is located at Pile No. K1+337 on the dam axis. Main structure of ship lock is located in the branch beach at the right side and the dam crest bridge spans over the lock chamber. Axis of second-line ship lock is set at the right side and the axis distance is 120m. The effective size of ship lock is 180*23*3.5 and the ship lock consists of upper and lower shiplock heads, upper and lower lock chambers, upper and lower approach channels, upper and lower remote regulation and the anchorage. Length of both the upper and lower shiplock head is 31m and length of the lock chamber is 180m. The downstream and upstream approach channels are asymmetrically arranged (lock in: curve-line; lock out: straight-line). The total straight-line length from upper approach channel to lower approach channel is 1,361.8m. Bottom width of the upper and lower approach channels is 65m and bottom elevation of approach channels is 44.20m and 43.45m respectively. Separation levees with length of about 365m are set between the upper and lower approach channels and power house and the crest elevation is 55.72m and 53.50m respectively.

Power house: The power house is of low-head type and set on the right bank of the riverbed. It connects with the sluice gates at the left side and connects with the linkage dam at the right side. The length in the dam axis direction is 185.6m. The length of the installation site is 42.0m, the length of the main power house is 135.1m and the width of the main power house in the flow direction (including trash rack) is 80.78m. It is designed to install 6 *12.5MW bulb tubular turbines power generators in the power house. As for power house parting, partition for each generator is used. The installation elevation is ∇37.70m and the generator spacing is 21.8m and the wheel diameter is 7.3m. The installation site is located at the right side of the main power house and the central control room is located in downstream of the installation site and is close to the downstream auxiliary power house.

Fish pass: The fish pass is of bionic type and temporary protect fishway is set, considering that construction the downstream Nianpanshan complex is not begun. The

bionic fishway uses trapezoidal cross-section and has bottom width of 2m, slope of 1:2.5, gradient of 1/100, and water depth of 2m and total length of 560.2m. The project fishway uses rectangular cross-section and has width of 3m, water depth of 3m, gradient of 1/60 and total length of 361.6m and the length of fishway pool room is 3.6m.

Dam crest road and bridge: Dam crest bridge consists of cross-ship lock section, cross-sluice gate section and cross-power station section and total length of the bridge is 1,087m. Length of the cross-ship lock section is 380m and length of the cross-sluice gate section and length of the cross-power station section is 707m. Bridge main span is made of box girder with variable cross section and side span is of pre-stressed concrete hollow core slab structure.

The complex management area: For operation of the complex, office and production house, transport facilities, power supply for project management, water supply facilities for production and greening of the project management area are required. The complex management office is set at the right side of the dam site and for the site layout, the needs of production and living in the future should be taken into consideration and the site can also be combined with the complex buildings to form a relatively closed management area. Construction of the project owner camps includes construction of office building, ship lock management room, welcome center, dormitory, activity center, canteen, warehouse, substation, fire-fighting station and outdoor courts and the greening. Construction area of the complex management area is 8,140m2.

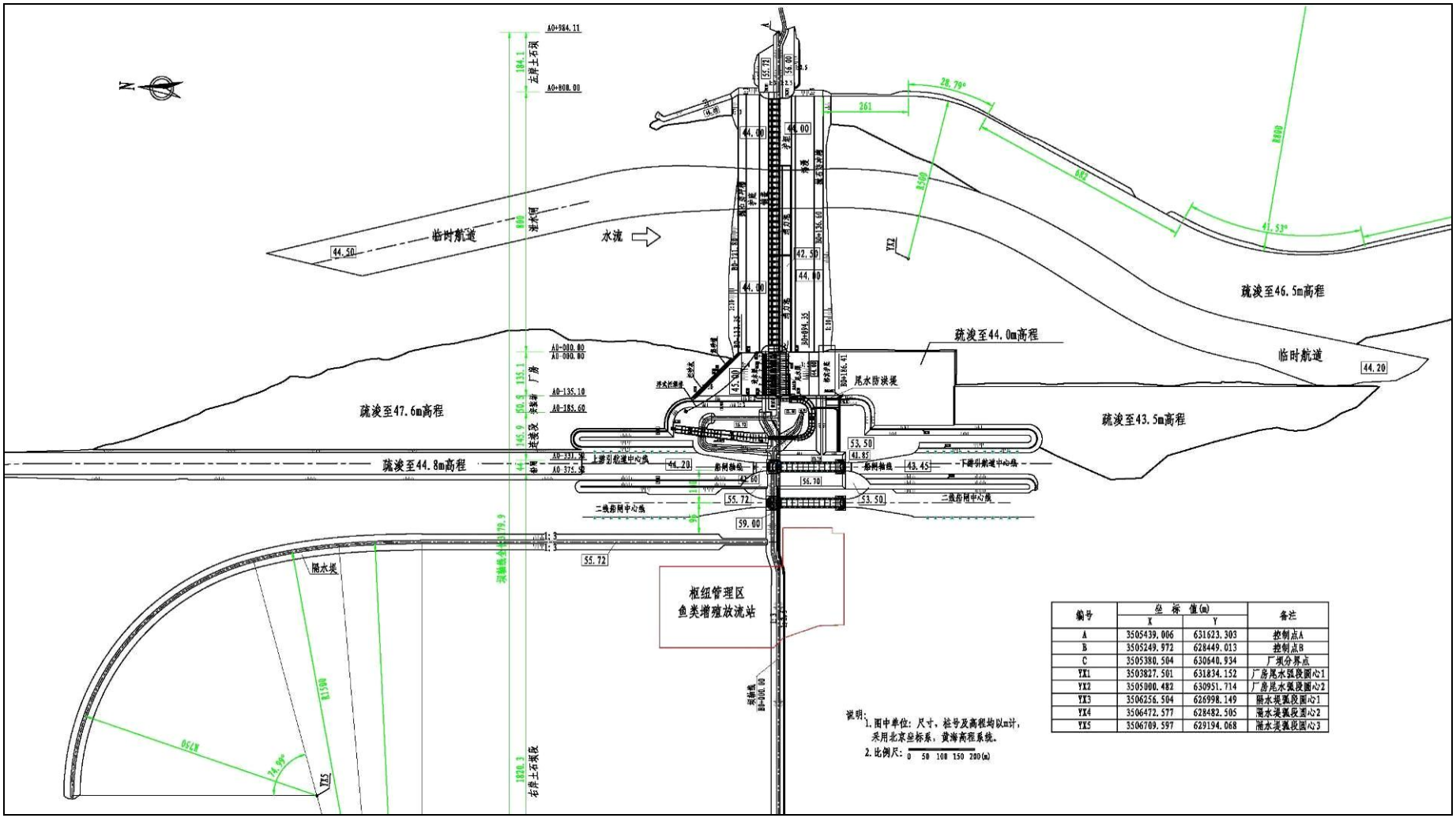
Engineering characteristics of Yakou Navigation Complex Project is shown in Table 2-4.

Table 2-4 Characteristics of Yakou Navigation Complex Project

No.	Items	Unit	Feasibility study data	Preliminary design data
I	Reservoir			
1	Water level			
	Check flood level (P=0.33%)	m	55.51	55.41
	Design flood level (P=2%)	m	54.37	54.36
	Normal water level	m	55.22	55.22
	Dead pool level	m	54.72	54.72
2	Area of the reservoir	km^2	85.38	-
3	Backwater length	km	52.67	-
4	Capacity			
	Total capacity	100 million m^3	4.073	3.54
	Capacity of reservoir under normal water level	100 million m^3	3.502	3.37
	Regulating storage	100 million m^3	0.415	0.4
	Daily regulating storage for navigation	100 million m^3	0.324	-
II	Project benefits indicator			
1	Navigation benefits			
	Improvement of navigation scale standard	Level	III	III2

No.	Items	Unit	Feasibility study data	Preliminary design data
	Channelized waterway mileage	Km	52.67	52.67
	Design throughput capacity of navigation structures	Million t/Year	980	1122
2	Power generation benefits			
	Installed capacity	MW	74.2	75
	Guaranteed output	MW	25.4/19.0 Before/after construction completion of Nianpanshan complex	37.15/19.10 Before/after construction completion of Nianpanshan complex
	Average annual energy output	100 million KWh	3.22/2.52 Before/after construction completion of Nianpanshan complex	4.111/2.521 Before/after construction completion of Nianpanshan complex
	Annual utilization hours	h	4343/3407 Before/after construction completion of Nianpanshan complex	5481/3361 Before/after construction completion of Nianpanshan complex
III	Structures of the complex			
1	Water retaining structures			
	Top elevation	m	59.0	59.0
	Top length	m	1322.5	2150.3
	Maximum dam height	m	14.0	16.5
2	Sluice gates			
	Type		Open sluice with horizontal bottom	Open sluice with horizontal bottom
	Design flood discharge	m^3/s	20200	20200
	Size and quantity of gate	drain holes, m*m	48 holes 14m*14.1m	44 holes 14.0m*11.22m
3	Navigation structures			
	Type		Single line Class I ship lock Room for second-line ship lock is reserved	Single line Class I ship lock Room for second-line ship lock is reserved
	Highest and lowest navigable water level in the upstream	m	55.22, 52.77	55.22, 48.70
	Highest and lowest navigable water level in the downstream	m	53.21, 45.53	53.28, 45.85/50.32(Before/after construction completion of Nianpanshan complex)
	Effective size of lock chamber	m	180 * 23 * 3.5	180 * 23.0 * 3.5
	Fleet size	m	167 * 21.6 * 2.0	167 * 21.6 * 2.0
4	Power house			
	Type			

No.	Items	Unit	Feasibility study data	Preliminary design data
	Size (L*W*H)	m	194.5 * 77.2 * 54.8	135.1 * 80.78 * 53.17
	Count of machine		7	6
	Rated flow	m^3/s	330.2	372.4
	Rated head	m	3.8	4
	Unit capacity	KW	1.06	1.25
V	Total investment			
	Total investment for the complex	Ten thousand Yuan	324571.1	334996.49
	Total static investment for the project	Ten thousand Yuan	319076.1	330342.33
	Installed investment per unit KW	Yuan / kW	42624	44640



编号	坐标值(m)		备注
	X	Y	
A	3505439.006	631623.303	控制点A
B	3505249.972	628449.013	控制点B
C	3505380.504	630640.934	厂坝分界点
YX1	3503827.501	631834.152	厂房尾水弧段圆心1
YX2	3505000.482	630951.714	厂房尾水弧段圆心2
YX3	3506256.504	626998.149	隔水堤弧段圆心1
YX4	3506472.577	628482.505	隔水堤弧段圆心2
YX5	3506709.597	629194.068	隔水堤弧段圆心3

Figure 2-7 Plan of Yakou Navigation Complex Project.

(2) Water diversion works

Diversion is implemented by stage and through earth-rock cofferdam. The design flood standard of cofferdam is flood of ten-year return period. Dredge the downstream river course and temporary waterway first and realize overflow and navigation through the main riverbed.

In the first stage of diversion, cofferdam the ship lock and power house on the left bank and 16-gate dam on the right bank, realize overflow and navigation through left-bank dredged riverbed, use all-year around earth-rock cofferdam and the diversion period is October of the second year to October of the fourth year, the design flood standard of diversion is flood of ten-year return period. Q=13,500m3/s and begin to dismantle the cofferdam built in the first stage in middle October of the fourth year.

In the second stage of diversion, build the phase II overflow cofferdam and cofferdam the remaining left-bank gate dam; the diversion period is from November of the fourth year to May of the sixth year; realize overflow through right-bank built gate dam and navigation through the built ship lock under the water retaining conditions; when the inflow is in excess of the retained flow, combined discharge through the right-bank built gate dam and Phase II overflow cofferdam and navigation through the built ship lock is realized; installation and construction of mainframe section and the plants continues under the protection of inlet blocking door and tail water blocking door. Q in the second stage of water diversion equals to 8,000m3/s and the overflow standard is flood of ten-year return period and Q=13,500m3/s.

(3) Waterway regulation

According to the complex layout and construction scheme, original bottom elevation of entrance area of upper approach channel of ship lock and the linkage section is relatively higher and dredge according to the design water depth of 2.4m is required during the construction period and the quantity of dredging is about 800,000m3. Such sections can meet the navigation demands of the construction period (500t) and the operation period (1000t) after dredging. The range of dredging under the dam is the area within 2.5km on the right bank, the dredging width is about 400m and quantity of the dredging works is about 1 Million m3.

Approach channel and dredging works within the cofferdam is constructed with land machines, namely, excavation through backhoe shovel and transport through dump truck. As for the approach channel and dredging works outside the cofferdam, in accordance with water level of the construction period, the part above the water can be constructed with land machines and the part under the water can be constructed with cutter-suction dredger.

Part of the excavated materials is used for backfill of the ship lock and will be firstly stockpiled in the right-bank spoil piling areas; the rest is used to backfill both the left-bank and right-bank Class I terrace so as to lift the construction site and cultivated land (refer to the next sections for introduction to waste dump site).

2.3.3.2 Material sites

(1) Sand and gravel aggregate

It is recommended in the preliminary design that all untrimmed quarry stones will be exploited in Longmentan quarry of the reservoir area and the total exploitation of sand-gravels is 2,673,800 tons (equivalent to 1,249,400m3). Because of sand drain caused

by underwater mining, the sand-gravels transported to the stock yard is 2,410,000 tons and the graded wastes is 44,600 tons. Hence, another 97,100 tons of pebble with particle size of 40 to 80mm have to be purchased from Hualong quarry in downstream of Yakou dam site. Apart from the excavated materials, the cofferdaming in first and second stage will also require altogether 302,000m3 sandy peddle mixture which will be exploited in Longmentan quarry.

Longmentan quarry has smooth terrain and elevation of 55m to 56m. It is the continent in the center of mainstream of Han River and most of the quarry is under the water. Stone materials in the quarry need to be exploited with dredge of 120m3/s and transported to the dock on the right bank with barge of 180m3 and to the stockyards with belts. The water transport distance to Yakou dam site is about 37km. Hualong quarry is located in Yupeng Village, Liushui Town which is in downstream of Yakou dam site. The quarry is under exploitation at present and is the riverbed of mainstream of Han River. The land transport distance to the dam site is about 9.0km (left bank) and the water transport distance is about 8.5km.

(2) Earth borrow area:

The clay required for the water diversion works is 150,500m3. The clay required for anti-seepage of left-bank cofferdam is 69,300m3 and the clay required for anti-seepage of right-bank cofferdam is 81,200m3. 191,200m3 clay have to be acquired from the earth borrow area. The left-bank cofferdam requires earth of 88,000m3 from Yakou earth borrow area and right-bank cofferdam requires earth of 103,200m3 from Luojiazhuang earth borrow area. Reserves of the left-bank and right-bank earth borrow area are 365,200m3 and 2,368,000m3 respectively, meeting the project demands. The surface layer of the earth borrow area is stripped off with bulldozer for the reclamation in the later period and the useful clay is excavated and loaded with dredger of 2m3 and transported to the cofferdam with 15t dump truck.

Luojiazhuang earth borrow area is located in Luojiazhuang Village within right-bank embankment and is connected to the dam site with road and the transport distance is 1km. Yakou earth borrow area is located in Yakou Village and is connected to the dam site with road and the transport distance is about 2km. These two earth borrow areas are the newly exploited quarry for this project. According to laws of China, the land acquisition shall be done and the approvals over exploitation shall be obtained before exploitation and the earth borrow area shall be restored upon completion of use. The impacts of exploitation of these two earth borrow areas on the environment and the relevant protective measures are assessed in this report. Refer to Chapter 8 for details.

(3) Dimension/block stones

The clay required for the water diversion works is 150,500m3. The clay required for anti-seepage of left-bank cofferdam is 69,300m3 (taking the restoration of sub-cofferdam after overflow of the cofferdam into consideration) and the clay required for anti-seepage of right-bank cofferdam is 81,200m3. 191,200m3 clay have to be acquired from the earth borrow area. In light of the stone materials required by the project, it is planned to purchase the finished stones from the existing commercial stone quarry. The stone materials for left-bank cofferdam will be purchased from Matoushan quarry and that for right-bank cofferdam will be purchased from Jinniushan quarry. The reserves of these two quarries exceed 600,000m3 and 400,000m3 respectively, meeting the project demands. These two dimension stones quarries are commercial quarries with permits.

Matoushan dimension stones quarry is located in Banqiaodian Town and is under exploitation of non-governmental sectors. Such quarry is beside the provincial road 306 and is about 20km away from Yakou dam site. Jinniushan dimension stones quarry is located in southwest of Leihe Town. Such quarry is beside the provincial road 250 and is about 30km away from Yakou dam site. The exploited stones will be transported to the construction site by 25t dump truck through the above mentioned provincial roads and Yipukong county road.

Location of the above mentioned material sites and the transportation roads are shown in Figure 2-8.

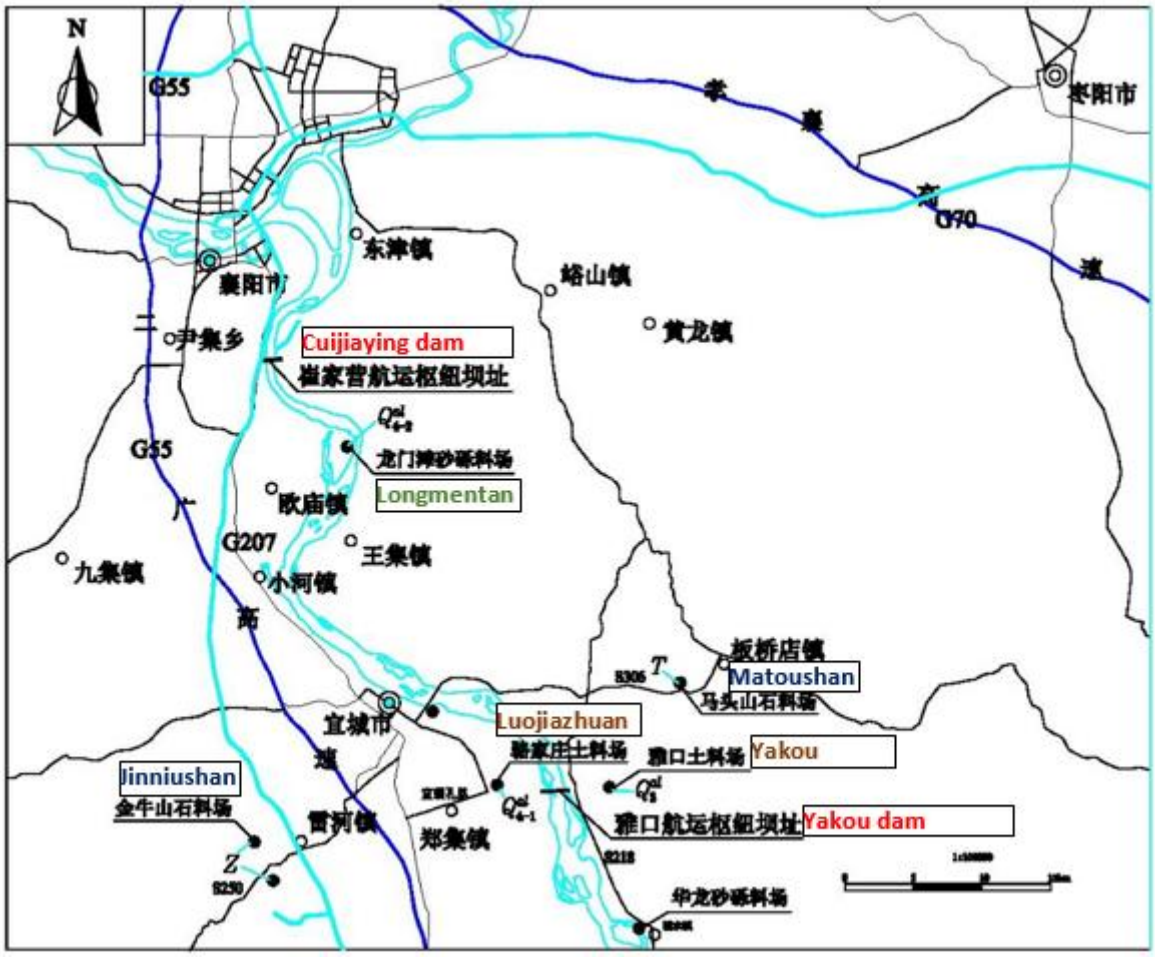


Figure 2-8 Quarry location and transportation roads

Yakou earth borrow area

Matoushan stone quarry

Longmentan gravel and sand area

Jinniushan quarry

S218 Transportation roads

Yipukong county road

Figure 2-9 Natural building materials and current conditions of main transportation roads

2.3.3.3 Waste dump site

All of the spoils in the complex area will be recycled and used to form the construction site or lift the cultivated land. In accordance with layout of the complex and terrain conditions near the construction site, there is a large number of Class I terrace in upstream of the dam site. Within the reservoir inundated area, this condition will be fully used and the excavated spoils will be used to lift the ground and protect the cultivated land resource to the utmost degree. Left-bank waste dump site is set in Class I terrace in downstream of the dam line and the piling of spoils will make the ground level rise from

about 44.0 -53.0m to 59.0m. Right -bank waste dump site is set in Class I terrace near the dam line and the piling of spoils will make the ground level rise from about 47.0-53.0m to 570m. Quantity of the left-bank spoils and right-bank spoils is 1,335,000m3 and 3,381,200m3 and the total is 4,716,200m3. Refer to Table 2-5 for the planning on spoil and refer to the general layout of construction for the specific layout.

Table 2-5 Planning of Spoil Sites

Waste dump site	Area (Ten thousand m^2)	Spoil elevation (m)	Average elevation (m)	Spoil quantity (Ten thousand m^3)	Planned quantity (Ten thousand m^3)	Remarks
Right-bank spoil (slag) site	84.12	57	4.2	338.12	356.3	Concurrently used as right-bank stockyard and temporary construction area
Left-bank spoil (slag) site	15.66	59	8.9	133.5	140.0	Concurrently used as left-bank stockyards
Total	120.66			471.62	488.3	

2.3.3.4 Transportation works

(1) Public roads

At both banks, there are roads leading to Chengguan Town, Yicheng City and there are township roads on the left bank connecting with S218. There is road over the flood control embankment and the road width is about 6 to 8m; this road connects with Yipukong county road and leads to G207. Refer to Figure 2-1 and Figure 2-3.

Build new access road with pavement elevation of 59.0m and total length of 1.3km on the left bank to connect with S218. The existing road on flood control embankment on the right bank is used. The first part with total mileage of about 10.4km starts from the junction between dam axis of Yakou complex and Yixi embankment of Han River, deviates from Han River embankment and extends towards southwest in front of Yejicheng sluice and ends at the junction between Zhenxing Avenue, Yicheng City and Yipukong road. The second part starts from Yejicheng sluice and ends at junction between Hanjiang Road and Han River Embankment and the total mileage is about 1.6km. The load is designed according to secondary road. The subgrade width of Han River embankment section is 5.0m and the subgrade width of the section from Han River Embankment to the ending point is 10m.

(2) Roads in the construction site

Equipment and materials will be transported into the site mainly through roads on the right bank during the construction period and during the construction period of phase II, the mechanical equipment and some equipment and materials on the left bank at the earlier stage can be transported into the site through roads on the left bank. During construction period of Phase II, the transport between both banks is mainly realized through the dam crest road and bridge built in the Phase I construction period, the downstream section of phase II longitudinal cofferdam and the foundation pit. According to layout characteristics of the complex, construction and diversion procedures and construction schedule, the

complex is constructed by two stages. In accordance with the terrain and traffic conditions of the dam site and the construction needs, apart from the existing roads within the site and the crest roads, another 8 temporary roads with total length of 12.2km for construction have to be built at both banks to form traffic network within the site. Characteristics of main roads within the site are shown in Table 2-5.

Table 2-6 Main characteristics of roads in the site

No.	Section	Length (m)		Road grade	Pavement width (m)	Pavement structure	Remarks
		Newly built	Rebuilt				
R2	Right-bank dock to gravel processing system to phase I cofferdam	2600		Grade II	9.0	Concrete	
R3	Right-bank temporary construction site to phase I cofferdam	900		Grade II	9.0	Concrete	
R4	Phase I upstream cofferdam to foundation pit	1000		Grade II	9.0	Concrete	
R5	Phase I downstream cofferdam to foundation pit	2600		Grade II	9.0	Concrete	
R6	Left-bank S218 to phase II downstream cofferdam	800		Grade II	9.0	Concrete	Left bank: mobilization at earlier stage
R7	Left-bank downstream cofferdam to upstream foundation pit	1000		Grade II	9.0	Mud stones	Pit excavation
R8	Left-bank downstream cofferdam to downstream foundation pit	300		Grade II	9.0	Mud stones	
R9	Left-bank longitudinal cofferdam to downstream foundation pit to upstream foundation pit	1000		Grade II	8.0	Concrete	Phase II construction concrete Transport corridor
	Other roads	0	2000	Grade III	8.0	Mud stones	
Total		10200	2000				

2.3.3.5 Construction camp

(1) Living camp

According to the construction schedule and upon calculation, there will be 2100 labors on the right bank during the peak construction period. Therefore, living houses and facilities and office houses with construction area of about 12,600m2 are required. According to the principle of facilitating construction, living and management, the office and living camps are set within the temporary construction facilities areas on both the left and right banks in a centralized way.

(2) Processing Plants and Workshops

The construction plants are set within the right-bank temporary construction facilities area in a centralized way. Aggregate processing system, concrete system, reinforcement processing plant, timber processing plant, equipment repair workshop and metal structure processing plant are all set beside the roads within the area. Right-bank prefabricated concrete component plant is set closely to the concrete mixing building. According to the

engineering quantity statistics, the total quantity of concrete is about 926,700m3 and the total quantity of finished gravels is about 2,199,000 tons. In accordance with the construction and diversion procedures and general layout of construction, aggregate processing system and concrete production system are to be set on the right bank. Capacity of aggregate processing system is 400t/j and concrete production system is set near to the aggregate processing system. 2 concrete mixing buildings of 3*1.5m8 will be set for the concrete production system.

The warehouse includes the warehouse storing cement, reinforcement, hardware, chemical products, labor protection articles, mechanical & electrical equipment and explosive materials and so on. The warehouse storing large number of materials (such as reinforcement, timbers and cement and so on) used by the construction plant is set within the corresponding construction plants. Integrated warehouse storing other materials (such as hardware, chemical products, labor protection articles and so on) is set within the warehouse areas on both the left and right bank.

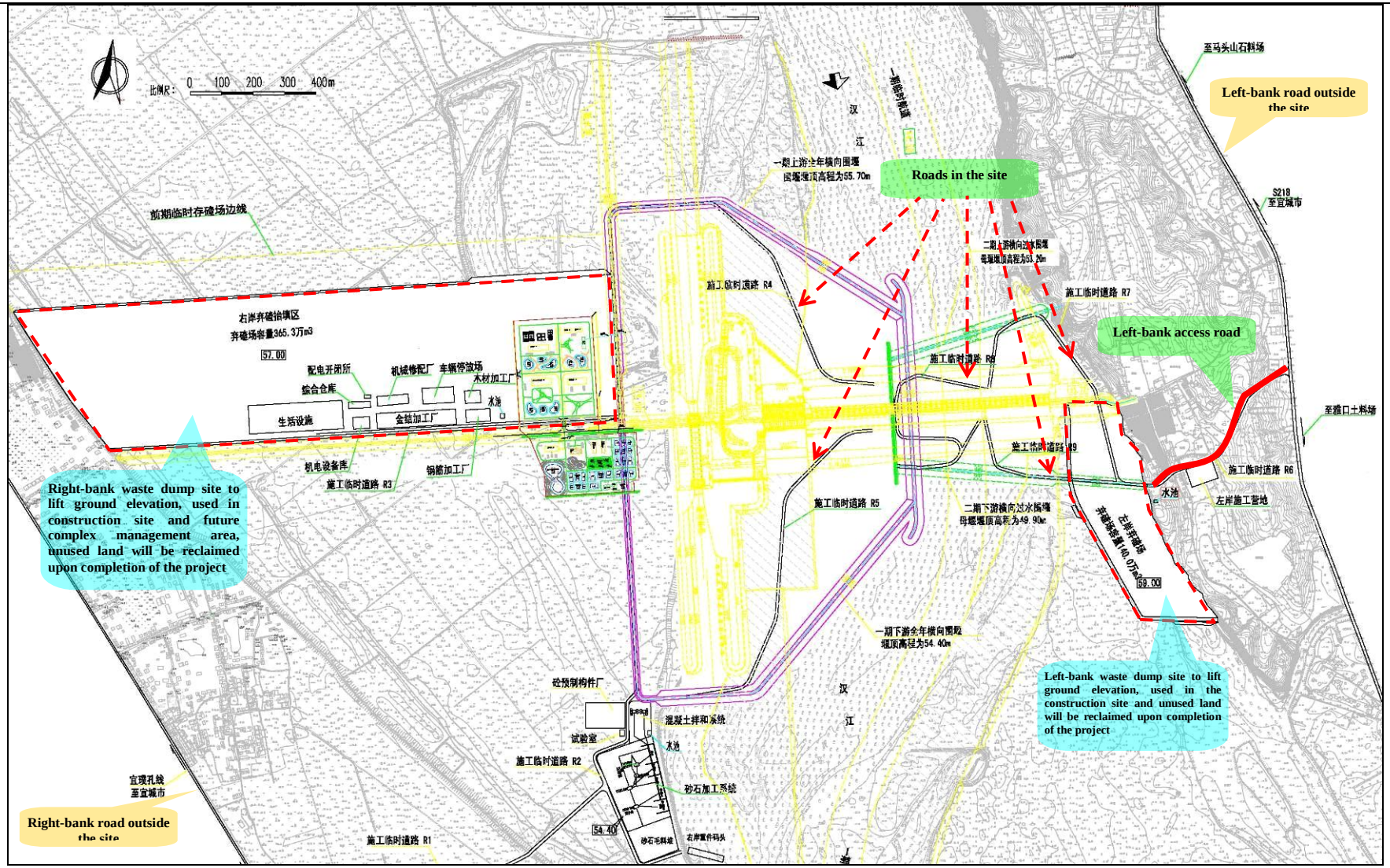


Figure 2-10 General layout of construction site of Yakou Navigation Complex Project.

2.3.4 Reservoir inundation and resettlement

Impoundment scope of the reservoir area upon completion of Yakou Navigation Complex Project is located within the existing Han River Embankment. If no protective measures are taken, the following related to agriculture will be influenced:162 households with population of 636, houses of 34906.03m2 (all are private houses); land of 112,768.87mu including water area of 71,911.0mu and land area of 40,857.87mu (including cultivated land of 13,800.01mu, river flat of 15,542.18mu, forest land of 9,631.48mu, residential land of 23.20mu and other land of 1,861.00mu); 3 water pumping system; 3 sand plants; 3 stock yards and pool of 135.40m3. And the following professional items will be influenced: roads for farm machinery of 7.5km, 4 ferry crossings, 30 sand & gravel wharfs, 3 cargo terminals; 110KV power cable of 3km; 10 water intake pump stations and 12 drainage culverts and sluices. The impoundment of reservoir will not inundate the city and towns.

After taking the protective measures, the inundation will affect 3 cities (districts), 8 towns and 34 villages; 18 households with population of 91, houses of 13,238.47m2 (private houses); land of 99,495.03mu including water area of 71,911.0mu and land area of 27,584.03mu (including cultivated land of 865.27mu, river flat of 15,542.18mu, forest land of 9,631.48mu, residential land of 9.77mu and other land of 1,535.33mu); the other indicators will be the same as that before protective measures are taken. Complete the displacement of inundation-affected residents and the bottom cleanup before impoundment of the reservoir.

Reservoir inundation and resettlement works include resettlement, reconstruction (reform) of the professional items and reservoir area protection and so on. The resettlement works include production arrangement and relocation. Reconstruction (reform) of the professional items includes waterlogging design and inundation treatment and so on. The components of resettlement works are shown in Table 2-6.

Table 2-6 Components of resettlement works

Project		Project composition at feasibility study stage	Changes of preliminary design
Resettlement	Production arrangement	Population requires production arrangement till the planned year 2018 is 23,401, including: 23,307 in the reservoir-affected area and 94 in the construction area of the complex.	Population requires production arrangement till the planned year 2019 is 660.
	Relocation	The total population to be relocated till the planned year 2018 is 1,805 and all are in the reservoir area of the complex. Relocation of houses of rural displace persons is realized through house construction in both centralized and decentralized ways.	The total population to be relocated till the planned year 2019 is 91 (in 18 households) and will be resettled within the village groups in a decentralized way.
Reconstruction of special facilities	Transport facilities	Reconstruct farm machinery accesses of 2.2km, 1 port, 2 wharfs and 2 ferry crossing.	Reconstruct roads for farm machinery of 7.5km, 3 cargo terminals and 4 ferry crossings;
	Drainage design	Draft open channel excavation plan for drainage and excavate lateral ditch to connect with Yidao Ditch; it is planned to excavate branch ditches within the	Change direction of gradient of Huangjia Ditch and deepen Huangjia Ditch on the right bank; reform Guohai Sluice and build Yejicheng pump station; build two waterlogging

Project		Project composition at feasibility study stage	Changes of preliminary design
		inundation-affected scope on the left bank to connect with the existing drainage channels.	pump station at Guanzhuang Culvert and Sluice and Guhekou Culvert and Sluice on the left bank.
	Electricity and telecommunication facilities	Rebuild optical cables of 2.5km and power cable of 3km	The reservoir inundation will influence lines of 3.0km, protect the No. 51 pole tower and reform the No. 52 pole tower.
	Water conservancy and hydropower facilities	Seal the culverts and sluices or expand the holes or rebuild the culverts and sluices that are affected by the reservoir inundation of Yakou Navigation Complex.	Appropriately raise 10 small pump stations, rebuild the 12 culverts and sluices, reform the pump station, seal and compensate or expand them and so on.
Protection works	Cultivated land protection work	Not applicable	Protect the cultivated land of 13,413.79mu through lifting the land
	Residential area protection works	Not applicable	Protect Yaowan residential community with gravity retaining wall with length of 779.5m and drainage system.
	Embankment protection works	Consolidate the Yicheng urban section, Yicheng Hedong section, Xiaoheying village section and Huijiazhou section.	Consolidate the Xiangyang Oumiao section, Yicheng urban section and Yicheng Hedong section.

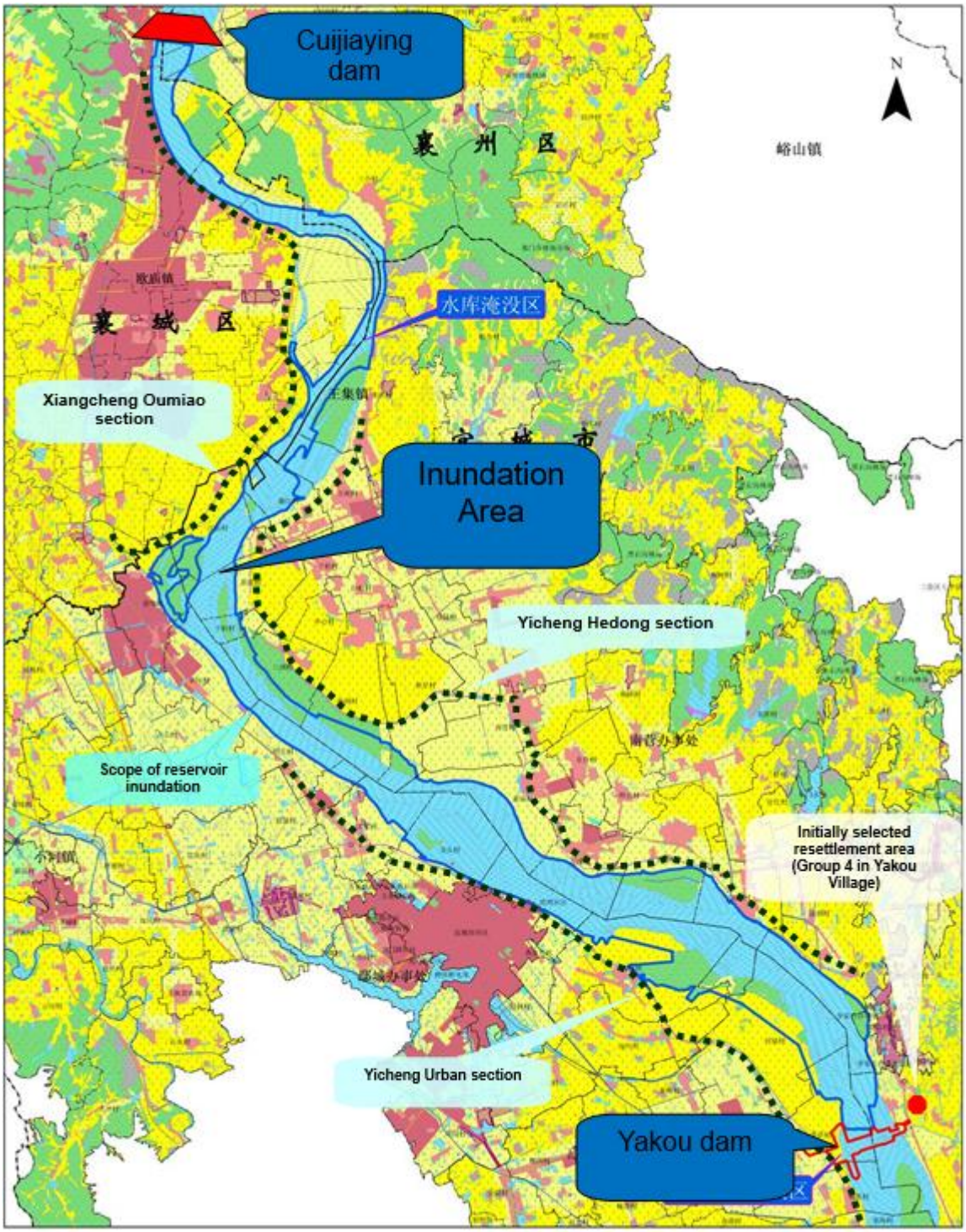


Figure 2-11 Reservoir area of Han River Yakou Navigation Complex Project

Within the reservoir inundated area, the main environmental impacts caused by impoundment of reservoir mainly include inundation over land and various auxiliary facilities, change of the water quality in the reservoir area, change of ecological environment in the reservoir area and impact on the original residence environment. The corresponding mitigation measures have been described in the RAP.

In the formulation process of resettlement action plan, the environmental carrying

capacity of relevant areas has been analyzed and the potential impact of this project on surrounding ecological environment and the potential impact of newly built resettlement areas on the surrounding ecology have been assessed in the original EIA Report. In the preliminary design phase, resettlement in a decentralized way remains unchanged and no new adverse impact on the environment is exerted. This supplemental ESIA presents the comprehensive analysis and assessment over the potential environmental and social impacts exerted by construction of current resettlement areas and relevant facilities.

2.3.4.1 Resettlement

(1) Production arrangement planning

According to the existing conditions of the reservoir area, the people who requires production arrangement will be resettled around the reservoir area. In accordance with the topography, soil, climate and irrigation conditions of the land resources around the reservoir area and production habits of the displace persons, the production arrangement is as follows: Production for 379 people will be arranged within the group and 335.3mu (all are dry land) cultivated land will be adjusted within the group. 227.6mu (all are dry land) cultivated land for 224 people will be adjusted outside the group but within the village. 87 people will be arranged to engage in secondary and tertiary industries (service, transportation and individually-run business) with support of the compensation.

(2) Relocation and resettlement plan

In accordance with the field survey and opinions of the local government of various levels and representative of displace persons, 35 households with population of 91 in the reservoir area will be resettled within the village in a decentralized or centralized way. Among them, 18 households scattered in the reservoir area will be resettled in a decentralized way; in accordance with the survey on willingness of the displace persons, most of 17 households in fisherman's cooperative of the dam site located Yakou, Liushui Town will purchase the house by themselves and only 2 of them choose to be resettled in Group 4, Yakou Village where resettlement house will be built in a centralized way.

2.3.4.2 Reconstruction of special facilities

(1) Transport facilities

Upon investigation, the reservoir inundation will influence altogether 7.5km roads for farm machinery, 3 cargo terminals including 5 berths, 30 sand & gravel wharfs and 4 ferry crossings. The reconstruction plan is as follows:

Roads for farm machinery: Restore the roads for farm machinery to the original scale according to size of land-lifting areas and needs of agricultural production;

Cargo terminals: Niping terminal and Yaowan terminal are 500t berths. Niping terminal is located on the right bank of Han River and upstream of Yicheng Han River Bridge. Yaowan bulk cargo terminal is located on the right bank of Han River and downstream of Yicheng Han River Bridge. These two terminals will be relocated in the reserved places in Xiaohe Port and will be built into 1000t berths.

Sand & gravel wharfs: According to port area planning and riverbank planning and files of local port and waterway administration bureau, the sand & gravel wharfs are operated by individuals without certificates. In accordance with opinions of the competent departments, these sand & gravel wharfs are facilities constructed without legal permits

and the operators are ordered to dismantle these wharfs without any compensation.

Ferry crossings: It is planned to appropriately compensate the ferry crossings in the reservoir inundated areas and the affected villages will restore or reform the ferry crossings according to actual conditions of the villages.

(2) Drainage design

Right bank: Maintain the original channel system, change the direction of gradient of Huangjia Ditch and drain all the water to the area below the dam through Yidao Ditch; Guohai Sluice does not meet the drainage requirements and needs to be re-designed; Huangjia Ditch needs to be deepened for it has to drain the daily waterlogging in seepage interception ditch; build a pump station at Yejicheng to timely drain the urban waterlogging and a small pump has to be designed at Yejicheng and operated all the year around so as to meet the daily seepage interception needs since water of the relief wells is continuously drained to Yejicheng.

Left Bank: A pump station needs to be built at the left bank since the water is unable to be drained by itself due to rise of the water level of Han River. Torrential flood is drained into the take-over zone via flood-diversion ditch. In order to facilitate operation and management, two drainage pump stations will be built at Guanzhuang culvert and sluice and Guhekou culvert and sluice. Guanzhuang pump station will drain the water of waterlogging areas controlled by original Nanzhou culvert and sluice, Guanzhuang culvert and sluice, Annao culvert and sluice and Gongnao culvert and sluice. Guhekou pump station will drain the water of waterlogging areas controlled by original Guhekou culvert and sluice and Baijiatao culvert and sluice.

(3) Reconstruction of electricity and telecommunication facilities

The restoration and reconstruction plan determined according to the inundation conditions of various areas and the actual topography of the reservoir area: ①As for No. 51 pole tower, tower foundation protective measures will be taken: set water retaining wall on the original slope protection facilities and fill with soil to prevent long-term submerge of the tower foundation; ② As for No. 52 pole tower, the power company will replace it with a higher one.

(4) Water resources and hydropower facilities improvement planning

Inundation of Yakou reservoir will influence 10 small pump stations. Reforming the pump stations will eliminate the inundation impacts and meet the local irrigation needs at the same time. The measures are appropriately lifting the pump stations and reforming the foundation of hydraulic structures.

Inundation of Yakou reservoir will influence 12 culverts and sluices. In accordance with Letter of Explanation of General Office of Hubei Provincial People's Government concerning Embankment Reinforcement Project of Yakou Navigation Complex Project Reservoir Area, the embankment reinforcement works include consolidation of 12 culverts and sluice.

2.3.4.3 Protection works

(1) Cultivated land protection works

According to the detailed investigation and field survey on scope of reservoir inundation, there are 13,800.01mu cultivated land in the backwater inundation area. The

farmland protection planning is implemented according to backwater standard of five-year flood by combining with the local conditions and upon actively communication and altogether 12 areas of cultivated land (involving 13,413.79mu cultivated land) will be protected through land-lifting, see Figure 2-12.

Cultivated land protection plan through lifting: It is planned to use the excavated waste soil in the construction process to lift and reclaim the land in shallow areas of the inundated dam areas and the reservoir areas and the protective measures are combination of engineering measures and ecological measures. Base of the part below normal water level will be consolidated with mortar masonry and the revetment will be smoothed with dry stone masonry. The part from the part above normal water level to field shoulder will be protected with EM4 three-dimensional vegetation net. The earth for land-lifting is from the land outside of the embankment works of the land-lifting areas.

(2) Residential area protection works

Yaowan residential community, Yancheng subdistrict office, Yicheng are located at the right side and in upstream of Yicheng Han River. Such community is affected by water level of ten-year flood and houses of total 29,650.52m2 and 144 households with population of 545 of the community is affected by the flood. Upon communication with relevant departments of Yicheng City, Yaowan residential community will be protected with gravity retaining wall with length of 779.5m and drainage system.

(3) Embankment protection works

In the embankment reinforcement planning of Han River, embankment reinforcement of Yakou reservoir area has been taken into consideration. Meanwhile, the reinforcement will focus on main embankments of Han River Yakou Navigation Complex Project reservoir area, such as, Yicheng urban section, Yicheng Hedong section and Xiangcheng District Oumiao section, to meet the water retaining requirements of Yakou reservoir area all the year around. Therefore, the reinforcement cost is not calculated into the project cost and the reinforcement works will be assessed as the linked projects (see section 2.3.6 for more details).

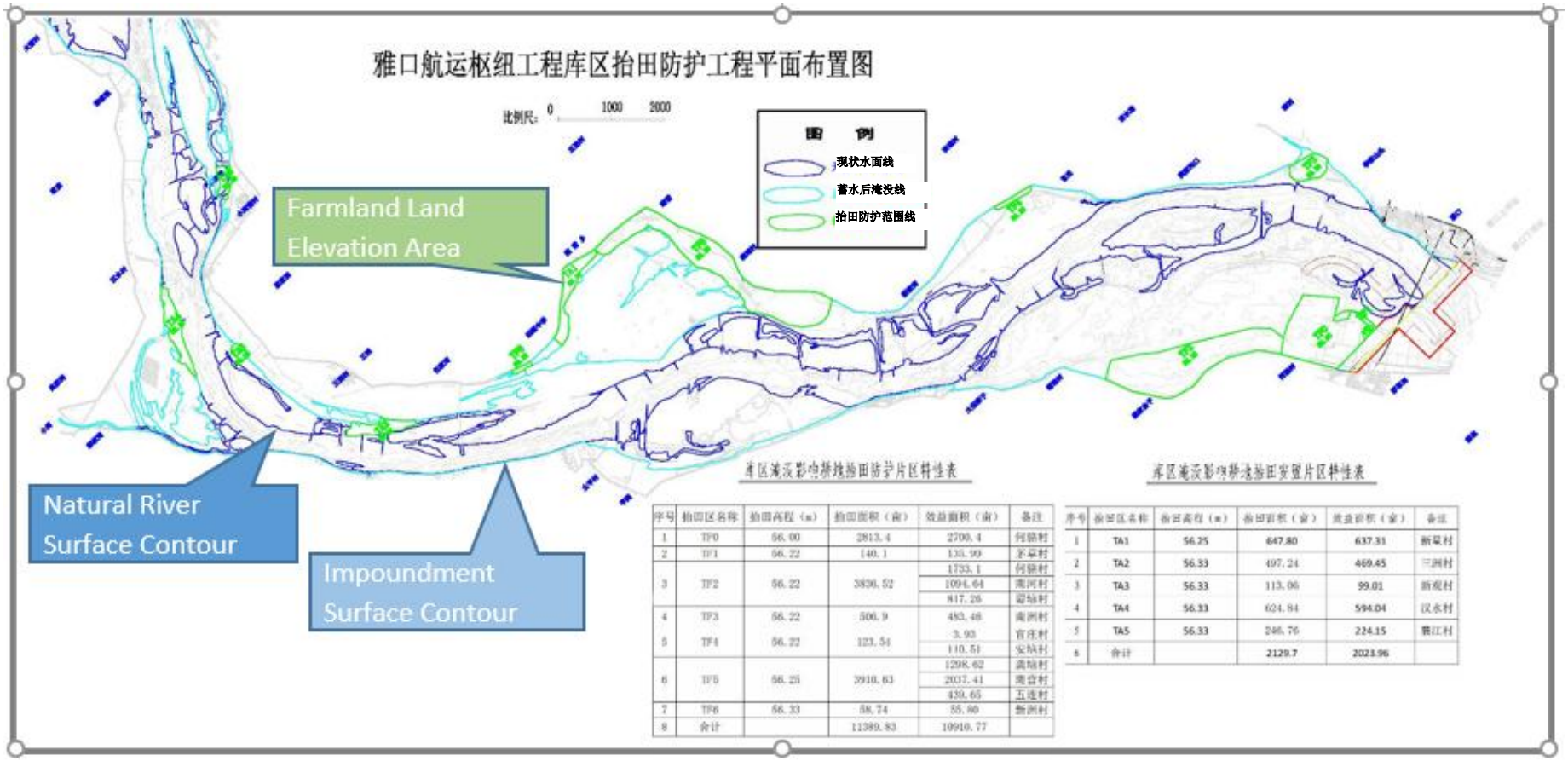


Figure 2-12 Plan layout of land-lifting protection works of the reservoir area

2.3.5 Transmission line

It is required to lay 110KV single-circuit overhead line of 12km from Yakou Navigation Complex to Zhengji substation and Hubei Electric Power Company will be responsible for the laying. It is preferable that the mode of transmission line is LGJ-400 and an outgoing line interval of 110KV at Zhengji substation should be built. The total investment of the access system works is 15,930,000 Yuan.

Such works will be implemented under organization of local power departments. Since the preparatory work of domestic EIA Report of the project has not been formally started, the relevant environmental and social impacts of the project will be preliminarily analyzed on the basis of identified local environmental baseline in this report. This will also offer directions for formal implementation of the domestic environmental impacts assessment in the future.

2.3.6 Embankment reinforcement in the reservoir area

Embankment reinforcement project of Han River is the linked project of Han River Yakou Navigation Complex Project. Xiangyang Water Resources Bureau and Xiangyang Waterway Administration are responsible for the implementation of embankment reinforcement.

Middle and lower reaches of Han River is wandering river in plain and embankment in the past were built to protect the farmland and towns. Xiangyang Han River embankment is located in Xiangyang administrative region and protects the cultivated land of 1,121,000 and population of 2,434,000 on both banks. Xiangyang Oumiao section, Yicheng Hedong section and Yicheng urban section are located in Yakou reservoir area, i.e., area between Cuijiaying complex and Yakou complex. The crest elevation is usually 1.0m to 2.0m higher than the water level of flood in 1964 (equivalent to flood of twenty-year) and total length of the embankment is 86.7 kilometers. Both banks of other sections are terrace, meeting flood control requirements. Refer to Figure 2-13.

Embankment reinforcement on both banks of Yakou reservoir area river section is implemented by Xiangyang Water Resources Bureau in accordance with Feasibility Study Report of Han River Embankment Reinforcement Project (in Xiangyang) of Hubei Province. The report has been approved by the competent industry department. In accordance with the national standard Flood Control Standard (GB50201-94) and Flood Control Planning of Yangtze River Basin (June 2008), flood control standard of embankment in middle and lower reaches of Han River is to withstand flood in 1935 (equivalent to flood of one-hundred-year) and that of embankment in mainstream of Han River is to withstand flood in 1964. In accordance with the protected areas and importance of the protection area and according to the relevant standard and norms, embankment in Xiangyang Oumiao section, Yicheng Hedong section and Yicheng Urban section is determined as Class II embankment.

Main contents of Han River embankment reinforcement work in river sections of Yakou reservoir area are shown in Table 2-7. Figure 2-13 shows the status quo of river embankment.

Table 2-7 Main works of reservoir embankment reinforcement in river section of Yakou reservoir area

No.	Main works	Xiangyang Oumiao section Right bank	Yicheng Hedong section Left Bank	Yicheng urban section Right bank	Total
1	Embankment reinforcement (km)	18.922	34.301	33.516	86.739
2	Flood control crest roads (km)	18.922	30.301	33.516	82.739
3	Revetment outside the embankment (m)	18922	4000	4572	27494
4	Consolidation of embankment body (m)	18922	0	0	18922
5	Probing and grouting of embankment body (m)	16322	25101	30316	71739
6	Seepage control of embankment foundation (km)	4.3	0	3.2	7.5
7	Backfill of pools (m2)	20000	71198	13000	104198
8	Embankment-crossing culverts	3	6	7	16
9	Small pipe culverts	0	2	1	3

Embankment will be the passage for danger finding and transport of emergency supplies. Width of the crest of Xiangcheng Oumiao section, Yicheng Hedong section and Yicheng Urban section is determined as 6m and width of the crest road is determined as 4.5m. Crest road in Yicheng urban section will be of concrete pavement and that in other sections will be of clay-bound macadam pavement. In accordance with different geological conditions, the seepage control of embankment foundation will be realized through inside weight treatment, deep cement-soil mixed pile walls on the crest, probing and grouting of embankment body or seepage cutoff wall treatment on the crest. In this project, smooth revetment is the main slope protection form and wall revetment will be applied in some sections. The part below the design lowest water level will be protected by concrete revetment and the part below the design lowest water level will be protected by smooth revetment.

Embankment at left-bank dam site

Embankment of right-bank dam site

Figure 2-13 Han River embankment works in river section of Yakou reservoir area

Embankment in Yakou reservoir area guarantees the bank protection of reservoir area of Han River Yakou Navigation Complex Project. In accordance with the plan, the

embankment reinforcement project will be commenced in 2016 and completed in 2018, namely completing before impoundment of Yakou reservoir to meet the requirements of Yakou reservoir area protection.

2.4 Environmental and Social Sensitive Areas and Receptors

In the preparation process of the environmental assessment, main environmental and social sensitive areas and receptors within the expanded project areas were identified in accordance with the surveys on aquatic ecosystem since 1978, baseline survey on terrestrial and aquatic ecosystems, survey on cultural relics, field survey and expert opinions as well as public consultation. Refer to Table 2-8 and Figure 2-14 and the analysis are as follows:

- **Spawning grounds of fish producing pelagic eggs (i.e. floating eggs):** In accordance with the historical data, there are three large spawning grounds of fish producing pelagic eggs in upstream and downstream of Yakou complex. They are Yicheng spawning ground in 14.5km upstream of Yakou dam site, Guanjiashan spawning ground in 13.5km downstream of Yakou dam site and Dengjiatai spawning ground (i.e. Zhongxiang spawning ground) in 61.8km downstream of Yakou dam site. *Yicheng spawning ground existed in 2004 when the aquatic ecosystem survey was implemented and was not found in 2014 when the survey on spawning grounds was conducted. The two spawning grounds in downstream of Yakou dam site are far away from Yakou complex and construction and operation of the complex will exert little impact on them.*

- **Ecological sensitive area**: There are two wetland parks in Yakou reservoir area and they are Cuijiaying Provincial Wetland Park (Xiangyang) and Wanyangzhou National Wetland Park in 4.5km upstream of Yakou dam site. *This project will exert little impact on Cuijiaying Wetland Park and the assessment will focus on Wanyangzhou Wetland Park.*

- **Drinking water protection zone:** Yicheng Drinking water protection zone is located in river section of Yakou Navigation Complex reservoir area and water intake of Yicheng Water Plant is located on the right bank and 20.0km in upstream of Yakou dam site. The water in section from 1000m upstream of the water intake to 100m downstream of the water intake is Class I protection zone and the water in section from 3000m upstream of the water intake to 300m downstream of the water intake is Class II protection zone. *Construction of the project will exert little impact on the drinking water protection zones and the assessment will focus on the impact on water quality upon formation of the reservoir area.*

- **Cultural relics and historical sites:** Through the survey on cultural heritage, 12 underground cultural heritage sites are found in the reservoir area. Among them, Wangjiagang tomb is protected by county-level government and protection level of other 11 have not yet been determined. Haogouquan cemetery, Wangjiagang tomb and Tongmei cemetery are influenced by erosion and others are affected by inundation. *Cultural heritages (material cultural resources) protection plan are supplemented in this supplemental ESIA Report.*

- **Animals and plants under key protection:** In accordance with historical data on ecology survey, some animals under key protection of the national government or

the provincial government are living in the project areas. Such as, three species of national Grade II protected wild animals: common buzzard, black kite, kestrel; 26 species of wild animals under key protection of Hubei Province including 5 species of amphibians, 2 species of reptiles, 18 species of birds and 1 species of beast. The part of this report in respect of impacts on ecology focuses on the assessment on their current conditions and the potential impacts of this project. The survey found out that there is 1 old pistacia chinensis which is 550 away from the reservoir flooded line. *No wild plants under protection of the national or provincial government is found in the reservoir inundated area and the project area.*

- **Sensitive social receptors:** Yakou village, Maocao Village and Heluo Village distributed at both banks of the project construction area. The report introduces the assessment on the disturbance to the residents of these villages and the potential impacts on their livelihood exerted by the project construction and operation.

Table 2-8 Overview of sensitive receptors of Yakou Navigation Complex Project

Environmental elements	Sensitive receptors/ areas		Positional relationship with the project	Size and characteristics	The main source of influence	Possible impacts	Requirements
Water environment	Drinking water protection zone of the reservoir area	Drinking water protection zone of Yicheng Water Plant	Water intake of Yicheng Han River Water Supply Company is located on the right bank of the reservoir area and 20.0km upstream of the dam site.	25,000 t/d, riverside combined water intake structure, pile framing water intake and elevation for water intake is 43m.	Reservoir inundation and change of pollutant dispersion conditions in water source	Deepening of the water depth at water intake, water flows slowly and water quality may change when the pollution loading remains unchanged.	Ensure that water quality of the reservoir meet the function zoning requirements of water environment, well do the bottom cleanup, strengthen harness over pollutant sources according to pollution prevention and control planning of the basin, protect water quality of the reservoir and formulate emergency plan.
		Wangji Town water intake, water intake of Xiangnan Prison Water Plant and water intake of Danjiangkou Resettlement Area Water Plant	All are located on the left bank of the reservoir area and is 33.0km, 2.8km and 1.2km away from the dam site respectively.	The capacity is about 5000t/d, 2000t/d and 5000t/d respectively and the water intake structures are of riverside separate type, bell type and floating type respectively. The elevation for water intake is 38m to 42m.			
	Reservoir area Agriculture Irrigation stations	Yingshan, Zhangzui, Nanying irrigation pump stations	Left bank of Han River mainstream in the reservoir area	Riverside tower or box type water intake structure, elevation of the water intake is 55m to 57m and the irrigation area is about 110,000mu.			Ensure that the water amount and quality meet the irrigation requirements.
		Ronghe irrigation pump station	Right bank of Han River mainstream in the reservoir area	Riverside tower or box type water intake structures, elevation of the water intake is 56m and the irrigation area is 50,000mu.			
	Water intake for industry use in the	Water intake of Beijing Yanjing Beer Group	Right bank of Han River mainstream in the reservoir area,	Water for production, floating type water intake structure and elevation of	Rise of water level of the reservoir and deepening of	More convenient for taking water	-

Environmental elements	Sensitive receptors/ areas		Positional relationship with the project	Size and characteristics	The main source of influence	Possible impacts	Requirements
	reservoir area	Corporation	upstream of Yicheng Han River Bridge and 15.5km away from the dam site	the water intake is 41m to 45m	the water depth		
		Water intake of Anneng Biomass Power Plant	Right bank of Han River mainstream in the reservoir area, downstream of Yicheng Han River Bridge and 14.5km away from the dam site	Water for production, floating type water intake structure and elevation of the water intake is 41m to 45m			
	Water intake under the dam	Water intake of Liushui Town Water Plant	Water intake is located on the left bank and 8.0km under the dam	5,000 t/d, riverside separate water intake structures Pile framing water intake and elevation of water intake is 42m.	Discharge of wastewater during the construction period and the operation of the reservoir during the operation period.	The construction will exert adverse impact on downstream water intake for living; during the operation period, water amount in the low flow years will be guaranteed.	Guarantee the water amount of the water intakes and discharge volume meets the demands for water. Guarantee the downstream water supply safety, not reduce the water quality; ban discharge waste water (sewer) into the water intake, formulate emergency plan.
Atmospheric environment and acoustic environment	Right bank	Heluo Village	West side of the right-bank access road (the nearest one is 125m away)	About 190 households with population of 580	Wastes from construction Transportation	Reduce the air quality of the areas and exert some impacts on acoustic environment of the sensitive receptors.	Ensure the air quality of the areas meet the function zoning requirements. Eliminate dust by spraying water, the equipment and vehicle should meet the environmental protection requirements, implement blasting and transportation in the fixed time period. Meet Grade II standard of Ambient Air Quality Standard (GB3095-1996) and Class II standard of Environmental Quality Standard for Noise.
		Maocao Village	Close to aggregate processing system and concrete system in the construction area (the nearest one is 160m away)	About 320 households with population of 958			
		Luojiazhuang Village	Close to Luojiazhuang earth borrow area and the	About 80 households with population of 215	Quarry mining		

Environmental elements	Sensitive receptors/ areas		Positional relationship with the project	Size and characteristics	The main source of influence	Possible impacts	Requirements
			nearest one is 170m away from Luojiazhuang				
	Left Bank	Yakou Village	Around construction site of Yakou complex and Yakou earth borrow area (the nearest one is 100m away)	About 120 households with population of 380	Dam foundation excavation Transportation		
		Shangwan Village	South side of Matoushan stone quarry and aggregate processing system and the nearest one is 200m away from Group 8 of Shangwan Village	About 58 households with population of 210	Quarry mining Aggregate processing		

Table 2-8 (Continued)

Environment	Sensitive receptors		Positional relationship with the project	Size and characteristics	The main source of influence	Possible impacts	Requirements
Terrestrial ecology	Terrestrial plants	one old pistasia chinensis	Located in Luojiahe, 500m away from the resettlement area and not affected by this project	-	-	-	-
		Camphor	Common species, around the residential areas in the reservoir area	National Grade II Protected Plants, typical androphile.	Raise of the water level Land occupation by the project	No impact	Avoid to protect the tree and ensure that they are not reduced
	Terrestrial animals	5 species of amphibians, 2	Shrubs and dense grass around the reservoir area	Hubei provincial key protected wild animals	Reservoir inundation	Some habitats are inundated	No hunting of wild animals, strengthen monitoring, search and

		species of reptiles, 18 species of birds and one species of beast					rescue them and timely restore the destroyed vegetation.
		Three kinds of birds: common buzzard, black kite and kestrel	High altitude mountains around the reservoir area and the nearest one is about 1km away from the construction area.	National Grade II key protected animals	Project construction	-	Protect the diversity of local terrestrial animals and plants and ensure that they are not affected by the project construction
Aquatic ecology	Fish spawning grounds		Yicheng spawning ground in the reservoir area, Guanjiashan and Dengjiatai spawning grounds of fish producing pelagic eggs in downstream of the dam site.	Yicheng spawning ground is 14.5km away from the dam site Guanjiashan spawning ground is 13.5km away from the dam site and Dengjiatai spawning ground is 61.8km away from the dam site	Raise of the water level Blocking of the dam	Spawning grounds of black carp, grass carp, silver carp and bighead carp as well as elopichthys bambusa, ochetobius elongates and luciobrama macrocephalus are not influenced	Protect fish resources to make sure that the quantity is not significantly reduced because of blocking of the dam and reservoir inundation. Strengthen fish breeding and releasing, build fishway and implement coordinated management of complexes and local fishery management department should strengthen management on the reservoir and waterway.
	Rare and precious fish		Luciobrama macrocephalus, ochetobius elongates, saurogobio gyaoilicaudatus, onychostoma macrolepis (varicorhinus macrolepis), leiocassis longirostris and anguilla japonica and so on	5 kinds of Hubei Provincial Protected aquatic wild animals; migration fishes and semi-migrating fishes	Impact of blocking of the dam	-	
Wetland Park	Cuijiaying Provincial Wetland Park (Xiangyang)		End of backwater of Yakou to Cuijiaying Navigation Complex and sightseeing district of Cuijiaying Provincial Wetland Park is involved	Typical river wetland in Han River basin, unique wetland type, good ecological environment, diverse and rich creatures, and total area is 5100hm^2.	Reservoir inundation	No inundation on terrestrial vegetation in the wetland park	Basically no impact on ecological function of the wetland park
	Hubei Yicheng Wanyangzhou National Wetland Park		4.5km away from Yakou dam site and the water area is entirely in the inundation scope.	It is permanent river wetland and flood plain wetland and the wetland rate is 69.53%.	The reservoir inundates the land area	Increase of water area and wetland rate, positive impact on the ecological function.	Fully consider the impact of Yakou Power Station in the detailed planning of next stage and reasonably plan the five functional zones.
Social environment	Cultural relics and historical sites		In the survey, 12 underground cultural heritage sites like Guanzhuang Han Dynasty	Wangjiagang tomb is determined as county protected cultural	Impact of reservoir inundation or	Partially inundation and erosion impact	Survey the cultural heritage sites and have archaeological excavation

		Tomb, Wangjiagang Tomb, Tongmei Cemetery, Heluo Village Six Dynasties Cemetery and Yakou Village Tomb were found in the reservoir area.	heritage and protection level of other 11 has not been determined.	immersion		
	Displaced residents	Reservoir inundation and land occupation by construction	Production of 660 people is to be arranged and 91 people are to be displaced.	Reservoir inundation Land occupation by the project	Impacts of project construction Impact of reservoir inundation	Control production and development of the reservoir area, protect the original vegetation of the reservoir area, compensate according to the national standard and avoid social conflicts.

	
Xiangnan Prison Water Plant	Water intake of Xiangnan Prison Water Plant
	
Danjiangkou Resettlement Area Water Plant	Water intake of Danjiangkou Resettlement Area Water Plant
	
Wangji Town Water Plant	Water intake of Wangji Town Water Plant
	

Monument of drinking water protection zone of Yicheng City	Water intake of Yicheng Water Plant
	
Water intake of Beijing Yanjing Beer Group Corporation	Water intake of Anneng Biomass Power Plant
	
Ronghe irrigation pump station	Zhangzui Electric Pump Station

Figure 2-14 Current conditions of some sensitive receptors

3 Summary of Original EIA Report

3.1 Main conclusions of domestic EIA Report

Entrusted by Port and Waterway Administration of Hubei Provincial Department of Transportation, HydroChina ZhongNan Engineering Corporation (subordinate to Power Construction Corporation of China) (hereinafter referred to as the company) undertakes the environmental impact assessment of Han River Yakou Navigation Complex Project. The report was submitted to the Ministry of Environmental Protection of PRC in November 2015 for review. Environmental Engineering Assessment Center of the Ministry of Environmental Protection held an assessment meeting in Xiangyang, Hubei Province in June 2015 and the report was further modified, supplemented and improved in accordance with opinions of the experts. In December 2015, the report passed the review and full text of the report was disclosed on the website of the Ministry of Environmental Protection in January 2016. The Ministry of Environmental Protection approved the report with document numbered H.S.[2016] No. 13 in February 2016.

This chapter summarizes the baseline conditions of various environmental factors, main environmental impacts and protective measures as put forward in the original domestic EIA Report and introduces the supplemental environmental impacts assessment related matters. It should be noted that basis of the original EIA report is the feasibility study report and this supplemental ESIA report is developed on the basis of preliminary design report of the project. Compared with the feasibility study, the preliminary design further details and optimizes the project contents, including: The dam line is slightly adjusted and moves 1km upwards, the distance between the dam line and the nearby villages is enlarged and the area of inundation area is reduced; quantity of waste dump sites is reduced from 3 to 2 and quantity of the earth borrow area is increased from 1 to 2 and one gravel quarry is added; the RAP is more clear and specific, such as, implementing land-lifting in the reservoir area to reduce the inundation area and quantity of land acquired and houses demolished. *On the whole, the environmental and social impacts brought by the project are reduced through optimization of the preliminary design.*

3.1.1 Water Environmental Impact Assessment

3.1.1.1 Baseline And Protected Targets

1) Baselines

Hydrological regime: The average annual natural inflow of Yakou Navigation Complex dam site is about 47.1 Billion m3 and the average annual discharge is 1,490m3/s.After water diversion of Middle Route (phase I) Project of South-to-North Water Diversion in 2015, the average annual discharge of Danjiangkou reservoir is 25.8 Billion m3 and the average annual runoff between Danjiangkou to Yakou dam site is 9 Billion m3. Then the average annual inflow of Yakou Navigation Complex after water diversion is about 34.8 billion m3 and the average annual discharge is 1,100m3/s.

Calculating by Tennant method as specified in the *Technical Guidelines for Environmental Impacts Assessment of Ecological Water for Waterway, Low-temperature Water and Fish Pass in Hydropower and Water Conservancy Construction (trial),* the minimum ecological flow of Yakou Navigation Complex dam site is 110m3/s. If relatively good ecology is maintained and if the minimum ecological flow is 20% of the average

annual discharge, it will be 220m3/s. In accordance with relevant provisions of Navigation Standard of Inland Waterway and in order to meet the demands of downstream navigation for the minimum water depth, the discharge volume for power generation is determined to be not less than 450m3/s. *This release flow rate can meet the ecological flow requirements for teh downstream waterways.*

BOX-1 Danjiangkou Reservoir and South-to-Noth Diversion

1) *Danjiangkou complex is located 800m downstream of the confluence of the mainstem of Han River with Dan River in Danjiangkou City, Hubei Province. The controlled drainage area is 9.52×10^4 km^2; annual inflow into the reservoir is 40.9 billion m3;*
2) *Danjiang complex was put into operation in 1973; normal pool level 157m; normal storage capacity 17.45 billion m3; annual average flow (at dam site) 1230 m3/s; installed capacity 900MW; navigable by ship elevator;*
3) *South-to-North Diversion Project intends to move water from Danjiangkou reservoir to north China to alleviate its severe water scarcity issue. To meet the objective, the dam was heightened to allow normal water level of 170m; reservoir storage capacity increased to 29.05 billion m3; and multi-year annual runoff 1,100 m3/s. The project was put into operation on December 12, 2014. Annual diversion water amounted to 2-3 billion m3.*
4) *The Danjiangou complex is capable of muti-year regulation capacity while its downstream reservoirs are run-of-river type that are of daily regulation or no regulation capacity. Danjiangkou complex to a large extent controls the hydrological regimes of the middle and lower Han River, which are fundamental to the ecosystems and human activities in the middle and lower Han River basin.*

Surface water: In accordance with Environmental Function Categories of Surface Water in Hubei Province (2000), the project located river section is "Han River reserve area in section from Xiangyang to Yicheng to Zhongxiang" in respect of water function zoning and follows Class II standards of Environmental Quality Standards for Surface Water (GB3838-2002) in respect of water environment function and other tributaries of the reservoir follows Class III standards of Environmental Quality Standards for Surface Water (GB3838-2002) in respect of water environment function. In accordance with monitoring results on surface water of the assessed river section from August 2013 to December 2014, other 21 monitoring factors of the 4 cross-sections along Han River mainstream in river section from Cuijiaying to Yakou dam site that follow Environmental Quality Standards for Surface Water (GB3838-2002) meet requirements of Class II standard, except the concentration of dissolved oxygen (Class IV) and concentration of total nitrogen (Class IV or Class V) in August 2013 (normal flow period) and concentration of total nitrogen in December 2014 (low flow period), and the water temperature of the monitoring cross-section is basically the same. *On the whole, the water quality of the assessed river section is good.* The reason that the concentration of dissolved oxygen exceeds the standard is that the temperature is August is relatively higher, the contact between water and air and growth of algae dissolve the oxygen. The reason that the concentration of total nitrogen exceeds the standard is direct discharge of some domestic sewage of the villages and towns along Han River without standard treatment into the water.

Groundwater: In accordance with the results of monitoring on ground water on the right bank of the proposed project construction site in August 2013, 16 monitoring factors meet Class III standard of Quality Standards for Groundwater (GB/T14848-1993), except the concentration of ammonia nitrogen, manganese and total coliform. *This indicates that water quality of the ground water is good.* The fact that concentration of ammonia nitrogen and total coliform exceeds the standards is related to direct discharge of domestic sewage without treatment and seepage of this sewer into the ground through pores of the soil. Concentration of manganese is related to higher background value of manganese in the soil.

2) Water Environment Protection Targets

There are altogether 5 water intakes in the EIA scope. Water intakes of 4 water plants are distributed in the river section of the reservoir area. They are water intake of Wangji Town Water Plant, water intake of Yicheng Han River Water Supply Company, water intake of Xiangnan Prison Water Plant and water intake of Danjiangkou Resettlement Area Water Plant and they are 33km, 19km, 3.4km and 1.5km away from and in the upstream of the Yakou dam site. Yicheng Han River Water Supply Company has water supply capacity of 25,000t/d and the water around its water intakes has been classified as drinking water protection zone. Water intake of Liushui Town Water Plant is located in the downstream of and 3.5km away from the dam site of the proposed project. There are also another 4 pump stations in the reservoir area.

3.1.1.2 Environmental Impacts and the Proposed Environmental Protection Measures.

1) Hydrological Regime:

Excavation of open channel and three-stage water diversion plan is used in the project construction so that drying up of the river will not be caused. In accordance with the water diversion plan, the discharge and navigation will be realized through the right-bank riverbed during the first-stage construction; the discharge and navigation will be realized through the left-bank open channel during the second-stage construction; the discharge will be realized through the built 40 sluice gates and navigation will be realized through the ship lock during the third-stage construction. The period from the interception of third-stage to the time when the navigation conditions are met is break period which will last about 45 days.

This project design is under the premise of heightening of dam of Danjiangkou Navigation Complex and that annual water diversion capacity of Middle Route (Phase I) Project of South-to-North Water Diversion is 9.5 Billion m3. After water diversion, the average annual discharge of dam site of this project is 1,100m3/s. To meet the navigation requirement of this river section that the minimum water depth should be 2.0m, navigation base flow of not less than 450m3/s should be discharged during the impoundment and operation period of Yakou Navigation Complex (accounting for 40.91% of the average annual discharge of the dam site). Discharge of not less than 450m3/s will be realized through the sluice during the initial impounding (period) of this project. When the water reaches to the dead pool level, the power generation conditions are met. The discharge not less than 450m3/s and average water level of 45.53m in the downstream in the operation period are guaranteed through baseload power generation.

After formation of the reservoir, area and volume of the water, water depth and average water surface width in the reservoir area are increased and the water area is

increased from 35.5 m2 to 111.75m2. The average flow velocity is reduced from 0.8m/s to 0.11m/s and the swift current is changed into slow current.

Daily regulation of the hydropower station will exert little impact on annual inflow distribution from the upper reach but impose impact on discharge under the dam and daily changes of water level. In the report, it is predicted that the maximum change of water level under the dam in high flow period (July) is 2.91m and the maximum change of water level under the dam in low flow period (November) is 0.66m.

2) Water quality

Water pollutant sources during the construction period mainly come from the waste water of the aggregate processing system, waste water of the concrete system, oily waste water and domestic sewage of construction personnel. Waste water of the aggregate processing system, waste water of the concrete system and oily waste water will be reused upon recycling and the domestic sewage will be used for irrigation or dedusting after it meets standards of Reuse of Urban Recycling Water—Water Quality Standard for Urban Miscellaneous Water Consumption (GB/T18920-2002) upon treatment. Upon analysis, it is believed that discharge accidents of industrial wastewater in the construction area will not exert adverse impact on water quality of the downstream reaches since aggregate processing enterprises are distributed in Matoushan stone quarry.

Influenced by inundation, water intake pump station of Yicheng City Water Plant will be reformed by lifting and the water-taking will be guaranteed after formation of the reservoir. The inundation will not affect the sewage discharge outlet.

In the report, it is predicted that concentration scope of COD and ammonia nitrogen in the reservoir area after impoundment of the reservoir will be 5.85mg/l to 8.91mg/l and 0.12mg/l to 0.16mg/l respectively; concentration of COD and ammonia nitrogen of Yicheng Water Plant will be 8.02mg/l and 0.15mg/l respectively, *all meeting Class II standards of Environmental Quality Standards for Surface Water (GB3838-2002).* Concentration of total nitrogen and total phosphorus will be increased and the reservoir area will show status of mild eutrophication. Due to the frequent water exchange, the possibility of overall eutrophication is small.

Water quality protective measures put forward in the report mainly include:

① During the construction period, the industrial wastewater will be reused upon treatment and domestic sewage will undergo biochemical treatment with complete set of domestic sewage treatment plant and then be used for road dedusting, vehicle washing or greening. Thorough bottom cleanup should be done before impoundment of the reservoir.

② During the operation period, domestic sewage of the living and office areas can be reused for greening or dedusting of the areas upon treatment with buried small integrated equipment; the oily waste water will be treated with oil-water separator and the separated oil will be recycled while the separated water will be reused for greening or dedusting.

③ Strengthen the protection of water quality in the reservoir area, the ship shall be equipped with treatment device or storage containers matching the quantity of domestic sewage in accordance with the specifications. Domestic sewage of the ship shall be received by the ships recognized by the maritime department. Oily waste water of the ship shall be collected by the device of the ship and treated by the newly built riverside oily waste water receiving devices. The ecological environment around the reservoir area should be improved and the non-point source pollution should be controlled. Take

eutrophication prevention measures with pollutant source control as the core to protect water quality of the tributaries.

3) Water temperature

In accordance with analysis results of impacts on water temperature of the reservoir, Yakou reservoir is typical mixing reservoir. Therefore, the discharged water of Yakou reservoir will not exert impacts on water temperature of the downstream river section after formation of Yakou Navigation Complex Project, for the reservoir has relatively small capacity, poor regulating capacity and big runoff and the water temperature structure of the reservoir is basically the same as that of the river before formation of the reservoir, namely, the water temperature of the reservoir still maintains temperature of the natural runoff.

4) Groundwater:

Reservoir immersion is the main impact exerted by the proposed project on ground water and mainly occurs in the section from left-bank Zhangjiazhui to Nanzhou, the section from right-bank Zhangjiazui to Lijiadian and both banks of the section from Ruanjiapo to Yakou dam site. The total immersion area is 27.72m2, the area of left-bank immersion area is 9.01m2 and the area of right-bank immersion area is 18.71m2. There is no demand for centralized ground water consumption and any valuable spring or special ground water resource protection zones in the impact scope of ground water and it is predicted that there will no obvious changes of water quality of the ground water before and after formation of the reservoir.

In the report, it is proposed to set drainage ditches in the location inside the section from head of Yicheng Han River embankment to Yakou complex embankment and in the location inside the section from Xinzhou Village, Wangji Town to Nanzhou Village embankment, Nanying Subdistrict to drain the infiltrated water.

3.1.2 Ecological impact assessment

3.1.2.1 Baseline

1) Terrestrial ecology

According to the results of field survey carried out in September 2013 and April 2014 and with reference to related literatures, the vegetation in this project assessment area includes six types, i.e., broadleaved deciduous forest, bamboo forest, bushwood, shrub-grassland, economic forest and cropland vegetation, of which natural vegetation involves 18 formations. In the assessment area, there are 123 families, 370 genera and 582 species of vascular plants (including cultivar), and there are abundant angiosperms, mainly including shrubs and herbs. Plant species mainly include Melia azedarach, Pterocarya stenoptera, Italian poplar, Saliz matsudana, tung tree, Excoecaria sebifera, tea plant, oil-tea camellia, mulberry, etc. *According to the survey, there is one big old tree, pistacia chinensis bunge, in the assessment area, 550m away from the reservoir inundation line. Neither reservoir inundation nor land occupation will involve national and provincial key protected wild plants.*

According to historical records, in the assessment area there are 4 classes, 20 orders, 44 families and 81 species of terrestrial vertebrates, including 1 order, 3 families and 5 species of amphibians, 2 orders, 5 families and 10 species of reptiles, 12 orders, 31 families and 56 species of birds and 5 orders, 5 families and 10 species of mammals. There

is no first-level key protected wild animal, and there are three species of second-level national protected wild animals, i.e., Buteo, black kite and kestrel. In the assessment, 26 species of Hubei provincial key protected wild animals are founded, including 5 species of amphibians, 2 species of reptiles, 18 species of birds and 1 species of mammals. Among them, amphibians include Bufo bufo gargarigans, Pelophylax nigromaculata, Fejervarya limnocharis, Microhyla ornate and Pelophylax hubeiensis; reptiles include Elaphe taeniura and Zaocys dhumnade; birds include Gymnocalycium asterium, Egretta garzetta, Anas platyrhynchos, Phasianus colchicus, Sterna hirundo, Streptopelia chinensis, Cuculus canorus, Hoopoe, barn swallow, Hirundo daurica, Lanius cristatus, Lanius schach, Oriolus chinensis, Dicrurus macrocercus, Crested myna, cyanopica cyana, Pica pica and Turdus merula; and mammals include *Meles meles Linnaeus*.

2) Aquatic ecology

Plankton. According to the results of the surveys carried out in April and July of 2014 and the data of the aquatic ecology of the river segments surveyed in 1976, 1977, 1978, 2004, and 2009, in the river segments under assessment, there are 8 phylums, 65 genuses and 124 species of phytoplankton, 62 genuses and 110 species of zooplankton, 4 phylums, 30 genuses and 36 species of benthoic animals, 3 phylums, 25 genuses and 39 species of periphytic algae and 12 families, 26 genuses and 36 species of aquatic vascular plants.

Fish. The Hubei Ichthyography (1987) reported 93 species of fishes in the river section of Han River below Danjiangkou. *63 species were found in the survey river section from Yicheng to Zhongxiang and its tributaires*, which belong to 5 orders, 13 families and 51genuses. Among the 93 recorded species, there is *no national protected aquatic wild animal or fish recorded in China Red Data Book of Endangered Animals, and there is also no specific species in Yangtze River*. There are five species of Hubei provincial protected aquatic wild animals, i.e., Luciobrama macrocephalus, Ochetobius elongatus, Saurogobio gracilicaudatus, Scaphesthes macrolepis (Varicorhinus macrolepis) and Leiocassis longirostris, *but none of them was found in the survey*. Migratory fish includes Anguilla japonica, *which was not found in the survey*.

According to this survey, the main body of fishes in the survey water area is river and plain group of cyprinide fish, the second is southern plain group and paleogene-period group, and there are a few species of China and India mountainous area group and some river-sea migratory species. Advantageous species mainly include current-loving species, such as Culter oxycephalus Bleeker, Saurogobio dabryi, Parabotia bimaculata, Rythroculter ilishaeformis, Rhinogobio typus, Squaliobarbus curriculus, Zacco platypus, Opsariichthys bidens, etc.

Spawning areas. According to the results of the survey on the spawning of fish spawning pelagic eggs in the middle reaches of Han River carried out by Institute of Hydrology (MWR & CAS) in 2004, there are five spawning grounds of Asian carps in the middle reaches of the main stream in Miaotan, Yicheng, Guanjiashan, Zhongxiang and Maliang. *This survey (2014 survey) only found two spawning grounds in Guanjiashan and Zhongxiang (Dengjiatai). The two spawning grounds are 13.5km and 61.8km downstream from the Yakou Dam site respectively*. There is no large tributary in the Yakou Reservoir area. No spawning grounds were found in the Ying River and Man River downstream from the dam. The fishes laying pelagic eggs mainly include the *Four Domesticated Fish* (*black, grass, silver, and bighead carp*) and other economic fishes, such as Squalidus argentatus, Saurogobio dabryi, Xenocypris argentea, Erythroculter ilishaeformis and Parabramis pekinensis.

The spawning grounds of fishes laying adhesive eggs are mainly distributed in river branches with slow flow and lush aquatic plants and in shallow water areas, and such fishes mainly include Mystus macropterus, Glyptothorax sinensis, Zacco platypus, Opsariichthys bidens, Hemibarbus maculates, Scaphesthes macrolepis, etc.

3) Soil erosion

The Minjiang River downstream areas and Leshan City involved in the Project are part of the region under soil erosion supervision that is designated by the Sichuan Provicial Government. Generally, soil erosion in Yakou County is not servere; the average erosion modulus is 2,921.3 tons/(km2· year) and the annual amount of soil erosion is 2.12million tons. Soil erosion in Wutongqiao District is not severe; the average erosion modulus is 4,116 tons/(km2· year) and the annual amount of soil erosion is 1.1108 million tons. Vegetation on the mountains along the banks of the Minjiang River segment where Yakou Navigation and Hydropower Complex Project is located is well preserved; soil erosion in the area is primarily caused by water erosion and it is not severe.

3.1.2.2 Environmental impact and proposed protection measures

1) Terrestrial ecology

According to the report, the project will affect the vegetation and plants in the assessment areas. Construction involves an area of 377.08 hectares. The area inundated by the reservoir covers 8,494.12 hectares, of which 270.31 hectares is farmland. The main types of vegetation include cultivated land, plantation, and scrub. The project has an insignificant impact on plant species and landscape layout. Project construction and inundation may cause wild animals' terrestrial habitats to shrink, but the general impact is not significant. After project construction began, there has been no significant change in landscape layout; in the assessment areas, natural scenery remains intact and natural ecosystems remain stable.

According to the report, wildlife species under the Class II state protection category such as *Buteo buteo, Milvus migrans,* and *Falco tinnunculus* are highly adaptable to new environments; their habitats are far away from the construction areas and inundated areas. The direct impact of project construction to these species is insignificant. With regard to amphibians such as Bufo gargarizans, Fejervarya limnocharis, and Microhyla ornata and reptiles such as Elaphe taeniura and Zaocys dhumnades, the reservoir impoundment and operation will affect their current habitats. As the water level rises, they will gradually adapt to new habitats. Impact on animals throughout the construction comes primarily from the construction and blast of plants and supporting facilities as well as from mechanical noise.

According to estimates of soil loss, the landform disrupted by Yakou Navigation Complex Project involves an area of 607.72 hectares; the vegetation destroyed due to project construction involves an area of 403.64 hectares; and the volume of spoil produced due to project construction reaches 7.5187 million m2. The total quantity of soil loss caused by the project is 109,724 tons, of which 96,015 tons is the increased quantity of soil loss.

Protection measures proposed in the report: coupled with soil and water conservation measures, measures shall be taken to restore the terrestrial ecosystem of the construction sites. In the process of vegetation restoration, the ecosystem of the hills in the construction area shall be protected. Deciduous broad-leaved forests, scrubs, and shrub herbosa shall be

increased. Yakou borrow pit site and temporarily occupied farmland shall be rehabilitated. Before impoundment, wildlife shall be searched and rescued, especially the wildlife species under the Class II state protection category, such as Buteo buteo, Milvus migrans, Falco tinnunculus, Bufo gargarizans, Fejervarya limnocharis, Microhyla ornata, Elaphe taeniura, and Zaocys dhumnades. If any of these species are identified, they shall be reported to the relevant authorities. In case of accidentally injured animals, these animals shall be treated without delay. Authorities shall promote the protection of wildlife and forbid hunting. To prevent soil erosion in the project construction area, walls keeping out waste and drains shall be built; vegetation shall be increased

2) Aquatic ecology

Since the completion of Danjiangkou reservoir in 1973, the gene exchange between fish stocks in upper reaches and middle and lower reaches of Han River has been blocked. Fish species in the middle and lower reaches of Han River have undergone changes in terms of spawning period and scale under the impact of changed discharged water temperature and hydrological regime in Danjiangkou dam. Subsequently, Wangfuzhou Hydropower Complex (without fish pass) in Yakou upstream, Cuijiaying Navigation and Hydropower Complex (with fishway) and Xinglong Hydropower Complex (with fishway) in Yakou downstream were completed respectively in 2000, 2010 and 2014. Although complexes built in recent years are equipped with fishways and other fish conservation facilities, on the whole, fish migration channels between main streams in middle and lower reaches of Han River as well as mainstreams and tributaries have been affected. For example, it has been difficult to see migratory fish anguilla japonica in recent years; and individual species and genetic exchange of semi-migratory fish such as mylopharyngodon piceus, ctenopharyngodon idellus, hypophthalmichthys molitrix, aristichthys nobilis, coreius heterodon, elopichthys bambusa and so on have been blocked. Migratory and semi-migratory fish will be blocked after the completion of Yakou Navigation Complex.

After the completion of Yakou reservoir area, dominant species in the reservoir area remain unchanged, and the total fish composition basically remains the same. Fish stocks such as cyprinus carpio, culter mongolicus basilewsky, culter alburnus, hypophthalmichthys molitrix, carassius auratus, xenocypris argentea gunther and silurus asotus, which adapt to the slow flow or still water habitat are still the dominant species in the reservoir area. While fish stocks such as four major Chinese carps, opsariicjthys bidens, brass gudgeon, rhinogobio typus and saurogobio dabryi, which adapt to the rapid flow habitat will decrease in amount and gradually move to Yakou reservoir tail to river section under Cuijiaying dam or go into the reservoir tributaries.

Despite the failure to find in the 2014 survey of aquatic ecology five Hubei provincial key protected fish recorded in "Hubei Ichthyography" (1987), namely luciobrama macrocephalus, ochetobibus elongates, onychostoma macrolepis, saurogobio gracilicaudatus and leiocassis longirostris. It doesn’t mean that these fish species have completely disappeared in the project river section, and the completion of Yakou Complex may still have an impact on the living space suitable for these fish.

According to historical ecological survey data, as of 2004, there was still a spawning ground within river section in Yicheng urban area about 18 kilometers from Yakou Complex upstream, which is the habitat for fishes spawning floating eggs such as mylopharyngodon piceus, ctenopharyngodon idellus, hypophthalmichthys molitrix, aristichthys nobilis, parabramis pekinensis, spualiobarbus curriculus, xenocypris microlepis, erythroculter ilishaeformis and so on. But two ecological surveys in 2009 and

2014 show that the spawning ground no longer exists.

Guanjiashan and Zhongxiang spawning grounds are located below Yakou dam. Since the runoff regulation of Yakou Complex is weak, the impact on the two spawning grounds is limited.

Protective measures for aquatic ecosystem proposed by the ESIA Report mainly include:

① Fish pass. A fishway will be built between the ship lock of the project and the plant on the left side of the separation embankment of the ship lock. The fishway will generally be used by semi-migratory economic fish species such as mylopharyngodon piceus, ctenopharyngodon idellus, hypophthalmichthys molitrix, aristichthys nobilis, elopichthys bambusa, luciobrama macrocephalus, ochetobius elongates, leiocassis longirostris, megalobrama skolkovii, parabramis pekinensis, distoechodon tumirostris, squaliobarbus curriculus, and leiocassis crassilabris. The fishway will also be used by other fish species. The fish pass combines nature-like passage with staggered stones and fishway. The fishway is 951.08m long in total, of which 560.58m is nature-like passage section. The fishway's gradient is 1/100, with bottom area of 2.0m wide. When the water level of the fishway is 2m, the water surface is 12.0m wide. The engineering fishway is 390.5m long; its gradient is 1/60; seven pools for rest are arranged.

② A fish breeding station shall be built near the project owner's camp. The station shall cover an area of 86.7mu. The fish species that will be released in the near future include hypophthalmichthys molitrix, aristichthys nobilis, ctenopharyngodon idellus, mylopharyngodon piceus, leiocassis longirostris, megalobrama skolkovii, parabramis pekinensis, distoechodon tumirostris, and squaliobarbus curriculus; the fish species that will be released in the remote future is leiocassis crassilabris. Four million fish will be released per year. Of 4 million fish, 3.5 million ctenopharyngodon idellus, mylopharyngodon piceus, hypophthalmichthys molitrix and aristichthys nobilis are bred on commission; 500,000 leiocassis longirostris, megalobrama skolkovii, parabramis pekinensis, distoechodon tumirostris, and squaliobarbus curriculus are released per year. Researches shall be carried out on collection and domestication technology, artificial breeding technology, large-scale fry rearing technology and fish releasing technology of wild parent fish.

③ Habitat protection and compensation. It is recommended that the river sections (5km long and 7km long) downstream from Cuijiaying Dam and Yakou Dam where water flows at a rate of at least 0.2m/s should be marked as closure of fishing areas. Fishing is forbidden throughout the fish breeding season (from March to August); no-fishing signs shall be put up in the relevant areas to prevent fishing and other activities that may disrupt aquatic habitat. The 18km-long section from tributary Ying River Class II power station to the Han River estuary is marked as closure of fishing area for protecting the habitat of fish. Pebbles and gravels are arranged in the area, and aquatic plants are transplanted to the area to create a favorable habitat for fish. Artificial spawning grounds are built for fish. Long-term monitoring of the water quality, fish species, and aquatic life in the aforesaid area will be implemented.

④ The joint ecological operation of complexes shall be implemented to resume the spawning habitat for fishes spawning floating eggs. According to flood in Tangbai River, ecological operation shall be implemented at least twice from May to August every year under Danjiangkou in the Han River main stream. When the discharge measured by the

Dongpo flood prevention station in Tangbai River reaches the discharge at which ecological operation shall be launched, Cuijiaying, Yakou, and Xinglong reservoirs shall release flood together, creating a favorable upstream spawning ground for fish. Flood's release generally lasts five to seven days till the flood peak ends so that the eggs and fry of fish can easily drift downstream from the dams.

3) Soil erosion

According to the ESIA Report, the area of land and vegetation disrupted by construction totals 607.72hm2. The water and soil conservation facilities damaged mainly include terrace, paddy fields, garden plots, woodland, grassland, and water area, which totals 403.64hm2. Waste generated by construction amounts to 7.5187 million m3. It is estimated that project construction may cause 109,724 tons of soil loss, of which 96,015 tons are the increased amount of soil loss. There is a large amount of soil loss occurring in waste dump site and temporary soil storage site, so soil and water conservation measures shall be taken to prevent and control soil loss in these areas particularly.

Measures such as building slag walls, drains and desilting basins, as well as planting trees on the surface of waste will be taken to prevent and control soil erosion caused by project construction. Temporarily occupied land for the project shall be rehabilitated; the rehabilitated area totals 183.48 hm2. After these measures are implemented, 99.9% of the land disrupted by construction will be rehabilitated; 99.7% of the amount of soil loss will be controlled (the ratio of controlled soil loss to total soil loss is 1.02), 97.0% of waste will be retained by walls, 99.5% of vegetation will be restored. Implementation of these measures will not only control soil erosion in the project area, but it will also restore and improve the project area's original ecosystem and natural environment.

3.1.3 Ambient air impact assessment

3.1.3.1 Baseline and protection objectives

According to the results of the monitoring on ambient air in the construction area of Han River Yakou Navigation Complex carried out in August 2013, the air quality in the area is good, and all of fine particles (PM10), nitrogen dioxide (NO2) and sulfur dioxide (SO2) meet the second-level standard in Ambient Air Quality Standard (GB3095-1996) and is conforming to the requirements of Class-2 function zoning.

Ambient air protection objectives proposed by the ESIA Report mainly include the residents (about 660 households with 2122 people) near earth borrow area, waste dump site, transportation routes and dam construction area.

The air protection objectives are mainly in Yakou Village Group Five, Yakou Village Group Three, Yakou Village Group Four, Maocao Village Group Six, Maocao Village Group Five, Heluo Village Group Ten, Nanzhou Village, Haoji Village Group Four ad so on.

3.1.3.2 Environmental impact and protective measures to be taken

According to the ESIA Report, air pollution during the construction is mainly caused by construction dusts and waste gas emission from machinery. The dusts come from soil excavation, spoil dumps, transportation, site, temporary storage site and earth filling. Waste gas emission has a small impact on the environment. During the operation of ship locks, it mainly generates waste gases include SO2 and NO2, but since it only takes a short time for ships to pass the ship locks, the pollutants remain within the waterway and have

little impact on the surrounding sensitive receptors.

The protective measures for ambient air quality proposed in the ESIA Report mainly include: Exhaust gas emitted from the ships that use oil engine and automotive engine shall be treated through a waste gas purifier. Roads and stockyards shall be watered so as to reduce or prevent dust. After a blast, the quarry area shall be watered to reduce dust; the piles of ore shall also be watered. Sheds shall be built for covering all vehicles. Roads shall be cleaned and watered on a daily basis. Machines shall be examined before they are used. The use of defunct vehicles is banned.

3.1.4 Acoustic environmental impact assessment

3.1.4.1 Baseline and protection objectives

According to the results of the monitoring on seven points in the assessment area carried out in August 2013, the acoustic environmental quality in this area is good, and the noise at day and night doesn't exceed the standard. The acoustic environment of one monitoring point in the resident spot on both sides of the access road meets Class-4a standard in Environmental Quality Standard for Noise (GB3096-2008), and all of the other six points meet Class-1 standard in Environmental Quality Standard for Noise (GB3096-2008).

Acoustic environment protection objectives proposed by the ESIA Report mainly include the residents (about 660 households with 2122 people) near earth borrow area, waste dump site, transportation routes and dam construction area.

Within 200m outside the construction site, sensitive receptors of acoustic environment include Yakou Village Group Four on the left bank, and Maocao Village Group Five and Group Six on the right bank.

3.1.4.2 Environmental impact and protective measures to be taken

Noises during construction mainly come from machine operation, vehicle transportation and blasting. The noises from machine operation and vehicle transportation exceed the limits for daylight and nights of Maocao Village Group Five and Group Six and Yakou Village Group Four. The blasting has only a short term of impacts on surrounding sensitive receptors due to short duration. The following noise control measures shall be taken during construction: the timeframe of transportation shall be strictly controlled; vehicle speed shall be controlled; loud horn shall be banned; roads and vehicles shall be maintained; soundproof walls shall be built along the red line marked for the requisitioned land near the residential areas of Maocao Village and Yakou Village.

During operation, noise made by ships passing through the dam generally will not disturb local residents, but the number of ships passing through the dam shall be regulated, and continuous whistling from ships shall be prevented. A large number of ships traveling and whistling at night shall be banned in the waterway sections along which a large number of residents live. The speed of ships traveling at night shall be controlled.

3.1.5 Solid wastes

3.1.5.1 Main environmental impact

The amount of earthwork is 14.1375 million m^3, the amount of backfill soil is 6.8538 million m^3, and the amount of spoil is 7.5187 million m^3. There will be 3 spoil sites, 2

temporary storage sites, and a borrow area. The land type of the borrow area is cultivated land, with an area of 6.75 hectares and a storage capacity of 560,000 m^3. The gravel and stone required will be outsourced. The spoil (waste) will be piled in the designated waste dump, and relevant measures shall be taken to prevent soil erosion.

The number of staff in peak-hour will be 1500, so the maximum amount of domestic waste generated will be 1.50 ton/day. There will be 2,190t of domestic waste.

3.1.5.2 Major environmental protection measures

A centralized treatment facility will be adopted for domestic waste. For inorganic waste, we will store it in the refuse collection station in the construction camp. For kitchen waste, we can hand it to local farms for treatment. For other waste, we will hand it to local sanitation department in Yicheng City.

3.1.6 Assessment of Resettlement Impacts

The resettlement work involves 3 cities/districts (Xiangcheng District, Xiangyang District, Yicheng City), 8 towns and 36 villages. To 2018, the number of DPs due to production resettlement will be 19, 864, and the number of DPs due to house demolition will be 1, 805. The project involves tractor road (2.2km), harbor(1), port(2), passenger ferry(2), optical cable (2.6km) , power cable (3km) , pumping station (3), and drainage culvert (9). The facilities such as roads, bridges, transmission lines affected will be rebuilt or reconstructed. Within the project area, there are no environmental sensitive areas like nature reserves or scenic spots. The adverse impacts of the project mainly include: impacts on water environment, atmospheric environment, noise environment, ecological environment, and more.

As the environmental measures shall be taken by corresponding agencies, the report only puts forward relevant requirements for environmental protection. For instance: the industrial waste water in construction period shall be treated in desilting basin and reused; watering measures shall be taken for dust control; construction waste shall be reused as far as possible, and those cannot be reused shall be transported to designated area; the domestic waste shall be transported to landfill site of Yicheng City. The domestic sewage in operation period shall first be treated in septic-tank before being treated sewage treatment equipment; the treatment method for domestic waste in operation period is the same with that of the construction period.

3.1.7 Environmental risk assessment

The report suggests that environmental risk mainly occurs in construction period and operation period. At the present stage, the risk is mainly caused by grounding and oil spilling.

The report believes that oil-spill accidents can be controlled in the reservoir area. If emergency measures are taken, there will be no adverse impact on water quality of the downstream. If the accident occurs in the vicinity of water intake, it will cause problem. If oil spill occurs in lower reaches of the Yakou Navigation Complex, the diffusion of oil-film will cause pollution.

As the amount of oil spills or and its spilling time is uncertain, once oil spill occurs, we should promptly take measures and notify downstream water intake points.

Environmental prevention and emergency measures proposed in the report include:

The oil depots and powder house need to maintain sufficient distance from the residential area and living area. During its transportation, relevant regulations and operational procedures shall be observed. Daily management of the ship and the terminal shall be strengthened, so as to avoid ship collision. Management and education of construction staff shall be strengthened to prevent illegal operation. Warning signs shall be set up in the water intake and protection area of water resources. Prevention facilities for oil-spill shall be set up and emergency response center shall be built.

3.1.8 Assessment of impact on sensitive areas

The report shows that there are 2 wetland parks in the project area, namely, Cuijiaying Provincial Wetland Park in Xiangyang and Wanyangzhou National Wetland Park in Yicheng. Cuijiaying Provincial Wetland Park was built on the foundation of Cuijiaying Reservoir upon the approval of Provincial Department of Forestry in 2010. The reservoir impoundment of the project will only affect the sightseeing area of Cuijiaying Provincial Wetland Park. The reservoir impoundment of the project will not affect the impoundment of Cuijiaying Reservoir, and will not inundate the terrestrial vegetation of the wetland park. Therefore, the project only has a slight impact on the ecology of Cuijiaying Provincial Wetland Park.

The Wanyangzhou National Wetland Park got the approval of the State Forestry Bureau in December, 2013. According to the reply, the wetland park is a pilot project for recreation and urban development. The downstream boundary of the wetland park is about 4.5km from Yakou Dam. After reservoir impoundment, part of the land in Wanyangzhou National Wetland Park will be inundated. The detailed planning of the wetland park is being compiled. In March &May of 2015, the Yakou Navigation Complex got the approval of Yicheng Forestry Bureau and Wetland Conservation Center of Provincial Department of Forestry. In view of ecological impacts, the report suggests that the relevant proposals shall be fully considered in project planning phase. *During the preparation of ESIA, the opions were adopted and a detailed planning for the wetland park was prepared and approved.*

3.1.9 Public consultation

During the EIA preparation period, discussion meeting, information disclosure, questionnaire and other methods are taken for Public consultation. In August 2012, the project owner conducted online disclosure on government site of Yicheng city, and posted the EIA information in Yicheng City, Liushui Town and Zhengji Town (the first round EIA information disclosure) .In August 2014, the project owner disclosed EIA report (brief version) on government site of Yicheng city, and posted the relevant information in Yicheng City, Liushui Town and Zhengji Town (the second round EIA information disclosure). During the information disclosure period, the Evaluation Unit received 2 feedbacks. The feedback suggests that quantitative research be carried out on environmental impacts. The respondents are mainly concerned about the quality of drinking water as it might be polluted by the construction. Fully taking these suggestions into account, Xiangyang municipal government has formulated Implementation Plan for Water Pollution Control in Han River-Xiangyang section. The full text of the EIA report was posted on the website of the MEP on January, 2016.

3.1.10 Cumulative environmental impact

The former EIA report has not given a systematic evaluation on the cumulative effect of the project. However, former EIA report has given a retrospective assessment of the

environmental impact brought by Wangfuzhou & Cuijiaying Hydropower Complexes. Meanwhile, the report has analyzed the cumulative impact on aquatic ecosystem and put forth relevant protective measures in ecological operation.

3.2 Review comments to EIA report

3.2.1 MEP Comments on EIA

The environmental reviews of MEP (2016, No.13) stress that following key issues shall be the focus in project construction and management:

(1) Ecological scheduling operation plan shall be prepared for reservoir impoundment and water discharges in operating period. The management mechanism for ecological regulation shall be established and strengthened in accordance with Reply on Joint Ecological Operation Plan of Complexes along Han River Mainstream below Danjiangkou (trial), and trial run shall be implemented in 2016-2017.

(2) Strengthen the control of water pollution. Make environmental protection plan and strengthen the work in water protection during the initial impoundment phase. Coordinated with the local government and relevant departments, prepare and strictly implement water conservation planning in the reservoir area.

(3) Strengthen the protection of aquatic ecosystem. Protection measures include ecological operation, habitat protection, fish passage facilities, artificial releasing, and discharge of ecological flow. All protection facilities shall be completed before reservoir impoundment. Hydraulic model for fish passage facilities shall be optimized and constructed along with the main work.

(4) Strengthen the protection of terrestrial ecosystem. Take strict control of construction activities and implement water and soil conservation measures as well as plant rehabilitation measures, focusing on areas such as spoil area, stockyard, temporary construction area, construction road, etc.

(5) Strengthening environmental management during construction period. Strengthen the work such as water protection, domestic waste treatment, dust control, and noise control.

(6) Strengthen the work of environmental protection in resettlement. Pay attention to soil erosion control, water environmental protection, ecological protection and waste disposal.

3.2.2 Progress of implementing the requirements given in reply

In February 2016, the MEP approved the project of Yakou Navigation Complex. After that, the Port and Waterway Administration of Hubei Provincial Department of Transportation has organized several conferences, stressing the importance of joint ecological operation. Relevant experiments on ecological operation & bidding work have also been initiated.

4 Alternative Analysis

4.1 Analysis of Zero Plan

The main benefits of Han River Yakou Navigation Complex Project include:

• Transportation: Yakou Complex will effectively synergize with the upstream Cuijiaying Navigation and Hydropower Complex. The 52.67km waterway between the two Projects will be improved from the current Class IV to Class III, reducing the pressure on road traffic, with environmental benefits gained by reducing energy consumption and automobile emissions.

• Clean energy: The project will supply 2.52×108 kWh of additional electrical power each year to the Xiangyang region, mitigating the region's power shortage, and reducing the needs for coal power.

• Irrigation: The reservoir's permanent water level increase will enable the gravity irrigation of 80,000mu of farmlands on the two banks, belonging to Liushui Town, Zhengji Town, Yancheng, Nanying and others. It will also increase the irrigation probability of the planned Changshan Pump Station, to be built by Xiangyang Municipality on the left bank of the reservoir, which will draw its supply from Yingshan Mouth and irrigate 300,500mu of land. This will reduce the cost of water scheduling.

• Tourism: Based on past experience from the Cuijiaying Project, the completion of this Complex will widen the reservoir waterway to 2 to 5km, forming a water surface 12,700ha in area. This will provide ample opportunity for tourism development, and improve the city image and investment environment of Yicheng Municipality.

• Reduction of glasshouse gases and air pollutants: The net glasshouse gas emissions from the Yakou reservoir will be negligible. According to early design analysis, after the Complex Project starts operation, the power plant will have an annual output of 2.52×108 kWh, which is the equivalent of 101,850 tons of standard high-quality coal, or 142,440 ton raw coal. Data has raw coals' emission factors of SO2 and dusts at 39.2kg/t and 141.75kg/t. This means the Project's operation can be equalized to a reduction of 5,584t SO2 or 20,080t dusts per year, which is a significant reduction of emissions.

Additionally, the increase of water area size from the reservoir will lead to an increase in local air humidity, improving the climate of the assessed area, and benefit the agriculture of the region.

Without the Project, the following measures will need to be taken for transportation, power supply and irrigation to achieve the same goals set out by the plan for the Han River high-class waterway:

• Transportation: Without the Yakou Complex, dredging will be needed for the Cuijiaying-Yakou section to meet the 500t-class waterway standard. Meeting the planned 1000t-class waterway standard will involve large-scale dredging for the section and its five river flat groups, creating significant environmental impact.

• Power: Outsourced power supply was needed to mitigate the urban power shortage. Constructing a new coal power plant has been considered as an alternative to the Project's hydropower, and its costs can be compared to the Yakou Hydropower Plant. Accounting for differences between coal and hydropower in maintenance time and power plants' own consumption, we assume the capacity ratio between hydro and coal power to be 1.1, and

the conversion coefficient between the coal and hydro plants to be 1.05, and estimate the annual cost at about RMB 58.15 million Yuan.

• Irrigation: The Project's reservoir can serve as a source of irrigation water, increasing the region's probability of irrigation, saving costs of water scheduling, and contributing to local agricultural development. To meet the region's irrigation needs during dry season without the Project, the water supply facilities will need to be renovated, and considerable amounts of water pipe networks be built, adding to the operating costs. The alternative irrigation plan is estimated to have an annual cost at about RMB 15 million Yuan.

In conclusion, the Xiangyang section of Han River is highly unlikely to satisfy the needs for transportation, power and irrigation without the Yakou Navigation Complex Project. The Project will have significant benefits to the region's domestic economies, agriculture and tourism, as well as reduction of glasshouse gases and air pollutants. If the Project's impacts on the environment and water quality can be sufficiently understood, with effective mitigation and compensation measures formulated and implemented, the Project should lead to a maximization of the region's overall benefits.

4.2 Comparison of Engineering Options

4.2.1 Selection of dam sites

a) Dam sites

The Yakou Navigation Complex is the 6th complex among the planned 8 complexes for the Han River mainstream in Hubei Province. Based on the Level 6 section's morphology, the dam may be located in the following sections: **Upstream to Hongshantou**, **Hanshantou to Yicheng Bridge**, **Yicheng Bridge to Guanzhuang**, **Guanzhuang to Yakou**, and **Downstream of Yakou**, as seen in Fig. 4-1.

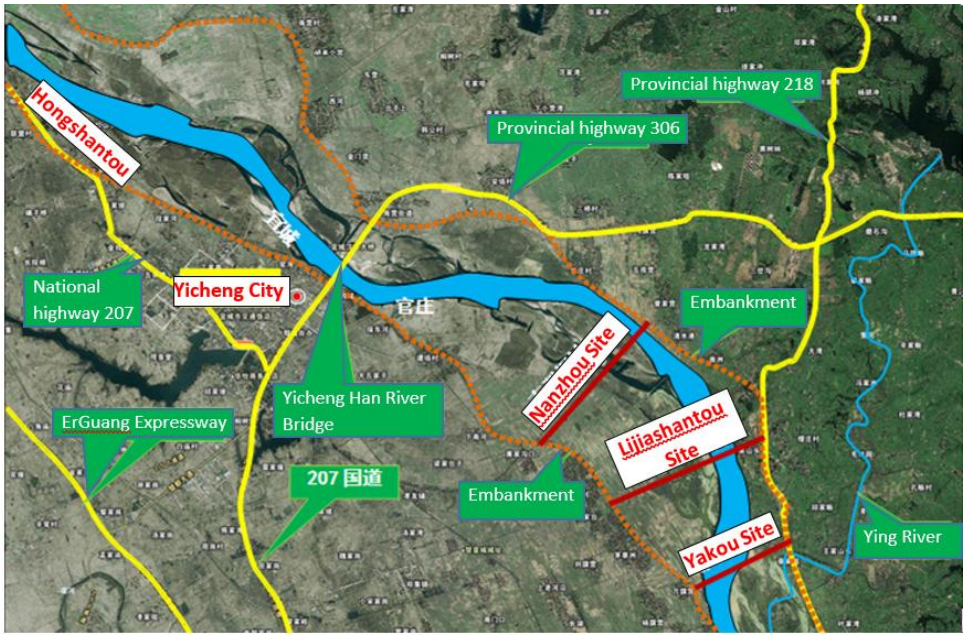


Fig. 4-1 River sections and dam site options

Downstream of Yakou: Ying River, a branch on the left bank lacks systematic embankment protection. The area is low in altitude with numerous settlements, meaning

many residents in a wide area will be affected by flooding. The further downstream, the river surface becomes wider, which will lengthen the dam axis, increasing both the construction work and flooding losses. Additionally, the closer to the downstream Nianpanshan Project, its backwater effect will be stronger, and the dam's water head will be lower, reducing the effectiveness of the hydropower plant.

Upstream to Hongshantou: Placing the site ~30km downstream from Cuijiaba will result in low flooding losses. However, this creates a disconnect of about 8km between the Class III waterways of Yakou and Nianpanshan Projects, both making hydropower less effective, and providing less improvement to the environment of Yicheng City.

Hongshantou to Yicheng Bridge: Placing the site ~40km downstream from Cuijiaba, the flooding losses will be low, but the hydropower efficiency and environmental improvement to Yicheng will both be lessened. Yicheng City also has the long-term plan to build a second bridge over Han River about 3km upstream from the existing Han River Bridge, meaning the dam site will be located between two bridges, less than 1.5km away from either, which significantly affects the safety of ships.

Yicheng Bridge to Guanzhuang: Placing the site ~45km downstream from Cuijiaba will result in low flooding losses, high environmental improvement for Yicheng City, and somewhat low hydropower efficiency. However, the river bed of the section is S-shaped, with about 4km of surface, a main runway moving from the right bank to the left, and the actual ship route in the middle. The reservoir waterway will have difficulties connecting directly to the natural waterways up and downstream, and will require significantly more excavation work. The reduced flooding losses do not constitute a cost advantage by comparison.

Both the Nanzhou and Yakou sites can meet the requirements for the waterway. For the Lijiashantou site, its downstream route will be located on a different bank from the S-shaped main runway, and the route in its exit and connecting sections will obliquely pass through the Complex's discharge area. This will increase the difficulty of ship navigation in the flow from open sluice gates (Q>2300m3/s). The Yakou site has the comparatively best waterway conditions. For the purpose of flood discharge, the Nanzhou site has the longest dam axis, the most severe side contraction before the dam, and the highest maximum damming height, followed by Lijiashantou, with Yakou at the lowest.

Based on the factors, with priority given to waterway conditions, the Yakou site was chosen as the recommended site.

c) Dam site comparison

Table 5-1 shows a detailed comparison between the sites in terms of geology, waterway, flooding, engineering, economy, environment and other factors.

Table 4-1 Dam site comparison chart

Item	Yakou	Lijiashantou	Nanzhou	Remark
Main works comparison				
Geo-morphology	Flat, wide basin; dam axis 2282m. Left bank: bedrock slope. Right bank: embankment. Sand delta in the middle. Main runway on the left side, width 550m~580m,	Flat, wide basin; dam axis 3240m. Left bank: bedrock slope. Right bank: embankment. Main runway on the left side, width 570m~620m, depth 4.5m~7.1m	Flat, wide basin; dam axis 3734m. Embankments on both banks. Runway has two branches; main runway on the left side, width 380m~420m,	All suitable for low-water head dam sites.

Item	Yakou	Lijiashantou	Nanzhou	Remark
	general depth 4.0m~6.0m.		depth 3.6m~5.8m.	
Rock bodies	Total overburden 13.5~25.3m. Fine siltstone 2.0~10.6m. Gravel stone 11.0~16.0m. Bedrock interbed and lenticle well developed.	Total overburden 10.5~20.3m. Fine siltstone 2.9~9.9m. Gravel stone 5.7~15.6m. Bedrock interbed and lenticle slightly developed.	Total overburden 10.7~17.5m. Fine siltstone 0.7~9.9m. Gravel stone 0~11.7m. Bedrock clay rock has stable distribution, with occasional marlstone and fine siltstone interbeds.	No significant differences in rock body strengths. Main geotechnical problems are similar.
Hydro-geology	Very weak corrosiveness in surface and ground waters. A few boreholes reveal the presence of confined waters in bedrocks, which are deep enough to pose no clear threat to buildings and foundations. The fine siltstones and gravel stones have high water permeability, and low permissive seepage gradients. Clay rock, fine siltstone, and medium to coarse siltstone have water permeability less than 10Lu. Gravel stone and fine siltstone with weak cementation have water permeability slightly above 10Lu. Loose gravel stone usually has water permeability above 20Lu.		Similar to Yakou, except no confined water was found.	Similar conditions.
Complex layout	Dam axis 3172m. Right bank ship lock + plant + left abutment 44 sluice gates.	Dam axis 3220m. Left bank ship lock + left abutment 34 sluice gates + plant + right abutment 14 sluice gates.	Dam axis 3734m. Left bank ship lock + left abutment 34 sluice gates + right abutment 14 sluice gates.	Similar layouts. The Nanzhou site requires the most excavation.
Flood discharge	Scattered sluice gates. Side contraction of flow before dam. Test model dam maximum damming height 0.28m.	Scattered sluice gates. Severe side contraction of flow before dam. Test model dam maximum damming height 0.38m.	Scattered sluice gates. Severe side contraction of flow before dam. Theoretically calculated dam maximum damming height 0.42m.	The Yakou site has slightly preferable conditions.
Waterway	Ship lock on the main runway. Upstream waterway connecting smoothly with the main runway after local dredging work. Downstream waterway connecting smoothly. Easy entry and exit of ships at each water discharge level.	Ship lock on the main runway. Upstream waterway connecting smoothly with the main runway, allowing easy entry and exit of ships at each water discharge level. Downstream route on a different bank from the S-shaped main runway; the route in its exit and connecting sections will obliquely pass through the Complex's discharge area. Ship navigation more difficult in the flow from open sluice gates (Q>2300m3/s).	Ship lock on the main runway. Upstream and downstream waterways connecting smoothly with the main runway. Easy entry and exit of ships at each water discharge level.	The Nanzhou and Yakou sites both meet the conditions. Yakou is preferable.

Table 4-1 (continued)

Item	Yakou	Lijiashantou	Nanzhou	Remark
Reservoir flooding	Flooded bank land: 30476.03 mu. Demolished houses: 36429.48m^2.	Flooded bank land: 28419.73 mu. Demolished houses: 36429.48m^2.	Flooded bank land: 25908.83 mu. Demolished houses: 36429.48m^2.	No significant difference in affected properties

	Relocated residents 152.	Relocated residents 152.	Relocated residents 152.	and residents.
Power generation	Capacity 75MW. Average per year: 3.22 / 2.52×10^8 kWh (Nianpanshan 49.22m / Nianpanshan 50.72m)	Capacity 72.6MW. Average per year: 3.19 / 2.50×10^8kWh (Nianpanshan 49.22m / Nianpanshan 50.72m)	Capacity 70.8MW. Average per year: 3.14 / 2.48×10^8kWh (Nianpanshan 49.22m / Nianpanshan 50.72m)	Advantage to Yakou.
Engineering & schedule	Three phases. During construction, passage is ensured by narrowed riverbed and ship locks. Total length 49 months.	Three phases. During construction, passage is ensured by large open channel and ship locks. Total length 58 months.	Three phases. During construction, passage is ensured by large open channel and ship locks. Total length 58 months.	Advantage to Yakou.
Expenditure	Static total investment: RMB 3,303,423,300 Yuan. Per kW: RMB 44641 Yuan.	Static total investment: RMB 3,278,073,300 Yuan. Per kW: RMB 46092 Yuan.	Static total investment: RMB 3,331,493,300 Yuan. Per kW: RMB 47593 Yuan.	
Comparison on environmental and social factors				
Water environment	Dredging needed before the Complex's downstream waterway can connect with Nianpanshan reservoir's dead pool level	Only small amounts of dredging needed before the Complex's downstream waterway can connect with Nianpanshan reservoir's dead pool level	Only small amounts of dredging needed before the Complex's downstream waterway can connect with Nianpanshan reservoir's dead pool level	Similar impacts from dredging
	Concrete: 803,900 m^3	Concrete: 809,300 m^3	Concrete: 810,900 m^3	More concrete needed by Nanzhou site, generating more wastewater.
	Both of Yicheng City's wastewater outlets, Laojianggou and Yidaodagou are below the dam, and will not be affected by Project. The source of the Yicheng water facility is in the reservoir area. The slower water flow and weaker self-cleaning capabilities of the reservoir will increase the water quality risk.			Similar between the site options.
Water environment	Scattered sluice gates. Side contraction of flow before dam. Maximum damming height 0.28m. Good for flood discharge, slightly lower risks for water pollution during high flow periods.	Scattered sluice gates. Severe contraction of flow before dam. Maximum damming height 0.38m. Higher risks for water pollution during high flow periods.	Scattered sluice gates. Severe contraction of flow before dam. Maximum damming height 0.42m. Higher risks for water pollution during high flow periods.	Advantage to Yakou.
Air & sound environment	Wide banks. Few settlements. Good for construction.	Dense settlements. More impacts on residents.	Dense settlements. More impacts on residents.	Advantage to Yakou.
Land ecology	Flooded bank land: 74512 mu. Demolished houses: 81332.4m^2. Relocated residents 1378. More flooded land areas and impacts to land surface.	Flooded bank land: 69769mu. Demolished houses: 81332.4m^2. Relocated residents 1378. More flooded land areas and impacts to land surface.	Flooded bank land: 66170mu. Demolished houses: 81332.4m^2. Relocated residents 1378. Less flooded land areas and impacts to land surface.	Advantage to Nanzhou.
Water and soil	Excavation: 10,250,000 m^3	Excavation: 10,780,000 m^3	Excavation: 12,850,000 m^3	Advantage to Yakou.

retention	Smaller area of disturbance, less occupation of vegetation, less soil losses.	Larger area of disturbance, more occupation of vegetation, more soil losses.	Larger area of disturbance, more occupation of vegetation, more soil losses.	
Water ecology	The investigated fish with pelagic eggs all have spawning grounds below from the dam. The Guanjiashan and Dengjiatai spawning grounds are 13.5km and 61.8km from Yakou Complex, and the spawning behaviors of major fish species will be obstructed.			Similar impacts on fish.
Waterway risks	Straight ship lock section with good line of sight. Lower risks.	Twisting ship lock section with bad line of sight. Higher risks.	Twisting ship lock section with bad line of sight. Higher risks.	Major advantage to Yakou.
Scenery	The sites are all downstream from Yicheng. The urban area is in the reservoir area, and can benefit from the improvement of the Project.			Similar impacts.
Conclusion	The Yakou site has more advantages overall.			

4.2.2 Selection of normal water levels

a) Normal water level

Comparison was made during the feasibility study stage between 54.72m, 55.22m and 55.72m as Yakou Plant's normal water level. The following conclusions were reached based on the main project:

Transportation: Each option can ensure good connection with the upstream Cuijiaying level. A higher water level would be better for the water passage, thus the 55.22m and 55.72m options are preferable.

Power generation: Increasing the normal water level will increase the power efficiency of Yakou Plant and the power generation of all the complexes, but the return is diminishing. This means an appropriately high water level is preferable, and the 54.72m option less so.

Flooding and submerging: A higher water level means more river bank farmlands will be submerged, and the stronger long-term impacts will increase the reservoir's engineering costs such as embankment and seepage prevention. No substantial differences exist in terms of population resettlement between the options.

Engineering investment: A higher water level will increase the costs related to reservoir flooding and protective engineering, while reducing the cost of per KWh generated, and any additional power generation costs will be negligible. The higher water levels are preferable.

Other areas: All options do not affect the Han River Bridge passage or flood control at Cuijiaying. Since all options need the reservoir embankment to be reinforced by the same flood prevention standards, they do not differ much in terms of reservoir safety. However, from the perspective of urban flood prevention, 55.22m is the preferable water level for Yakou Complex, which will ensure the water level at Yicheng to not surpass the current warning water level of 55.47m. The recommended normal water level for Yakou Complex is 55.22m.

Table 4-2 shows a comparison between the normal water level options.

Table 4-2 Normal water level options comparison

Factor	Item	Unit	Normal water level option		
			54.72m	55.22m	55.72 m
Hydro-logical para-	Water level increase before dam	m	7.04	7.54	8.04

Factor	Item	Unit	Normal water level option		
			54.72m	55.22m	55.72 m
meters	Mainstream backwater length	m	51.46	52.67	53.65
	Capacity at normal water level	10^8 m^3	2.717	3.097	3.097
	Flexible capacity	10^8 m^3	0.378	0.415	0.440
Water tempe-rature	α value (α-β) method		127.7	112.0	112.0
Water quality	Branch stream backwater		No significant difference.		
	Overall		No significant difference.		
Fish populations			Same flooding impact on the section's spawning grounds.		
Human health			No significant difference.		
Reservoir flooding and resettle-ment	Flooded land	mu	67166	74598	83280
	Of which: basic farmland	mu	3975	4054	4232
	Range of submersion	km^2	95	116.5	127
	Population with livelihood impact	person	18201	18333	18465
	Resettled population	person	1378	1378	1378
	Main rebuilding projects		No significant difference.		
	Cultural relics		No difference.		
	Environmentally sensitive areas		Reservoir flooding will always affect protected drinking water sources. No significant difference.		
Engi-neering work	Excavation	10^4 m^3	1032	1025	1022
	Concrete	10^4 m^3	81.91	80.39	79.80

NOTE: Data from "Feasibility Study Report of Han River Yakou Navigation Complex Project".

It can be seen that the normal water level options do not differ significantly in categories such as hydrology, water temperature, water quality, flooding, resettlement and fish impacts. A lower water level will have weaker environmental and social impacts. However, since the Project does not affect sensitive receptors such as natural preserves, important cultural heritage sites or protected drinking water sources, the differences in environmental impacts are not notable, and will not be the limiting factor in determining the normal water level.

Therefore, considering the need to reduce flooding and expenditure, 55.22m is a reasonable recommendation that satisfies the demands of the waterway and power generation.

4.2.3 Selecting complex layout configurations

During the early design, engineers had considered the issue of whether the ship lock should be separated or connected to the power plant facility. Three configuration options were considered for the current stage: Option 1 (right ship lock + sluice gates + plant + sluice gates), Option 2 (right plant + sluice gates + left ship lock), and Option 3 (right ship lock + plant + sluice gates).

The three options share common features including placing the main structures along

the dam axis, utilizing the road bridge to connect the traffic between the dam top and the two banks, and using open channels. They differ in the placements of the plant facility, sluice gates and the ship lock. Table 4-3 shows a comparison of the options.

Table 4-3 Comparison of complex layout configuration options

Item	Configuration		
	Option 1	Option 2	Option 3
Layout	Right bank ship lock + right abutment 36 sluice gates + left bank plant + left abutment 12 sluice gates	Right bank plant + 48 sluice gates + left bank ship lock	Right bank ship lock + middle plant + left bank 48 sluice gates
Waterway	The ship lock is located in the deep runway of right bank river bed. The upstream route can be smoothly connected to the main route after local dredging. The central line of the downstream route is parallel to the main route, ensuring connection. Low risks for collision, etc.	The ship lock is located on the river flat of right bank, and must be built after dredging. The downstream route must connect the main route through the S-twist. The route passes obliquely through the flood discharge area. High risks for collisions, etc.	The ship lock is located in the deep runway of right bank river bed. The power plant is close to sluice gates. Its inlet and outlet water will both disturb the waterway flow.
Flood discharge	Scattered sluice gates fit the river's natural discharge conditions, and cause less changes.	Concentrated sluice gates over a long span, severe side contraction of flow before dam. Negative impact on fish reproduction during discharge periods.	Same as Option 2
Operation	Power plant near left bank river flat. Power transmission lines must pass over the ship lock and sluice gates. Poor water outlet and inlet flows for plant. Fish pass unattractive for fish.	Power plant in the left bank main runway. Easy to place power transmission lines. Good water outlet and inlet flows for plant. Fish pass attractive for fish.	Power plant in the left bank main runway. Power transmission lines must go over the ship lock. Good water outlet and inlet flows for plant. Fish pass attractive for fish.
Construction	Three phases. Phase 1: using the original riverbed for discharge and passage. Phase 2: excavating an open channel for discharge and passage. Phase 3: ship lock for passage, 36 sluice gates for discharge. Cement mixing systems required on both banks. Power generation project period 46 months.	Three phases. Phase 1: using the original riverbed for discharge and passage. Phase 2: using narrowed riverbed after dredging. Phase 3: ship lock for passage, 24 sluice gates for discharge. Cement mixing systems required on both banks. Power generation project period 54 months.	Three phases. Phase 1: using the original riverbed for discharge and passage. Phase 2: excavating an open channel for discharge and passage. Phase 3: ship lock for passage, 48 sluice gates for discharge. Power generation project period 48 months. Ship lock is close to plant facilities, potentially disturbance to each other during construction.
Geology	The locations of dam axes have simple, consistent geological conditions, only different in geomorphology and overburden thickness. No limiting factors on dam construction exist. However, issues exist including the weak bedrock strength, non-uniform settlement, and impact of confined waters on foundations.		

Overall, each option has its advantages in conditions of waterway, operation, flood discharge, engineering, and geology. They are similar in engineering work required and

environmental impacts. We agree with the recommended Option 1 (right ship lock + sluice gates + plant + sluice gates) which offers better waterway conditions. Additionally, two auxiliary anchorages will be constructed for the Project, located respectively 1.7km up and downstream from the ship lock. They will not affect sources of drinking water and livelihood water. The anchorage services will be provided by procured barges, which reduces disturbance on the riverbed, and minimizes environmental impact.

4.2.4 Selecting fish pass facilities

a) Fish pass

Hydrological projects are more likely to affect the upstream movement of fishes. For this project, facilities will be used to preserve the fishes' upstream passages. What follows is an overview of common upstream fish pass facilities.

(1) Fishway: they have a long history, with over 100 fishways built in 19th century France. A fishway works by dividing the height of the dam into multiple smaller levels, as a series of small ponds. The ponds are partitioned by walls with openings for fish to pass through. Their structures can dissipate the energy of water, slowing down the water flow. Fishways can be categorized by partition types, such as Daniel, overflow weirs, and vertical slits partitions.

(2) Artificial (close-to-natural passages): These are manmade streams on the bank, using gravel beds to reduce the water flow energy. They require small gradients and large spaces, and are generally used on projects with small height differences between up and downstream.

(3) Fish elevator: Consisting of entrance, shaft and exit, fish elevators are similar to other elevators. The downstream fish is lured into the entrance, and driven into the shaft. The shaft is then filled with water until the water rises to the upstream, and the fish is raised by the elevator floor grid. Fish elevators do not require much space while allow for a large height increase, and are often used on projects with high water heads.

(4) Fish lock: These are similar to ship locks, using two gates to lift the water level. Its operation begins by fully opening the downstream gate and slightly opening the upstream gate, creating a flow that attracts fish into the lock. The lock is then closed to lift and release the fish to the upstream. They require less effort from the fish, and are suitable for fish with weak swimming abilities.

(5) Fish collecting and transporting facility: These work by luring downstream fish into a ship or container. The ship or container is then moved by the ship lock or automobile to the upstream. This method is suitable for dams with high water heads, and often used as a temporary measure before the fish pass facilities are completed. Its downside is fish is more likely to be injured during transportation.

A variety of fish pass facilities have been designed for different projects. Table 4-4 shows a comparison.

Table 4-4 Comparison of fish pass facilities

Option	Pros	Cons	Mainly used in
Fishway	✓ Good energy dissipation ✓ Stable structure	× Manmade structure × Difficult to renovate	Projects with medium to low water heads

Option	Pros	Cons	Mainly used in
	✓ Small space ✓ Continuous passage		
Close-to-natural passage	✓ Easier for fish to adapt to ✓ Continuous passage ✓ Easy to renovate	× Inefficient energy dissipation × Unstable structure × Difficult to adapt to water level changes × Large space	Projects with low water heads
Fish elevator	✓ Small space ✓ Suitable for high water head projects	× Difficult to collect fish × Complicated operation × High operation cost	Projects with medium to high water heads
Fish lock	✓ Small space ✓ Suitable for high water head projects	× Difficult to collect fish × Complicated operation × High operation cost	Projects with medium to high water heads
Fish collecting & transporting	✓ Flexible ✓ Suitable for high water head projects	× Complicated operation × High operation cost	Projects with medium to high water heads Complementary to other fish pass facilities

Since the Complex Project only has a maximum water head around 10m, belonging to the low range, the fish elevator, fish lock and collecting options are not suitable, due to issues including non-continuous passage, instability, difficulty in operation, and high costs.

Fishways and close-to-natural passages can provide the water flow parameters needed by fish, and are both feasible for this Project. They are both possible options for the Complex.

b) Comparison of fish pass options

1) Site location

Based on the project's layout, four options, shown in Fig. 5-2 were suggested for the location of the fish pass or close-to-natural passage: between the power plant and the left sluice gates; between the plant and right sluice gates; between right sluice gates and the ship lock; and on the right bank.

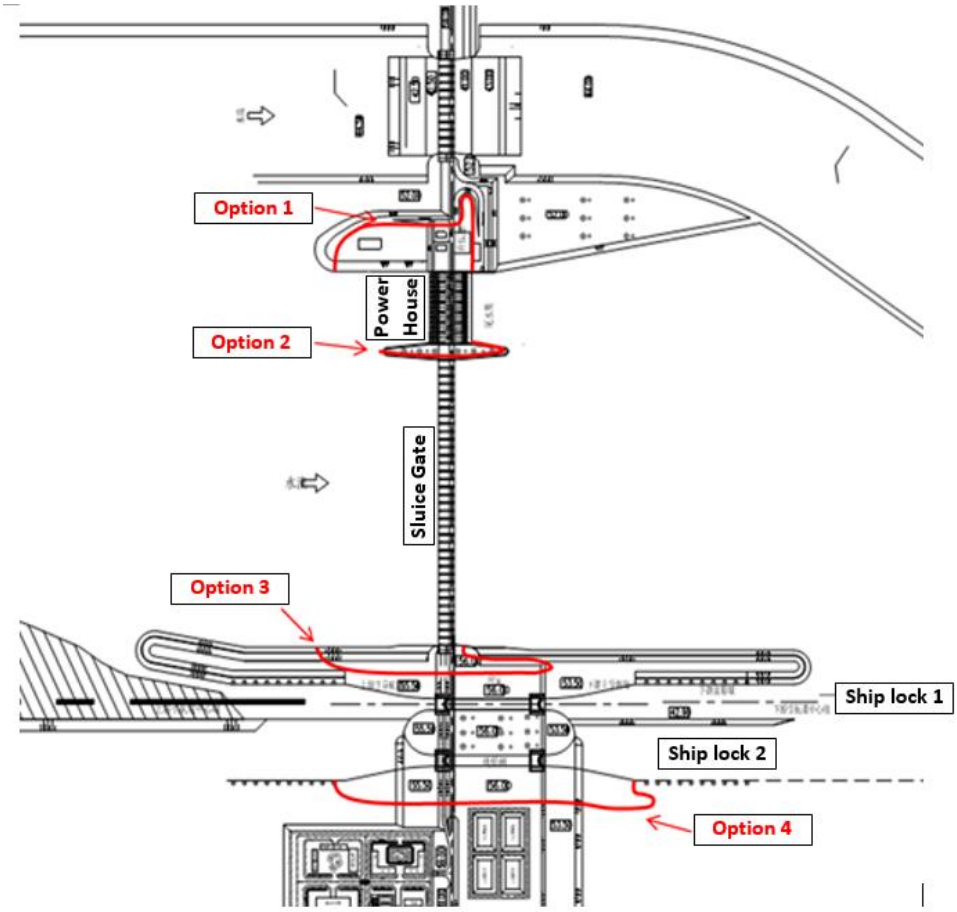


Fig. 4-2 Fish pass facility sites

The option 1 is notable for having frequent discharge flows, making it more attractive to fishes. Moreover, placing the passage entrance on the delta makes it easier to discover for fishes moving upstream along the bank. Therefore Option 1 (between the power plant and left sluice gates) was recommended. Table 4-5 shows a comparison between options.

Table 4-5 Comparison of fish pass options

Option		Pros and Cons
1	Between power house and left sluice gates	✓ Close to the plant, frequent discharge flows, attractive to fish; ✓ Delta close to bank, easier for fish to approach.
2	Between power house and right sluice gates	✓ Close to the plant, frequent discharge flows, attractive to fish; × Limited space; × Too close to river center, more difficult for fish to approach.
3	Between right sluice gates and ship lock	× Unattractive to fish without discharge flow; × Far from bank, difficult for fish to approach.
4	Right bank	✓ Close to bank, easier for fish to approach. × Unattractive to fish without discharge flow.

2) The detailed plan

A close-to-natural passage will be built on the delta. Its entrance will be located on the bank in the front area of left bank facilities. It will bypass the front area, make a turn under the dam, and then move upward into the upstream river. After the completion and

damming of the downstream Nianpanshan Project, the downstream water level at Yakou Complex will stabilize, and become suitable for the close-to-natural passage. Since the water level will be high variable prior to Nianpanshan's completion, it has been suggested to add a fishway to the close-to-natural passage to address this short term need.

3) Facility types

Each option has pros and cons. The following is a comprehensive comparison between a traditional fishway, close-to-natural passage, and the additional close-to-natural fishway options in terms of attractiveness to fish, passage capacity, fish adaptability, and construction and maintenance costs.

All three options can be attractive to fish with well-placed entrances and water flow. Due to the high variance of downstream water level, the close-to-natural passage will generally be 1.0m~2.0m deep, with 1:2 side slopes and a trapezoid section. When the water depth varies, the water flow will vary in a nonlinear fashion, making this passage less adaptable to the changes, and more prone to variable water flow conditions. The close-to-natural passage will require multiple entrances for the different downstream water levels. Switching frequently between these entrances, and the changing conditions may affect the movement of fish. Therefore the water level variance may greatly affect the passage's efficiency.

For the passage capacity, flow conditions and riverbeds similar to natural streams may give advantages to the close-to-natural passage. However, the low gradient, and long and wide passage of the close-to-natural passage involves higher excavation costs. Its gravel bed is easy to be moved by water flow, affecting its performance, and calls for more maintenance work.

By comparison, the close-to-natural fishway combines the advantages of the other two options. It provides close-to-natural and diverse conditions suitable for multiple species, and can adapt to water level changes. The current suggestion is to use the close-to-natural fishway.

4.3 Comparison of construction planning and scheduling

4.3.1 Selecting raw material sites

a) Sand and gravel

The Project needs about 2,199,000 ton of total finished sand and gravel materials. Comparison was made between excavating natural sand and gravel, and grinding procured Dimension stones. Calculation gives the results as: Option 1: using natural sand and gravel, with unit prices at RMB 78.20 Yuan/m3 for sand, RMB 76.85 Yuan/m3 for gravel; Option 2: grinding Dimension stones into sand and gravel, with unit prices at RMB 100.40 Yuan/m3 for sand, RMB 81.07 Yuan/m3 for gravel. The lower cost of Option 1 suggests all raw materials should be excavated from sand and gravel quarries.

Comparison was made between the Longmentan and Yicheng Daqiao quarries. Both sites have enough material quantity and quality for the Project. While the Longmentan Quarry is farther away from the site, its parameters are better than Yicheng Daqiao Quarry, such as gravel grade and silt content. It also has less unusable matter, while Yicheng Daqiao Quarry was covered by a 5m-thick layer of silt. Therefore Longmentan Quarry is the current choice for the natural sand and gravel source. It is an existing quarry located on

the Longmentan flat 37km upstream from the dam site, which is a delta on the Han River mainstream with height between 55~56m. It is connected to the road network, ensuring the convenience of transportation. The quarry is an alluvial deposit of riverbed materials, covered by a fine sand overburden 0~1.2m thick. It does not affect environmentally sensitive areas such as important fish habitats, and is 17km away from the protected water source of Yicheng's water facility, while Yicheng Bridge Quarry is closer to these sensitive areas. All these factors make Longmentan preferable.

b) Dimension stone

The Project will need about 583,600m³ of Dimension stone materials, with 132,100m³ for the left bank, 451,500m³ for the right bank, primarily for backfilling, gabions and Renault pads (for protecting river banks), bottom protection for cofferdams, and cofferdam construction.

Based on site surveys, the Dimension stone materials will be procured from external sources, which have ample local supplies in the form of Matoushan Quarry on the left bank, and Jinniushan Quarry on the right bank, preventing any environmental impact from excavating new quarries. Both are properly registered commercial quarries with sufficient quantity and quality for the Project, and connected to the dam site by roads.

It is the responsibility of the project owner to communicate with the supplier about the importance of environmental impact from the excavation of sand, gravel and stone materials, and minimize environmental damage to vegetation and wildlife. Based on the principle that "the perpetrator of environmental damage should be responsible for their restoration", the suppliers must shoulder the responsibility for protecting the environment and soil resources of their quarries. When signing the procurement contract, the project owner must make this fact clear to the suppliers. The external procurement of materials will mitigate environmental impacts from mining new quarries, such as vegetation damage, water and soil losses, farmland occupation and resettlement.

c) Earth borrow areas

The Project's diversion component needs a total of 150,500m³ in clay, consisting of 69,300 m³ for the left bank cofferdam's seepage protection, and 81,200m³ for the right bank. A total of 191,200m3 will be excavated, with the plan to excavate 103,200m3 from the right bank's Luojiazhuang borrow area, and 88,000m3 from the left bank's Yakou borrow area. The former is a Class I terrace alluvial deposit near Luojiazhuang Village, with height between 53~56m, connected to the dam site by road over a 1km distance. The latter is located at Yujiawan, Yakou Village Liushui Town, which is 2km from the dam site, connected by well-maintained rural roads. Both borrow sites ensure easy transportation of materials.

The borrow sites have sufficient quantity and quality for the Project, and are not located near landslide hazards. Cultivation can be restored at the end of their temporary occupation, which conforms to the technical standards on water and soil preservation. It will be necessary to provide the borrow areas with additional drainage systems and protective measures to reduce soil losses. Investigation shows that the quarries have little surface vegetation other than some cultivated land, and the excavation will have little impact on biodiversity. However, the Yakou borrow area is only 80m away from the nearest settlement, making it necessary to keep the excavation to designated areas, and minimize impact on residents.

Overall, the choices for material sites appear to be environmentally sound. It is suggested that more detailed geological surveys be conducted in the next design phase, in order to optimize the utilization of borrow sites, maximize the use of the Project's own excavation, and reduce wastes.

4.3.2 Selecting disposal sites

The main sources of wastes from the Complex Project zone are the excavation of the open channel, the sluice gates, the removal of cofferdams, and plant construction. According to construction procedure, the waste dump sites will be the river flat on both banks near the Project zone, so that excavated wastes can be directly transported to the dump sites, without temporary stockpiling or overwater transportation. The goal will be to balance the excavation and backfilling through proper scheduling, minimizing wastes and the need for land occupation by waste dumps. The planned two dump sites will shorten the distance of transportation, reducing noise and dust pollution, and contribute to soil preservation.

The left bank dump site is located on a Class I terrace upstream from the dam axis. The original terrace has a height between 44.0~53.0m, which will be increased to 59.0m with the wastes, occupying a land area of 15.66ha. 1,335,000m³ (bank volume; similarly hereinafter) of wastes will be piled, to an average pile height of 8.9m. The pile will be flat on top, and have a side slope of 1∶3. The right bank site is located on a Class I terrace near the damp site, original height between 47.0~53.0m, which will be increased to 57.0m with the pile. In total, 2,791,200m3 of wastes will be dumped. With the added material to raise the dump site elevation, the final stockpile will total 3,381,200m3. After Project completion, the cultivation or vegetation of dump sites will be restored.

The Project's waste dump sites are flats located upstream outside embankments, and will be flooded as part of the reservoir area. The sites are currently cultivated lands and woods utilized by local farmers. The wastes will raise the height of what have been river flats, and reduce the submerged areas. The raised lands will be cultivatable afterwards. As a run-of-river plant, the reservoir capacity taken up by the upstream dump sites will have little effect on the Project's performance. Measures including obstruction of free water loss, proper drainage, and restoration of cultivated lands and vegetation will conform to technical requirements on water and soil preservation. The plan still needs additional details on measures against surface soil losses for areas that are not cultivated lands or woods, as well as protective measures for temporarily stockpiled surface soils. Some areas of dump sites can be used for construction tasks, reducing land occupation by the Project.

The dump sites are locations with good conditions, low slope gradients, at low risks of geological disasters. With proper planning and protection, their utilization will minimize environmental damage. Therefore the choices of the dump sites are environmentally sound.

4.4 Resettlement plan

It is necessary to minimize impacts on the affected populations' way of life and social relationships, and cause no increase to their farming radiuses. According to the resettlement plan, residents of all affected villages will be relocated as near as possible and within the corresponding administrative areas, in order to preserve their way of life, customs and social relationships. Cultivation and domestication will remain the main livelihood of resettled rural residents. Agriculture will be supported by improving local farmland infrastructure and agricultural portfolio.

The current resettlement plan has given sufficient consideration to local resources and environmental conditions. It has provided a unified plan for the resettlement areas' infrastructure, which will improve the residents' housing, roads and access to water resources. Follow-up support has also been included to improve the residents' quality of life and production capabilities, and ensure sustainable development. If these measures can be implemented, the plan should satisfy the environmental requirements, but more work is needed on controlling the environmental impacts of the construction, as well as protective measures such as controlling water and soil losses, and future management of wastewater and domestic wastes.

5 Ecological Impacts and Mitigation Measures

In conducting the supplemental ESIA, the following aspects were examined and strengthened,

- Examined the study scope of terrestrial ecology and introduced the concept of riparian areas that is more relevant to the project; project impacs on birds were further analyzed;
- Further anaysis of the project impacts on the proposed Wanyangzhou wetland park from compliance, technical and ecosystem restoration perspective. In conducting the supplemental ESIA, the wetland park management authority reached an agreement with the Yakou project proponent and prepared a detailed planning for the wetland park;
- On aquatic ecosystem, consolidated the aquatic habitat and fish protection plans;
- A consolidated ecosystem restoration plan thus is developed and included in the project ESMP.

5.1 Terrestrial/Riparian Ecology

Terrestrial ecology, per doemestic EIA technical guidelines, covers various non-aquatic habiats including riparian areas, wetland, and upland; wildlife inhabiting or using the habitats; and ecological function areas such as a forest park and wetland park. It should be noted that in the domestic regulatory context, ‘wetland’ includes permanent waterbody. Therefore, a wetland park is often a combination of vast waters and nearby riparian areas.

The original EIA set scope of terrestrial ecological impact assessment as the following: the river section from dam site of Cuijiaying dam/reservoir to the place 5km downstream of Yakou Navigation Complex, extending 2km at both sides or extending to the first watershed (when the distance from first watershed is shorter than 2km). The total area is about 211.07km2.

Impacts on the terrestrial/riparian ecosystem are summarized in below,

- The project construction area covers a total area of 377.08 hm², accounting for 0.25% of the total assessment area. The lands occupied include farmland, forest land, land for water area and water conservancy facilities and other lands, of which forest land and farmland predominate. The permanently and temporarily occupied forest lands are few. The plant species are mainly artificial forest, secondary shrub and bushes. Therefore, the impact on the vegetation of the area is slight. Figure 5-1 shows the vegetation coverage in the assessment area.
- Reservoir formation will result in inundated area of 78.68 km², and the newly inundated area is mainly covered by arable crops, followed by poplar-occupied woodland, as well as grass land with vegetation such as paper mulberry, hemarthria compressa and horseweed. The plants affected by the inundation are local species widely distributed around the reservoir area. Therefore, there is no possibility that the inundation will cause the

disappearance or obliteration of plant population. *During conducting the supplementary ESIA, we rechecked the occupied land in the construction area and the reservoir area. The land occupied by project construction, reservoir inundation area and types of occupied land haven't changed significantly in the preliminary design stage.*

- There is no national-level key protected wild plant in the assessment area, so the terrestrial ecological impact is slight. There is only one "Famous and Old Tree" of *Pistacia chinensis*, located in Luojiahe and situated 500m from the reservoir flooded line, so it will not be affected by the project.

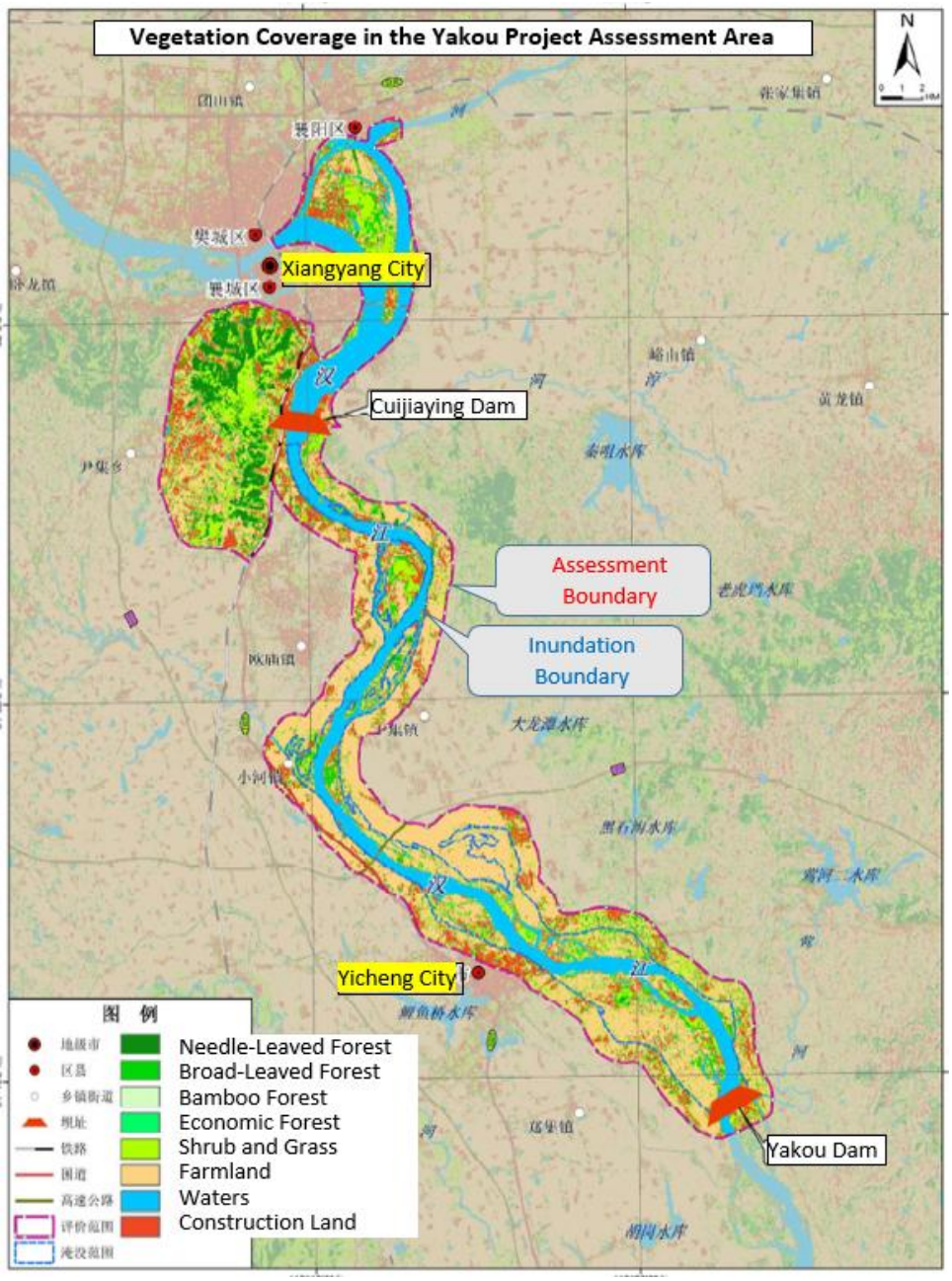


Figure 5-1 Vegetation Coverage in the Yakou Project Assessment Area

- In terms of wildlife, no Level I national key protected wildlife has been found, while three Level II national key protected wildlife have been found: Common Buzzard (*Buteo buteo),* Black-eared Kite *(Milvus migrans)* and Common

Krestrel *(falco tinnunculus)*. The three species are all birds of prey (See Table 5-1). They inhabit mountanous and hilly area and generally fly over woodland and the open ground near woodland. The habitat of these species won't been inundated or occupied by the project. Only human activities and the noise produced by construction may affect these species as the areas where they fly and look for food are disrupted. In conclusion, the project has a small impact on the species.

- There are 26 kinds of Hubei provincial key protected wildlife in the assessment area. Among them, 5 species are amphibians, including *bufo gargarizans, pelophylax nigromaculata, fejervarya multistriata, microhylaonata and pelophylax hubeiensis*, which live in land near water or still and slack water; 2 species are reptiles, including *elaphe taeniura and zoacys dhumnades*, which belong to arboreal and bywater animals, and mainly live in the woodland near water and bush fallow; 1 species is beast, namely *meles meles*, which mainly live in plain and wilderness, bush and embankment. Since the project area and reservoir just narrow the animal habitats of the above amphibians, reptiles and beast a little, and their suitable habitats are widely distributed, therefore there's little impact on them.

- The 18 bird species reported include waterfowls (i.e. wading birds and swiming birds), forest birds and land birds, in addtion to the 3 raptors at Level II national protection. Table 5-1 shows the type, habitats and migratory features of the birds. A majority of those birds are forest or land birds that often inhibit forest, mountains, hills, and open areas that are far away from the project-affected area. Swiming birds prefer lake, reservoir and ponds. Of concern is wading birds and other species that inhibit riparian wetland, swamp, rivershore; they are more susceptible to the loss of river flats and wetland resulting from reservoir formation. Only one wading bird was found in the project assessment area, namely Little Egret. Considering the widespread wetlands in the middle and lower Han Rier, such birds will find alternative habitat. On construction impact side, those birds are good at flying, and are able to avoid construction interference, the construction will have little impact on birds.

Table 5-1 Birds in the Project Assessment Area

English/Latin Name	Chinese Name	Type	Habitats	Migratory/ Residential
3 National Level II Protected Wildlife				
Common Buzzard (*Buteo buteo)*	普通鵟	Raptor	Woodland and shrubs	Winter migratory
Black-eared Kite *(Milvus migrans)*	黑(耳)鸢	Raptor	Moutainous and hilly area	Residential
Common Krestrel *(falco tinnunculus).*	红隼	Raptor	Farmland, grassland and open area	Residential
18 Hubei Provnical Protected Wildlife				
Great Crested Grebe (*podiceps cristatus)*	凤头䴙䴘	Swiming bird	Lake, reservoir	Residential
Little Egret *(egretta garzetta)*	白鹭	Wading bird	Mudflat, lakeshore meadows	Summer migratory
Mallard *(anas platyrhynchos)*	绿头鸭	Swiming bird	Lake, reservoir	Summer and winter migratory

Common Pheasant *(phasianus colchicus)*	环颈雉（雉鸡）	Land bird	Farmland, grassland and open area	Residential
Common Tern (*Sterna hirundo*)	普通燕鸥	Shorebird	Waters, swamp, rivershore	Summer migratory
Spotted Dove *(streptopelia chinensis)*	珠颈斑鸠	Land/forest bird	Moutainous and hilly area; woodland and shrubs; Farmland, grassland and open area	Residential
Eurasian Cuckoo *(cuculus canorus)*	大杜鹃	Forest bird	Woodland and shrubs	Summer migratory
Eurasian Hoopoe *(upupa epops)*	戴胜	Forest bird	Farmland, grassland and open area	Residential
Barn Swallow *(hirundo rustica)*	家燕	Land bird	Near villages	Summer migratory
Red-rumped Swallow *(hirundo daurica)*	金腰燕	Land bird	Near villages	Summer Migratory
Brown Shrike (*lanius cristatus)*	红尾伯劳	Forest bird	Woodland and shrubs	Summer migratory
Long-tailed Shrike *(lanius schach)*	棕背伯劳	Forest bird	Woodland and shrubs	Residential
Black-naped Oriole *(oriolus chinensis)*	黑枕黄鹂	Forest bird	Woodland and shrubs; near villages	Summer migratory
Black Drongo *(dicrurus macrocercus)*	黑卷尾	Land bird	Farmland, grassland and open area; near villages	Summer migratory
Crested Myna *(acridotheres cristatellus)*	八哥	Forest bird	Farmland, grassland and open area	Residential
Azure-winged Magpie *(cyanopi cacyanus)*	灰喜鹊	Forest bird	Woodland and shrubs	Residential
Black-billed Magpie *(pica pica)*	喜鹊	Forest bird	Woodland and shrubs	Residential
Eurasian Blackbird *(eurasian thrush)*	乌鶇	Forest bird	Farmland, grassland and open area; Woodland and shrubs	Residential

- Covered by the assessment area there is a Yanshan Forest Park covered in the project EIA scope includes: southern section of the Ring Road on the North, the old National Highway 207 on the East, the new National Highway 207 on the West and South, covering an area of 68 km2. Yakou reservoir's inundation area does not involve the forest park, but the minimum distance of the flooded line from forest park border is 270m, so this sensitive area will not be affected.
- Two wetland parks were included in the original EIA's terrestiral ecology assesmsent. It should be noted that in the domestic regulatory context, 'wetland' includes permanent waterbody. Therefore, a wetland park is often a combination of vast waters and nearby riparian areas. Impacts assessment on wetland parks in presented in the next section. The distribution map of ecologically sensitive area is shown in Figure 5-2.

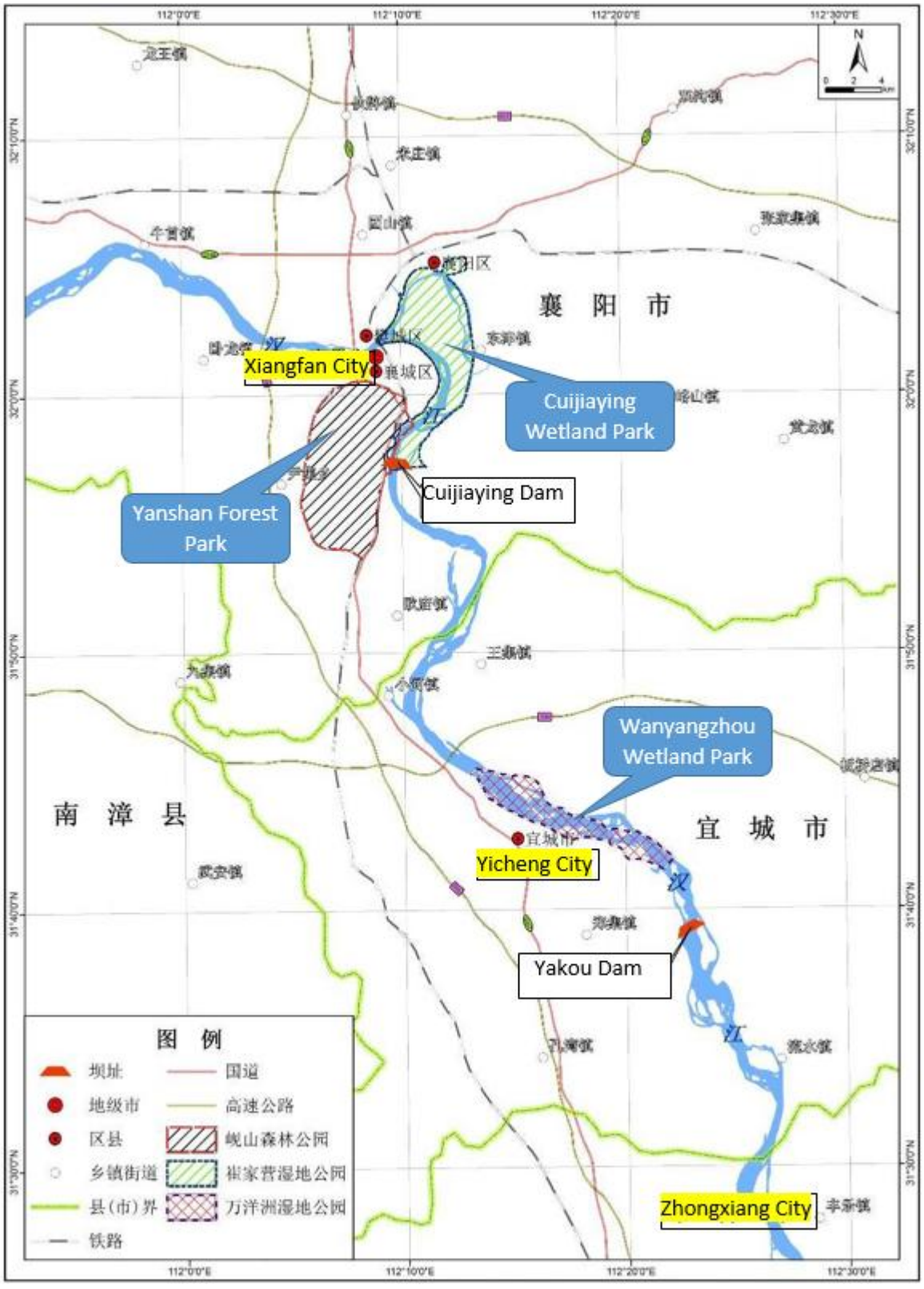


Figure 5-2 Distribution Of Ecologically Sensitive Areas in the Vicinity of the Yakou Project

5.2 Wanyangzhou Wetland Park

Two wetland parks are located in the vicinity of the Yakou project, namely the proposed Wanyangzhou National Wetland Park in Yicheng City and Cuijiaying Provincial

Wetland Park in Xiangyang City.

The Cuijiaying wetland park was authorized through the approval of the Forestry Department of Hubei Province (ELHH [2010] No. 547) on December 29, 2010. The main part of the Cuijiying wetland is the reservoir area formed after the construction of Cuijiaying Navigation Complex, which is located between Cuijiaying Dam in Xiangyang and First Han River Bridge at middle and lower reaches of Han River, and the total area is 3428 hm2. After the Yakou project is constructed, the area from the backwater end of the reservoir to Cuijiaying Navigation Complex only involves the dam sightsee zone of Cuijiaying Wetland Park (300m below the dam). There's no significant change in water level of this place. Therefore, the project will almost have no impact on the ecological functions of the Cuijiaying Wetland Park. The Wanyangzhou wetland park is discussed in this section.

5.2.1 Background and Compliance Analysis

On December 31, 2013, State Forestry Administration approved the establishment of "*Yicheng Wanyangzhou National Wetland Park in Yicheng (Pilot)*" under Reply (Forestry Wetland Development [2013] No. 243) and agreed to "*carry out the pilot work*".

The reasons of establishing the wetland park was stated in the wetland park master plan (prepared in 2013): *"… in view of the historical context that unregulated sand mining, grazing, land reclaimation for farming and aquaculture in the river stream and river flats became more and more severe; natural river flow in the river segement disturbed; water quality deteriorated; and wetland system integrity damaged. The construction objective of the wetland park rests with effective recovery and protection of Han Rier wetland ecosystem and to provide an ideal place to Yicheng residents for ecotourism, recreation and vacation*." Nonetheless, the wetland park development plan has not been implemented, except some landscaping and embankment rehabilitation works in the urban center of Yicheng City.

By denition of domestic regulations, a wetland park builds on its good ecosystem and diverse wetland landscape resources, with the main objectives of scientific education, making use of wetland functions and promoting wetland culture, to build certain tourism and recreational facility for sightseeing and entertainment. Hence a wetland park does not fall in the category of important wetland stanard. The Han River section where Wangyangzhou wetland park is located has not been included in the *Wetland Protection Action Plan for China* and *Important Wetland Inventory of China.* It is not included in the *Internationally Important Wetland Inventory* in line with international wetland convention either. Therefore, a wetland park is not considered a legally protected area per domestic regulation.

Per procedureal regulatory requirements, during the development of Yakou project EIA, the Yakou project proponent consulted with responsible authorites (Yicheng Municipal Government Forestry Bureau and Hubei Provincial Forestry Department). The two authorities provided written clearance to the Yakou project in March and May 2015 respectively.

5.2.2 Current Situations

Wanyangzhou wetland park uses the Han River mainstemYicheng section as the main body, situated on the north of Yicheng. It is mainly comprised of the river section of Han River flowing from northwest to southeast, with the geographic coordinates of

N31°41′28″-31°45′32″ and E112°13′07″-112°22′08″, covering a total area of 2466.03hm2, among which wetland area is 1714.81 ha with a wetland rate of 69.53%. Wetland types include permanent riverine wetland and flood plain wetland. The pemanent riverine wetland with an area of 1147.06 hm2 rerfers to the Han River mainstem; the flood plain wetland, with an area of 567.75 ha, consists of river flats on both sides of the Han River riverway and some sandbank. Figure 5-3 shows the current situation of the wetland park.

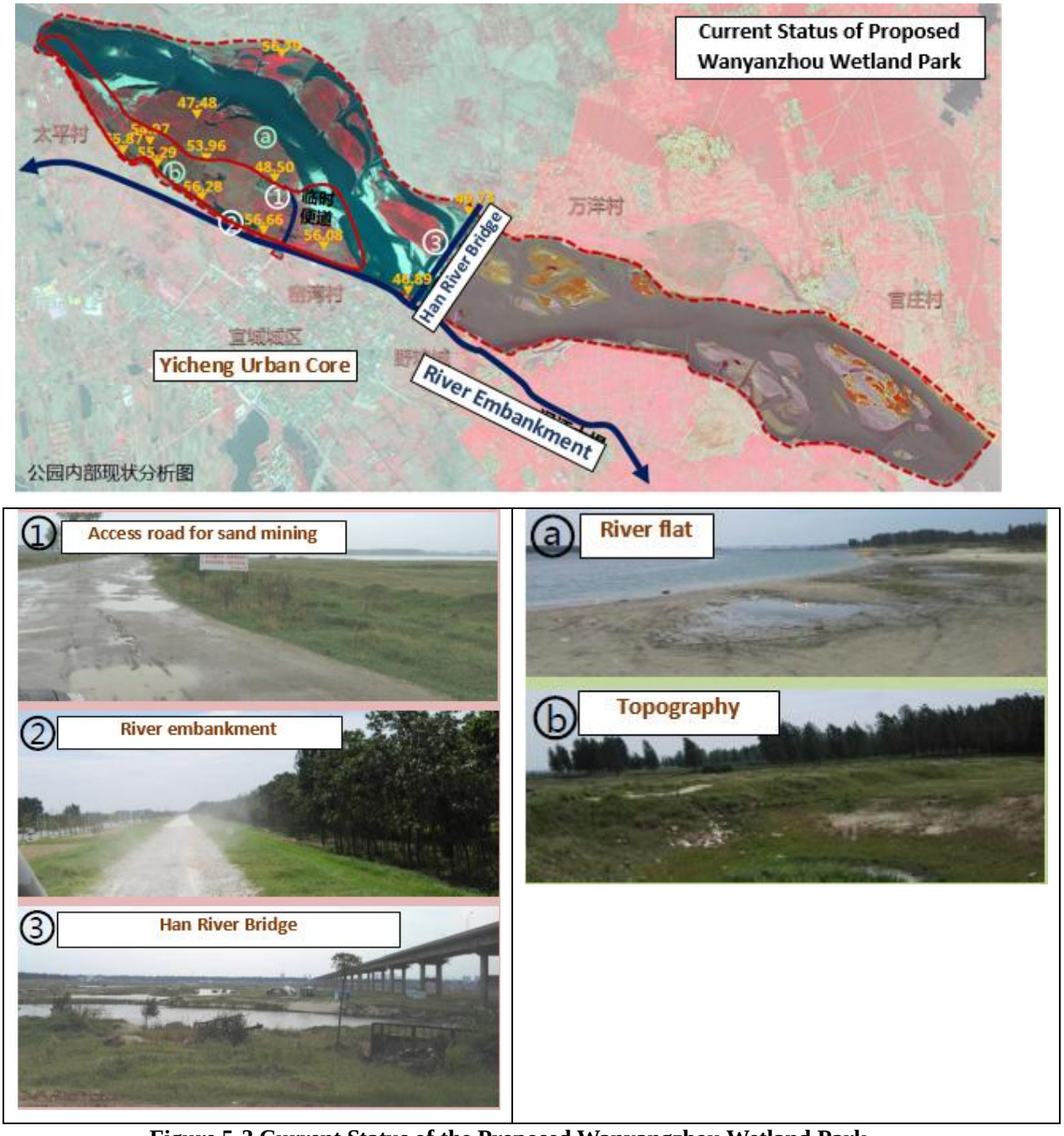


Figure 5-3 Current Status of the Proposed Wanyangzhou Wetland Park

The soils in the propsed wetland park is dominated by wet soils; paddy soils is prevalent near rivershore; sandy soils exist as well. Due to in-stream sand mining actities, currently there is an access road inside the park; a Han River #1 bridge crosses the proposed wetland park in the middle. Though earlier wetland development proposal

indicates the wetland park area is abundant in diversity, the flora suvey (see Figure 5-1) shows farmland, construction land and shrubs are dominant along the south bank of park area where it is close to the Yicheng urban core, and the roughly the same situation on the north bank where relatively more shrubs land and woodland are seen. A Wanyangzhou National Wetland Park Local Resource Survey Report states that flora species found in the wetland park area are common species that are widely distributed downstream and upstream of the wetland park. Field survey also suggests that the wetland park area, particularly the south bank has been highly modifield with intensive human activities. Overall, the wetland park area doesn't show distinctive significace compared to other river sections.

5.2.3 Impacts on the wetland park

The proposed wetland park is about 16 km along the length of Han Rier mainstem. The center of the park is about 15 km upstream of Yakou dam; its lowest end is about 4.5 km upstream of the dam. Construction of the dam is not expected to have impacts on the wetland park.

After impoundment of the forthcoming Yakou reservoir, Han River Yicheng segement will have a normal water level of 55.22m and highest water level of 56.22m. In the wetland park area, water level will rise meters in average. Though the area suffered from water level dropdown in the past decades that has affected the wetland functions, the forthcoming water level rise will inundate current woodland, grass land and river flats to a large extent. The flora species in the wetland area are common speices; inundation won't lead to extinction of rare speices. Increased water level, reduced flow velocity and river shores inundation will have impacts on water quality and wetland functions. After impoundment, the wooldland, shrubs will be gradually replaced by emergent and submerged aquatic plants. Shoals and farmland will be inundated as well.

Overall the riparian wetland biomass will reduce and habitat for wildlife, e.g. wading birds will dwindle. However, new shall-water swamp and riparian wetland will come into being and the wading birds will find alternative similar habitats nearby. The impacts are manageable. Expansion of water surface will be favorable for swimming birds.

On positive side, it is noted that the major ecological threats in the wetland park area is the dropdown of water level; river flats and shoals have been occupied by production activities; human disturbance is very intensive. Human acitivies have caused the shrinking of bird habitats. The Yakou project impoundment will inundate vegation, meanwhile it will turn the occupied riparian area such as farmland to river and return habitats to waterfowls.

Researches have reported that since the upstream Wangfuzhou reservoir was put into operation in 2000, enhanced management led to reduced human disturbance. Water release caused flooding process fostered new wetland habitats. Several birds under national level protection inhibit in the reservoir and downstream areas, such as swan, black stork, black kite and common kestrel.

5.2.4 Detailed Planning for Wanyangzhou Wetland Park

An optimal mitigation strategy to manage the impacts on the wetland park resulting from reservoir impoundment would be a well-conceived plan to fully take into account the impacts and incorporate ecosystem restoration efforts into the plan. During preparation of the supplemental ESIA, the Yakou project proponent agreed with the wetland park management committee to develop a detailed planning. Hubei Provincial Forestry Survey

and Design Institute was commissioned to prepare a Yicheng *Wangyangzhou National Wetland Park Core Area Constructive Detailed Planning*. According to the detailed planning, the zoning of the core zone of the wetland park is shown in **Figure 5-4**. The general layout of the wetland park is shown in Figure 5-5. It has significant sections of riparian areas restoration and restricting development acitivities, in addition to a science eduction zone and a reasonable utilization and management zone. The Yicheng Municipal Government approved the detailed planning on October 26, 2016, and requested the municipal forestry bureau to implement the plan as soon as possible.

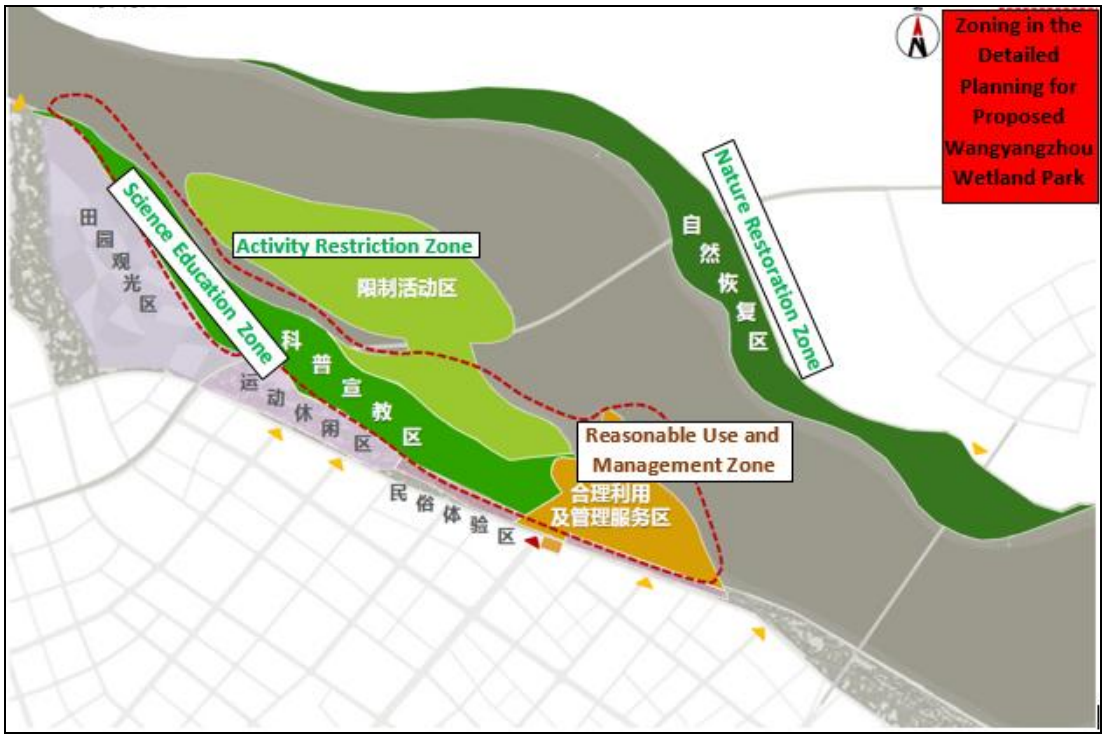


Figure 5-4 Zoning of Wangyangzhou Wetland Park Detailed Planning (2016)

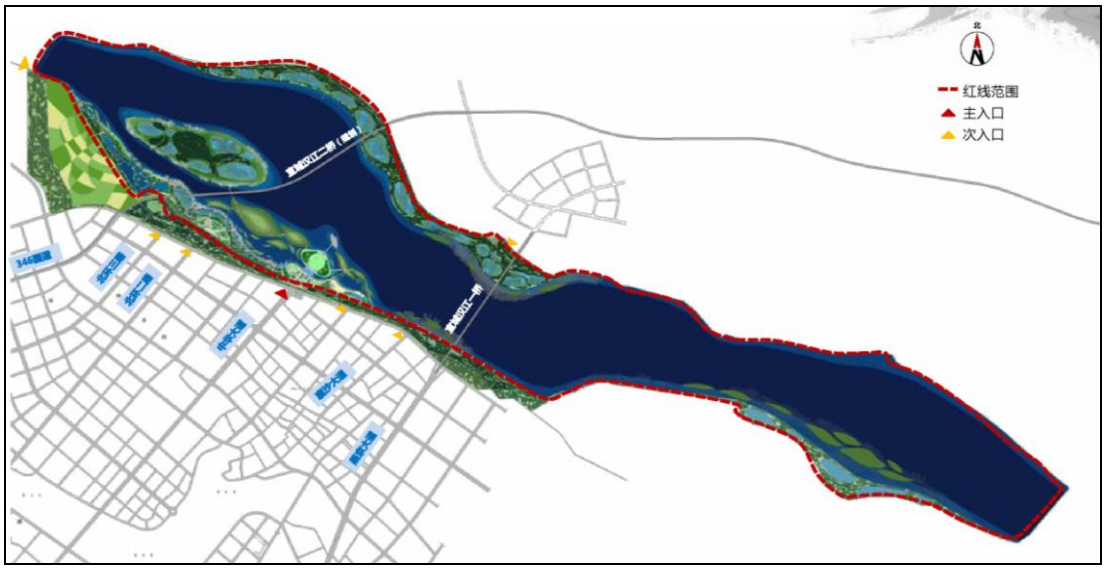


Figure 5-5 General layout of Proposed Wangyangzhou Wetland Park

The implementation of the wetland park plan will improve the management of the

wetland area through clearly defined functional zoninig, restrictions on detrimental development activities such as sand mining, and putting in place day-to-day oversight. The detailed planning of the wetland park includes a set of conservation measures including restoration of aquatic and riparian ecosystem, directives on shoreline use, planning for flora and other programs for associated facilities. Overall, the ecological and public benefits of the wetland park implementation will apparently outweigh the negative impacts. The wetland park planning should be funded and implemented in a timely manner.

5.3 Aquatic Ecology

The scope of aquatic ecological impact assessment is from Cuijiaying dam site to the Han River mainstream reach at 10km downstream from Yakou dam site, with a length of 62.67km. There are only two storm drains regulated by sluices between Cuijiaying dam and Yakou dam. Tributaries Ying River and Man River join the Han Rier about 10km downstram. The two tributaries are covered in the assessment scope as they are to be considered for habitat restoration.

In addition, the Han River section starting at 31.4km downstream of Yakou dam with a length about 108km is the national aquatic germplasm resources conservation zone for *elopichthys bambus, ochetobius elongates* and *luciobrama microcephalus* in Zhongxiang section of Han River. The core area of the conservation zone is taken into consideration in the early fish resources survey and impact assessment in the project EIA. And the conclusion is that the construction and operation of the Yakou complex project barely has any impact on the fishery conservation zone. There's further assessment on the impact of construction of navigation complexes along Han River on the national aquatic germplasm resources conservation zone for *elopichthys bambus, ochetobius elongates and luciobrama microcephalus* in the cumulative effects assessment.

According to the original EIA report, after the construction and operation of the Yakou complex, the change of water regime will change the composition of fish species in Yakou reservoir area from "fluvial facies" to "lake facies". Fishes which are adapted to slow or still water environment will become the dominant species, due to the slowed flow velocity and increased food organisms. On the other hand, the fishes which are adapted to the rapid habitat will gradually shift to the tail of the reservoir and the downstream area of Cuijiaying Dam, due to changes in feeding and reproduction conditions. Therefore, their number will decrease.

EIA particularly concerns about the impact and measures on fish produces pelagic eggs and its spawning ground after the construction of the Yakou reservoir area. The spawning and hatching of fish produces pelagic eggs require certain flow velocity. During the spawning process, the water level rises and the flow velocity increases, then the fish spawns under the stimulation of running water; and fish eggs can only be hatched into fish with certain flow velocity and process. In Yakou reservoir area, there used to be Yicheng spawning ground which was suitable for the production of fish with pelagic eggs, but it's not found in ecological survey in 2014; now there are Guanjiashan spawning ground and Zhongxiang spawning ground (Dengjiatai spawning ground) which produce fish with pelagic eggs at the Complex downstream river section. After the construction of Yakou Complex, the daily discharge volume does not change since Yakou reservoir is daily regulated reservoir. Therefore, Yakou Complex will not have significant negative impact on Guanjiashan and Zhongxiang spawning grounds at the downstream. In addition, in

order to meet navigation requirements, the minimum discharge volume of Yakou Complex is set as 450m3/s, and the minimum ecological water discharge of Yakou Dam Site calculated by Tennant is 110m3/s (If the ecology is well maintained, then the water discharge will be 220 m3/s), which can completely meet the ecological water needs of downstream water course.

The specific impact assessment and mitigation measures for the aquatic ecology due to construction and operation of Yakou Complex are described as follows. In order to maximize the protection and restoration of fish resources and habitat at the middle and lower reaches of Han River, Yicheng spawning ground as well as a series of fish resources protection and habitat protection and compensation measures are considered in the impact assessment and mitigation measures.

5.2.1 Aquatic ecology impact assessment

5.2.1.1 Impact on fishes

a) Barrier impact on fish resources

The last navigation complex in the construction of navigation complexes along Han River is Xinglong Complex, which is completed and put into operation in 2014; Danjiangkou and Wangfuzhou Hydro Complex and Cuijiaying Navigation and Hydropower Complex have been built in upper reaches of Han River. A number of hydropower stations have been built in most tributaries at middle and lower reaches of Han River. Nianpanshan Navigation and Hydropower Complex and Xinji Complex are planned to be completed and put into operation around 2020. Among these complexes built and planned to be built, the fifth complexes below Xinji (included) are equipped with fish passes like fishway. In recent years, migratory fish such as anguilla japonica is rarely found in the middle and lower reaches of Han River. The barrier impact of dam construction in Han River mainstream and tributaries on fish exists.

Yakou Complex’s potential barrier impact on fishes is reflected in the following aspects:

After the construction of Yakou Complex, river section and fish habitat in Han River mainstream below Cuijiaying will be further separated, which will obstruct the migration and gene exchange of fishes. Damage to continuity of river will strongly cut off activities of both migratory fishes and non-migratory fishes. River and ocean migratory fish like anguilla japonica spawns in the sea, and the juvenile fish can travel up the Yangtze River and grow in freshwater river; since there’s no dam below the Three Gorges, anguilla japonica can migrate into Han River, however, the construction of navigation complexes along Han River has barrier impact on the river and ocean migratory fish; river and lake migratory fishes such as four major Chinese carps, siniperca chuatsi, coilia macrognathos bleeker, squaliobarbus curriculus and takifugu obscurus are affected by the dam barrier, and are not able to complete living activities such as reproduction, feeding and overwintering, so their population will decrease significantly. Although fishway construction can effectively reduce the upstream migratory impact on fish, it can’t effectively reduce the downstream migratory impact on fish.

Analyzing from living habits of fishes, after the fishes in this water area are separated in the reservoir area, fishes spawning on plants can complete their living activities and form a certain group; but it’s difficult for the group of fishes spawning on gravels and fishes spawning floating eggs to survive. The related statement will be introduced in the

next section: impact of hydrological regime changes on fish resources.

b) Impact of hydrological regime changes on fish resources

After operation of Yakou Complex, the reservoir will operate at the normal pool level of 55.22m in low flow seasons. The water volume and area, level and depth increase, while the flow velocity decreases. The average flow velocity of water body in the reservoir area decreases from 0.8m/s to 0.11m/s. The average water depth increases from 0.98m in natural condition to 6.26m. The natural conditions of the original river change, the rapid river shrinks and the hydrodynamic process of the river will have certain changes. In particular, the water in front of the dam shows “hydrodynamic characteristics of lakes”. However, Yakou Complex is low-head hydropower station and water at the reservoir end is close to natural river, flow in areas from water in front of the dam to the middle of reservoir reduce slightly and water of these areas show hydrodynamic characteristics of river. When the flow at the dam site is larger than 8,710m3/s in flood season, sluice will be opened gradually and more water will be discharged to reduce water level of the reservoir until the normal water level is restored, which exerts limited impact on both the upstream and downstream hydrological regime.

The change of water regime will gradually change the composition of fish species in the reservoir area from "fluvial facies" to "lake facies". Analyzing from living habits of fishes, fishes spawning on plants are equipped with the conditions for spawning and breeding due to the stable water level, broad water surface, gentle river regime and abundant aquatic and hygrophilous vegetation. They can complete their living activities, form a certain group and even become dominant species, which include cyprinus carpio, carassius auratus, culter, xenocypris argentea gunther, silurus asotus, squalidus argentatus, opsariichthys bidens, siniperca scherzeri, pelteobagrus fulvidraco, pelteobagrus vachelli, bayesian, percocypris pingi, pseudorasbora parva, abbottina rivularis and rhinogobius giurinus. Since there are few spawning grounds for fishes spawning on gravels, and the spawning waters may further shrink after raising of water level, which will make it difficult for the fishes spawning on gravels to survive, such as xenocypris davidi bleeker, lepturichthys fimbriata, glyptothorax sinense, leiobagrus marginatus, etc. For fishes spawning floating eggs, such as four major Chinese carps, xenocypris argentea gunther, parabramis pekinensis, saurogobio dabryi, pseudolaubuca sinensis and brass gudgeonsince, since all spawning areas are inundated, there are no conditions for breeding in general. Only when the complex discharges water in flood season, and the river returns to the normal state, will there be satisfactory conditions for breeding of such fishes. However, there is little possibility for occurrence of open discharge flow upon operation of South-to-North Water Transfer Project, so it is also difficult for this species to survive.

Increase in water volume and area, expansion of habitat and activity space and improvement of biological productivity will lead to increase of total amount of fish resources and fish catches, such as cyprinus carpio, culter mongolicus basilewsky, culter alburnus, carassius auratus, silurus asotus, squalidus argentatus, opsariichthys bidens, siniperca scherzeri, pseudogobio vaillanti, zacco platypus, pelteobagrus fulvidraco, pelteobagrus vachelli, bayesian, percocypris pingi, pseudorasbora parva, abbottina rivularis and rhinogobius giurinus. Since backwater of the lower navigation complex reaches to the dam site, changes in discharge volume, flow velocity and water level will have limited impact scope and degree and thus limited effect on fishes.

c) Impact of water quality changes on fish resources

Water of the reservoir area flows slower, the sediment deposits, the transparency increases and the nutrient substance stagnates. According to water quality prediction, the overall water quality in the reservoir area will basically remain the same. After the reservoir is constructed, the concentration of each predictor becomes higher. The concentration of TN still exceeds the given standard, while the remaining indicators can meet the Category II standards stated in Environmental Quality Standard for Surface Water (GB3838-2002). Since the reservoir has poor regulation capacity, no obvious changes in nutritive salt of the reservoir area will occur. Biological productivity of water in the reservoir area will be improved in a limited way. Total fish types will always fluctuate.

Yakou Complex is a project with daily regulation and water temperature changes are not obvious, the possibility of gas super-saturation is extremely small and thus the impact on fishes under the dam is not obvious.

d) Impact of changes in biological base of food on fish resources

Since food resources for fishes change greatly after formation of the reservoir and transfer from nektonic organism, zoobenthos and periphytic algae to phytoplankton, the types of corresponding fish resources will also change. Fish loving flowing water environment will migrate towards the reaches above the reservoir end and the tributaries and even disappear from the reservoir area, while the fish living in slowly flowing and static water with phytoplankton as food will become the dominant species. The specific analysis is as follows:

Upon formation of the reservoir, nutrient substance stagnates here and biological productivity of the water is improved. These are good for breeding and growth of phytoplankton. Types and current quantity of phytoplankton will increase. This is good for growth of larval and young fish and fish living in subcritical flow or static water environment, such as cyprinus carpio, carassiusauratus, hypophthalmichthys molitrix and aristichthys nobilis. Amount of fish resources and fishery production will increase. However, without artificial release, it is impossible that quantity of fishes spawning floating eggs such as hypophthalmichthys molitrix and aristichthys nobilis will increase. The improvement in nutrient load of the water is good for breeding and growth of periphyton, zoobenthos and aquatic vascular plant. This further provides rich food for fishes like xenocypris argentea, onychostoma sima and rhinogobio typus. Types of zoobenthos living in flowing water will decrease while the types and quantity of tubificidae and chironomidae living in static water or slightly flowing water will increase. Mollusks living in static water or sand may also occur. This is good for growth and development of fish living at the bottom of static or slowly flowing water but the food resources for fishes living in flowing water will decrease significantly.

Yakou Complex generates power on the basis of base-load inflow. The current quantity of phytoplankton in downstream reaches of Yakou dam is basically the same as that in water in front of the dam. The dominant zoobenthos is flowing river sections under the dam is still the species living in flowing water and current quantity of periphyton will increase after improvement in transparency of the water. But there will still be zoobenthos and perphyton for fishes loving flowing water, indicating that the impact on fish resources is little.

5.2.1.2 Impact on fish under protection

There are no fish species under national level protection; there are 5 fish species under protection of Hubei provincial government. These fishes are:

- ***luciobrama microcephalus (***鲚***),***
- ***ochetobius elongates (***鳘***),***
- ***onychostoma macrolepis(***多鳞白甲鱼***),***
- ***gracilicaudatus (***细尾蛇鮈***), and***
- ***leiocassis longirostris (***长吻鮠***).***

None of the fish was found in the 2014 fish survey for the project EIA study.

Analysis of impact on these five provincially protected fish species is implemented according to their habits:

(1) ***Luciobrama microcephalus*** and ***ochetobius elongates*** are ferocious carnivorous fish and ***ochetobius elongates*** is mild carnivorous fish. Increase of water surface area and improvement of productivity of water due to construction of Yakou power station provide more food for these two fish species and may be good for their development. However, these two types of fish spawn floating eggs and there are no conditions for their spawning in most years. Currently, under the circumstance of severe depletion of luciobrama microcephalus and ochetobius elongates resources, it is hard for them to live in water of the reservoir area.

(2) ***Onychostoma macrolepis*** habitats at the bottom of water, spawns adhesive and demersal eggs and loves living in flowing water. Such species is mainly distributed in tributaries with crystal clear water. Main stream of Han River is not their main habitats and the environmental conditions after formation of the reservoir will still be unable to meet their demands for breeding and growth.

(3) ***Gracilicaudatus*** living at the bottom of water, loves slowly flowing water and spawns adhesive and demersal eggs. It mainly feeds on zoobenthos. After formation of the reservoir, deepening of the water in reservoir area is not good for inhabiting and feeding of gracilicaudatus. Shrinking of its habitats causes decrease of the quantity of such fish species.

(4) ***Leiocassis longirostris*** lives at the bottom of water, loves environment of flowing water and spawns floating eggs. After formation of the reservoir area, its habitats will further shrink and the quantity will further significantly decrease; such fish species will even disappear from the reservoir area.

5.2.1.3 Impact on spawning ground and larval resources of four major Chinese carps[1]

In accordance with investigation on spawning of fishes spawning floating eggs in middle reaches of Han River carried out by Institute of Hydroecology of the Ministry of Water Resources and Chinese Academy of Sciences in 2004, there are five major spawning grounds for four major Chinese carps. They are Miaotan, Yicheng, Guanjiashan, Zhongxiang and Maliang. There are three spawning grounds in Yakou assessment area. They are Yicheng, Guanjiashan and Zhongxiang spawning grounds. Among them, Yicheng spawning ground was not found in the investigation in 2014. See Figure 5- for the locations of spawning grounds for fish with floating eggs (represented by the four major Chinese carps).

[1] Four major Chinese cpars is terms as Four Doemsticated Fish in the CEA, namely black, grass, silver, and bighead carp, representative of fish species with floating eggs.

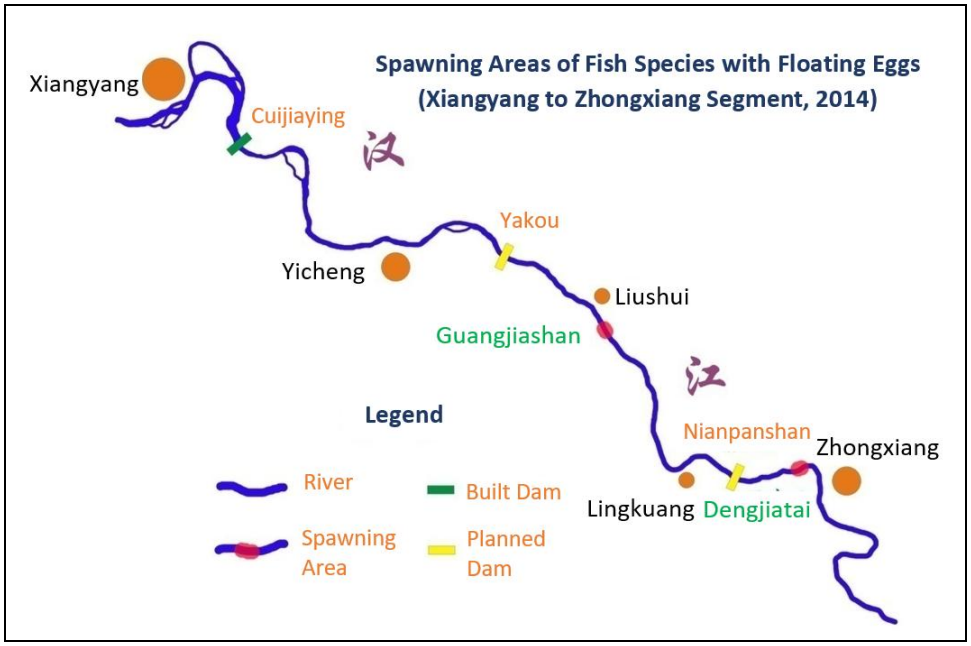


Figure 5-6 Spawning Grounds for Fish Species with Floating Eggs (2014 Results)

According to the investigation in 2014, no spawning grounds for four major Chinese carps were found in Yakou reservoir area, and Guanjiashan and Zhongxiang (Dengjiatai) spawning grounds were found in sections from Xinglong reservoir end to waters under Yakou dam. Since Yakou Complex does not have the regulation capacity, it usually will not exert obvious impact on the downstream spawning grounds. However, the reservoir can still flatten the flood peak to some degree, and the downstream flood peak will not be obvious under the circumstance of low-flow flood peak. For example, the maximum peak discharge at Huangzhuang gauging station in early September 2014 was 1,040m3/s, but flood peak was still formed under Cuijiaying dam after flattening of Cuijiaying reservoir; but the flood peak was hardly formed under Xinglong dam after flattening of Xinglong dam and the maximum flow was 400m3/s. Therefore, low-flow flood peak may be difficult to meet demands of the downstream spawning grounds for flood peak after double flattening of Cuijiaying and Yakou reservoir area. In recent years which are the consecutive low flow years, Danjiangkou reservoir operates at low water level and there was only one small flood peak in early September 2014. Meanwhile, Danjiangkou reservoir does not discharge water in this year due to water storage for South-to-North Water Transfer Project and flood peak in middle and lower reaches of Han River mainly comes from outflow of Bai River and the tributaries, then basically no flood peak is formed under Xinglong dam after double regulation of Cuijiaying and Xinglong reservoir when the flow is 1,040m3/s. Results of one monitoring on larval resources are unable to comprehensively reflect the breeding of fishes spawning floating eggs in middle and lower reaches of Han River. Therefore, investigation results of 2004 on the spawning ground are combined for the analysis.

According to the investigation in 2004, Yicheng spawning ground is located in Yakou reservoir area and extends from Xiaohe Town to Yicheng with length of 21km. Except that Yakou Complex reservoir area discharges water openly, Yicheng spawning ground will be entirely inundated after water storage of Yakou reservoir area due to connection of Yakou Complex reservoir area and Cuijiaying reservoir area. In accordance with preliminary scheduling plan of Yakou Complex, the plants will stop power generation

and water discharge will be increased when the flow is 8,710m3/s. But operation of South-to-North Water Transfer Project will remarkably reduce the chances for occurrence of flow of 8,710m3/s. As a matter of fact, the function of spawning grounds for fishes spawning floating eggs is basically lost.

Both Guanjiashan and Zhongxiang spawning grounds are located under the dam, about 13.5km and 61.8km away from Yakou Complex respectively. During spawning season, Yakou Complex basically does not regulate the runoff and the conditions of Guanjiashan and Zhongxiang spawning grounds will remain unchanged. But under the circumstance of low-flow flood peak, flattening of Yakou reservoir will make flood peak of the spawning ground be unobvious, thus affecting breeding of fishes.

5.2.1.4 Impact on national aquatic germplasm resources conservation zone for *elopichthys bambus, ochetobius elongates* and *luciobrama microcephalus* in Zhongxiang section in the lower reach of Han River

The national aquatic germplasm resources conservation zone for elopichthys bambus, ochetobius elongates and luciobrama microcephalus in Zhongxiang section of Han River is established in accordance with No. 1130 announcement of the Ministry of Agriculture of the People's Republic of China in October 2008 and is classified into second batch of national aquatic germplasm resources conservation zone on December 22, 2008. The conservation zone's total length is 108km. The core area extends from Zhongshan to Rentan river section with a total length of 43km. The experimental area is divided into two parts. The upper part extends from Jinhuatan to Zhongshan river section and the total length is 25km. The lower part extends from Rentan to Wanglong river section and the total length is 40km. The particular protection period of the core areas is from April 1 to June 30. Figure 5-7 shows the location of the fishery conservation zone.

Since Yakou Dam Site is far away from the national aquatic germplasm resources conservation zone in Zhongxiang section and is 31.4km away from boundary of the upper experimental area of the conservation zone, it will not exert direct impact on habitat and biological structure of the conservation zone and the main possible influential factor is changes of hydrological regime due to scheduling of Yakou Complex. Elopichthys bambus, ochetobius elongates and luciobrama microcephalus in the conservation zone spawn in the flood season. Since Yakou Complex only has daily regulation capacity, which has weak flattening and limited effect on flood peak, it will not affect the hydrological and hydraulic conditions necessary for spawning of these fishes in the conservation zone. In conclusion, the impact of construction and operation of Yakou Complex on structure and function of the national aquatic germplasm resources conservation zone for elopichthys bambus, ochetobius elongates and luciobrama microcephalus in Zhongxiang section of Han River is not obvious.

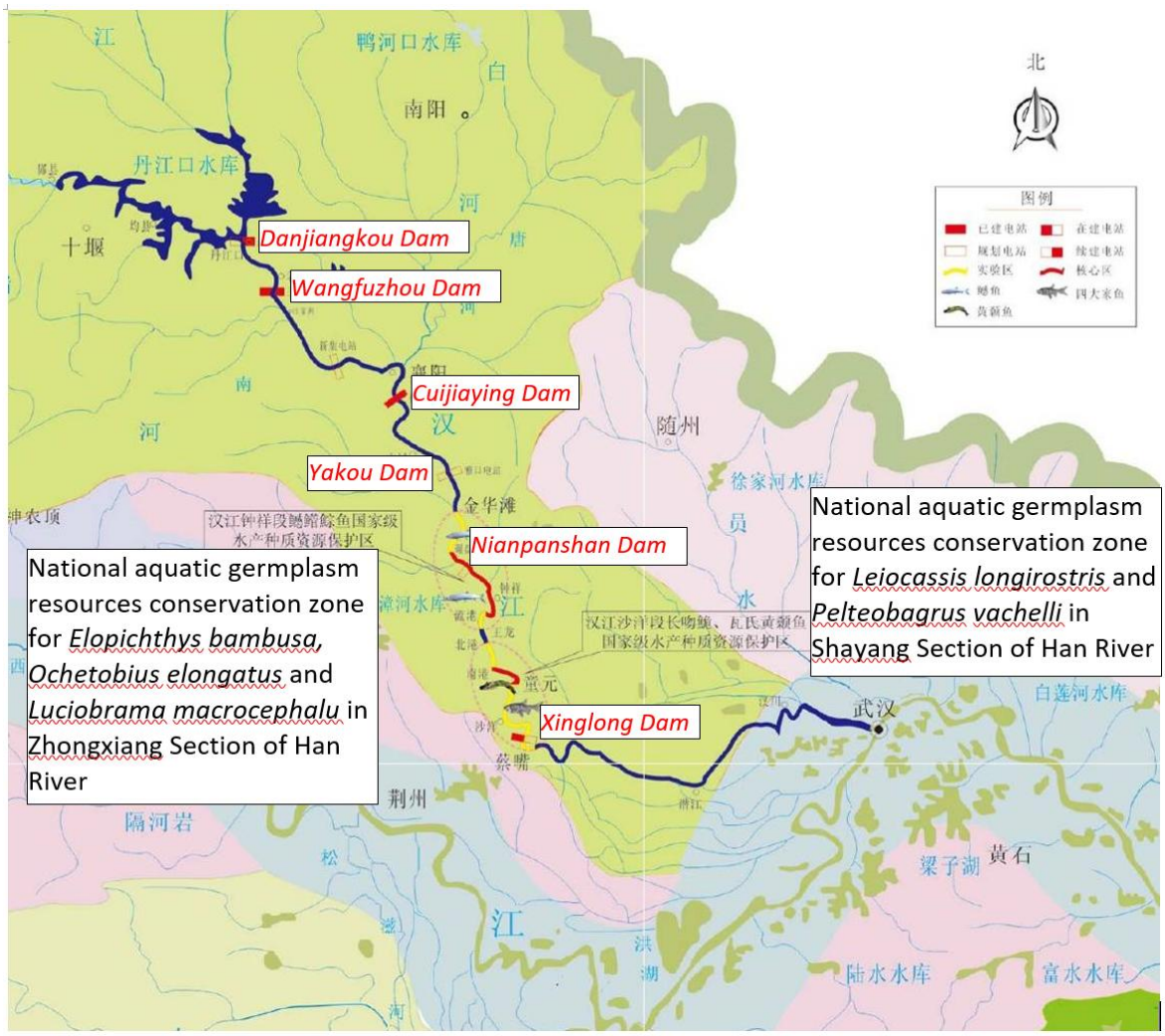


Figure 5-7 Location of Fisher Resource Conservation Zones on Han Rier

5.2.2 Fish protection measures

5.2.2.1 Habitat protection

Habitat protection is a major method to protect fish stocks and mitigate the impact of hydro-power development projects to fish. After Yakou Complex is put into operation, the quantity of the Han River downstream water will inevitably decrease, which will negatively affect local fish stocks and disrupt the hatching of fish that release pelagic eggs. Therefore, fish habitats in the Han River and tributaries shall be protected as a way to mitigate the project's impact on fish stocks.

a) Protection of habitats in the main stream

According to a survey, a majority of fish has been found in the rear section of the reservoir after the reservoir is built. Therefore, it is safe to say that the rear section of the reservoir is a habit to which fish in the reservoir area can adapt after the hydropower station is built. As the Han River segment upstream from the Yakou Complex joints Cuijiaying Navigation and Hydropower Complex, the rear section of the reservoir may form a water area when Cuijiaying Complex discharges flood downstream during flood seasons.

In addition, Yakou Complex discharges flood during flood seasons, so flowing water

area downstream from the Yakou dam can be generally maintained, which is generally conducive to the spawning of fish species that release pelagic eggs.

Therefore, during flood seasons, the river segments (between the area downstream from Cuijiaying dam and the rear section of the Yakou reservoir, and between the area downstream from Cuijiaying dam and Nianpanshan Reservoir) with a flow rate of 0.2m/s *should be protected as fish habitats in the main stream*. It is estimated that the river segments downstream from Cuijiaying dam and Yakou dam respectively that have a flow rate of at least 0.2m/s are 5km long and 7km long respectively. It is recommended that fishing should be banned in the aforesaid river segments. Closed fishing season shall be strictly abided by. During the breeding season (from March to August), fishing, sand mining, and other activities that may disrupt the aquatic habitat in the aforesaid areas shall be banned; warning signs shall be put up near these areas. Environmental flows discharged at a rate of 450m3/s from the Yakou Complex shall be guaranteed; an online monitoring system for environmental flows shall be established. Environmental flows shall be properly increased during the fish breeding seasons in order to ensure the ecosystem quality of the aforesaid areas for fish spawning and inhabiting.

b) Protection of habitats in tributaries

Tributaries, an integral part of the river ecosystem, play an important role in the biodiversity of rivers. According to surveys, most fish swim to and fro between the main stream and tributaries of a river for ingestion and spawning or hibernation. With the implementation of plans for hydro-power development in the Han River middle and lower reaches, aquatic habitats in the main stream will further dwindle. Therefore, aquatic habitats in the tributaries are very important for fish in the Han River middle and lower reaches and for fish whose spawning needs flowing water.

According to the site survey, there is no large tributary between Cuijiaying Dam Site and Yakou Dam Site, but only two seasonal storm drains, with culverts and sluices built at the entrance. Ying River and Man River flow into waters within 10km under Yakou dam. Man River's total length is 184km, its catchment area is 3,276km2, and the gradient of the river way of the main stream is 1.1‰. Since Man River is pollutant drainage, with poor water quality and small fish resources, it is no longer equipped with conditions for protection of habitats. Ying River's total length is 63km, and the basin area is 403.9km2. At the river mouth, the average annual discharge is 5.35m3/s. Although two reservoirs have been built in the upstream, its downstream is abound in pools and flood plains, with both bends and straight parts as well as rapid and slow flows. The Ying River's riverbed consists of pebbles, gravels, sand and mud, which provides spawning grounds for fish species that spawn adhesive and demersal eggs. Therefore, through a comprehensive comparison in water quantity, water quality, river regime of river bed and fish resources, it's appropriate to protect Ying River as fish habitat in tributaries. The river segment under protection is between the area downstream from the second Ying River Reservoir and the Ying River estuary, which is about 18km long. See figure 6-4.

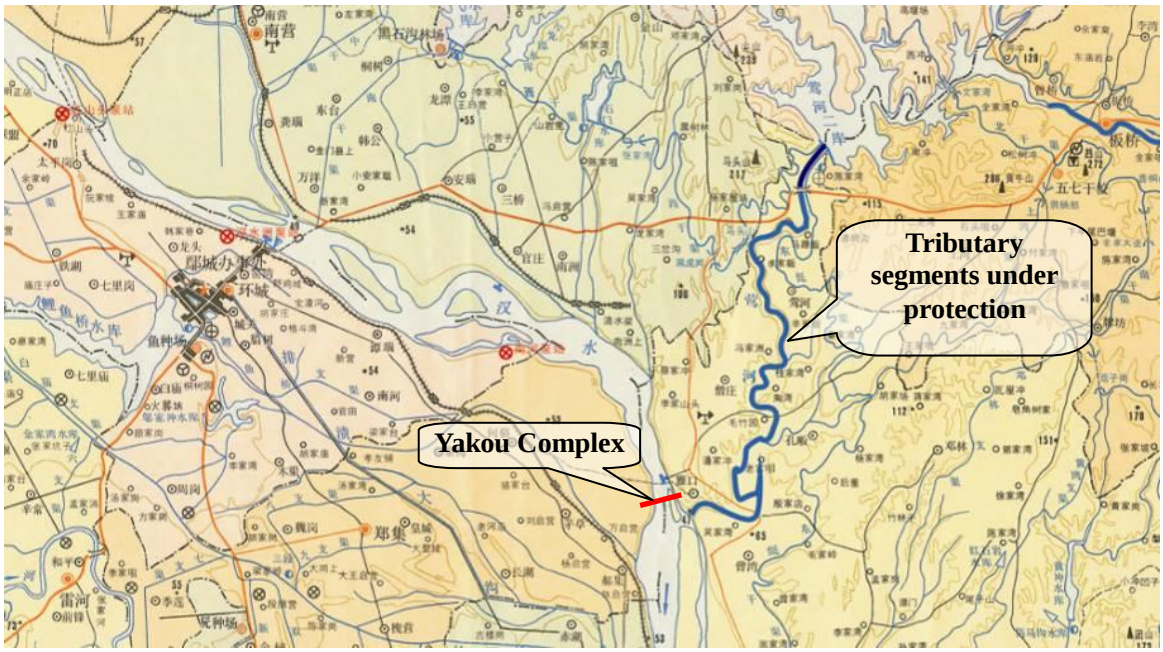


Figure 5-8 Protected river sections of Han River main stream and tributaries

Protected fish species in the tributary habitats are commercially important species and species endemic to the area, including culter alburnus, rhinogobio typus, squaliobarbus curriculus, xenocypris argentea gunther, hypophthalmichthys molitrix, aristichthys nobilis, mylopharyngodon piceus, ctenopharyngodon idellus, distoechodon tumirostris, parabramis pekinensis, squalidus argentatus, and saurogobio gracilicaudatus. The main protection measures are as follows:

① Creating habitats. Habitats for fish can be created by placing pebbles and gravels in an area and transplanting water plants to the area. Artificial spawning grounds can be built for fish. Pebbles (60%) having a diameter of 4-8cm each and gravels (40%) having a diameter of 1-3cm each can be used to pave the surrounding area or the beach of the river island. Area of pebble beach and gravel beach can be increased. These areas can serve as spawning grounds for fish. Spawning grounds for fish can also be created by transplanting hygrophyte to the river beach. Eight to ten plant species can be planted on the man-made river beach, with each species covering an area of 3~5m2.

② Fishing in the protected tributary segments shall be banned; these segments shall be marked with “no fishing” signs.

③ Long-term monitoring of fish species, aquatic life, and water quality shall be implemented.

④ Fishery administration shall be intensified. Fishery regulations shall be strictly enforced. Illegal fishing practices such as using electric shock, explosion, and poison to catch fish shall be prohibited.

⑤ During the breeding season (from March to August), fishing and any other activities that may disrupt aquatic habits in the aforesaid areas are banned. These areas shall be marked with “no-fishing” sings.

5.2.2.2 Fish pass

a) Purposes, targets and season of fish pass

1) Purposes

Bridging fish species upstream and downstream from the dam, ensuring the migration channels are free of obstacles, and protecting the integrity of fish's life record.

2) Targets

To ensure fish swims franguilla japonicay upstream and downstream from the dam through fish pass, relevant parties will pay close attention to hypophthalmichthys molitrix, ctenopharyngodon idellus, mylopharyngodon piceus, aristichthys nobilis, squaliobarbus curriculus and Leiocassis longirostris.

3) Season

In principle, fish can use fish pass all year round. Close attention shall be paid to the quantity of fish passing the dam through fish pass during the breeding season. So the main season for fish to use fish pass can be determined as a period from March to September based on the breeding season.

b) Fish pass planning

In consideration of the characteristics of the project, and through optimum comparison and selection (See section 4.2.4 of this report for details), nature pass combined with fishway combines advantages of fishway and nature-imitated pass, including a substratum similar to natural creek, diverse flow regime suitable for the passing of many fish species, and adaptability towards water level changes. In conclusion, it is recommended that the project fish pass adopts nature-imitated pass combined with fishway plan.

c) Fish pass water level

1) Inlet water level

Short term: prior to the construction of Nianpanshan, when inlet design water level is between 50.32m (unit shutdown, sluice open unrestricted) and 45.76m (minimum tail water level), downstream operating water level amplitude is 4.56m.

Long term: after the construction of Nianpanshan, downstream water level will vary between the normal Nianpanshan water level of 50.72m and the dead pool level of 50.32m, with downstream operating water level being relatively stable.

2) Outlet water level

Water level upstream of the project is relatively stable, being the normal water level of 55.22m most of the time. So outlet design water level is between 55.22m (maximum operating water level) and 54.72m (dead pool level); fishway flood prevention sluice gate will be closed and fishway will have no fish passing when extreme flood comes.

See Figure 5-9 for operating water levels in the upstream and downstream.

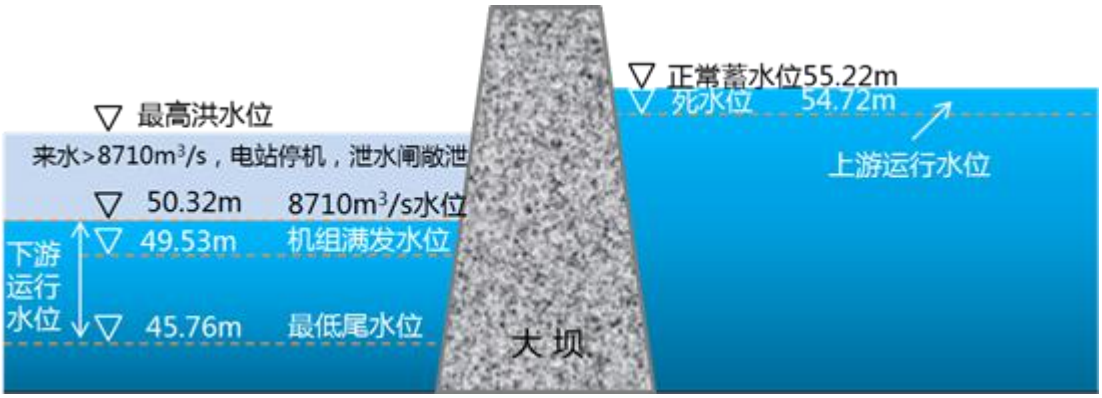


Figure 5-9 Upstream and downstream water levels of fishway (Translation see below table)

最高洪水位	Maximum flood level
来水＞8710m^3/s，电站停机，泄水闸敞泄	Inflow>8710m^3/s, unit shutdown, sluice open unrestricted
8710m^3/s 水位	8710m^3/s water level
机组满发水位	Water level when power plants operate in full load
最低尾水位	Minimum tail water level
下游运行水位	Downstream operating water level
大坝	Dam
正常蓄水位	Normal water level
死水位	Dead pool level
上游运行水位	Upstream operating water level

3) Water head difference

The maximum design water head difference of the project fishway is 55.22-45.76=9.46m; minimum operating water head difference=55.22-50.72=4.5m;water head difference amplitude is 4.96m.

4) Flow velocity

Combining historical research data and test data, recommended flow velocity value of fish-passing orifice/perpends of this fishway is 1.1m/s; fishway inlet fish-luring flow velocity is controlled at 0.48~0.96m/s and determined to be 0.88~1.10 m/s after correction; recommended value of minimum inductive flow velocity is 0.2 m/s.

d) Fishway preliminary design

1) Inlet and outlet design of fish pass

① Inlet

Given that inlet water level changes between 45.76m to 50.72m with water level amplitude reaching 4.96m, building one inlet would be difficult to meet such water level amplitude requirement, which will affect inlet fish-luring effect. After overall consideration, two inlets of high and low water levels of 48.72m and 44.26m are set up. Inlet of this fish pass is below the tail water on the left bank of hydropower station.

The flow of the fishway is about 1.5m3/s in normal operation, which is very few compared with the power station discharge. When passing fish through low inlet, it is not easy for the fish under the dam to find the fishway inlet. It is not conducive to lure the fish, so supplying water to the low inlet is needed. When passing fish through high inlet, fish is lured through the fish collection system on tail water sluice pier in the powerhouse, so supplying water to the fish collection system is needed. The supplied water is carried to the

dam through pipes. After it goes through a stilling pool for energy dissipation, it will flow to the fishway through rack.

② Outlet

Outlet operating water level of this fishway is relatively stable, with most of the time being the normal water level of 55.22m. Therefore, elevation of the fishway outlet floor is determined to be 53.22m. Outlet of this fishway is situated at a location about 350m from upstream of hydropower station on the left bank. The location is relatively far from hydropower station water inlet and fish species succeeded in swimming upstream will not be brought downstream by water flow.

2) Fishway structure

(1) Artificial (Nature-like) passage section

Both fishway and nature-like passage are comprised of levels of water pools which achieve the purpose of flow velocity reduction by energy dissipation through diaphragm within the water pool. According to different forms of internal diaphragm, nature-like passage can be of different structural types, including evenly-paved rock type, alternating rock type and weir type. Given that downstream water level variation amplitude is close to 5m, out of the three structural types, evenly-paved rock type nature-like passage cannot adapt to such water level amplitude; weir type is also not recommended as rise or drop affecting fish passing may occur due to large variations of flow velocity along the pools in the upstream and downstream during water level variations. Out of the three plans, only alternating rock type nature-like passage can adapt to such water level changes. Nature-like passage section of the nature-like fishway adopts alternating rock type using rock barrier within the passageway for flow velocity reduction by energy dissipation, with a bottom width about 2.0m, a side slope of 1:2.5, water depth of about 2.0m, surface water width of 12.0m under normal operating water depth, and a passageway longitudinal gradient of 1%.

(2) Fishway section

To meet the relatively large requirement of Yakou fish pass inlet water level amplitude prior to the construction of Nianpanshan Complex, a project fishway is to be built in addition to nature-like passage so as to meet the short-term fish-passing demand. In order to adapt to large water level variations prior to the completion of Nianpanshan, only the vertical perpends type can be used. To meet the demand of exchanges between the upstream and downstream of small-sized fish species and fish species with relatively weak swimming abilities, it is recommended that pool chamber structure adopts unilateral perpends type.

Considering fish-passing species and fish-passing scale, chamber length of this fishway is determined to be 3.6m; fishway width is determined to be 3.0m; fishway normal operating water depth is designed to be 3.0m, and the depth can be accordingly increased as it gets closer to downstream chamber; minimum width of fish-passing orifice of this fishway is determined to be 45cm; fishway base slope is 1/60; resting pools are to be built in turning corners of the fishway.

Project fishway adopts nature-like design. In order to try to make the fishway close to natural structure, and create a more complex flow field, pebbles with a diameter of 10cm~30cm are laid in the fishway; to reduce bottom flow velocity, fishway bottom is paved with pebble or gravel stone, using rock particles of a 10~30cm diameter in alternating layout of big and small rocks, and bottom rock also adopts grouted type;

diversity of velocity in the chamber can be enriched by roughening the fishway sidewall, so reinforced grouted rubble type can be adopted in the fishway sidewall according to the actual situation in order to reduce the flow rate near the sidewall in the fishway chamber, while be closer to river channel characteristics in natural circumstances.

3) General layout and parameter

Yakou Complex fish pass is arranged near the right side of the powerhouse. The major inlet is located at the right of the tailrace, and connects with the fish collection system on tailrace platform of the powerhouse. The low inlet is located at the end of the tailrace, and the outlet is located at the upstream of the inflow channel floating track rack of the powerhouse. The inlets are situated below tail water area including a high water level inlet (bottom elevation of 48.72m) and a low water level inlet (bottom elevation of 44.26m). Fish-passing passageway circles booster station, extends to the upstream after crossing dam structures, and further extends to the upstream reservoir area about 330m from dam axis.

Total length of fish pass is 951.08m, among which ecological passageway simulation is 560.58m and the project fishway section is 390.5m. Ecological passageway simulation has a trapezoid cross section, a 2.0m bottom width, a 1:2.5 side slope, a water depth of 2.0m, surface water width of 12.0m under normal operating water depth, and a passageway longitudinal gradient of 1%, including altogether 45 sections (section length 10m, divided by 200mm grouted rubble diaphragm) and 2 resting sections (total length 60m), with side slope using reinforced grouted rubble and bottom paved by pebble or gravel stone. Fishway adapts a rectangle cross section, with a chamber length determined as 3.6m and a water depth determined as 3m. Fishway has 7 resting pool sections among which 4 are in curved sections with 200mm diaphragm and minimum fish-passing orifice width determined as 45cm. Fishway floor and side walls adopt on-site concrete with an average fishway floor gradient of 1/60. Fishway floor is paved by pebble or gravel stone. The fish pass general layout is shown in Figure 5-10.

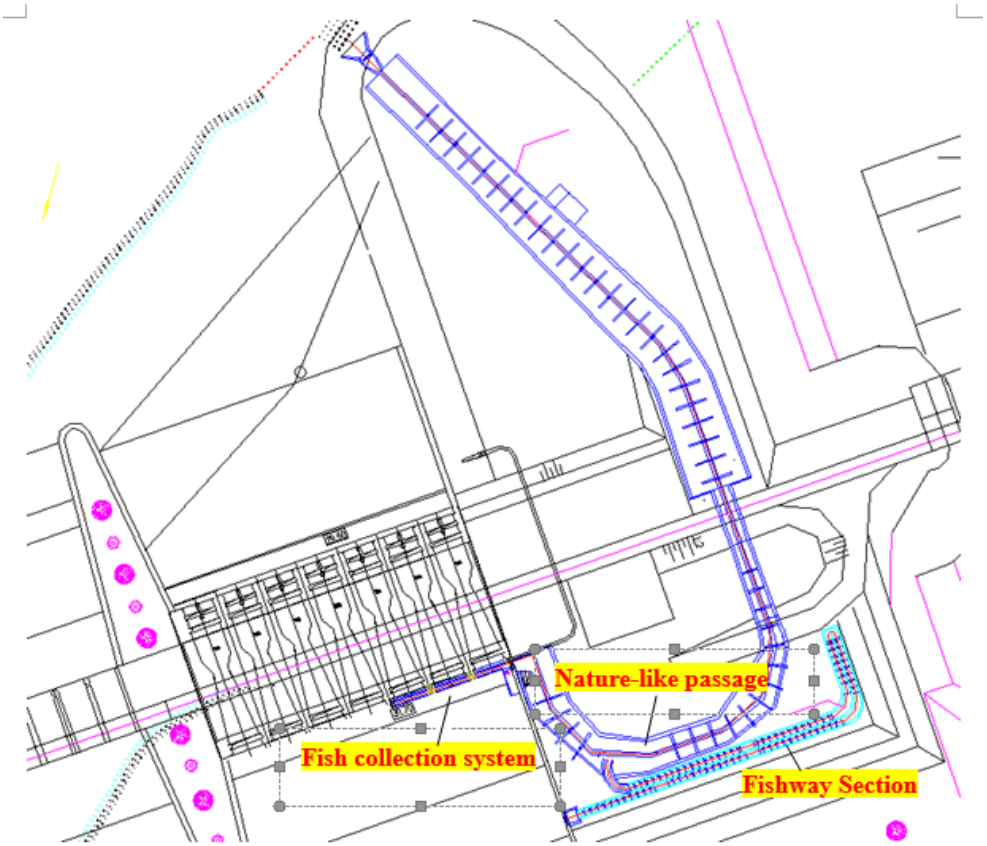


Figure 5-10 General layout of fish pass

4) Subsidiary facilities

Observation room: Fish pass should be equipped with two observation rooms. No.1 observation room should be situated near fishway inlet to observe the fish collection and luring effect of major inlet of fish pass and fish collection groove. No.2 observation room should be situated near fishway outlet to count fish species and numbers successful of swimming upstream, evaluate fish-passing effect of the fishway, prepare for future fishway structural improvement and improve fish-passing effect, with publicity and exhibition functions at the same time.

Fish collection pool: To monitor the operating effect of the fishway, and record detailed parameters including number counting, species verification and size measurement of passing fish, collection of fish from the fishway is necessary. Fish collection pool built next to the fishway can be used for fish collection.

Trash rack: In order to prevent the debris from going into the fishway and blocking the fishway, upstream outlet of fishway can be opened laterally, so that it is not easy for debris to enter, and a trash rack should be set up here. In the downstream inlet section of fishway, in order to prevent tree branches and other garbage from blocking the fishway inlet and affecting the normal operation of the fishway after receding of flood, the upper end of fishway at the inlet section should be covered with trash rack, to avoid garbage from entering into the fishway.

5.2.2.3 Artificial fish breeding and releasing

a) Releasing species

According to key protection subjects of the lower reach of Han River, combined with

features of fish resources and requirements of fishery development, breeding and releasing species given key considerations include leiocassis longirostris, megalobrama skolkovii, parabramis pekinensis, squaliobarbus curriculus, distoechodon tumirostris, luciobrama macrocephalus, ochetobibus elongatus, hypophthalmichthys molitrix, aristichthys nobilis, ctenopharyngodon idellus, mylopharyngodon piceus, elopichthys bambusa and leiocassis crassilabris. Given that fish species such as luciobrama macrocephalus and ochetobibus elongatus have not been seen in the reservoir area for many years and thus cannot carry out domestication or reproduction research or practice, they can only be key observatory subjects needing survey on resources situation. Hypophthalmichthys molitrix, aristichthys nobilis, ctenopharyngodon idellus and mylopharyngodon piceus are proposed to be sub-contracted as they have developed systems of protospecies and fine breed and Hubei province can provide enough quality fries on its own. Elopichthys bambusa, being a ferocious fish of relatively great impact to fish populations, is not suitable for releasing at the moment and may be suitable for breeding and releasing based on further resources monitoring situations. Leiocassis crassilabris is currently not yet successful in artificial domestication and reproduction, and may be suitable for breeding and releasing when with matured technology resulting from the recently started research on domestication and reproduction technologies. Therefore, immediate key releasing species include hypophthalmichthys molitrix, aristichthys nobilis, ctenopharyngodon idellus, mylopharyngodon piceus, leiocassis longirostris, megalobrama skolkovii, parabramis pekinensis, squaliobarbus curriculus and distoechodon tumirostris; breeding and releasing subject added in the long term include leiocassis crassilabris.

b) Releasing standard

Fry released must be first filial generation of artificial reproduction from wild parents. Some Han River fish eggs collected by aid station can be incubated and cultivated as parent fish for the purpose of reproduction, however, over 60% shall be wild parents introduced from Yangtze River. Fry released must not have disabilities or diseases and must be physically strong. It is recommended that releasing fry species technical specification should be formulated by national fishery administrative authorities.

c) Releasing number and size

Fry releasing standard: Fishery production is highly seasonal, so is the buying and selling of fish fry. For general production, “Shuihua”, “Xiahua” and “Dongpian” are sold. “Shuihua” refers to fry without mouth opening for food; “Xiahua” refers to small-sized fingerling with fresh scale; “Dongpian” refers to large-sized fingerling after one year cultivation. Their sizes are respectively 0.8-1.0cm, 3cm and 10-15cm. Sizes of fry released should be according to the actual situation of fry production.

The larger the size of fingerling released, the stronger adaptability to environment and ability to avoid enemy organism, the higher the survival rate. However the larger the fingerling size, the higher the cultivation cost and the more production facilities required. In conclusion, size of artificial breeding and releasing should be within a total length of 4-10cm; releasing size of the aid station from the period of incubation to smooth swimming should be around 3cm.

Breeding and releasing number: It requires overall consideration of current resources situation, fishery development planning and water quality management, and is generally related to natural environment of releasing water body, hydrological climate, physicochemical property, food organism resources, current fishery resources, population

structural feature, biological feature, size and quality of the subject released, releasing frequency and timing. Breeding and releasing protection measures taken after hydropower project construction are compensational releasing, therefore, determination of breeding and releasing number is also closely related to the range and level of impact on fish resources from project construction and operation.

Preliminary releasing number is 4 million fish/year, among which 3.5 million are to be subcontracted for cultivation and 500 thousand fish are to be reproduced and cultivated by the breeding and releasing station. See Table 5-1 for details.

Table 5-1 Fish stock breeding and releasing scale of Yakou Navigation Complex Project

Serial No.	Species	Releasing standard and number (ten thousand fish) of Yakou Project			Source
		Total length 4-6cm	Total length 6-8cm	Total length 8-10cm	
1	*Ctenopharyngodon idellus*			40.0	Sub-contract production
2	*Mylopharyngodon piceus*			10.0	
3	*Hypophthalmichthys molitrix*			200.0	
4	*Aristichthys nobilis*			100.0	
5	*Leiocassis longirostris*	3.0	12.0		Build breeding and releasing station for production
6	*Megalobrama skolkovii*		17.0		
7	*Parabramis pekinensis*		8.0		
8	*Squaliobarbus curriculus*	3.0	3.0		
9	*Distoechodon tumirostris*	4.0			
	Total	10.0	40.0	350.0	400.0

d) Releasing cycle and releasing location

1) Releasing cycle

According to compensation of biological resources loss and compensation term (multiple) of Clause 7.2 of Technical Specification of Impact Evaluation of Construction Project on Marine Biological Resources: biological resources loss by occupying fishery water area shall be compensated for 3 years should the term of occupation be less than 3 years; shall be compensated for the actual term of occupation should the term of occupation be from 3 to 20 years; shall be compensated for no less than 20 years should the term of occupation exceed 20 years. The project has planned for a 20-year fish releasing cycle. After 20 years, releasing plan will be adjusted according to the restoration situation of fish resources.

2) Releasing location

Selection of releasing location need to meet the following requirements: ① convenient transport; ②reservoir bay with relatively open water area or riverway backwater bay, featuring stable and slow water flow; ③water depth within 5m and few ferocious fish; ④relatively plentiful food organism. According to the result of baseline survey on aquatic organism, combined with water regime of Yakou reservoir area and downstream of the dam, as well as flow field distribution situation, 3 releasing locations were proposed, namely Tangbai River estuary of Cuijiaying reservoir area, Wei River estuary of Yakou reservoir area, and Ying River estuary downstream of the dam.

e) Process design of the plan

1) Design objective

1) Meeting immediate scale requirement of fish stock breeding and releasing

Immediate releasing species of Yakou Navigation Complex Project are leiocassis longirostris, megalobrama skolkovii, parabramis pekinensis, squaliobarbus curriculus and distoechodon tumirostris, with an annual releasing amount of 500 thousand fish. Releasing of mylopharyngodon piceus, ctenopharyngodon idellus, hypophthalmichthys molitrix and aristichthys nobilis will be subcontracted.

2) Medium and long term fish stock breeding and releasing requirement

The purpose of carrying out fish stock breeding and releasing is to protect and restore fish resources of the project involved river section and maintain a stable water ecosystem. In designing a fish breeding and releasing station, considerations need to be given to research platform and facility of fish stock breeding and releasing technology, which carry out medium and long-term research on fish stock breeding and releasing technology regarding fish in the lower reach of Han River, so as to realize medium and long-term fish stock breeding and releasing for the protection of basin fish resources.

(3) Han River basin fish protection demonstration project

Fish breeding and releasing station is an important environmental protection project of water-related project. Focusing on environmental protection, it will be developed into an ecological zone of certain scale, publicity and educational point for environmental protection, and an environmental protection demonstration project.

2) Technical work procedures

Technical work procedures of the breeding and releasing station include mainly: collection and purchase of parent fish, domestication and cultivation of parent fish, artificial spawning induction and insemination, artificial incubation, fry cultivation, releasing, releasing effect monitoring, production scale and method adjustment, with structures designed meeting corresponding production procedures.

3) Breeding plan

The production in fish breeding and releasing station can be divided into three stages: parent fish cultivation; spawning induction, incubation and cultivation of freshly incubated fry; fry cultivation.

Parent fish cultivation: earth-pool still water cultivation and flowing water cultivation. Circulating water cultivation belongs to flowing water cultivation adding water treatment system and recycling of wastewater from cultivation. According to living habits of releasing fish species, the cultivation method of outdoor parent breeding pool refilled

regularly with new water is adopted given that releasing fish originally live in river section of Han River basin where soil is generally adhesive.

Spawning induction, incubation and cultivation of freshly incubated fry: these three production links feature short time and large impact on annual production, and are essential links to aqua-cultural fry production as well as releasing fry production of fish breeding and releasing station. In aqua-cultural fry production, spawning induction and incubation both use clear water and are mostly carried out indoor; cultivation of freshly incubated fry is also generally carried out in fry mesh cage (referred to as "water flower cage" in the aquaculture industry) by yolk feeding. Aqua-cultural fry ground is generally equipped with water storage tank of relatively large size and depth (generally over 20 mu in size) to be used for one production cycle. The tank will be disinfected and kept 10 to 15 days prior to fish reproduction. Two settling and impounding reservoirs will be used alternatively with circulating water treatment equipment for clear water supply for links of spawning induction, incubation and cultivation of freshly incubated fry.

Fry cultivation: earth-pool still water cultivation, flowing water cultivation and mesh cage cultivation. According to living habits of releasing fish fries, slightly flowing water cultivation can be adopted with cement protection slope and anti-leakage treatment of the pool bottom.

4) General layout and building structure

Yakou Complex fish breeding and releasing station is situated on the south side of project owner camp. Breeding functional area site has a design elevation of 56.0m, covering 86.7 mu. Water intake pump house is situated near the second-line ship lock on the east side of the camp.

According to releasing subject, releasing scale, construction condition, production technique and production scale, preliminary design includes structures such as: ①one spawning induction incubation and freshly incubated fry breeding plant, internally equipped with two spawning induction pools, three GFRP incubation tanks, three Yushchenko incubator, two conical incubation barrels, 30 1m-diameter cultivating pots and one set of circulating water treatment system; ②one fry cultivating plant, internally equipped with 40 2m-diameter cultivating pots; ③13 outdoor fry breeding pools covering 8.13 mu; ④9 parent fish cultivation pools covering 8.97 mu; ⑤one stock transition pool and live food breeding pool, covering 5.79 mu; ⑥2 quarantine pools; ⑦two impounding reservoirs; ⑧two backup parent fish pools, covering 2.22 mu; ⑨6 large-scale fry breeding pools covering 7.28 mu; ⑩complex building of 1059.64m2, with exhibition room, warehouse, lab and office quarter.

Layout of the recommended design of fish breeding and releasing station is shown in Figure 5-11.

Figure 5-11 Layout of the recommended design of fish breeding and releasing station

f) Scientific research and design

In order to ensure successful completion of the task of breeding and releasing, and achieve the purpose of species conservation, it is necessary to carry out scientific and

technological research on appropriate technology. Research projects mainly include four aspects of wild parent fish of fish conservation: collection and breeding technology, artificial breeding technology, technology of large-scale fry rearing, releasing technology.

The collection and breeding technology for wild parent fish mainly includes collection location of parent fish, domestication conditions, breeding management methods, disease control, etc. The research content of this part is to mainly ensure that a sufficient number of wild parent fish can be collected, and to ensure them alive in the base until artificial breeding completed.

Artificial breeding technology of parent fish includes selection criteria, artificial spawning, fertilization methods, research on incubation conditions, etc. The research of this part is to mainly ensure to obtain fertilized eggs of releasing species and hatch them.

Technology of fry rearing includes breeding method, disease control, and appropriate specifications of releasing, etc. The technology is to ensure rapid and efficient breeding of larvae until suitable specifications.

Releasing technology includes mark method selection, suitable releasing specifications, location and time, etc. The project is mainly to evaluate the effect of breeding and releasing. In study on releasing technology, it should also establish standardized procedures, such as temporary rearing time and location in Jinsha River before releasing.

There exists differences and similarities among different fishes of related content in these four aspects of technology, so it can combine actual situation for bundled tender or separate tender. As guarantee of task completion in breeding and releasing at breeding and releasing station, the units in charge of the project should not only ensure to complete releasing task of the current year but also to present a series of operation norms and standards as a basis for subsequent production.

5.2.2.4 Ecological scheduling operation

a) Objectives of ecological scheduling operation

Due to reservoir regulation, the hydrological regime and physical and chemical properties of water of river section under the dam will both present a series of changes, such as frequent fluctuation of water level, flood process weakening, water discharging to change downstream riverbed bottom sediment, etc. At the same time, it forms a water reduction river section of a long distance for water regulating, channel water diversion and power generation, so it needs to discharge appropriate ecological flow. In addition, the peak period of agricultural irrigation water is often overlapped with fish breeding period, so it needs to consider different water demand. Therefore, it needs to combine with reservoir operation for reasonable utilization in adjusting flow reservoir capacity based on reproductive biology of downstream fish, coordinate the relations among taking and regulating water, power generation, flood control and ecological water demand, and optimize scheduling scheme. Especially during the period of fish breeding, according to the ecological needs of fish breeding, it needs artificial scheduling to form a suitable flood process, so as to create conditions for fish reproduction.

The main economic fishes with typical pelagic eggs in this river section: hypophthalmichthys molitrix, aristichthys nobilis, ctenopharyngodon idellus, mylopharyngodon piceus, parabramis pekinensis, elopichthys bambus, luciobrama macrocephalus, xenocypris argentea, coreius heterodon, rhinogobio typus, rhinogobio

cylindricus. These fish need certain flow stimulation when spawning, so they can hatch successfully in constant flow impulse. Therefore, it is suggested that during the spawning period, certain running water conditions should be guaranteed.

b) Ecological scheduling operation scheme

During the spawning period of "four major Chinese carps" in Han river every year, it can make sure a certain ecological flow of discharge through Danjiangkou, and implement the discharge and regulation in complex joint combined with a certain scale of Tangbai River flood at least for 2 times. Ensure the smoothing in spawning of existing spawning grounds, drifting hatching of fertilized eggs and fertilized fish migration channels to finish the reproduction.

By analyzing the peak process of four major Chinese carps' spawning monitored by water engineering ecology over the years, as for breeding of four major Chinese carps in the middle and lower reaches of Han river, although Danjiangkou discharge has positive effect on the spawning scale, it mainly relies on the Tangbai River flood. During the period of the flood, in case of the discharge in Huangzhuang Hydrological Station of Han River (located about 75km under Yakou dam) up to 1200 m^3/s, all the early resources of four major Chinese carps were monitored (in 2014 survey, the discharge of Han River when spawning floating fish eggs is 1040 m^3/s, which is coordinated with the demands that Huangzhuang Hydrological Station's discharge is above 1200 m^3/s when complex joint ecological operation is proposed in the retrospective assessment report), so as to meet hydrological requirements of ecological operation.

Therefore, the ecological operation will take Tangbai River flood as the basis, combined with the interval inflow, every year from May to August, combined with tributary Tangbai River flood process at least for 2 times of ecological operation in complex joint of Danjiangkou of Han River, specifically: In the second half of May to August of high flow years and normal flow years, when Tangbai River Dongpo Flood Control Station forecasts flood flow quantity is equal to or above 600 m^3/s 24 hours in advance, or forecasts flood is equal to or above 300 m^3/s 24 hours in advance in low flow years, it should immediately start ecological operation scheme, namely it starts ecological operation when Tangbai River forecasts flood quantity is equal to or above 600 m^3/s in the second half of May to July; in case of no flood of 600 m^3/s in the second half of May to July, it can be judged the year as low flow year, and it will immediately start ecological operation when Tangbai River forecasts the flood flow quantity is up to 300 m^3/s in August. At this time, Danjiangkou will discharge ecological flow of 400 m^3/s according to regulation requirements, which can ensure the flow of Huangzhuang Hydrological Station is up to 1200 m^3/s (i.e. meeting flow requirements of ecological operation in complex joint proposed by retrospective assessment). Wangfuzhou Complex has no water storage, but discharges according to inflow; for 3 complexes in Cuijiaying, Yakou and Xinglong, it needs to start gates for pre-discharge 24 hours in advance, reduces water level of the reservoir, and implement joint discharge in Cuijiaying, Yakou and Xinglong when the actual flow monitored by Tangbai River Dongpo Flood Control Station is up to start flow of ecological operation, with discharge time of 5 to 7 days, until the end of flood peak, in order to facilitate eggs and fry drifting down dam.

In special low flow years, when Tangbai River Dongpo Flood Control Station has not occurred flood equal to or greater than 600 m^3/s in the second half of May to August, and has not occurred flood equal to or greater than 300 m^3/s, in the early and middle September of autumn season, when Tangbai River or Han River occurs flood in any scale, it needs to

start an ecological operation in joint according to the way above mentioned.

At present, Hubei Provincial People's Government in Hubei government letter [2015] No. 235 issued an approval to "Joint Ecological Operation Scheme of Complex below Danjiangkou of Han River Mainstream in Hubei Province (trial implementation)". Make clear that ecological operation range covers complexes below Danjiangkou of Han River mainstream, including Wangfuzhou (built), Cuijiaying (built), Yakou (this project) and Xinglong (built), and complexes (Xinji, Nianpanshan) built in the future should also be included in joint regulation. The objective is during the spawning period of "four major Chinese carps" in Han River every year, certain ecological flow should be discharged through Danjiangkou, and the discharge and regulation in complex joint should be adopted in combination with a certain scale of Tangbai River flood to ensure the smoothing in spawning of existing spawning grounds, drifting hatching of fertilized eggs and fertilized fish migration channels to finish the reproduction.

5.2.2.5 Fishery administration

To strengthen fishery administration is one of the effective means to protect fish resources.

a) To strengthen team construction of fishery

It is recommended by local fishery sectors to establish and improve fishery administration institutions, strengthen the construction of fishery administration team and its capacity, and improve ability of law enforcement and strength of fishery sectors. To strengthen the propaganda of fish resources protection, in strict enforcement, without any fishery production activities in prohibited fishing area, especially those illegal fishing practices in ways of explosives, poisons, electricity and any other means.

b) Strict enforcement of period and area system of prohibited fishing

To make sure prohibited fishing period and area, and fishing during the period in cluster of fish spawning easy for fishing is forbidden, so as to protect fish to successfully complete process of life. To take essential habitat of fish as prohibited fishing area, where any form of fishing activity will be prohibited; to take time easy to capture and important time as prohibited fishing period, when the whole river will be prohibited for fishing, especially for river sections where fish are relatively concentrated.

For Han River prohibited fishing period, it implements spring prohibited fishing period of the Yangtze River, from April 1st to June 30th every year, according to biological characteristics of Han River fish resources reproduction, considering the effect of discharge water in low temperature of Danjiangkou power plant (Huangjiagang water temperature data under Danjiangkou dam for many years show that, the water temperature after the construction of dam is 2.1 - 2°C lower than that before the construction in March to August, 0.8 - 4.7°C higher from September to January, the highest temperature in August reduced about 2°C, and the lowest temperature in January increased 3.5°C. Changes in water temperature of discharge bring certain influence to fish reproduction of Xiangfan section, it should postpone 20 days in case of meeting the requirements of spawning minimum temperature of 18 °C, with fish reproduction period delayed, so it is suggested to adjust prohibited fishing period of Han River for May to July.

According to the prediction of the fish resource investigation and changes, in survey area, at the end of the reservoir, upper reaches of the river water and branch Ying River will be an important habitat river of Yakou Complex, it should be a prohibited fishing area

to be protected. The survey area is not set prohibited fishing areas, during prohibited fishing period there still has fishing activities. Therefore, it is suggested the local fishery sector, for the protection of fish resources, taking essential fish habitat for prohibited fishing area and strictly enforce system of prohibited fishing period.

c) To strengthen fisheries management

To further strengthen the management of fisheries production, protect the resources of fish, so as to achieve sustainable development of fisheries production. Fishing gears and fishing methods should be limited, small size nets less than 6cm should be resolutely banned, and some fishing methods such as explosives, poisons, electricity etc., whose destruction to fish resources is often devastating, should be strictly prohibited. It is necessary to implement fishing permit system, according to the situation of fish resources to control the number of fishing vessels, and implement quota fishing to control the total amount of fishing. To stipulate fishery catching standard. In biology, general provisions of fishing standard take fish length, weight and age for first maturity as its capture standards; in economics, it should stipulate suitable capture standards according to the growth of fish and feed utilization of biological resources, so as to ensure that the maximum sustainable utilization in fish resources and quality of product fish. At the same time, we should strengthen the prevention and control of water pollution, prevent the occurrence of water pollution incidents, so as to ensure a good living environment of fish.

5.2.2.6 Scientific research

Hydropower development has a certain impact on aquatic ecology, therefore, Yakou project proponent cooperate with relevant research institutes to carry out relevant research, so as to effectively protect aquatic habitats and fish resources. Recommended related research projects including:

(1) Habitat conservation and habitat restoration research of fish;

(2) Technology study of ecological operation and formulation and testing of joint scheduling scheme;

(3) Succession of aquatic organisms in the middle and lower reaches of Han River after formation of reservoir area;

(4) Effect evaluation and technology research of fish over fishway;

(5) Evaluation research of artificial breeding technology and fish tagging and effect.

At present, there are no fishes such as luciobrama macrocephalus, ochetobius elongatus, etc. in the reservoir area for many years. So it’s unable to carry out domestication and breeding research and practice on them, but only able to survey their resources as key concern objectives. Once they are found, key domestication should be conducted on them, and corresponding research should be carried out so as to successfully lay a solid foundation for artificial domestication and breeding in the future. Leiocassis crassilabris has not been successful in artificial domestication and breeding. Recently domestication and breeding technology research will be carried out, and releasing will be implemented after the technology is mature.

6 Cumulative Effects Assessment and Mitigation

A standalone Cumulative Effect Assessment report has been prepared as part of this supplemental ESIA report. This section summarizes the key findings and conclusions of the CEA.

6.1 Cascade Development on Han River

Cascade development plans for Han River mainstem has been developed and updated since 1950s; the first dam Danjiangkou was built in 1973. According to the latest *Comprehensive Plan for the Trunk Han River* (2012), a 15-stage cascade development along the some 1500km long Han River mainstem was determined. Since after 2000, the implementation was accelerated and it is expected in coming 3-5 years, the cascade development will be completed. In addition to project-specific impacts, system-wide study on the indirect and long-term impacts associated with the cascade development is needed.

6.2 Scoping of Cumulative Effects

The CEA was prepared following internationally widely-acknowledged guidance and good practices. The 15-stage cascade development on the Han River mainstem was reviewed firstly. It was recognized that putting the emphasis on the middle and lower Han River (Danjiangkou reservoir and its downstream) would be meaningful and practical for the following key reasons: a) a major assessment objective was agreed among various stakeholders was that it should lead to a workable inter-agency coordination mechanism and implementable action plans to address cumulative effects. Setting the study scope in the middle and lower Han River that is under the jurisdiction of Hubei Province makes the objective achievable. 2) The hydrologic regimes (hence water availability, various ecosystems and socio-economic aspects) in the middle and lower Han River are largely controlled by releases from Danjiangkou reservoir given its huge storage capacity and multi-year regulation capacity. The middle and lower Han River thus can be treated as a relatively independent system for study.

Of the 7 dam/reservoirs along the length of middle and lower Han River mainstem, four have been built and operational (i.e., Stage 1 Danjiangkou, Stage 2 Wangfuzhou, Stage 4 Cuijiaying and Stage 7 Xinglong); the remaining three stages (i.e., Stage 3 Xinji, Stage 5 Yakou and Stage 6 Nianpanshan) are expected to be completed in coming 3-5 years. Several valued environmental components (VECs) were identified through comprehensive desk review and public consultations with pertinent agencies, technical experts and other stakeholders; hydrologic regime, water quality, fish and riparian areas were considered of high priority among those identified VECs.

6.3 Affected Environment

Review of the historical conditions, trends and inter-dependency of the VECs leads to the following findings, a) Hydrologic regimes: flow measurement results at each fixed cross-section on the middle and lower Han River mainstem since 1956 suggest that annual average runoff ranged from 1,100-1,500 m3/s. The Danjiangkou reservoir (built in 1973) and increased human uses reduced the overall flow rate moderately compared to the natural conditions. Combined with subsequent dam/reservoirs, the spatial and temporal distribution of the runoff varied markedly as demonstrated by reduced annual variations,

elevated levels, expanded areas, reduced flow velocity and decreased solid contents; b) Water quality in the mainstem and major tributaries in the past 15 years has seen continuous improvement. In recent years the designated Class II standard have been fully attained in the mainstem, while the tributaries' water quality ranged from clean to polluted status; 3) The fishery resources present a declining trend over the past 4 decades, as evidenced by the facts that the abundance and diversity of traditionally dominant fish species with floating eggs (represented by the *Four Domesticated Fish*, namely *black, grass, bighead and silver carps*) and their spawning grounds reduced markedly; fish species favoring stagnant waters such as common and crucian carps became dominant; the sizes of individual fishes decreased. Overfishing, water pollution, dam/reservoir development and other activities such as in-stream sand mining cumulatively contributed to the changes. Meanwhile, the government has made extensive protection and restoration efforts, such as water pollution control and no-fishing regulation that have helped mitigated the negative effects, as exemplified by the improved water quality; and 4) Riparian habitats and wildlife. Terrestrial ecology was examined routinely in traditional Han River EA studies. Drawing on international advancements in research and EA practices, this CEA study specially examined the riparian areas, which are transitional between terrestrial and aquatic ecosystems, presenting distinguished ecological functions and higher relevance to the proposed developments than the general terrestrial ecosystem. Apparently, many riparian areas along the Han River have been lost due to intensified human activities (e.g. farming and urban development) and inundation resulting from reservoirs formation. Currently the riparian corridor is dominated by secondary vegetation (such as poplar and willow), shrubs, grass and crops. Wetland and adjacent emergent/submerged plants provide habitats for fish, birds and other wildlife. 44 waterfowls (13 swimming birds and 31 wading birds) were recorded, including two national Class I protected wading bird species, namely Oriental White Stork (*Ciconia boyciana*) and Black Stork (*Ciconia nigra*); and four national class II protected waterfowls. Following the formation of Wangfuzhou and Cuijiaying reservoirs, local governments established a wetland nature reserve and a wetland park in each reservoir area; two other wetland parks have been proposed. These actions result in ecological and recreational benefits as well.

6.4 Cumulative Effects and Mitigation

Based on the deepened understanding of past activities and their cumulative effects on the key VECs, major future development activities were identified: a) Completion of the 7-stage cascade development on the middle and lower Han River in coming 3-5 years is a high likely condition; b) the South-to-North Water Diversion (SN Diversion) project that was put into operation in Dec 2014 and transfers water from Danjaingkou reservoir to north China. Other present and future activities that may have cumulative effects on the VECs were also considered though quantitative evaluation were impossible. Specifically, cumulative effects and mitigation measures include the following.

a) Hydrologic regimes. The SN Diversion currently transfers 2-3 billion m3/year water from Danjiangkou reservoir annually, compared to the 40 billion m3/year annual inflow into the reservoir. Flow reduction in the middle and lower Han River is moderate. In future, combined with the full cascade development, the cumulative effects on flow rate and flow velocity will be significant. The formation of reservoirs in the middle and lower Han River will to certain extent compensate for the river width and depth reduction resulting from the flow reduction but will

turn the river into connected lakes. To mitigate the cumulative effects, a regulation has been enacted to ensure that the minimum releases from each dam must meet downstream environmental flow, navigation and water supply needs.

b) Water quality. Initial mathematically modelling suggests that cumulatively the SN Diversion and full cascade development may result in significant loss of water environmental carrying capacity and non-compliance with the designated Class II surface water standards. More aggressive domestic/industrial wastewater pollution and agricultural non-point source pollution control plans, and more stringent pollution discharge standards are being implemented to mitigate the impacts;

c) Fish. Changes of flow regimes and fragmentation caused by the dams have and will further negatively impact on fish species with floating eggs such as the *four domesticated fish* through disturbing their breeding and hatching life stages and spawning grounds, while fish species favoring lake-like conditions will become more dominant. Mitigation measures include fish breeding facilities and fish reproduction programs that are implemented and financed by each dam operator; fish passages in the 5 dams downstream of Wangfuzhou (Stage 2), coordinated dam operation (i.e., ecological scheduling) to provide needed water rise, flow velocity and floating distance for the successful reproduction of fish species with floating eggs; fish habitat protection and restoration in the mainstem tail waters and tributaries; fishery administrative measures such as no-fishing zone and season, and educational activities.

d) Riparian areas. Riparian/floodplain areas along the middle and lower Han River will be further impacted due to the changes of hydrologic regimes (e.g. changes of seasonal flooding process) and inundation. Since riparian ecology is a relatively new area of study internationally and in China, a general mitigation strategy was proposed, including expanding the existing ecological scheduling program and create flooding process that is essential to riparian wetland (current ecological scheduling is designed for fish needs primarily), riparian vegetation restoration and other good management practices addressing over-farming, grazing and other development activities. The proposed Wangyangzhou wetland park (linked to Yakou project) has the potential to demonstrate riparian ecosystem restoration as well.

6.5 Inter-agency Coordination Mechanism

The CEA also carefully examined inter-agency coordination mechanism that is essential to address cumulative effects. Existing coordination mechanism as exemplified by the coordinated dam operation program (i.e. ecological scheduling) is overseen by the provincial government and involves pertinent provincial departments, dam operators. Proposed habitat restoration, fishery administration (e.g. no-fishing zone), and wetland park development will require close engagement with local governments, agriculture and fishery departments. In addition, the uncertainty associated with future actions require an adaptive monitoring and management approach to incorporate those scientific, technical, institutional uncertainties into the implementation and further development of cumulative effects action plans. To this end, a more detailed cumulative effect assessment will be carried out during the Yakou project implementation building on the preliminary CEA prepared during the project preparation. The primary objectives of the detailed CEA include: a) expanding the VECs and deepening understanding of the cumulative effects; 2)

maintain and enhance the inter-agency coordination mechanism; and 3) develop a long-term adaptive monitoring and management plan.

7 Physical Cultural Resources Impacts and Management Plan

7.1 Impact on PCR and mitigation measures

7.1.1 PCR Survey

In July 2012, the Yakou project proponent commissioned Hubei Provincial Institute of Cultural Relics and Archaeology to conduct a field survey. The survey was carried out in accordance with the requirements of the 3rd survey of cultural heritages issued by State Administration of Cultural Heritage and relevant procedures. During the survey, appropriate records were kept, including text, photography and GPS positioning data. For some PCRs, preliminary exploration was carried out. The survey shows that there are a total of 12 underground PCRs in project affected area, where there is a county-level CH (Wangjiagang Cemetery) and 11 unrated PCRs. See Table 7-1 for details and Figure 7-2 are the photographs of site survey.

Table 7-1 General information of cultural heritages in project area

S/N	Item	Location	Coordinates	Elevation (m)	Period	Cultural heritages class	Preservation status	Relation with project route
1	Han dynasty Cemetery in Guanzhuang Village	Group 6, Guanzhuang Village, Nanying Street Sub-district Office, Yicheng City	N31° 42′ 56.2″ E112° 20′ 46″	53.5	Eastern Han Dynasty, Six Dynasties and Ming Dynasty	Unclassified	General	Inundation
2	Haogouquan Cemetery Complex	Ziran Village, Haogouquan, Ronghe Village, Xiaohe County, Yicheng City	N31° 47′ 11.0″ E112° 9′ 33.0″	68	Han Dynasty	Unclassified	General	Erosion
3	Wangjiagang Cemetery	Wangjiagang, Mingzheng Village, Xiaohe County, Yicheng City	N31° 45′ 24.0″ E112° 12′ 30.0″	71	Han Dynasty	County level	Relatively good	Erosion
4	Tongmei cemetery complex	Tongmei Village, Zhengji County, Yicheng City	N31° 39′ 38.0″ E112° 19′ 16.0″	57	Wei and Jin Dynasties to Sui Dynasty	Unclassified	General	Erosion
5	Six Dynasties Cemetery in Group 3, Tongmei Village	Group 3, Tongmei Village, Zhengji County, Yicheng City	N31° 40′ 12.0″ E112° 19′ 23.5″	53	Six Dynasties	Unclassified	General	Inundation
6	Six Dynasties Cemetery in Heluo Village	Group 6, Heluo Village, Zhengji County, Yicheng City	N31° 40′ 5.9″ E112° 20′ 45.3″	52	Six Dynasties	Unclassified	General	Inundation
7	Six Dynasties Cemetery in Maocao Group 3	Group 3, Maocao Village, Zhengji County, Yicheng City	N31° 39′ 31.1″ E112° 21′ 25.3″	53.5	Six Dynasties	Unclassified	General	Inundation
8	Cemetery at Taishanmiao	Group 5, Tannao Village, Yancheng Office, Yicheng City	N31° 42′ 22.7″ E112° 17′ 29.2″	55	Ming and Qing Dynasties	Unclassified	Relatively poor	Inundation
9	Ming and Qing Dynasties cemetery in Tannao Group 3	Group 3, Tannao Village, Yancheng Office, Yicheng City	N31° 42′ 23.1″ E112° 18′ 15.2″	53.5	Ming and Qing Dynasties	Unclassified	Relatively poor	Inundation
10	Han dynasty cemetery at Shuita in Tannao Group 3	Group 3, Tannao Village, Yancheng Office, Yicheng City	N31° 42′ 23.1″	53	Han Dynasty to Six Dynasties	Unclassified	General	Inundation

S/N	Item	Location	Coordinates	Elevation (m)	Period	Cultural heritages class	Preservation status	Relation with project route
			E112° 18′ 15.2″					
11	Miaotai cemetery in Nanhe Village	Group 11, Nanhe Village, Yancheng Office, Yicheng City	N31° 40′ 57.3″ E112° 19′ 6.9″	54	Ming and Qing Dynasties	Unclassified	Relatively poor	Inundation
12	Yakou Village Cemetery	Fishery community of Liushui County, Yicheng City	N31° 39′ 51.3″ E112° 23′ 15.7″	54	Six Dynasties and Ming Dynasty	Unclassified	General	Inundation

After analyzing their distribution, we find that the construction of the navigation complex and linked projects will not have an impact on the Cemetery. The main impact will be bought after the formation of the reservoir; for the 12 underground PCRs, Haogouquan Cemetery, Wangjiagang Cemetery and Tongmei Cemetery will be eroded, while other Cemetery will be inundated.

Figure 7-1 Location of PCRs in project affected area

	
1 Guanzhuang Cemetery, Han Dynasty (partial)	1 Bricks of Guanzhuang Cemetery (Han Dynasty)
	
2 Close shot of Haogouquan Cemetery	3 Close shot of Wangjiagang Cemetery
	
4 Close shot of Tongmei Cemetery	4 Bricks of Tongmei Cemetery

	
5 Group 3, Tongmei Village-Cemetery of the Six Dynasties (partial)	5 Group 3, Tongmei Village-Cemetery of the Six Dynasties (bricks)
	
6 Cemetery of the Six Dynasties in Heluo Village(partial)	6 Long shot of Cemetery of the Six Dynasties in Heluo Village
	
7 Group 3, Maocao Village-Cemetery of the Six Dynasties(partial)	7 Group 3, Maocao Village-Cemetery of the Six Dynasties (bricks)

	
8 Close shot of Taishanmiao Cemetery	8 Bricks of Taishanmiao Cemetery
	
9 Group 3, Tannao Village-Cemetery of Ming and Qing dynasties (close shot)	9 Group 3, Tannao Village-Cemetery of Ming and Qing dynasties(bricks)
	
10 Shuita Cemetery-Han Dynasty(close shot)	Bricks of Shuita Cemetery(Han Dynasty)

	
11 Miaotai Cemetery, Nanhe Village(close shot)	11 Miaotai Cemetery, Nanhe Village(bricks)
	
12 Cemetery of Yakou Village(partial)	12 Cemetery of Yakou Village (bricks)

Figure 7-2 Photos of 12 PCRs in project affected area

7.1.2 PCR management plan

The project owner has commissioned Hubei Provincial Institute of Cultural Relics and Archaeology to carry out works of heritage conservation before reservoir impoundment. The works include: Archaeological investigation, CH avoidance (bypassing), archaeological exploration, archaeological excavations, data compilation & preparation of reports, and heritage preservation & exhibition.

Hubei Provincial Institute of Cultural Relics and Archaeology has completed its archaeological survey of the 12 PCRs, and has given its advice on their conservation in the next stage. Among the 12 PCRs (Cemetery), there is no one which needs to be bypassed. The survey gives the conclusion that the conservation work for the PCRs shall be divided into A, B, C, D levels, in accordance with their richness, research value and time span. According to this standard, there are 1 A-level PCRs, 4 B-level PCRs, and 7 C-level PCRs and 0 D-level PCRs.

A-level PCRs refer to historic cultural sites or Cemetery with high cultural deposit and value, which will provide substantial references for study of ancient culture. Large-scale and careful excavation need to be carried out in A-level PCRs.

B-level PCRs refer to historic cultural sites or Cemetery with relatively high cultural deposit and value, which will provide references for study of ancient culture. General excavation work needs to be carried out in B-level PCRs.

C-level PCRs refer to historic cultural sites or Cemetery with little cultural deposit and value, which will provide few references for study of ancient culture. General

excavation and archaeological survey need to be carried out in C-level PCRs.

D-level PCRs refer to historic cultural sites or Cemetery with poor cultural deposit and value, which will provide no references for study of ancient culture. Registration and archiving work need to be carried out in D-level PCRs for future reference.

According to Article 29 of Law on the Protection of Cultural Relics: In carrying out major construction projects, the project proponent should report to administrative department for cultural relics, so as to delegate archaeological excavation teams to carry out archaeological investigations & explorations in project affected area. According to this provision, archaeological survey needs to be carried out before reservoir impoundment. According to above-mentioned requirements, both general archaeological survey and key archaeological survey shall be carried out. For A-level PCRs, general archaeological survey accounts for 50%, and key archaeological survey accounts for 50%. For B-level PCRs, general archaeological survey accounts for 70%, and key archaeological survey accounts for 30%. For C-level PCRs, general archaeological survey accounts for 90%, and key archaeological survey accounts for 10%.

According to conservation & excavations principle, for A-level PCRs, conservation & excavations work shall be taken as a priority. For B-level PCRs, conservation & excavations work shall be implemented in a limited area.

Table 7-2 shows the conservation plan of the 12 PCRs. It is estimated that the cost of archaeological survey, explorations and excavations will be 2.325 million yuan.

Table 7-2 Conservation plan of the 12 PCRs

No.	Name	Location	Conservation level	Conservation plan
1	Guanzhuang Cemetery (Han Dynasty)	Group 6, Guanzhuang Village, Nanying Subdistrict Office, Yicheng City	B	Survey and excavation
2	Haogouquan Cemetery	Haogouquan, Ronghe Village, Xiaohe Town, Yicheng City	B	Survey and excavation
3	Wangjiagang Cemetery	Wangjiagang, Mingzheng Village , Xiaohe Town, Yicheng City	A	Survey and excavation(with priority)
4	Tongmei Cemetery	Tongmei Village, Zhengji Town, Yicheng City	B	Survey and excavation
5	Group 3, Tongmei Village-Cemetery of the Six Dynasties	Group 3, Tongmei Village, Zhengji Town, Yicheng City	C	Survey and excavation
6	Heluo Village-Cemetery of the Six Dynasties	Group 6, Heluo Village, Zhengji Town, Yicheng City	B	Survey and excavation
7	Group 3, Maocao Village-Cemetery of the Six Dynasties	Group 3, Maocao Village, Zhengji Town, Yicheng City	C	Survey and excavation
8	Taishanmiao Cemetery	Group 5, Tannao Village, Yancheng Branch Office, Yicheng City	C	Survey and excavation
9	Group 3, Tannao Village-Cemetery of Ming and Qing dynasties	Group 3, Tannao Village, Yancheng Branch Office, Yicheng City	C	Survey and excavation
10	Shuita Cemetery(Han Dynasty)	Group 3, Tannao Village, Yancheng Branch Office, Yicheng City	C	Survey and excavation

No.	Name	Location	Conservation level	Conservation plan
11	Nanhe Village Miaotai Cemetery	Group 11, Nanhe Village, Yancheng Branch Office, Yicheng City	C	Survey and excavation
12	Cemetery of Yakou Village	Fishing Community, Liushui Town, Yicheng City	C	Survey and excavation

7.2 Impact on ordinary cemetery and mitigation measures

According to the RAP, the project will involve the relocation of the 467 Cemetery. According to field survey, the local Cemetery is located on the mountains near the village. According to local customs, the relocation of Cemetery is a major event. The common process is "unearthing, ceremony, and burial". Attention shall also be taken as to local customs such as date, time, place & ceremony of relocation. The graves affected will be compensated according to local prices and the related costs have been incorporated into the RAP.

7.3 Protective measures for cultural heritages during construction period

The following measures will be taken in accordance with the ESMP so as to prevent damage to valuable & intangible cultural heritages.

a) The construction workers will be trained so as to help them identify CH. Besides, construction workers will be trained so as to know importance of the CH, and the reporting procedures;

b) The following steps shall be taken to protect the previously unknown CH;

1) Once the worker confirms that it is a CH, he shall report to the site supervisor;

2) The site supervisor shall make a judgment as to whether the CH is real one;

3) If the CH is real, the site supervisor shall immediately cease the work within 50m;

4) Site supervisor shall be report immediately to the contractor -environmental coordinator;

5) The contractor - environmental coordinator will report to the environmental supervisor in Environmental Management Unit, while the environmental supervisor will report to the Supervision Company-project manager and county-level PMO.

6) According to the requirements of the law on cultural relics, the scene will be kept intact, and the local administrative department of cultural relics will be immediately notified.

c) Within 50m of the scene, temporary fences or similar facilities will be set up for protection.

d). No work shall be carried out within 50m of the scene without the approval of the Environmental Management Unit.

e) 15 days prior to the construction of the scene, the contractor -environmental coordinator shall be notified.

f) The guidance or requirements issued by Supervision Company- Environmental Management Unit shall be conveyed to the construction staff and strictly implemented.

8 Impact of Auxiliary Works and Mitigation Measures

8.1 Environmental management of transmission lines

The construction of transmission lines will be carried out in the later stage of the project, and the project will be implemented by local power sectors. Therefore, this section will focus on the environmental & social impact brought by the implementation and operation of the transmission line. The aim is to provide references for the planning of EIA and environmental mitigation measures.

8.1.1 Environmental impact analysis

This auxiliary project mainly involves the construction of a 12 km transmission line (110kV, Yakou Power Station-Zhengji Substation). The route of transmission line is shown as follows.

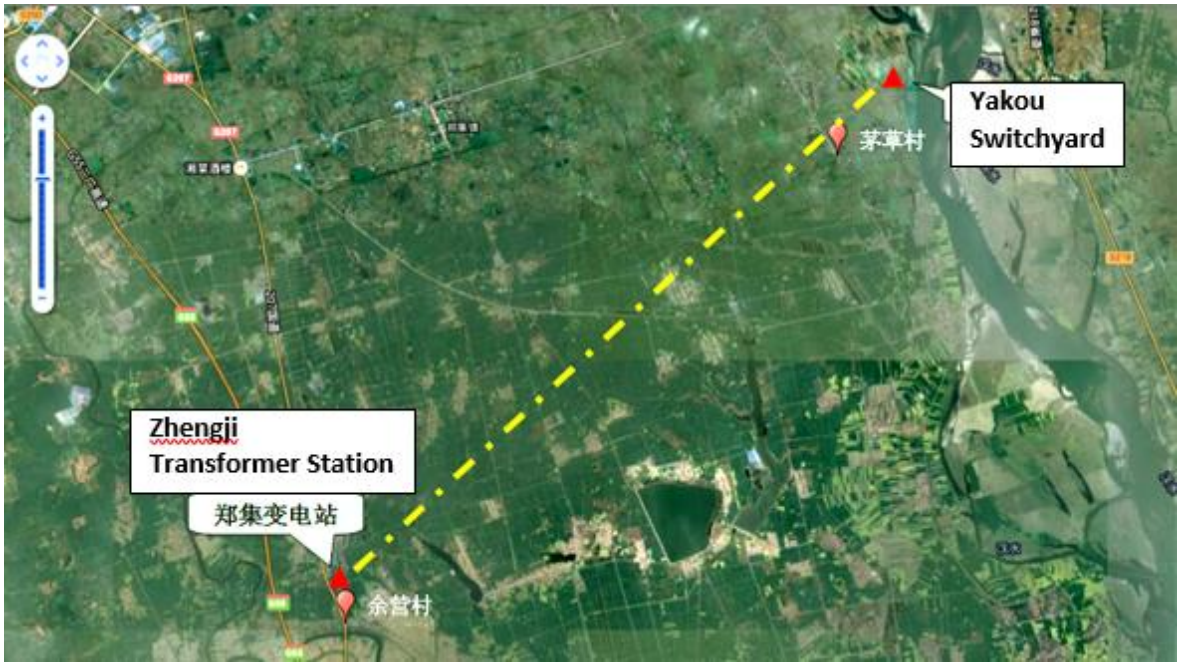


Figure 8-1 Routes of transmission line of Yakou Power Station (110kV)

Seen from above, the transmission line will only go through Maocao Village. The adverse environmental impacts are mainly brought by construction, operation and maintenance of the transmission line. The main environmental impact factors of the project are listed:

a) Construction period

(1) The original function of land occupied will change;

(2) Local vegetation might be damaged, thus causing soil erosion. Local plants & animals, as well as ecological environment & natural landscapes, will also see a adverse impact.

(3) In construction activities such as road construction, material transport, tower foundation construction, tower assembly, wire & grounding wire erection, and cable-laying,

the waste water, dust and noise produced might destroy local environment.

(4) The installation of transmission lines will bring safety risk, and may cause power outages. This will bring an impact on local power grid's operation;

b) Operation period

(1) In the process of power transmission or voltage conversion, power frequency electric field and power frequency magnetic field can be formed. These will cause interference to the local radio, affecting the normal operation of wireless communications, information technology and medical equipment in the surrounding environment;

(2) During the operation period, the corona generated in adverse weather will cause audible noise;

(3) Transmission lines and transmission towers may cause local birds to get electric shock;

(4) The structure of the transmission line may affect the local landscape;

](5) The maintenance personnel may cause damage to the local ecological environment;

(6) Improper erection of transmission lines may cause fire, electric shock and other risks, endangering public property and safety.

Potential environmental and social impacts associated with the 110kV transmission line are shown as follows:

Table 8-1 Overview of potential environmental impact of the 100kV transmission line

Aspects	Potential impact
I. Construction period	
Soil and water loss	Construction activities such as excavation and filling will cause the loss of land and water.
Ecology	The construction will lead to damage of local vegetation and habitats of local terrestrial animals.
Air quality	Dust from construction and transportation activities may result in deterioration of air quality near the construction site or along the transportation route.
Acoustic noise	Construction activities such as excavation will cause acoustic noise.
Water quality	Sewage brought by construction activities, if not properly treated and discharged, may deteriorate the water quality of the local river.
Solid waste	Solid waste from construction activities, if not properly treated, may worsen the water quality of the local river.
Construction safety	When transmission lines are crossed, there may cause power failure and interference to local power grid.
Cultural heritage	Cultural heritage which may be found in construction site might be damaged.
II. Operation period	
Ecology	In maintenance of transmission line, the maintenance staff may destroy the local ecological system..

Aspects	Potential impact
Solid waste	When the weather is not good, there is the possibility that noise might by generated by the corona.
Magnetic radiation	In voltage change or electro-transfer, the magnetic radiation will produce the power frequency electric field & magnetic field. Magnetic radiation will bring an impact on the local environment and residents, as well as wireless signal, local communication, IT equipment and medical equipment.
Public health and safety	The transmission line installed will be ignited or catch fire during the operation period. This will bring harm to public assets & public security.

8.1.2 Environmental and Social Management Measures

We have formulated following environmental-social management framework for construction and operation period of the transmission line, which can provide reference in EIA and project preparation in the future.

Table 8-2 Environmental and social management framework for construction and operation period of the transmission line project

Environmental/social factors	Potential impact/issues	Mitigation measures / action plan	Implementing agency	Oversight bodies
I Construction period				
Land requisition and resettlement	The project will occupy a certain amount of land, thus affecting the lives of surrounding residents. However, as the project design has not come out, the project impact is yet to be determined.	Optimize the project line, reduce the area, and avoid crowded areas as far as possible. The construction of transmission line project will be implemented by local power sectors. Its implementation shall be in accordance with Chinese laws and regulations, and relevant resettlement plan on shall be prepared and implemented.	Project implementation department, local government	Government at a higher level, local land department
Water and soil erosion and ecology	The project may destroy the original topography and land vegetation, thus causing soil erosion. In addition, construction activities may also cause disturbance and destruction of the living environment of local wildlife.	● Avoid natural protection area and environmental sensitive areas as far as possible, and make full use of existing road as far as possible. ● Use height-span to avoid the felling of trees in forest region; use cast-in-place concrete pile in iron tower foundations; use temporary frames to avoid the disturbance of vegetation. ● In construction of tower foundation, topsoil and deep soil shall be separately piled up. In backfilling, fill the deep soil first. Smooth the redundant mellow soil around the tower foundation. Timely restore the vegetation. ● Avoid the rainy and windy weather in construction to reduce soil and water erosion. ● Strengthen the training of construction staff, strengthen the environmental management, strictly control the scope of construction, and standardize construction activities. Wildlife hunting is prohibited.	project owner, project contractor, construction supervisor	Municipal water resources bureau, Municipal EPA

Environmental/social factors	Potential impact/issues	Mitigation measures / action plan	Implementing agency	Oversight bodies
Ambient air	The dust caused by construction activities will have a certain impact on local air quality.	● The accumulation slope for soil materials should not be too steep. The dump site should be timely compacted. In sunny & windy days, open-air soil materials shall be properly humidified. ● For centralized area of excavation, take dust suppression measures in non-rainy days. ● Avoid the windy weather in construction. ● Install closed fence in sensitive receptors of the construction site in accordance with the forecast of EIA.	project owner, project contractor, construction supervisor	Municipal EPA
Acoustic noise	The noise caused by the construction activities will have a certain impact on the residents along the construction area.	● Strictly implement existing standards for construction machinery and noise control. ● Forbid construction activities of high noise at night in residential area. ● Install sound barrier and other temporary engineering measures in surrounding sensitive receptors in accordance with the forecast of EIA.	project owner, project contractor, construction supervisor	Municipal EPA
Water quality	Domestic sewage and waste water in the construction period, if untreated, may pollute the local groundwater.	Install sedimentation tank at construction site and construction camp to properly treat the wastewater before discharging.	project owner, project contractor, construction supervisor	Municipal EPA
Construction safety	The installation of transmission lines will bring safety risk, and may cause power outages. This will bring an impact on local power grid's operation.	Strengthen construction management and strengthen safety education and training for construction staff.	project owner, project contractor, construction supervisor	Electric power administration department
Material& cultural resources	The excavation work might damage valuable underground relics or art ware.	If any historical or cultural resources are found, cease the construction immediately and take protection measures.	PMO, project contractor, construction supervisor	County-level Press and Publication Bureau, Municipal Bureau of Cultural Relics
II Operation period				
Ecology	The maintenance personnel may cause damage to the local ecological environment.	Strengthen the education and training of the maintenance personnel and strengthen their awareness on ecological protection.	Electric power administration department	Municipal EPA
Acoustic noise	During the operation period, the corona generated in bad weather will cause	- Avoid resident areas and other environmental sensitive receptors. -Optimize design; chose high-voltage electrical equipment & conductors;	DI, project owner, project contractor, construction	Electric power administration

Environmental/social factors	Potential impact/issues	Mitigation measures / action plan	Implementing agency	Oversight bodies
	audible noise.	increase the equivalent radius of the wire; take verification measures of corona in sunny days.	supervisor	department
Solid waste	Maintenance personnel may live domestic waste in his working area.	Maintenance personnel are required to take the domestic waste away from the working area.	Electric power administration department	Municipal EPA
Electromagnetic radiation	In transmission of electrical energy or voltage conversion, power frequency electric field and power frequency magnetic field will be produced, thus causing electromagnetic radiation and affecting the surrounding environment and residents. Besides, it may cause interference to radio, affecting wireless communication and medical instruments in surrounding environment.	● Chose reasonable route and path: try avoid the resident area and other environmental sensitive receptors. ● Chose equipment and accessories with low power frequency electric field & low power frequency magnetic field, and low radio interference level; take necessary shielding/sealing measures for high-power electromagnetic devices. ● Increase overhead height of the transmission line. Install shielding wire in places with good shielding effect to avoid the interference on communication system.	DI, project owner, project contractor, construction supervisor	Electric power administration department
Public health & safety	Improper erection of transmission lines may cause fire, electric shock and other risks, endangering public property and safety.	● The erection of transmission line shall meet the requirement stated in Design Code for Overhead Transmission Lines (110~750kV) ●Strengthen inspection & maintenance work in operation period.	DI, project owner, project contractor, construction supervisor	Electric power administration department

8.2 Environmental Management of Tempoary Works

8.2.1 Impact of road works and mitigation measures

Due to the large amount of earthwork volume & high construction intensity, road transportation is chosen. On the left and right bank of the dam's downstream/upstream section, roads leading to the working face of construction are arranged. The road is 13.50km long in the site, of which approach road totals 1.30km (permanent road), covering lands such as dry land, woodland, land for transport, inland river flat, and vacant land. In addition to access road, the cultivated land & woodland occupied by temporary construction roads will be recovered by measures such as topsoil stripping and backfilling, land rehabilitation and vegetation restoration. In addition, according to the requirements of field-lifting area and farming, rehabilitation measures shall be taken to roads for transporting (7.5km) which is inundated by the reservoir.

Environmental impact of road works is mainly concentrated in the construction period. Therefore, its relevant environmental impact and mitigation measures are analyzed as follows:

Table 8-3 Impact and mitigation measures of road works

No.	Environmental factors	Main environmental impact	Mitigation measures
1. Construction period			
2	Air quality	Dust generated by road construction will bring an impact on ambient air quality, including concrete mixing, mechanical operation, soil excavation, land leveling, material handling, stacking and other construction works.	Concrete mixing station shall be equipped with filter so as to make the dust discharged meet national demand; certain emission reduction measures shall be taken, including sprinkling, installation of aprons & tarpaulins. Management of transport vehicles shall be strengthened by limiting overloaded vehicles, speed limiting, watering, and covering of transport materials.
3	Acoustic noise	Noise made by vehicles on the access road may affect the normal life of the surrounding residents, including those in Yakou Village & Maocao Village.	Try to use low-noise vehicles as far as possible; take greening measures and strengthen & vehicle maintenance to reduce noise; strengthen the management of vehicles: In roads close to the residential areas, limit the speed and prohibit making loudspeakers. In access roads & intersections of temporary roads, install warning signs and speed restriction board.
4	Water quality	Alkaline wastewater produced by concrete processing, oil-containing wastewater produced by mechanical operation, and domestic sewage discharged by construction camps, if not properly treated, will bring an impact on ambient water quality. Piling and construction in bridge works will also bring an impact on ambient water quality.	The waste water generated by concrete processing system will be treated and used for dust fall. The amount of domestic sewage is small. After treatment, the water 15m from the outlet can meet the Class-III requirement in Environmental Quality Standard for Surface Water. The amount of oil-containing wastewater is small. It will be discharged after simple treatment.
5	Solid waste	Waste from construction activities and construction camps will bring an impact on environmental quality without proper treatment.	The amount of construction waste shall be strictly controlled in accordance with construction plans and operating procedures. The surplus materials should be orderly stored for future use.
6	Soil and water loss	The temporary & permanent road of the project is 13.5km long. Excavation work will directly damage the surface, leading to changes of ecosystem, atrophy & degradation, or soil erosion; the bridge works will also cause soil erosion to some extent .	Drainage system shall be installed on both sides of the temporary road. For construction road and permanent road, slope protection measures shall be taken, including the planting of avenue trees and frame protection. After the construction is completed, temporary roads shall be immediately cleaned and rehabilitation measures shall be taken in accordance with site conditions.
		The spoil of the project may cause soil erosion during its disposal.	Use waste dump designed for the project for disposal. Use retaining wall, drainage systems, and plant vegetation for protection.
7	Ecology	The construction of the project will lead to damage of local	According to regional characteristics of vegetation, vegetation restoration measures

No.	Environmental factors	Main environmental impact	Mitigation measures
		vegetation and habitats of local terrestrial animals. However, the species affected are common species. Besides, the scope of affection is small & temporary, and will gradually disappear.	shall be taken on both sides of the road.
8	Cultural heritage	Cultural heritage which may be found in construction site might by damaged.	If any cultural relics or historic sites are found, the contractor shall immediately protect the scene and report to construction supervisor as well as local heritage preservation department. Before the approval of competent authorities, the construction work at the scene shall not start.
9	Occupation of land	Temporary and permanent land occupied by the project would change its original function.	After completing temporary works, the temporarily occupied land shall be restored to its original use as soon as possible; for permanently occupied land, compensation work shall be taken in accordance with the RAP.
Operation period			
10	Acoustic noise	Vehicles on permanent road may cause some noise on the surrounding environment, but the impact is small.	Strengthen traffic management measures on vehicles. For permanent roads close to residential areas, arrange warning board and speed restriction board.
11	Air	Emission from vehicles on permanent road may cause air pollution on surrounding environment.	Strengthen traffic management measures on vehicles. Restrict overloads & over-speed, and take watering measures to reduce the amount of dust.

8.2.2 Impact of material sites and mitigation measures

The amount of stone required by the project is approximately 583,600 m³, of which the left-bank accounts for 132,100 m³, and the right-bank accounts for 451,500 m³. The stones are mainly used as backfill materials of main works, gabion materials, and interception materials for cofferdam. The stone of the project is obtained by outsourcing. The stones of left-bank will be purchased by Jingniu Quarry. The prevention of soil erosion shall be implemented by the selling party.

The sand & gravel of the project will be obtained from sand field (We recommend Longmentan Sand Field). The aggregate processing system will be arranged 1km away from the downstream of right bank. Production capacity of the aggregate processing system is 400t / h (design criteria: three-graded concrete aggregate).

The project would take from the borrow area 191,200 m³ of soil. Wherein the left-bank needs 88, 000 m³ of soil from Yakou Borrow Area, and the right-bank needs 103, 200 m³ of soil from Luojiazhuang Borrow Area. The project owner shall be responsible for environment protection and management.

Environmental impact of this work is mainly concentrated in the construction period. Therefore, its relevant environmental impact and mitigation measures are analyzed as follows:

Table 8-4 Impact of stockyards and mitigation measures

No.	Impact factors	Main environmental impact	Mitigation measures
1. Quarry & aggregate processing system			
1	Air	The main source of atmospheric pollutants include mining dust, dust in processing sand, transportation dust, and dust from loading and unloading. Gas and dust emissions caused by construction activities will affect the ambient air quality.	Sand dust generated by sand mining shall be controlled by wet operation. Install sprinklers for crushing and screening process. Take watering measures for dust suppression on the road. Take covering & watering measures for dust control of the quarry and sand field. We suggest that manufacturers adopt multi-time transportation for raw materials, and reduce the stack time of raw materials.
2	Acoustic noise	The noise comes mainly from sand & stone processing equipment, forklifts, which may bring impact on the daily life of the local residents.	Try to use low-noise vehicles as far as possible. Take soundproofing & and vibration reduction measures. Pay attention to daily maintenance of equipment. Construction work shall not be implemented at noon or night.
3	Water quality	Wastewater from the aggregate processing system, if left untreated, may affect ambient water quality.	Wastewater shall be treated in sedimentation tank and reused. It will not be discharged. Storage areas for raw material & finished goods shall install wastewater collection system. The wastewater will be treated in the sedimentation tank before reusing. Flood-diversion trench will also be installed to prevent water and soil loss. Rainwater will be collected into the sedimentation tank, and be reused or discharged after precipitation.
4	Solid waste	Without proper treatment, waste from construction activities and construction camps will bring an impact on environmental quality.	Sediment shall be regularly cleaned and piled up in storage yard after filter press. The storage yard shall be able to store sediment for at least 3 years. After completing the project, land reclamation measures shall be taken to restore its ecology. The domestic waste shall be regularly treated local sanitation department.
5	Ecosyste m	Sand mining operation will destroy the benthos and affect the surrounding living beings to some extent.	Sand mining operation shall be implemented in strict accordance with the design plan.
6	Environm ental risk	The overflow of wastewater from sedimentation tank will cause environmental problems.	Regularly clean the sedimentation tank to ensure a sufficient volume of space. Construct diversion trench and canopy to prevent rainwater from entering into the sedimentation tank.
2. Borrow area (for soil)			
1	Land occupatio n and resettleme	The project will cause permanent & temporary land occupation and will lead to resettlement.	Prepare resettlement plan and put it into practice in accordance with Chinese laws and regulations.

No.	Impact factors	Main environmental impact	Mitigation measures
	nt		
2	Air quality	Gas and dust emissions caused by construction activities will affect the ambient air quality.	Install shielding walls or shutters no less than 2m high and dust-proof net. Take watering measures to control dust. Vehicles coming out of the construction site shall be cleaned & covered. Earthwork at the storage area shall be compacted and covered to prevent dust.
3	Acoustic noise	Construction noise may affect the daily lives of residents nearby.	The distance from the excavation site of the borrow area to residential area shall not be less than 200m; use low-noise equipment and place them in proper place; take sound insulation and shock absorption measures.
4	Solid waste	Solid waste from construction activities, without proper treatment, may have adverse effects on the surrounding environment and water quality.	Under the principle of "recycling, reducing, and detoxification", earnestly implement the requirements for sorting, collection, treatment and disposal of solid waste.
5	Water and soil conservation	Land filling will increase the risk of soil and water loss.	After completing temporary works, the temporarily occupied land shall be restored to its original use as soon as possible; for permanently occupied land, compensation work shall be taken in accordance with the RAP.
6	Ecology	The construction of the project will lead to damage of local vegetation and habitats of local terrestrial animals.	Reclamation measures shall be taken, such as the stripping-off of topsoil, backfilling and re-cultivation. If the topsoil will long be stacked up, sow white clover seed on its surface.
7	Cultural heritage	Cultural heritage which may be found in construction site might be damaged.	If any cultural relics or historic sites are found, the contractor shall immediately protect the scene and report to construction supervisor as well as local heritage preservation department. Before the approval of competent authorities, the construction work at the scene shall not start.

8.2.3 Impact of the spoils sites and mitigation measures

According to terrain conditions of the construction site and layout of the project, 2 waste dumps will be arranged. The left-bank waste dump will be located on Grade-I terrace at downstream of the dam (close to Yakou Village); the right-bank waste dump will be located on Grade-I terrace near the dam (close to Maocao Village & Heluo Village). The right-bank waste dump will also be used as stockyard and construction-arrangement area. The land types of waste dump include dry land, forest land and inland river flat.

Construction activities around the waste dump will change, damage or bury the original landscape and vegetation, and change the landforms and the conditions of runoff.

If drainage and protective facilities are not arranged, in rainy season, surface erosion, gully erosion and debris flow will increase the risk of soil and water loss. This will not only impact on the surrounding ecological environment, but also block the water channel, thus affecting flood flowing.

Environmental impact of waste dump is mainly concentrated in the construction period. Therefore, its relevant environmental impact and mitigation measures are analyzed as follows:

Table 8-5 Impact of waste dump sites and mitigation measures

No.	Impact factors	Main environmental impact	Mitigation measures
1. Construction period			
1	Land occupation and resettlement	The project will cause permanent & temporary land occupation and will lead to resettlement.	Prepare resettlement plan and put it into practice in accordance with Chinese laws and regulations.
2	Air quality	Transportation, stacking and construction activities will generate a lot of dust, thus having an impact on ambient air quality.	Dust control measures shall be taken, including sprinkling, installation of aprons & tarpaulins. Management of environment & transport vehicles shall be strengthened by limiting overloaded vehicles, speed limiting, watering, and covering of transport materials.
3	Acoustic noise	Noise made by vehicles on the road may affect the normal life of the surrounding residents, including those in Yakou Village & Maocao Village.	Try to use low-noise vehicles as far as possible; take greening measures and strengthen & vehicle maintenance to reduce noise; strengthen the management of vehicles: In roads close to the residential areas, limit the speed and prohibit making loudspeakers. In access roads & intersections of temporary roads, install warning signs and speed restriction board.
4	Solid waste	Construction produces a variety of wastes, thus affecting the surrounding environment quality.	The amount of construction waste shall be strictly controlled in accordance with construction plans and operating procedures. The surplus materials should be stored in an orderly way and reused.
5	Soil and water loss	The spoil of the project may cause soil erosion during its disposal.	Use retaining wall for the protection of waste dump. Besides, use drainage systems, and plant vegetation for protection.
6	Ecology	The construction of the project will lead to damage of local vegetation and habitats of local terrestrial animals.	According to regional characteristics of vegetation, vegetation restoration measures shall be taken.
		It is difficult for plants in the top soil of the spoil area to restore in a very short period of time, as the spoil area is a mixture of stone, gravel, and weathered materials.	The top soil is mixed with the base material for greening, so as to reduce the use of top soil. For main works, consider the rehabilitation of the top of the waste dump. Plant poplar trees to fix the waste residue and enhance stability.

No.	Impact factors	Main environmental impact	Mitigation measures
7	Heritage conservation	Cultural heritage which may be found in construction site might by damaged.	If any cultural relics or historic sites are found, the contractor shall immediately protect the scene and report to construction supervisor as well as local heritage preservation department. Before the approval of competent authorities, the construction work at the scene shall not start.
8	Occupation of land	Temporary and permanent land occupied by the project would change its original function.	After completing temporary works, the temporarily occupied land shall be restored to its original use as soon as possible; for permanently occupied land, compensation work shall be taken in accordance with the RAP.

8.2.4 Impact of worker camps and mitigation measures

The peak number of construction staff is 2,100 and the construction lasts 4 years and 10 months. The area for construction camps, office buildings and ancillary facilities totals 12,600 m².2 construction camps & office buildings will be arranged, which are located at temporary-building area of the left and right bank. The production and living water are taken from the Han River by the water pump station on the left and right bank. There is a Denglin Substation (110kV) which is 3 km from the left bank, and there is a Zhengji Substation (220kV) which is 7km away from the right bank. The electricity needed in construction period can be supplied by the two substations.

The dense population of construction staff will demand large-scale logistics service, which will provide employment opportunities for local residents. However, if basic sanitation facilities are insufficient, it will bring a certain impact on regional environmental health, population health and social environment. Environmental impact of construction camp is mainly concentrated in the construction period. Therefore, its relevant environmental impact and mitigation measures are analyzed as follows:

Table 8-6 Impact of construction camps and mitigation measures

No.	Impact factors	Main environmental impact	Mitigation measures
1. Construction period			
1	Acoustic noise	As the number of construction staff increase, human activities will bring impact on the quality of regional sound environment.	Vehicles without permission are not allowed to go out after 22:00, and construction time shall be reasonably arranged to avoid acoustic noise.
2	Domestic sewage	The amount of domestic sewage from washing, bathrooms and dining room is 420m³/d. If left untreated, it will have a certain impact on the water quality of the river.	We recommend that a complete set of domestic sewage treatment equipment be used for water treatment. Compared with septic-tank, the treatment equipment we recommended is of higher cost. However, it owns high processing efficiency, small footprint, and is reusable.
3	Solid waste	onstruction waste & domestic waste (1.3t/d), if discarded without treatment, have a adverse impact on the environment.	The amount of construction waste shall be strictly controlled in accordance with construction plans and operating procedures. The surplus materials should be stored in an orderly way and reused. After sorting, the

No.	Impact factors	Main environmental impact	Mitigation measures
			domestic waste shall be treated at landfill sites of Yicheng City.
4	Soil and water loss	Site excavation will directly destroy the land surface, resulting in the change of ecological system and increasing the risk of soil erosion.	Arrange drain ditch around the construction site. The hard surface shall be reinforced by concrete or paving tile. As to greening and beautifying, consider ornamental plants such as trees and shrubs.
5	Ecology	The construction of the camp will destroy the living environment of wild animals, which will lead to the change of their habitat. Construction staff may catch snakes, frogs and other wild animals, leading to the destruction of wildlife resources.	Distribute handbook of ecological environment protection to construction staff, and set up warning signs on ecological environment protection to raise their awareness of ecosystem protection.
6	Heritage conservation	Cultural relics or historic sites might by found during the construction process.	If any cultural relics or historic sites are found, the contractor shall immediately protect the scene and report to construction supervisor as well as local heritage preservation department. Before the approval of competent authorities, the construction work at the scene shall not start.
7	Public health	The considerable amount of construction and migrant workers will increase health risks to local residents.	Sanitation measures shall be taken to reduce the density of pathogenic microorganisms and insect-pollinated animals in construction area. Construction staff and management personnel entering the construction area shall undergo health quarantine to prevent the spread of disease.
8	Site clearing before demobilization		Disinfection of toilet, land improvement, and vegetation restoration.

9. Impacts of Resettlement Areas and Mitigation Measures

9.1 Impact Assessment

The Yakou porject and reservoir inundation will involve 8 towns (sub-district) and 36 villages in Yicheng city, Xiangcheng District, Xiangzhou District under the jurisdiction of Xiangyang Municipality. Since the resettlement areas are mainly artificial woodland and farmland, the house and infrastructure construction in the resettlement area will bring some impact on resettlement area and the ecological environment.

The resettlement planning includes resettlement of affected residents and production. Resettlement of production: by compensable transfer of land, the affected residents who demand production resettlement will get cultivated land, the size of which will not be less than that of the original one. House relocation involves centralized relocation and decentralized relocation. 35 residential buildings will be relocated, among which 17 residential buildings in Yakou Fisherman's Cooperative will undergo centralized relocation, and 18 residential buildings will undergo decentralized relocation. There are 2 households which hope to get house-building plot to build their houses, while others hope to get cash compensation to buy houses. The resettlement area is located in Group 4, Yakou Village, which is about 800m away from the area of the houses to be demolished. The relocation sites are mainly dry land, enjoying convenient communications and stable geological conditions.

Figure 9-1 Location of resettlement site and its design (preliminary)

The resettlement area is mainly occupied by shrubs such as *broussonetia papyrifera, vitex, cynodon dactylon, alternanthera sessilis, and artemisia lavandulaefolia*. Therefore, the construction of the resettlement area will not have significant impact on plant resources.

Potential environmental and social impacts of the resettlement area are shown in Table 9-1.

Table 9-1 Potential environmental and social impacts of the resettlement area

Items	Potential environmental & social impacts
I. Construction period	
Impact on terrestrial vegetation	The resettlement area is mainly cultivated land (dry land), and some construction land and forest land. The impact on ecological environment is

Items	Potential environmental & social impacts
	mainly shown in the loss of biomass caused by the damage of plantations and cultivated land.
Animal	This impact is mainly shown in occupation of animal habitat caused by newly-built houses. The resettlement area can provide new source of food and shelters to the animals affected. Therefore, there is only slight impact on their survival.
Soil and water loss	Construction activities such as excavation and filling will increase the risk of soil erosion.
Air quality	Dust from construction and transportation activities may result in deterioration of air quality near the construction site or along the transportation route.
Acoustic noise	Construction activities such as excavation, piling & transportation will cause acoustic noise.
Water quality	Sewage brought by construction activities, if not properly treated and discharged, may deteriorate the water quality of the local river.
Solid waste	Solid waste from construction activities, if not properly treated, may worsen the environmental quality.
Cultural heritage	Cultural heritage which may be found in construction site might be damaged.
Social impact (traffic safety)	Construction activities will increase the risk of traffic accidents.
Vulnerable groups	The construction activities will increase the traffic volume, thus increasing the risk of vulnerable groups. Residents' activities in the resettlement area will bring impact on animals nearby and protected areas.
Woman	As women are less involved in training and working, their real needs may be overlooked, such as: The appearance & arrangement of the house; women are more subjected to debt. Women-dominated households may be more vulnerable in the resettlement.
Local residents	Following the resettlement, the area of land per person will be reduced, increasing the pressure on public infrastructure and services; besides, the allocation of public resources will also be a problem.
II. Operation period	
Water quality	The domestic sewage, if not appropriately treated, will worsen the water quality of local river.
Solid waste	The solid waste, if not appropriately treated, will worsen the quality of local environment.
Ecology	Relocated people's daily activities may bring damage to wildlife habitats & nature reserves nearby.
Pest control	562.9mu of cultivated land have been planned to improve the planting structure of the resettlement area. Pesticides may be used in pest control of

Items	Potential environmental & social impacts
	rice and other crops. Improper pest control may cause environmental pollution.
Social impact	Quality of life: the project will not have an impact on the PAP's way of life and livelihood; however, the PAP's living environment and traffic conditions will be significantly improved.
Public health	In reservoir impoundment, the waste from the toilet, pen barn and the Cemetery in the flooded area will lead to water pollution not properly treated; increased water area will increase the population of mosquitoes and mice, increasing the risk of infectious diseases.
Community organization	The resettlement may affect the integrity of the local village and change the local community's organizations; the PAP may face a series of relevant problems.
Traditional culture	Family ties may be affected by the resettlement.

9.2 Environmental protection measures for resettlement area

The Article 31 of the Land Administration Law of PRC stipulates that (August 1998): The State fosters the system of compensations to cultivated land to be occupied. In the cases of occupying cultivated land for non-agricultural construction, the units occupying the cultivated land should be responsible for reclaiming the same amount of land in the same quality as that occupied according to the principle of “reclaiming the same amount of land occupied". Whereas units which occupy the cultivated land are not available with conditions of reclamation of land or the land reclaimed is not up to requirements, the units concerned should pay land reclamation fees prescribed by provinces, autonomous regions and municipalities for reclaiming land for cultivation the land reclaimed. We should rationally use land resources according to the principle of resettlement planning. We should fully protect the environment and strictly prohibit random reclamation and felling. We should promote courtyard greening and adjust the planting structure to restore the living standards of relocated people in a short time.

The compensation for reservoir inundation, water and soil conservation and environmental protection are important in ensuring the smooth implementation of resettlement and soil protection. Therefore, local government and relevant departments should strengthen the supervision and management of the use of resettlement funds, so as to ensure the use of funds as ear-marked.

9.2.2.1 Domestic sewage treatment

a) Wastewater

Due to poor economic development, the domestic sewage of the resettlement area is mainly from human and animal manure. As farmers use them as farm manure, there is less direct discharge and less impact on the water environment.

b) Plan selection

The domestic sewage in the resettlement area will be treated by the sewage treatment plant or the biogas tank, and the domestic sewage of relocated people buying/building

houses in the urban city will be incorporated into regional sewage treatment system.

For domestic sewages from concentrated resettlement area, use unpowered treatment equipment for centralized processing. The effluent water after treatment can be used in surrounding cultivated lands or garden plots.

For domestic sewage from decentralized rural resettlement areas, we use biogas pool for treatment. Each rural relocated household will arrange a biogas tank (8m3). The organic component from the sewage can be degraded, and the harmful bacteria are killed in the high-temperature environment of the biogas tank. The biogas tank preliminarily digesters the sewage and provide fuels for the relocated people. Besides, the flushing and transudates of the biogas tank can be used as farm manure, saving a part of fertilizer costs.

9.2.2.2 Domestic waste treatment

Bio waste generated in domestic life can be fermented in the biogas tank. Meanwhile, we propose to build a waste transfer station for each of the resettlement area for storing the biochemical waste. Sanitation department will carry out the waste lorry work regularly.

9.2.2.3 Ecological environmental protection measures

a) Vegetation protection measures

In construction, greening and farmland protection measures shall be taken in resettlement areas to avoid the impact on forest vegetation.

The biogas tank can be used for sewage treatment and fuel, thus reducing the demand for fuel wood. Therefore, this will further reduce deforestation.

Strengthen the forest protection project and prohibit deforestation. After the completion of resettlement houses, encourage farmers to develop courtyard economy by planting trees around the house.

b) Protection measures for terrestrial animals

Carry out ecological education in the resettlement area. On one hand, forbid the killing of wild animals; on the other hand, control the use of chemical fertilizers and pesticides.

9.2.3 Health protection measures for resettlement area

a) Protection measures for drinking-water source

To protect drinking-water sources, the following measures shall be taken: Set up clear signs in wells/water tunnels, and delineate the scope of cleaning. Within 30m of the wells, no residential housings, pens, toilet or sump are allowed. Within 5m of the wells, no toilet brushing, washing, or livestock drinking are allowed. For newly-built wells, dry up the well and use chlorine for disinfectants; carry out cleaning 1-2 time every year during its year of service.

The following measures should be taken to protect the underground drinking-water source of relocated people: For concentrated resettlement area, build water-storage tanks; for decentralized resettlement area, build specialized water facilities.

b) Control measures for epidemics

The main measures to be taken include: Take a sampled health monitoring of the

project affected people before/after the construction and during the construction period; carry out sanitation & cleaning work; carry out education on health and epidemic prevention through promotional materials, radios and conferences.

Carry out planned and large-scale de-ratting activities to reduce the rat density to a safe level. Put toxicant bait for de-ratting of the resettlement area 2 times a year. Distribute the de-ratting pellets (1kg/40 people). Strengthen the management of manure matters in rainy season to prevent it from overflow. To prevent Encephalitis B, we should carry out anti-mosquito and pest control activities.

To prevent infectious disease, anti-mosquito and pest control activities shall be taken. Newly-built house should pay attention to ventilation and light transmission; house, toilet, and pens for livestock shall be separated; remove construction waste and fill up the ditch; spray anti-mosquito drugs to eliminate the breeding ground of mosquitos. Encourage people to hang mosquito nets in summer and autumn days.

Carry out sanitation management in the resettlement area; make planning for drinking water; make regular monitoring of drinking-water sources.

10 Social Impact Analysis and Mitigation Measures

Based on Social Assessment report prepaerd by Wuhan University, this section summarizes the key findings and recommendations of the report.

10.1 Survey on willingness of resettlement

Early in September and October of 2015, relevant departments have organized and held the discussion meetings to hear the willingness of PAPs: Most of the local residents are supportive of the project, and they believe the project has little impact on their income. Most of the PAPs in the reservoir area are supportive of the project and believe that the project will help develop the local economy; 74% of the PAPs chooses centralized resettlement (adjusting cultivated land) while 26% of PAPs chooses secondary or tertiary industries for resettlement.

In-home visit for gathering opinions and suggestions

Explanation of the resettlement policies and views hearing

Figure 10-1 Survey on willingness of resettlement

10.2 Analysis of Social Impacts

10.2.1 Positive Impact of the Project

10.2.1.1 Positive impact on regional economy

This is a comprehensive water resource utilization and development project. A waterway will be formed and a dam will be constructed for power generation. Although the profitability of the project is restricted to a large extent by the feed-in tariff and debts must be paid during project construction and operation, this project, as a large public infrastructure project, will promote waterway upgrade and local economic development and therefore create huge social benefits.

a) Benefit of shipping

Han River is an important part of the main waterway network of Yangtze River. The development of Han River is of great significance to national inland river shipping industry. The Planning Report on Comprehensive Utilization of Water Resources of Yangtze River

(State Council, 1990, No.56) and Planning Report on Shipping of Han River (Hubei Province, 2003) both state that the waterway classification of Wuhan-Danjiangkou, Danjiangkou-Ankang shall be Class-III, Class-IV, respectively. After the project is completed, the shipping capacity of the river section upstream from the dam with length of 52. 67km will be promoted from 500t to 1000t. On one hand, the cost of waterway improvement and maintenance is decreased. On the other hand, this project lays a foundation for the formation of Danjiangkou-Xinglong waterway and helps to realize the 2020 waterway planning target of the mainstream of Han River.

After the project is completed, the shipping capacity of Han River will be greatly improved, and due to advantages of water transport (i.e., low cost, small coverage of land, large transport capacity and low consumption) part of bulk cargos such as coal and minerals may be transferred from land to water. As a result, the energy consumption will be decreased and the emission of harmful substances will be reduced. At the same time, the 52.67km waterway upstream from the project site will be formed and large ships are allowed to go through Han River. Total fuel consumption of ships will decrease by 30-40% and cost saving of water transport will create more economic benefits. Besides, the economic benefits from water & land transportation will facilitate the integrated development of transportation modes.

b) Power generation

Xiangyang Power Grid is the supply hub of Hubei Power Grid. With rapid economic development, the electricity consumption is fast growing. The power supply has been unable to meet the development of electricity load. The installed capacity of Yakou Power Plant is 74.2MW, and its guaranteed output is 19.0 MW. Its average annual generating capacity is 252 million kW · h. When completed, it will be able to ease the tension of power supply in Yicheng City & Xiangyang City. Besides, as the project is a hydroelectric project, it will be able to annually reduce 80,960 t of coal (equivalent to reducing 212,100 t of CO2 or 73,800 t of carbon), and 690t of SO2. Therefore, it brings massive benefits in energy saving and emission reduction.

c) Irrigation

In respect of agricultural production, after the project is finished, the normal water level of this section of Han River will be raised and the reservoir water can be used for irrigation for 80,000mu farmland at Liushui, Zhengji, Yancheng and Nanying. The insurances probability of irrigation water will get higher and irrigation cost will be decreased to facilitate the development of high-efficiency eco-agriculture. Besides, the project will correspondingly reduce the land occupation required by thermal power station, railway & coal mine construction. Furthermore, the PAPs will be able to carry out comprehensive planning and rational development of land resources and get the opportunity for non-agricultural industries. Finally, the broad water surface of the reservoir will provide good conditions for aquaculture. After its completion, the project can bring huge economic benefits for the residents.

d) Tourism

The project area is rich in tourism resources and enjoys convenient transportation. The completion of the project will bring more benefit for development of tourism resources. Close to Xiangyang, Yicheng City is surrounded by tourism resources such as Chu Imperial City, Ancient Longzhong, Old City Wall, and Yuliangzhou Scenic Area.

After the project is completed, the width of river course in this section will increase to 2-5km, water surface of the reservoir will reach 12,700 hectares, and the reservoir will join to Cuijiaying Hydropower Complex to form a beautiful natural scenery belt. Tourism and other related industries will be boosted and living quality of the residents on both banks will be improved. Meanwhile, the project will provide a new tourist route to Chu Imperial City and Ancient Longzhong.

e) Other economic benefits

1) Impact on Watershed (regional) Economic Development

This project will accelerate urban construction of Yicheng City, improve its investment environment and promote the economic development of Xiangyang City and even its upstream area.

The south of Shaanxi province is rich in water, mineral and biological resources but Hubei province has to import iron ore, petroleum and coal from other places, so they depend on the water transportation of Han River. Yakou shipping hub will improve the conditions of Yujiahu port and Yicheng port, facilitate the formation of the waterway from Wuhan to southwest Hubei province, promote the north-to-south coal transfer, and stimulate the economic development of Xiangyang City, Shiyan City and even south Shaanxi province and west Henan Province.

2) Mitigate the adverse impact of south-to-north water diversion

The south-to-north water diversion project results in the reduction of the amount of discharged water from Danjiangkou Reservoir the dry season (with water discharge of 800 m^3/ s) will be extended from current 3 months to 8 -10 months). This will have a huge impact the water use of middle & lower reaches of Han River. To solve the problem, China builds a canal in Hubei Province and Xinglong Hydropower project in Han River to directly supply the Han River from the Three Gorges Reservoir. However, this project only retains the water of downstream cities (such as Wuhan). The water problem of Xiangfan and other regions (from Danjiangkou-Xinglong) still exists. After the completion of the Yakou Navigation Complex, the adverse impact on Xiangfan area brought by south-to-north water diversion project will be minimized.

10.2.1.2 Positive impact on local community

After the project is completed, a 52.67km waterway will be formed. The shipping capacity of Han River will be greatly improved and the multi-modal transportation structure at this area will be more complete. For a long time, low shipping capacity of Han River led to low competitiveness and poor performance of shipping enterprises in this area, and most of their employees had a poor life. Yakou shipping hub will promote the development of shipping industry in Hubei province and bring new hope to the shipping enterprise in distress and their staff.

From the perspective of social harmony and stability, the construction and operation of this project and the development of related service industries will bring new jobs to local residents and attract some migrant workers back home. As a result, the incomes of local residents will be increased and local educational, cultural and health conditions will be improved.

10.2.2 Potential Impacts

The negative social impacts of the project are mainly brought by project construction, reservoir inundation, land occupation and resettlement. Besides, fishermen's livelihoods, vulnerable groups, women, community organizations, local residents and traditional cultures are also impacted.

10.2.2.1 Impact on the livelihoods of fishermen

a) Fishing of Yicheng section (Han River)

Relevant survey shows that in the fishermen in Yicheng section are divided into two types: Full-time fishermen and part-time fisherman. However, both do not come from professional fishing villages or fishing towns. Full-time fisherman mainly comes from the fisherman's cooperative of Yakou Village, Liushui Town. Currently, there are 17 households engaging in fishing activities. Field survey shows that there are no fisherman younger than 50. In Yakou Village, there remain only 2 men engaging in ferry work. The reason is this: since the late 1970s, the amount of fish resources sees great reduction, making it difficult to make a living; after rural reform in late 1970s, farmers get more opportunities to engage in non-agricultural activities. Since then, fishing as an occupation sees little social recognition.

b) Impact on fishery resources in Yicheng Section

The impacts area mainly in shown in following aspects:

First, after the construction of the dam, the habitat of commercial fishes will be obstructed, such as grass carp, silver carp, bighead carp, and triangular bream. The commercial fishes have to live in river channel or river bend.

Second, after the construction of the dam, the changes in hydrological conditions will be beneficial for the growth of filamentous algae and *limnoperna lacustris*, thus increasing the populations of fishes feeding on them. Besides, due to slight increase of plankton, the amount of fish feeding on the plankton will be reduced accordingly.

Third, after the construction of the dam, the spawning ground (in middle and lower reaches) for commercial fishes with pelagic eggs (including eggs with micro-viscosity) will no longer suit for spawning. Besides, due to short flow length in spawning ground of upper reaches, the incubation of fish eggs will be affected. The formation of navigation complexes in series makes it difficult to form new spawning grounds.

Fourth, after the construction of the dam, the population of fishes adaptive to open water will be greatly increased. The construction of the dam will bring some adverse impacts on the reproduction and growth of commercial fishes. However, it is beneficial for fish-overwintering and the growth of other types of fishes. As time goes by, the fishes will gradually adapt to the changed condition, and each maintain a certain population in middle and lower reaches of Han River.

c) Impact on fisherman in Yicheng Section

The impact can be summarized as coexistence of challenges and opportunities. The challenges:

(1) Reduction of fish stocks.

(2) Increase of difficulty in fishing.

New opportunities also rise as reult of the project.

(1) The development of reservoir fisheries can provide more job opportunities for fishermen.

(2) More non-agricultural job opportunities.

(3) The fishermen hope that the government/ project owner can throw in more minnows in the reservoir.

(4) The fishermen hope that the government can develop cage aquaculture to reduce losses.

10.2.2.2 Impact on vulnerable groups

Vulnerable groups are those who find it more difficult to adapt the changes brought by the project. Vulnerable groups include the elderly, single-parent households, households with minimum living guarantees, the disabled, and other needy families. According to our survey, there are 5 households (10 people) belonging to vulnerable groups in fisherman's cooperative of Yakou Village.

In the 6 towns of project affected area, the percentage of poor households (annual income below 3, 360 Yuan) in Liushui Town and Nanying Town is 7.95% and 6%, respectively. Annao Village (Nanying Town), Hanshui Village and Xinzhou Village (Wangji Town) are listed as poor villages in poverty alleviation program. Hanshui Village has no access roads to outside world, and there are three villages which do not have access to tap water.

The resettlement work for these vulnerable groups may face greater risks. First, these groups, due to their poor physical condition or earning capacity, may easily be overlooked in the process of resettlement. Second, the housing relocation and transformation will undoubtedly increase the pressure on their lives, making them more vulnerable than others. In addition, these groups do not have enough social support, making it difficult to complete the task of relocation and resettlement.

10.2.2.3 Impact on women

Generally speaking, women are part of vulnerable groups. Our survey shows that production and living conditions of the rural women in project affected area are very similar to those from the central and western regions. Its basic features: First, women play a major role in agricultural production. As a large number of men-labor is engaged in non-agricultural activities in urban or rural areas, women-labor shoulders most of the tasks in agricultural production. Second, more than 60% of the women choose to stay at home of their own accord. They are in favor of the idea of "men managing external affairs women internal". Third, interviews and household survey shows that almost all of the employment opportunities are male-preferred. In absence of job opportunities, 75% of respondents hold that men should first take the jobs available, while only 14% doesn't agree with this view.

The impact of the project on women: First, the land occupation (permanently or temporarily) will bring adverse impact on women involving in agricultural production. Second, as some business activities will be affected by the project, the job opportunities for women will also be impacted. For example, as some services in Happy-Fishing Restaurant were mainly provided by women, if the restaurant needs to be demolished, the women will loss their jobs. Third, in villages with developed vegetable cultivation industry, the jobs, such as production and transportation of vegetables are mainly borne by women. Therefore,

land occupation will affect the job opportunities of the women.

10.2.2.4 Impact on community organization

Our survey shows that the resettlement works are mostly completed within the original area, and the scope of relocation is not large. Therefore, this project brings no significant impact on the organization of the community.

10.2.2.5 Impact of construction

The construction will be taken at the place where the dam is located, involving 3 villages (Yakou Village, Liushui Town), Heluo Village & Maocao Village (Zhengji Town). Construction activities such as site excavation, land leveling, and material handling will produce a lot of dust, gas, noise and solid waste, affecting the daily lives & health of nearby residents; in addition, construction activities will also affect nearby traffic, causing traffic jams and affecting traffic safety.

In project construction, there will be a large number of out-and- in workers & staff. On the one hand, this will promote the development of tertiary industries such as catering & accommodation, increasing the income of local residents. Besides, the construction of supporting facilities will also benefit local residents. On the other hand, due to high population density, poor living facilities, and poor hygiene, it may lead to the spread of diseases such as: Typhoid, dysentery, hepatitis, sexually transmitted diseases and AIDS. Meanwhile, with the increase of temporary residents, public security & social order becomes a difficult problem.

10.2.2.6 Impact of reservoir inundation, land occupation & resettlement

A total of 99,495.03 mu of land will be inundated, among which the water area is 71,911.0mu, and the land area is 27,584.03mu. The land area is located between the embankments of Han River. In accordance with national law and classification criteria of land & resources, the lands within the embankments of Han belong to state-owned land for water conservancy facilities. However, within Yicheng City, as the area of tidal flats in embankments of Han River increases, these tidal flats are gradually developed into cultivated lands. The cultivated lands are then incorporated in Occupy-Fill Balance Plan of Hubei Province. In second round land contracting of 1990s, the cultivated lands are given to villagers. According to resettlement survey, the area of such lands is14,279.06mu. Yicheng City is a prefecture-level agricultural city. Inundation of land will reduce the agricultural income of local residents, thus affecting their livelihoods. The house demolition will also increase their cost of living.

10.2.2.7 Impact on local residents

Our survey shows that the vast majority of project affected households have varying amounts of cultivated lands (state - owned or collective land, or overflow land). Each household has an average of 14.41mu. The agricultural income of these households averages 78,804 yuan. As the project occupies the land, 64% of agricultural income will be affected.

10.2.2.8 Impact on minorities

According to the data provided by Population Reference Bureau of Yicheng City, the Han population accounts 99.7% of the total. Minorities (with a population of 0.12 million) account for 0.23% of the total, including Hui, Man, Zhuang, Miao, Li, Yao, Tibetan,

Mongolian, Tujia, Xibe and Uygur. The random survey of social assessment involves 431 households (1163 people), where the Han population accounts for 1163 people (100%). As no ethnic minority are found, so there is no impact on the minority.

10.2.2.9 Openness & transparency of public consultation

A successful implementation of the RAP needs the full participation and supervision of the public. The participatory process covers (1) information disclosure in project preparation phase; (2) land readjustment, house reconstruction and compensation in project implementation phase. Openness and transparency is a prerequisite to implement the RAP.

However, due to lack of capacity & channels, the effectiveness of public consultation is insufficient. The phenomenon is common in rural areas, where bottom-up feedback & consultation approach sees congenital deficiencies. And the participation right of rural residents is easily overlooked. If openness & transparency cannot be ensured in public consultation, the grievance channel of project stakeholders, resettlement targets, and affected residents will be blocked, thus preventing or delaying the smooth implementation of the RAP and the project.

10.3 Mitigation Measures

In response to these social impacts, a Social Management Plan (SMP) is prepared, as shown in Table 10.3.

10.3.1 Measures to Enhance the Positive Impact of The Project

10.3.1.1 Measures to enhance the positive impact on regional economy

The project will inundate 5 river flats, thus increasing the navigation level of the river section (upstream of the dam site, 52.67km) from 500t to 1000t (L3 channel). Total fuel consumption of ships will decrease by 30-40% and cost saving of water transport will create more economic benefits.

After implementation of the project, the total installed capacity of the power station will be 75.0MW, with an annual generation capacity of 252 million kW.h (considering own demand and transmission loss, the on-grid capacity will be 247 million kW.h.) The annual economic benefits brought by power generation are expected to be 58.15 million yuan.

After implementation of the project, the reservoir's normal water level will be 55.22m, corresponding to a storage capacity of 303 million m^3. This will raise the water level of the reservoir area.

After the completion of this project, the reservoir's channel width will be 2-5km, and water area will be 12,700 hectare. Considering the coexistence of Cuijiaying Reservoir, we will see a unique & delightful natural landscape.

10.3.1.2 Promote social development of local area

The construction of the project will provide a lot of job opportunities for local residents.

Besides, the project can directly or indirectly promote the development of infrastructure construction and related services industries.

After the completion of the project, shipping enterprises or workers will see a better

working environment. The government of this section can develop aquaculture and tourism industries, thus increasing the income of local residents.

10.3.2 Measures to Reduce the Potential Impact of the Project

10.3.2.1 Reducing the impact on livelihoods of fishermen

We give the following recommendations:

(1) Implement the fishing-off policy to maintain the ecological balance of Han River.

(2) Construct artificial fish-way and take fish-release measures to restore and protect fish species.

(3) After the project is completed, the local government shall increase its efforts in cage culture so as to restore the fishery industry of Yicheng Section.

(4) Protect the aquatic environment of the reservoir, and strengthen fisheries management.

10.3.2.2 Reduce the impact on vulnerable groups

For adverse impacts of the project, we give the following recommendations:

(1) In project construction and field-lifting, employ local labor as far as possible. Give preferences of the labor force from poor families (especially in odd jobs).

(2) The PMO and all construction agencies, in procurement of daily services or daily goods (such as grain, vegetables), shall give preference to the poor;

(3) Arrange job training for poor Individuals having the ability to work.

(4) While considering construction works, the PMO shall also arrange construction team to maintain or update the public infrastructures of project affected area(like roads, irrigation system). For poverty-prone villages, the PMO shall consider upgrading the rural road to improve their living & production conditions.

10.3.2.3 Promote the development of women

We give the following recommendations:

(1) Stimulate women's motivation in project participation.

(2) Give necessary training for women.

(3) Pay special attention to poor women.

10.3.2.4 Reduce the impact on local residents' daily life

We give the following recommendations:

(1) Transportation: Implement section-to-section construction to reduce the impact brought by traffic; set up road signs & speed limit; prepare contingency plans; raise residents' awareness of traffic safety by propagation.

(2) Noise: The Construction Company shall strictly abide by the requirements for construction noise and take measures to reduce noise; night construction with loud noises shall be avoided as far as possible.

(3) Dust, exhaust and garbage: watering the road on a regular basis to control dust; take regular cleaning & disinfection measures in temporary buildings and potentially

contaminated area.

(4) Disease control: Strengthen the disease control of project area (especially sexually transmitted diseases and AIDS); employ dedicated staff and management staff to carry out periodic health check and epidemic prevention; strengthen the workers' and managers' awareness of disease control by health education.

Establish an effective mechanism to solve the problems above.

10.3.2.5 Reduce the impact of reservoir inundation, land occupation & resettlement

We give the following recommendations:

(1) Give fair compensations for PAPs to help restore their living & production; provide necessary assistance for female-headed households and vulnerable households; provide labor training with the cooperation of local government; provide non-technical job opportunities for PAPs.

(2) Establish a complaint mechanism to address the problems in resettlement.

10.3.2.6 Reduce the impact on local residents

We give the following recommendations:

(1) Provide labor training with the help of local governments.

(2) Provide non-technical job opportunities for PAPs.

(3) Establish a complaint mechanism to address the problems in resettlement.

10.3.2.7 Strengthen public consultation

Establish an effective complaint mechanism and a public consultation plan.

Table 10-2 Social Management Plan (SMP) for Yakou Navigation Complex

Social factors	Potential impact	Mitigation measures	Time Arrangement	Budget (ten thousand yuan)	Implementers	Supervisor	Monitoring indicators	Frequency
1. Positive impacts								
Shipping	Improving the navigation capacity of Xiangyang section in Han River.	Positive impact, no mitigation measures required	/	/	/	/	/	/
Power supply	Meet regional power demand and promote sustainable economic development	Positive impact, no mitigation measures required	/	/	/	/	/	/
Irrigation	Improving depend ability of irrigation and reducing operating costs.	Positive impact, no mitigation measures required	/	/	/	/	/	/
Tourism	Promote tourism and related industries	Positive impact, no mitigation measures required	/	/	/	/	/	/
Employment, income	Increase employment opportunities and improve the income level of local residents	Positive impact, no mitigation measures required	/	/	/	/	/	/
2. Potential impacts								
Fishermen' livelihood	Factors such as reservoir operation may lead to reduction of fish population, affecting the income of fishermen	a. Implement joint operation to reduce the reverse impact; b. Consider measures such as habitat protection, fish passage facilities, artificial reproduction and releasing to reduce the impact brought by the blocking of the dam; c. Strengthen fishery management.	2016-2021	Included in the EIA	DI, PMO, Fishery Management Station, Animal Husbandry and Fishery Bureau, Agriculture Bureau	PMO, EIA agencies, Fishery Management Station	See monitoring indicators of aquatic ecosystem in the EIA	See monitoring frequency of aquatic ecology in the EIA
Vulnerable groups	Their interest easily to be overlooked; labor shortage, making it difficult to complete the relocation; low participation ratio; multiple difficulties;	a. Provide special assistance. For example, in cooperation with the Civil Affairs Bureau, set up a special support fund; b. Provide labor training and more employment opportunities for vulnerable groups; c. Provide more non-technical job opportunities for vulnerable groups; d. Provide	2016-2021	Included in the resettlement compensation and the special funds of Civil Affairs Bureau.	PMO, Construction Company, Civil Affairs Bureau, County-level Human Resources and Social Security Bureau, Agriculture Bureau, Village Committee	PMO, Civil Affairs Bureau, Supervisor, External Monitoring Agency	Extent of public consultation; number of people in non-technical positions; number of participants in training, as well as the number of	2 times / year

Social factors	Potential impact	Mitigation measures	Time Arrangement	Budget (ten thousand yuan)	Implementers	Supervisor	Monitoring indicators	Frequency
		housing subsidies to vulnerable groups； e. Help them select house-building plots and assist them in house moving and housing construction.					recommendations; subsidy for vulnerable groups; progress of relocation	
Women	Adverse impact on women involving in agricultural production and employment; land acquisition affects the employment opportunities for women; women's real needs and ideas are neglected in activities such as selection of houses & layout of kitchen	a. Consider needs and recommendations of women in project design ; b. Provide more non-technical job opportunities for vulnerable groups, including women; c. Provide job training for women; d. Shorten the length of the project; e. If reserved collective lands are available, give preferential right to married women in the project area.	2016--2020	Included in the special funds of resettlement and Women's Federation.	PMO, Women's Federation, Village Committee, Agriculture Bureau, Human Resources and Social Security Bureau	PMO, Women's Federation, External Monitoring Agency	The number of participants & frequency of discussion meetings; the number of women in non-technical posts; project progress; land compensation	2 times / year
Community organization	The resettlement will be completed within the original village, having no significant impact on the community organization.	No mitigation measures required	/	/	/	/	/	/
Project construction	The dust, exhaust, noise, solid waste produced by construction activities will be harmful to health; the travel and transportation activities of local residents will be affected; the project will be good for the development of accommodation, catering and other services; risk of disorder and spread of disease;	Traffic: a. Implement section-to-section construction to reduce the impact on transportation of the local residents; b. Disclose construction information in advance to make local residents be prepared; shorten the construction period under the premise of ensuring the project quality; c. add signs, speed limit and propagate traffic safety. Noise: a. Strictly implement noise standards and take measures to	2016-2020	Included in the cost for EIA	Implementation Unit, PMO, Healthcare and Medical Institutions, Centre for Disease Control	PMO, Supervisor, External Monitoring Agency, EPA, Disease Surveillance	See the EIA for monitoring indicators of traffic, noise, and dust; complaints and its treatment 况	Traffic, noise, dust and domestic waste: 3 times/year; disease control: as required by CDC; complaints: 2 times/year

Social factors	Potential impact	Mitigation measures	Time Arrangement	Budget (ten thousand yuan)	Implementers	Supervisor	Monitoring indicators	Frequency
		reduce noise. b. Avoid night construction as far as possible. Dust, exhaust, domestic waste: a. Carry out regular watering for access roads and construction road to control dust; b. Strengthen management for construction personnel and clean up the domestic waste in a timely manner. Disease control: a. Strengthen the propaganda & control of AIDS or sexually transmitted diseases; b. Carry out health education for construction staff. Complaint mechanism (see RAP and EIA)						
Inundation, land occupation and resettlement	The inundation covers 3 cities (districts), 8 towns and 34 villages, involving 91 people in 18 households. The area of houses affected is 13, 238.47m²; the inundation will affect 99, 495.03mu of land, including land area of 27,584.03 mu(865.27 mu of cultivated land, 660 people for livelihoods resettlement, and 91 people for relocation). Inundation of land will reduce the agricultural income of local residents, thus affecting their livelihoods. The house demolition will also increase their cost of living.	a. Carry out public consultation before project design to protect the PAP's interest; b. Provide special assistance for women and other vulnerable groups; carry out labor training with the help of local government; provide more non-technical post for PAPs; c. establish complaints mechanism.	2016-2019	Included in cost of resettlement	PMO, Implementation Unit, County Immigration Bureau, Agricultural Bureau, Land Bureau, Forestry bureau, Town & Village Committee of project area	PMO, External Monitoring Agency	Public consultation, resettlement and land transfer, land & house compensation, job training, employment of non-technical posts, production & development, development of specialized farmer cooperatives	2 times / year

Social factors	Potential impact	Mitigation measures	Time Arrangement	Budget (ten thousand yuan)	Implementers	Supervisor	Monitoring indicators	Frequency
Local residents	Reduction of land resources, pressure on infrastructure, public services & allocation of public resources	Land resources: a. Before land adjusting, seek the views of local residents; b. Provide fair compensation to the PAPs in accordance with relevant policies. Public resources: a. Construct supporting service facilities and ensure the supply of water, electricity & gas in project affected area. b. The government needs to properly guide the allocation of common assets.	Since 2016	/	PMO, DI, Implementation Unit, village committees in project area	PMO, External Monitoring Agency	Willingness survey; land compensation; infrastructure and supporting facilities; allocation of collective assets; complaints of local residents.	2 times / year
Public consultation	Bottom-up feedback and participation mechanism are ignored; stakeholders are not well informed of the project information; the complaints of stakeholders are not well treated.	Establish an effective complaint mechanism and a public consultation plan.	Since 2016	/	PMO, Village Committee, Stability-maintaining Agencies(county / town / village / group level), Comprehensive Treatment Office, Letters and Visits Bureau	PMO, External Monitoring Agency	Implementation of public consultation; treatment of complaints	2 times / year

11 Impacts of Embankment Reinforcement and Mitigation Measures

Embankment reinforcement project of Han River is the linked project of Han River Yakou Navigation Complex Project. Xiangyang Water Resources Bureau and Xiangyang Waterway Administration are responsible for the implementation of embankment reinforcement.

11.1 Project Background

Middle and lower reaches of Han River is wandering river in plain and embankment in the past were built to protect the farmland and towns. Xiangyang Han River embankment is located in Xiangyang administrative region and protects the cultivated land of 1,121,000 and population of 2,434,000 on both banks. Xiangyang Oumiao section, Yicheng Hedong section and Yicheng urban section are located in Yakou reservoir area, i.e., area between Cuijiaying complex and Yakou complex. The crest elevation is usually 1.0m to 2.0m higher than the water level of flood in 1964 (equivalent to flood of twenty-year) and total length of the embankment is 86.7 kilometers. Both banks of other sections are terrace, meeting flood control requirements.

Embankment reinforcement on both banks of Yakou reservoir area river section is implemented by Xiangyang Water Resources Bureau in accordance with Feasibility Study Report of Han River Embankment Reinforcement Project (in Xiangyang) of Hubei Province. The report has been approved by the competent industry department. In accordance with the national standard Flood Control Standard (GB50201-94) and Flood Control Planning of Yangtze River Basin (June 2008), flood control standard of embankment in middle and lower reaches of Han River is to withstand flood in 1935 (equivalent to flood of one-hundred-year) and that of embankment in mainstream of Han River is to withstand flood in 1964. In accordance with the protected areas and importance of the protection area and according to the relevant standard and norms, embankment in Xiangyang Oumiao section, Yicheng Hedong section and Yicheng Urban section is determined as Class II embankment.

Main contents of Han River embankment reinforcement work in river sections of Yakou reservoir area are shown in Table 11-1 and Figure 11-1 (dotted line).

Table 11-1 Yakou Navigation Complex Reservoir Backwater Embankment Reinforcement Project

No.	Protected areas	Length of the embankment sections in the protected areas (km)	Flood control standard (year)	Project class
1	Oumiao embankment in Xiangcheng District	18.922	20	2
2	Yicheng urban embankment	33.516	20	2
3	Han River east (Hedong) embankment in Yicheng	34.301	20	2

Data source: Feasibility Study Report of Han River Embankment Reinforcement Project (in Xiangyang), Hubei Provincial Water Resources and Hydropower Planning Survey and Design Institute, 2015

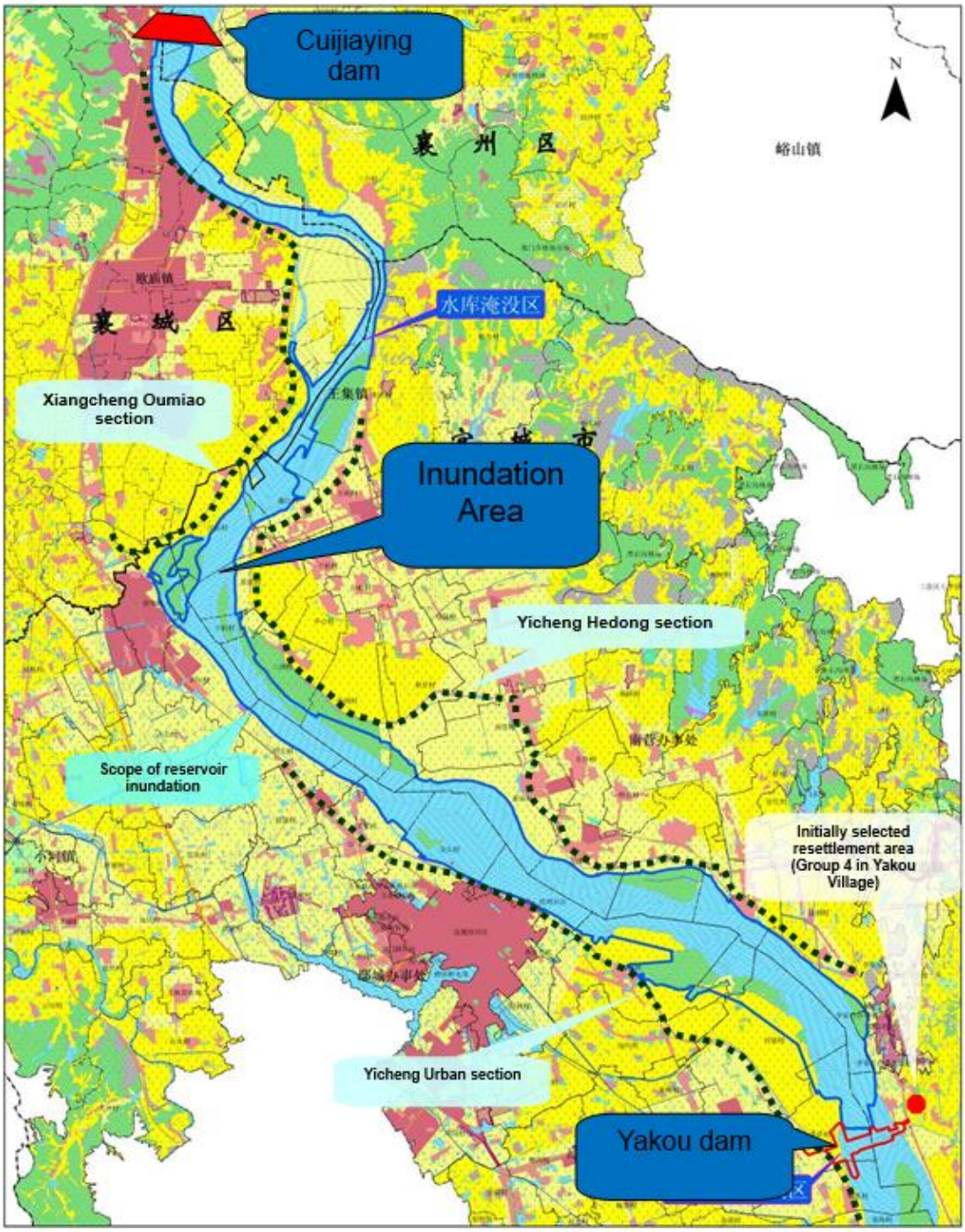


Figure 11-1 River Embankment Sections in the Yakou Reservoir Area

Embankment in Yakou reservoir area guarantees the bank protection of reservoir area of Han River Yakou Navigation Complex Project. In accordance with the plan, the embankment reinforcement project will be commenced in 2016 and completed in 2018, namely completing before impoundment of Yakou reservoir to meet the requirements of Yakou reservoir area protection.

11.2 Due Diligence of Embankment Reinforcement Environment Managment

11.2.1 Purpose and Method

To supervise the implementation of the environmental management plan for Xiangyang Urban Flood Control Project and to ensure that the original mitigation measures are effectively implemented, Zhongnan Engineering Corporation Limited, authorized by the Port and Waterway Administration of Hubei Provincial Department of Transportation, has carried out due diligence for the project's environmental management.

During the due diligence, environmental management for the project will be fully reviewed in order to evaluate whether the project is implemented in accordance with the national and local environmental management rules and to evaluate the implementation of the mitigation measures listed in the original EIA so that improvement advice can be made.

Document review and on-site inspection are the two methods used in this due diligence.

- Document review: documents related to the project will be collected and read, including
  - ✓ *Environmental Impact Statement of Han River Embankment Reinforcement Project (in Xiangyang)* (January, 2016)
  - ✓ *Feasibility Study Report of Han River Embankment Reinforcement Project in Xiangyang* (October, 2015)
- On-site inspection: in March of 2016, we visited the PMO of Han River Embankment in Xiangyang and the completed embankment section in Yicheng's urban area. Through the visit and the direct communication with the PMO, we have fully understood the progress of the Xiangyang embankment project and the implementation of environmental management.

This due diligence involves

- reviewing the Project EIA Report;
- verifying the approval of the Project EIA Report;
- verifying the project environmental management organizations;
- inspecting the implementation of the project environmental management plan;
- offering advice on improving environmental & social management

Among the planned embankent reinforcement works, the construction of the a embankment section in Yicheng City is completed. Therefore, this due diligence will focus on the environmental management throughout the operation of the completed embankment section.

11.2.2 Relevant Environmental Management Organizations

Relevant environmental management organizations and their responsibilities throughout the implementation of the project are as follows:

- Xiangyang Municipal People's Government: responsible for leading, organizing,

and coordinating the work related to the project as well as for internal supervision and inspection;

- Xiangyang-Han River Banks Construction Project Management Office: responsible for project construction and for guiding, coordinating, and supervising environmental management;
- Xiangyang River Course Management Department: responsible for project construction and for guiding, coordinating, and supervising environmental management throughout the construction, as well as for environmental management and the maintenance of the completed project throughout the operation;
- Project Contractor: responsible for implementing the environmental and social management plan throughout the construction;
- Project Supervision Organization: responsible for supervising the implementation of the environmental and social management plan throughout the construction

During visiting Xiangyang's urban flood control construction project management office and communicating with its officers, it is noted that every project contractor and every supervision organization are staffed with at least one full-time worker responsible for implementing and supervising environmental management. We also learned that all the aforesaid project contractors and supervision organizations have rich experience in hydraulic complex construction and management and that they are capable of fulfilling environmental management responsibilities and obligations.

11.2.3 Laws and Regulations

National and local laws and regulations on environmental management for the project include

• *Environmental Protection Law of the People's Republic of China (January 1, 2015)*

• *Water Law of the People's Republic of China (October 1, 2002);*

• *Law of the People's Republic of China on Water and Soil Conservation (March 1, 2011);*

• *Land Administration Law of the People's Republic of China (August 28, 2004);*

• *Law of the People's Republic of China on Prevention and Control of Pollution from Environmental Noise (October 29, 1996);*

• *Water Pollution Prevention and Control Law of the People's Republic of China (June 1, 2008);*

• *Law of the People's Republic of China on Prevention and Control of Atmospheric Pollution (September 1, 2000);*

• *Law of the People's Republic of China on the Prevention and Control of*

Environmental Pollution Caused by Solid Wastes (April 1, 2005);

• *Law of the People's Republic of China on Environmental Impact Assessment (September 1, 2003);*

• *Regulations on the Administration of Construction Project Environmental Protection (Order No.253 of State Council, November 18 of 1998);*

• *Environmental Protection Regulation of Hubei Province;*

• *Technical Guidelines for Environmental Impact Assessment – General Provisions (HJ2.1-2011);*

• *Technical Guidelines for Environmental Impact Assessment – Surface Water Environment (HJ/T2.3-93);*

• *Technical Guidelines for Environmental Impact Assessment – Atmospheric Environment (HJ2.2-2008);*

• *Technical Guidelines for Environmental Impact Assessment – Acoustic Environment (HJ2.4-2009);*

• *Technical Guidelines for Environmental Impact Assessment – Ecological Impact (HJ19—2011);*

11.2.4 Reservoir Embankment Project EIA Report and its Approval

According to Regulations on the Administration of Construction Project Environmental Protection (Order No.253 of State Council, November 18 of 1998), Law of the People's Republic of China on Environmental Impact Assessment, and other relevant laws and regulations, Xiangyang Municipal Water Resources Bureau authorized Xiangyang Environmental Protection Science Research Institute in November of 2015 to assess environmental impacts.

According to the EIS, the proposed Han River Embankment Reinforcement Project (in Xiangyang) is a very important flood control project. The project serves to protect the lives and property of local people and of people in the flood control areas along the Han River, maintain normal production, and protect local environment. Therefore, the project is conducive to the sustainable socio-economic development of the region. The reinforcement of the Han River embankment conforms to the relevant national and local industrial policies.

Project construction may have certain impacts on the environment. In particular, the construction may cause loss of land resources and disrupt the local ecosystem. Other adverse impacts caused by the construction only last a short period of time and reach small areas. These impacts can be reduced or prevented by taking proper measures to strengthen the construction management. The impact of construction on the environment will fade away as the construction ends. The implementation of the project will not greatly change

the hydrological regime or disrupt the local aquatic habitat and ecosystem. The adverse impacts of the project on the environment can be effectively mitigated by strengthening the environmental management throughout the construction and implementing the ecological restoration and compensation measures proposed in the EIA Report. If the project is implemented in accordance with the relevant national laws and regulations, the "three simultaneities" system is implemented as required by the EIS, environmental management is strengthened, and the environmental protection measures listed in this report are implemented, the project will be deemed feasible from the perspective of environmental protection.

The total investment in environmental protection for the Han River Embankment Reinforcement Project is 8.1615million Yuan. With this investment, the local ecosystem is expected to be restored or even improved within 3 years.

Table 11-2 Reservoir Embankment Project Impact on the Environment and Mitigation Measures

Timeframe	Environmental factors	Main effects	Mitigation measures	Implementation parties
Construction	Terrestrial ecosystem	- During the embankment construction, permanent and temporary land use may disrupt local vegetation - As there are only a few wild animals and plants inhabiting the vicinity of the project area, the construction of roads and the embankment will not cause a large decrease in the number of these wild animals and plants.	• Woodland shall not be used as borrow area. • Using arable land as borrow area shall be avoided. If arable land is excavated, its topsoil shall be reserved; after the works is completed, the topsoil shall be filled back in the original place. • Soil and rocks shall not be disposed at the cost of farmland and other facilities. The disposal of soil and rocks shall not block the flow of river water. The site for the disposal of soil and rocks shall be carefully selected. • The green project for the Han River banks will be designed while the main works are being implemented; the design shall first allow for the use of local trees, shrubs, and grass, so as to compensate for and restore the removed vegetation. Relevant project costs have been included in the project investment.	Contractor
	Aquatic ecosystem	Revetment project is arranged in December through March of the following year, which avoids the fish breeding season (in April through June). Therefore, the revetment construction will not greatly affect fish. Underwater riprap construction may slightly disrupt the activities of a few fish species that release	• Construction workers' awareness of aquatic life protection shall be raised; fishing and hunting in the river segments under construction are banned. • Earthworks shall be regulated and managed during construction in order to prevent soil erosion and water pollution. • Construction shall be properly scheduled in an effort to minimize the impact of construction on water and fish in	Contractor

Timeframe	Environmental factors	Main effects	Mitigation measures	Implementation parties
		viscid eggs near the river banks.	the relevant river segments. In particular, underwater riprap should not be constructed during the fish breeding season.	
	Soil erosion	As excavation, spoil, and construction greatly disrupt the original landform and vegetation, soil erosion may easily occur when it rains.	• Within the three months after the subgrade construction is completed, trees and grass shall be grown at the side slopes and the proper sites along the proposed roads. • If the current irrigation or drainage system broke down, the system shall be repaired for rebuilt. • Proper measures will be taken to prevent soil and rocks from blocking the river, aqueduct, or current irrigation and drainage system. • Temporary aqueducts or pipes will be built for irrigation and drainage when a permanent drainage system is being built. - Proper measures shall be taken to prevent sewage produced during construction from directly discharging into rivers and irrigation aqueducts. • Retaining walls or geotextile fences shall be put up along the subgrade under construction, borrow area, spoil ground, and bulwark construction site as a way to control soil erosion. • Excavation shall be avoided during the rainy season.	Contractor
	Noise	During the construction, noise comes primarily from construction machinery and vehicles. The noise may affect the residential areas nearby. According to *Noise Limits for Construction Site*, the effect of the noise produced by construction machinery will be controlled at a distance of 40m (during daytime) and 300m (during nighttime) away from the construction sties.	• *Standard of Noise at Boundary of Industrial Enterprises* will be strictly implemented in order to protect construction workers from being harmed by noise. Workers close to the source of intensity noise shall wear earplugs and helmets; their working time shall be limited too. • Fixed construction machinery shall not be arranged in an area within 300m from any school or large residential area. If the fixed construction machinery has to be arranged in such an area, noise shall be reduced by putting up noise barriers or taking other measures.	Contractor

Timeframe	Environmental factors	Main effects	Mitigation measures	Implementation parties
			• Construction machinery with loud noise shall not be used during nighttime at the construction sites from which residential areas are within 300m; construction should be avoided during nighttime. • Machinery and vehicles should be maintained on a regular basis to ensure that they operate at a low level of noise.	
	Air	Dust produced by lime soil mixing, excavation, and backfill during construction may pollute the air in the downwind area of 100-500m; dust produced by the transport and loading/unloading of construction materials will pollute air along the road.	• Watering and other measures will be adopted to reduce the concentration of TSP in air, especially in the vicinity of residential areas. • Storage yards shall not be near residential areas; storage yards shall be covered or watered to reduce dust. The trucks used for transporting materials shall be covered with canvas in order to prevent spillage. • Mixing equipment shall be properly sealed and equipped with dust removers.	Contractor
Construction	Environment monitoring	-	• Air: TSP and pitch fume in the sensitive receptors and residential areas near the lime soil mixing station, spoil ground, and parts of the construction road will be monitored twice a year. • Noise: noise within 45m of the large residential areas or sensitive receptors (e.g. schools) near the construction sites will be monitored twice a year. • Water: each of the embankment sections in Taipingdian, Xiangyang urban area, and Yicheng urban area respectively will be equipped with a water pollution monitoring station. A total of 7 items will be monitored, including pH, suspended solids (SS), dissolved oxygen (DO), permanganate index, CODCr, petroleum, and fecal coliform	Xiangyang Environment Monitoring Station (authorized by the project owner)
Operation	Socio-economic benefits	Project construction will greatly improve the roads and flood control facilities along the Han River banks, facilitating the sustainable development of	No mitigation measures are needed	/

Timeframe	Environmental factors	Main effects	Mitigation measures	Implementation parties
		Xiangyang's economy, attracting more foreign investment, and boosting the development of the industry, agriculture, tourism, commerce, trade, and other industries in the region.		
	The quality of the residents' lives	After the project is put into use, the rich resources in the project area can be developed for the purposes of recreation, entertainment, and tourism, which will in turn boost the development of relevant industries and facilities. As a result, job opportunities for the local residents will increase and the quality of their lives will improve accordingly.	No mitigation measures are needed	/

Source：EIS of Han River Embankment Reinforcement Project (in Xiangyang)

11.2.5 Implementation of Environmental and Social Management Plan

Xiangyang Municipal Water Resources Bureau implemented embankment works on an annual baisis. The 5km long Wanyangzhou section was visited during the due diligence . Field visit and discussions with the manager of Yicheng Urban Embankment Project Management Office and supervision engineers were carried out. Main findings and conclusiosn are discussed in below.

With regard to the completed embankment section, the construction of the section has conformed to the relevant national/local laws and regulation; it has not caused any pollution or complaints. According to the on-site inspection, the roads and flood control facilities along the Han River banks within the completed embankment section have been greatly improved. Vegetation restoration measures have been implemented in accordance with the project design. Vegetation has been growing well. The vicinity of the completed embankment section has been frequented by local residents for relaxation. Moreover, consultants have noticed that the construction of the river embankment landscape belt has driven development along the Han River banks, improving the local residents' living conditions and generally realizing the social and environmental benefits as expected.

Figure 11-1 the completed embankment section in Yicheng City

The implementation of the project conforms to the relevant national/local laws and regulations. According to the PMO, 5km of the embankment section in Yicheng City has been built. However, the embankment section in Yicheng City is only one section of the project, so it will not undergo acceptance testing by the local environmental protection department until all the other sections are built.

11.2.6 Conclusion and Suggestion

According to the aforesaid results of the due diligence, the preparation and implementation of Xiangyang City Embankment Project complies with the national and local laws and regulations on environmental protection; it has been conforming to the World Bank environmental protection policy so far. With its rich experience in construction, the project contractor has effectively implemented mitigation measures against soil erosion, air pollution, noise pollution, disruption of the ecosystem, and other adverse impacts on the environment throughout the construction. Vegetation has been grown along the completed embankment section, greatly improving the surroundings and local residents' living conditions and generally realizing the environmental and social benefits as expected.

In order to further improve environmental management for the project based on the results achieved, the following suggestions are made:

(1) Relevant parties should take measures to prevent soil erosion at the construction site, frequently water the site, and keep materials from being exposed. During the rainy season in particular, they should ensure that the soil erosion prevention and control measures are implemented so as to prevent and control soil erosion caused by construction from disrupting agricultural production in Xiangyang and flood flowing in the river course, and from polluting the Han River.

(2) Relevant parties should keep records of the environmental management throughout the implementation of the project and archive the records. They should record the implementation of mitigation measures, its results, and other project-related environmental aspects in the Monthly Supervision Report; the records should be archived for reference.

(3) The project owner and project contractor should be informed of the results of environment (air, noise, etc.) monitoring near the construction sites by the local environmental protection department, so as to keep track of the environmental quality of the sites and take mitigation measures accordingly.

12 Public Consultation and Information Disclosure

12.1 Principles and Early Consultations during EIA Preparation

As an integral part of the EIA for the construction project, public consultation and information disclosure is designed to keep the public informed of the basic information of the project. The basic information includes the necessity of the project, project planning, the objectives of the project, the scale of construction, potential impact on the environment, and environmental protection measures. Through public consultation, relevant parties can be informed of public opinions on the project and achieve the following objectives:

• ensure that the concerns, experience, and suggestions of project stakeholders (affected persons in particular) are taken into consideration when the project is being designed, planned, and implemented;

• increase the public's understanding of the project, especially increase the public's understanding of the mitigation measures against the adverse impact of the project and the measures for improving the livelihood of the affected persons;

• make wise decisions on the project based on the opinions of the affected population so as to ensure that the environmental protection measures proposed in the EIA are feasible.

Between August of 2012 and December of 2015 when the Project EIS (Chinese version) was being compiled, we organized the affected persons (including government officials, farmers, fishermen, self-employed people, and people working in science, education, culture, and public health) from the areas directly affected by the Yakou Navigation Complex Project (including Oumiao Town in Xiangcheng District, Dongjin Town in New Dongjin District, and six villages and towns in Yicheng, namely Liushui, Nanying, Wangji, Zhengji, Yancheng, and Xiaohe) to join public consultation activities in the forms of questionnaire and meeting (see the table below for details). According to the results of the questionnaire, 88.4% of the respondents are supportive of the project while 11.0% of the respondents take neutral stance. The questionnaire also shows that the positive roles the project plays in developing shipping, boosting the local economies, and improving local people's lives are well received among the respondents. In addition, according to the survey, the primary concern of the public with regard to the implementation of the project is economic benefits. Following economic benefits are resettlement compensation and the impact of construction and inundation to the ecosystem. The public hope that the adverse impact of project construction to the environment can be minimized through strengthened environmental management. We have informed the project proponent of public opinions on the project and proposed the environmental protection measures. The project proponent have promised to implement the environmental protection measures throughout the construction with the support of the local governments.

Table 12-1 Early Public Consultation on Yakou Project EIA

Method	Organizer	Participant	Timeframe	Location
Questionnaire, visit, and consultation	The Port and Waterway Administration of Hubei	517 of 530 distributed questionnaire forms are filled; the respondents include government	August to September of 2012 August to	Construction areas and 8 villages and towns in the

	Provincial Department of Transportation, Zhongnan Engineering Corporation Limited	officials, villagers, fishermen, self-employed people, etc.	September of 2014	reservoir area
Public meetings		Competent authorities of 8 villages and towns, the representatives of villagers	August 7, 2014	The meeting room on the 6th floor of the Yicheng Municipal Government building
		Municipal Government, CPPCC Municipal Committee, Municipal People's Congress, Environmental Protection Agency; the governments of Xiangcheng District, Xiangyang District, and Yicheng City.	August 9, 2014	The meeting room on the 4th floor of the Xiangyang Municipal Government building

Table 12-2 Yakou Project EIA-Early Information Disclosure

Method	Organizer	Timeframe	Website
Posting information (e.g. project overview, public consultation methods) online	The Port and Waterway Administration of Hubei Provincial Department of Transportation, Zhongnan Engineering Corporation Limited	August, 2012	http://www.ych.gov.cn/
Posting information (e.g. the main impact of the project to the environment and mitigation measures, EIA Report conclusions) online		August, 2014	http://www.yichengnews.com/, http://www.hbghj.gov.cn/
		January, 2015	http://www.xfhbj.gov.cn/

During the prepartion of the supplemental ESIA, preliminary design was being carried out. As an increasing number of potential impacts of the project to material and cultural resources, ecosystem, and displaced persons are identified, we arrange the additional public consultation and information disclosure for supplemental ESIA based on the original public consultation with the help of the Port and Waterway Administration of Hubei Provincial Department of Transportation when compiling the Supplemental ESIA Report. This section focuses on the methods of public consultation and information disclosure, the public consultation results, and the persons to whom the information is disclosed.

12.2 Project Stakeholders

Based on the identified potential impact of Yakou Navigation Complex Project to the environment, the stakeholders of the project and their potential concerns are identified as follows.

Table 12-3 Project stakeholders and their concerns

No.	Project stakeholders	Concerns
1	Villagers (including displaced persons, fishermen, etc.) of 26 administrative villages under 8 townships	The impact of the project and resettlement policies to the livelihood

	in the affected Yicheng City, Xiangyang's Xiangcheng District, and Xiangyang's New Dongjin District	of the affected persons, and rehabilitation measures
2	The governments at county-and township-levels and village committees in the affected areas	Resettlement of the displaced persons from relevant townships and villages
3	Project-related local authorities, such as Yicheng Municipal Administration of Culture, Sports, Press, Publication, Radio, Film and Television; Xiangyang Center for Disease Control and Prevention; Yicheng Forestry Bureau, etc.	Identification of the inundated cultural relics, the quality problem of drinking water, and the affected woodland; vegetation restoration and reconstruction requirements
4	The Project owners of the proposed hydropower and navigation complexes, residents along the Han River banks	Impact of the Han River hydropower and navigation complexes to the River and to the livelihood and lives of the residents along the river.

The design of public consultation methods for supplemental ESIA has fully tanken into account aforesaid stakeholders' concerns and needs.

12.3 Methods of Public Consultation for Supplemental ESIA

The public consultation on supplemental ESIA has four stages and includes interviews with the affected persons and local authorities, public meetings, and EIA discussions. By June of 2016, the following (see table 12-4 below) public consultation activities have been conducted. The problems identified in public consultation and their solutions will be elaborated in the following sections.

Table 12-4 Public Consultation on Supplemental ESIA for Yakou Navigation Complex Project (as of June of 2016)

No.	Method	Organizer	Participant	Timeframe	Location	Focus
1	Stage I: visit and information collection	project owner, Zhongnan Engineering Corporation Limited	Persons in charge of Xiangyang Center for Disease Control and Prevention	2016.3.15	Xiangyang Center for Disease Control and Prevention	Impact on the quality of water from the Han River water sources; impact on water intake facilities
			NGO, Green Han River (Xiangyang City Association of Environmental Protection)	2016.3.15	Green Han River	Sources of Han River pollution; impact of main works on the environment, environmental protection measures
			Xiangyang Bureau of Aquatic Products	2016.3.16	Bureau of Aquatic Products	Impact of the project to fish species; the feasibility and effectiveness of the measures of restoring fish species
			Persons in charge of Yicheng Municipal Administration of Culture, Sports, Press, Publication, Radio, Film and Television	2016.3.16	Yicheng Municipal Administration of Culture, Sports, Press, Publication, Radio, Film and Television	Potential impact of project implementation to the local cultural relics; identifying the impact of project

						implementation to the local cultural relics; procedures for relocating the cultural relics
			Persons in charge of Yicheng Forestry Bureau	2016.3.17	Yicheng Forestry Bureau	Impact of the project to the national-level wetland park in Wanyangzhou
			Yakou Village head, villagers, and fishermen	2016.3.18	Yakou Village	Impact of the project to the local residents
			Villagers of other villages	2016.3.18	Maocao Village	Understanding the affected villagers' concerns about the potential impact of the project to the environment
2	Stage II: public meetings	project owner, Zhongnan Engineering Corporation Limited	Yicheng Municipal Government officials, the villagers of the affected villages	2016.4.28	Yicheng Municipal Government	The main potential impacts of the project, including the impact on the aquatic ecosystem, the impact on material and cultural resources, the displaced persons' livelihood rehabilitation, etc.
3	Stage III: interviews for CEA	project owner, Zhongnan Engineering Corporation Limited	The Project owners of the hydropower and navigation complexes in the Han River middle-and lower reaches, villagers along the Han River	2016.5.16		Accumulative impact of the hydropower and navigation complexes in the Han River middle and lower reaches; impact of the hydropower and navigation complexes to local production and the livelihoods of local residents
4	Stage IV: meetings for CEA	project owner, Zhongnan Engineering Corporation Limited	The Project owners of the hydropower and navigation complexes in the Han River middle-and lower reaches, local governments and departments	2016.6.21 -6.22		Accumulative impact of the hydropower and navigation complexes in the Han River middle and lower reaches to the environment; the river basin

						management proposals

12.4 Key Findings of Public Consultation for Supplemental ESIA

12.4.1 Stage I: visit and information collection

This public consultation for supplemental ESIA proceeded in the form of public meetings. To make these meetings more fruitful, the the project proponent and EIA institute have repeatedly visited the project area and local authorities, identified the impact of the project to the environment, and directly communicated with local residents about the potential environmental impact.

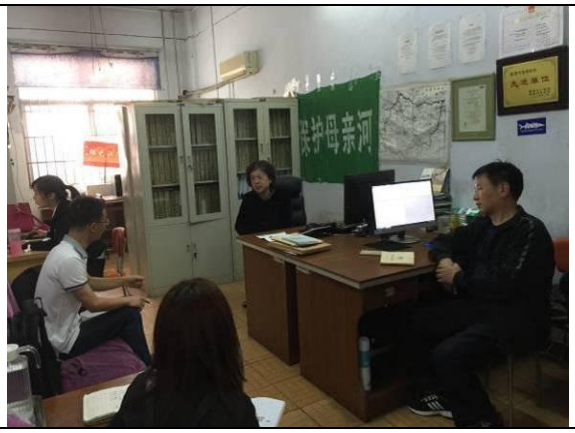
Table 12-5 Visit to the project area

No.	Date	Location	People to meet	Focuses and solutions
1	2016.3.15	Xiangyang Center for Disease Control and Prevention	Persons in charge of Xiangyang Center for Disease Control and Prevention	Paying a return visit for addressing the concerns (e.g. "worry that project construction may exacerbate water pollution in the reservoir area and pollute water sources") of the Center's workers who oppose the project; confirming that the quality of water in the reservoir area at the completed Cuijiaying Navigation Complex can meet the function zoning requirements; pollution in the Yakou reservoir area is primarily domestic pollution and the complex is a run-of-river power station, so Yicheng's water can be drinkable after the reservoir is built.
2	2016.3.15	NGO: Green Han River (Xiangyang City Association of Environmental Protection)	Persons in charge of the NGO	Understanding that the potential impact on the Han River water and ecosystem makes it imperative to make the Yakou Navigation Complex Project construction more environment-friendly; tightening environment monitoring, especially water quality monitoring while implementing the environmental protection measures required by the EIA and its approval; disclosing the monitoring results in a timely manner
3	2016.3.16	Xiangyang Bureau of Aquatic Products	Persons in charge of Xiangyang Bureau of Aquatic Products	Construction of the reservoir dam has greatly changed the hydrological conditions of the Han River and the habitats of fish and other aquatic life. The spawning sites of Asian carps have either disappeared or moved downstream from within the reservoir area. Fishery authorities request project proponent to compensate for these changes in accordance with *Fisheries Law of the People's Republic of China*.
4	2016.3.16	Yicheng Municipal Administration of Culture, Sports, Press, Publication, Radio, Film and Television	Persons in charge of Yicheng Municipal Administration of Culture, Sports, Press, Publication, Radio, Film and Television	In 2012, cultural relics departments inspected the reservoir area of Yakou Navigation Complex. Through the inspection, they identified that 12 ancient tombs and sites (including Wangjiagang Tomb, a county-level cultural relics protection site) were inundated. None of these ancient tombs and sites is under special protection. After they are unearthed and the information of them is preserved in accordance with the cultural relics protection implementation plan, the impact of the project to cultural relics can be minimized.
5	2016.3.17	Yicheng Forestry Bureau	Persons in charge of Yicheng Forestry Bureau	*Populus euramevicana cv*, secondary succession bushes and grass, and bushes and grass on the arable land have been identified as the main vegetation in the inundated areas. There are no precious wild plants or ancient trees in the inundated areas. Only the protected plants such as planted *Metasequoia glyptostroboides* and *Cinnamomum camphora* are found near the roads or residences, but they are not affected by the construction.
6	2016.3.18	Yakou Village	Yakou Village head, villagers, and	With regard to pollution caused by domestic waste and by the dust and noise produced by construction, residents in the vicinity of the construction areas have proposed tightening

			fishermen	pollution control in order not to reduce environmental quality. Fishermen have mixed feelings about the project. On one hand, they worry that the decrease of fish stock may reduce their family incomes; on the other hand, they believe that the development of reservoir fishery will bring more job opportunities
7	2016.3.18	Maocao Village	Maocao Village head, villagers, and fishermen	Communicating with villagers about other impacts of the project to the environment; villagers expressed their wishes to see the project implementation start at an early date.

Based on the information gathered during field survey, we have developed a plan for convening public meetings. The plan includes participants, time, and detailed agenda. The meetings focus on fishery, drinking water safety, tomb relocation, and other impacts on the local residents' lives. At the meetings, relevant parties will respond to the public concerns, such as livelihood rehabilitation, the improvement of environmental infrastructure, etc.

Health and Family Planning Commission of Xiangyang Municipality



Visiting the NGO "Green Han River"

Xiangyang Bureau of Aquatic Products

Xiangyang The River Embankment Construction

Interviewing the villagers of Yakou Village

Interviewing the villagers of Yakou Village

Interviewing the villagers of Maocao Village

Interviewing the villagers of Maocao Village

Figure 12-1 Stage I visit and information collection

12.4.2 Stage II: public meetings

In accordance with the public meeting plan, the Port and Waterway Administration of Hubei Provincial Department of Transportation convened a public meeting about the supplemental ESIA for Yakou Navigation Complex Project on April 28 of 2016. The meeting was hosted by Mr. Sheng, director of Yicheng City Transportation Bureau. A total of 18 persons attended the meeting; they were the representative of Zhongnan Engineering Corporation Limited (the company responsible for compiling the supplemental ESIA report), the representatives of some villagers and six towns and villages (namely, Liushui, Nanying, Wangji, Zhengji, Yancheng, Xiaohe), and the persons in charge of Yicheng Municipal Government, CPPCC Municipal Committee, Municipal People's Congress, Development and Reform Commission, Forestry Bureau, Environmental Protection Agency, Transportation Bureau, and Administration of Culture, Sports, Press, Publication, Radio, Film and Television.

At the meeting, people talked about the impact of the project to the Han River aquatic life, forest resources, wetland parks, local material and cultural resources, and the quality of drinking water, as well as livelihood rehabilitation for the displaced persons. See table 12-6 for more about the meeting

Figure 12-2 Public Meeting about the Supplemental ESIA for Yakou Navigation Complex Project

Table 12-6 Summary of the public meeting for supplemental ESIA

Time	April 28, 2016	
Location	The meeting room at the 3rd floor of Yicheng City Transportation Bureau	
Documents provided for public consultation	Supplemental ESIA Report and EMP (1st edition, April of 2016)	
Participants	A total of 18 persons attended the meeting and they are the representative of the Port and Waterway Administration of Hubei Provincial Department of Transportation, the representative of Zhongnan Engineering Corporation Limited (the company responsible for compiling the supplemental ESIA report), and the representatives of some villagers and six towns and villages (namely, Liushui, Nanying, Wangji, Zhengji, Yancheng, Xiaohe), as well as the persons in charge of Yicheng Municipal Government, CPPCC Municipal Committee, Municipal People's Congress, Development and Reform Commission, Forestry Bureau, Environmental Protection Agency, Transportation Bureau, and Administration of Culture, Sports, Press, Publication, Radio, Film and Television	
Problem		Solution
Project progress: preparation for Yakou Project started in 2012. The project has been slowly progressing. As the cost of resettlement increases year by year, the original compensation standard can no longer serve the resettlement needs. Moreover, the delayed implementation of the project has affected the lives of local villagers. For instance, a non-local woman who newly married a local man may find it difficult to get a household registration. Displaced persons hope that the project is implemented at an early date so that the cost caused by the delay can stop increasing.		The compensation standards for resettlement have been raised based on the current price levels; the raised standards are being applied for approval. Meanwhile, relevant parties strive to secure loans for the project from the World Bank. The implementation of the project is expected to start in October, 2016.
Upgrading of the water intake facilities of Yicheng Waterworks: it is believed that raising the water level of the reservoir during the dry season serves to obtain water. However, the current pumping equipment and pump rooms need to be upgraded; the pumping equipment and pump rooms that are near the reservoir banks should be fenced off. Water pollution control shall be tightened. It is recommended that waterworks should be upgraded and floaters in the reservoir area should be removed on a regularly basis in order to ensure water safety in the reservoir area.		Upgrading of the water intake facilities of Yicheng Waterworks has been included in the specialized reservoir facility reconstruction project. The EIA Report proposes measures to assure the quality of drinking water from the waterworks and to prevent water pollution. It is recommended that drinking water should undergo advanced treatment. In case of pollution risks, joint operation will be launched to increase water discharge within a short period of time so as to rapidly dilute the pollutants.
Construction of the reservoir dam has greatly changed the hydrological conditions of the Han River and the habitats of fish and other aquatic life. The spawning sites of Asian carps have either disappeared or moved downstream from within the reservoir area. According to *Fisheries Law*		Measures such as joint ecological operation, building rock-ramp fishway, and fish breeding and releasing will be adopted to mitigate the adverse impact of the project to

of the People's Republic of China, project proponent shall compensate for these changes by building new spawning grounds for fish in the Han River.	fish and other aquatic life in the Han River, especially to Asian carps and other fish species that release pelagic eggs.
Wanyangzhou Wetland Park and wild animals: wild animals such as boar and muntjac can be found near the villages from time to time. Wetland protection regulations have been disclosed to villagers by the township governments through propaganda and announcement. The river beach and wetland in the reservoir area shall be protected; river beach development shall be minimized.	Wanyangzhou Wetland Park will not be adversely affected by the project. The park rules allow for the impact of the Yakou Project impoundment to this park.
Livelihood: the incomes of villagers in the project area come primarily from jobs in towns/cities with avocation such as forestry, farming, and fishery. With the construction of Han River navigation and hydropower complexes, the quantity and species of fish in the Han River has remarkably decreased. The impact of the project implementation is expected to be small. Local farmers generally grow rice. The current food prices are not high. Based on the local land conditions, rice is grown for only one season by farmers just to ensure their food self-sufficiency. Implementation of the project may cause farmlands to decrease, which will affect the livelihoods of the villagers living on farming, but the impact is insignificant.	The resettlement action plan (RAP) for the project has allowed for livelihood rehabilitation for the villagers whose farmland has decreased and relevant mitigation measures. The mitigation measures will be implemented and the livelihoods of the relevant villagers will be rehabilitated during the project implementation.

At the meeting, the participants showed that they were supportive of Yakou Navigation Complex Project and expressed their wishes to see the project implementation start at an early date so that compensation for resettlement can be made and the benefits brought about by the project can materialize as soon as possible. In addition, the participants recognized the project's environmental benefits and paid great attention to the social impact brought by the project. They hoped that displaced persons would be properly resettled, cultural relics and tombs would be properly rebuilt in other places, and local production and the livelihoods of local residents would be restored.

12.4.3 Stage III: Interviews for CEA

On May 16-18 of 2016, led by the project proponent, the EIA institute interviewed the Project owners of the navigation and hydropower complexes in the Han River middle and lower reaches and the residents along the Han River. Through the interviews, we learned that Danjiangkou Hydropower Complex, Wangfuzhou Hydropower Plant, Cuijiaying Navigation Complex, and the newly built Xinglong Hydropower Complex have affected the daily lives of local residents. We also learned that local residents are concerned about the potential environmental and social impact brought by the construction of Yakou Navigation Complex. See table 12-7 for the results of the interviews

Table 12-7 Interviews with the residents along the Han River for CEA

No.	Interviewee	Complex/village	Occupation/age	Interview
1	Mr.Zhu	Danjiangkou Hydropower Complex	Cadre/42	The dam of Danjiangkou Hydropower Complex is a primary source of water for the South-North Water Transfer Project (Phase I) and an important source for replenishing water in the areas along the Han River middle and lower reaches. Implementation of the South-North Water Transfer Project (Phase I) may affect the hydrological regime, water quality, and aquatic ecosystem of the Han River middle and lower reaches, so it is necessary to keep track of and assess the impact. Construction of the navigation complex will boost the local economy and increase the incomes of local people.

No.	Interviewee	Complex/village	Occupation/age	Interview
2	Mr. Ye	Wangfuzhou Hydropower Complex	Cadre/47	Comparing with the quality of water before the reservoir is built, the quality of water in the reservoir area, especially the quality of water in the dam area, will remarkably improve. As a result, the quality of both domestic water and process water along the banks of the reservoir area will improve, which will be conducive to the development of fishery in the reservoir area. Fish species that release pelagic eggs will disappear from the reservoir area because the original spawning sites are no longer available and there is no way to increase their eggs and fry in the area. The reservoir area will be generally inhabited by lacustrine fish species (these species are suitable to inhabit still or slow flowing water).
3	Qu Wanguo, Shen Zhibin, etc.	Villagers in the vicinity of Wangfuzhou Hydropower Complex	Fisherman	The quantity of both fish and water in the Han River has been decreasing in recent years, because there is a large number of people using electrofishing techniques, the hydropower facilities in the Han River has disrupted fish migration, and the use of pesticides and chemical fertilizers has contaminated water and thus disrupted the growth of fish. The main concern is that a large area of fertile land along the river will be inundated because of the construction of Yakou Navigation Complex.
4	Mr. Qiao	Cuijiaying Navigation and Hydropower Complex	Cadre/41	Comparing with the quality of water before the reservoir is built, the quality of water in the reservoir area will remarkably improve, not only because the environmental protection agencies have taken measures to control the sources of pollution, but also because of the water self-purification capacity of the reservoir. Fishway has mitigated the impact of the dam to the fish species that migrate. Fish breeding and releasing serves to replenish the fish stocks in the Han River.
5	Zhao Zhengtao, Li Wanqing	Qianying Village at the Cuijiaying Dam site	Displaced person	Due to project construction, 57 households (223 persons) of Qianying Village are relocated. The incomes of these people have remarkably increased. According to the interviews, relocated people are satisfied with the new living and working conditions. Displaced persons who are resettled in the vicinity of their original villages can adapt to the new living and working environment and maintain a harmonious and friendly relationship with their neighbors.
6	Mr. Liu	Zhongxiang Waterway Station	Cadre /41	As the dam of Nianpanshan Hydropower Complex is located at the core of “the national-level aquatic resource reserve for

No.	Interviewee	Complex/village	Occupation/age	Interview
				Elopichthys bambusa, *Ochetobius elongatus*, and *Luciobrama macrocephalus* in the Han River segment in Zhongxiang", ecological compensation and restoration measures will be implemented throughout the project development to mitigate the impact on fish. Hopefully after the Yakou Project and Nianpanshan Project are implemented, fish stocks in the Han River can be restored to their current level with joint ecological operation and other compensation measures.
7	Mr. Wang	Xinglong Hydropower Complex	Cadre /47	The construction and operation the Han River hydropower facilities, especially the construction and operation of Xinglong Hydropower Complex, have remarkably mitigated the damage of floods to the local areas and have thus reduced the loss caused by floods. In general, construction of hydropower facilities brings more benefits than harms to local people in general.
5	Ms. Zhang	Villager in the vicinity of Xinglong Hydropower Complex	Farmer/55	A large number of human activities and dredges in the Han River have reduced fish's living space. As a result, fish stocks in the Han River have been decreasing. Moreover, the use of pesticides and chemical fertilizers has disrupted fish's habitat. Development of Han River navigation and hydropower complexes itself only has a small impact on fish.

Visiting Danjiangkou Hydropower Complex

Visiting Wangfuzhou Hydropower Plant

Visiting Cuijiaying Navigation Complex

Surveying Nianpanshan Dam Site

Visiting Xinglong Hydropower Complex

Visiting Yangtze River-Han River Water Transfer Project

Figure 12-3 Site Visits for CEA

According to the results of the interviews, local residents have witnessed the deterioration of the Han River environment and the decrease of fish stock in the river. A large number of human activities and the widely use of pesticides and chemical fertilizers as a result of the Han River development have polluted the Han River water. The interviewed villagers have been supportive of the further construction of Yakou Navigation Complex. They believe that project construction and operation will improve navigation in the Han River, boost the local economy, and increase the incomes of local people. Some farmers are concerned about travel during the construction, fish stocks, and farmland occupation, about which consultants have communicated with the relevant farmers. Solutions to address these concerns have been included in the RAP and the environmental and social management plan respectively.

12.4.3 Stage IV: Meetings for CEA

Besides the already built Danjiangkou Hydropower Complex, Wangfuzhou Hydropower Complex and Cuijiaying Navigation and Hydropower Complex, the proposed Xinji Hydropower Station and Yakou Hydropower Complex are also located in Xiangyang City; the proposed Nianpanshan Hydropower Complex is located in Zhongxiang City; the already built Xinglong Hydropower Complex is located in Qianjiang City. Therefore, public consultation for the CEA of hydropower and navigation complex projects in the Han River middle and lower reaches involves the governments and relevant departments of Xiangyang, Zhongxiang, and Qianjiang. The representatives of local governments and relevant departments would attend the meetings; their ideas and advice on the construction

of hydropower and navigation complexes in the main stream of the Han River middle and lower reaches would be solicited.

"Public meeting for the CEA of hydropower and navigation complex projects in the Han River middle and lower reaches" will be held in Xiangyang and Zhongxiang in the afternoons of June 21 and 22 respectively for the representatives of local governments and relevant organizations to attend. Each meeting lasts half a day.

a) Xiangyang meeting participants

A total of 25 representatives of 18 organizations attended the meeting held in Xiangyang. The representatives came from the Danjiangkou, Wangfuzhou, and Cuijiaying complex management offices, the Xinji and Yakou project preparation offices, Xiangyang Municipal Government, Xiangyang Municipal People's Congress, Xiangyang Municipal Committee of CPPCC, Xiangyang Environmental Protection Agency, Xiangyang Development and Reform Commission, Xiangyang Transportation Bureau (Maritime Safety Administration), Xiangyang Immigration Office, Xiangyang Land and Resources Bureau, Xiangyang Forestry Bureau, Xiangyang Municipal Bureau of Water Resources, Xiangyang Municipal Bureau of Aquatic Products, Xiangyang Municipal Bureau of Agriculture, and Xiangyang Municipal Administration of Culture, Sports, Press, Publication, Radio, Film and Television, as well as from the municipal governments, municipal people's congresses, environmental protection agencies, and water resources bureaus of Danjiangkou, Laohekou, and Yicheng.

b) Zhongxiang meeting participants

A total of 20 representatives of 15 organizations attended the meeting held in Zhongxiang. The representatives came from Xinglong complex management office, Nianpanshan project preparation office, Zhongxiang Municipal Government, Zhongxiang Municipal People's Congress, Zhongxiang Municipal Committee of CPPCC, Zhongxiang Environmental Protection Agency, Zhongxiang Development and Reform Commission, Zhongxiang Transportation Bureau (Maritime Safety Administration), Zhongxiang Immigration Office, Zhongxiang Land and Resources Bureau, Zhongxiang Forestry Bureau, Zhongxiang Municipal Bureau of Water Resources, Zhongxiang Municipal Bureau of Aquatic Products, Zhongxiang Municipal Bureau of Agriculture, and Zhongxiang Municipal Administration of Culture, Sports, Press, Publication, Radio, Film and Television, as well as from Qianjiang Municipal Government, Qianjiang Municipal People's Congress, Qianjiang Environmental Protection Agency, and Qianjiang Municipal Bureau of Water Resources.

Xiangyang meeting (1)

Xiangyang meeting(2)

Zhongxiang meeting (1)

Zhongxiang meeting (2)

Figure 12-4 Public meetings for the CEA of hydropower and navigation complex projects in the Han River middle and lower reaches

At the meetings, the representative of Port and Waterway Administration of Hubei Provincial Department of Transportation (Yakou Project project proponent) briefed the meeting participants on the planning of hydropower and navigation complex projects in the Han River middle and lower reaches and the background of this CEA. We (the assessment organization) briefed the participants on the result and conclusion of the retrospective study on the CEA of hydropower and navigation complex projects in the Han River middle and lower reaches. We also explained the agenda items of the meetings.

At the meetings, participants actively discussed the potential and existing impacts on the environment that are caused by hydropower and navigation complex projects in the main stream of the Han River middle and lower reaches, and the environmental remedial and protection measures. They also provided proper advice and suggestions on the CEA. This report summarizes the speeches delivered by the representatives. See table 12-8 for the details.

Table 12-8 Opinions of the representatives at the Xiangyang meeting

No.	Organization	Attitude	Opinions
1	Xiangyang Municipal Committee of CPPCC	Supportive	Hydropower and navigation complex projects in the Han River middle and lower reaches play an important role in boosting the socio-economic development of the areas along the Han River banks. The representatives are supportive of these projects; they call for people from all walks of life to pay more efforts in protecting the Han River ecosystem, especially after the South-North Water Transfer Project was put into operation in 2015. The operation has adversely affected farming, forestry, fishery, land, etc. Therefore, great attention should be

No.	Organization	Attitude	Opinions
			paid to water quality and fisheries throughout the construction of hydropower and navigation complexes.
2	Yicheng Environmental Protection Agency	Supportive	Hydropower and navigation complex projects in the Han River middle and lower reaches affect a wide range of areas, including underground water. It is recommended that environmental protection should be strengthened for navigation, such as preventing and controlling pollution from 1000t vessels. Adverse impacts should be accurately identified based on transportation, tourism, and pollution; an overall plan for environmental protection should be prepared accordingly. The quality of water should be effectively protected in accordance with the current *Regulations on Han River Water Environment Protection*.
3	Xiangyang Forestry Bureau	Supportive	The minimum flow rate of water discharged from Danjiangkou Reservoir is 384m^3/s, which adversely affects the downstream ecological water use, especially the water use for wetlands along both banks. Construction of the complexes causes the water levels to rise and the water tends to remain at the increased level, which is conducive to wetland development and protection as well as to wetland landscaping and forestry production. A requisition-compensation balance of cultivated land resources should be made and maintained as a way to compensate for the inundated tidal flats and the decrease of woodland resources. As the water level rises after the reservoir is built, water will flow at a slower rate and water environmental capacity will decrease. As a result, algal blooms tend to occur and biodiversity will be disrupted. It is recommended that impact on wetlands and biological resources should be monitored.
4	Xiangyang Development and Reform Commission	Supportive	As waterways in the Han River middle and lower reaches falls short of Class III waterway standard, the Port and Waterway Administration of Hubei Provincial Department of Transportation gives great impetus to the construction of Yakou Navigation Complex. Generally, Yakou Navigation Complex Project brings more benefits than harms to the local areas. It can boost the local socio-economic development. However, after the reservoir is built, its water purification capacity may decrease. The following measures should be taken to mitigate the adverse impacts: 1. Establish an ecological protection coordination and management mechanism to coordinate the relations between the Han River upper and lower reaches, different complexes, and various areas, e.g. a water reserving forest can be developed upstream from the reservoir. 2. Improve the Han River ecological compensation mechanism, retain sewage, and treat sewage; 3. Expand investment in ecological protection, e.g. besides national investment, draw social capital to invest in domestic sewage treatment and domestic waste treatment; 4. Establish a system supporting ecosystem monitoring; 5. Encourage public consultation for ecological and environmental protection, e.g. raise the public awareness of environmental protection; organize volunteer activities with regard to environmental protection.
5	Xiangyang Municipal Bureau of Aquatic Products	Supportive	Construction of the Han River navigation and hydropower complexes causes a number of environmental problems: biodiversity has changed, fish species have decreased, commercially important fish species have decreased, reproduction of Asian carps and other fish species that release pelagic eggs has been disrupted, rare and precious fish species such as *Anguilla japonica* and *Myxocyprinus asiaticus* can hardly be found. These adverse impacts shall not be ignored. The decrease of aquatic products has hurt the livelihoods of fishermen. It is recommended that remedial measures should be taken to restore the spawning grounds of fish and build artificial breeding grounds. Compensation for fishermen shall be made in accordance with *Fisheries Law of the People's Republic of China*.
6	Xiangyang Municipal	Supportive	The project proponent of Yakou Project have established good working contact with cultural relics departments and have prospected cultural relics in the areas

No.	Organization	Attitude	Opinions
	Administration of Culture, Sports, Press, Publication, Radio, Film and Television		where land is requisitioned for the project. They will implement protection measures for unearthing cultural relics as planned. Relevant departments are applying for "the Tea Road", including the Han River waterway, so cultural relics shall be further prospected throughout the implementation of the project, e.g. wharf construction, etc.
7	Xiangyang Municipal Bureau of Water Resources, Xiangyang The River Embankment Construction	Supportive	The decrease of the quantity of water discharged from Danjiangkou Reservoir and the drop of water levels of the Han River middle and lower reaches have caused negative impacts on the embankment and small hydropower facilities along the river banks, e.g. it is difficult to obtain water from the water intake between Xiaohe and Yicheng during the dry season. Water discharged downstream from the dam site may weaken the embankment, so relevant parties shall keep track of the geology of the areas along the Han River banks by monitoring it on a regular basis in order to take prevention and control measures accordingly.
8	Xiangyang Municipal People's Congress	Supportive	As the construction of the complexes lasts a long time, water resources can be effectively used. Generally, the complexes bring more benefits than harms to the environment. The quantity of water flows downstream from Danjiangkou Reservoir decreases. The Han River embankment protection will be taken into full consideration. With regard to sewage disposal, a highly operable coordination and protection mechanism will be established, e.g. increasing the treatment of wastewater from businesses and farms, ensuring wastewater discharged meet the relevant standards; tightening the management of catering service, recreation, and sand mining along the Han River banks, establishing relevant compensation mechanisms; striking a balance between project development and environmental protection, reducing industrial projects, and increasing green projects.
9	Laohekou Environmental Protection Agency	Supportive	Establish a long-term monitoring mechanism, establish a river basin monitoring platform, keep track of and disclose the monitoring results.
10	Danjiangkou Environmental Protection Agency	Supportive	Construction of the complexes has caused seasonal algal blooms and the changes in water self-purification. Advice on aquatic ecosystem protection are as follows: 1. Establish a coordination and management mechanism for implementing ecological operation and relevant protection measures; 2. Increase fish breeding and releasing; 3. Develop ecological compensation standards and implement ecological compensation measures
11	Villagers' representatives	Supportive	Hopefully the construction of Yakou Navigation Complex begins at an early date. Compensation for displaced persons shall be made. Ecological agriculture shall be encouraged. Sandstorm and other adverse impacts caused by construction to the surrounding areas should be reduced or prevented by watering the areas more frequently.
12	Business representatives	Supportive	Adhering to the sustainable development philosophy, Hanjiang Group will increase investment in environmental protection and commit to the Han River ecological protection, e.g. implementing joint ecological operation and preventing and controlling algal blooms in the Han River middle and lower reaches

Table 12-9 Opinions of the representatives at the Zhongxiang meeting

No.	Organization	Attitude	Opinions
1	Zhongxiang Municipal Government	Supportive	With the construction of the Han River navigation and hydropower complexes, especially after the South-North Water Transfer Project was put into operation, algal blooms once occurred in Zhongxiang. Study on algal blooms shall be increased so as to find effective methods of controlling or preventing algal blooms. The decrease of the quantity of water discharged from Danjiangkou has

No.	Organization	Attitude	Opinions
			caused negative impacts to the water intakes and irrigation facilities along the Han River middle and lower reaches. Construction of the complexes is conducive to mitigating these negative impacts.
2	Zhongxiang Environmental Protection Agency	Supportive	Yakou Project has been approved by the Ministry of Environmental Protection. Nianpanshan Project EIA Report is in preparation and it will be submitted to the Ministry of Environmental Protection for approvel before construction begins. It is recommended that environmental protection measures should be implemented in accordance with the EIA and its approval documents throughout project construction so as to reduce the negative impacts of the project to the surroundings. Zhongxiang Environmental Protection Agency shall tighten the supervision of project construction in order to prevent pollution.
3	Zhongxiang Municipal Bureau of Agriculture	Supportive	Generally speaking, the complex project development has an insignificant impact on farming. The project will be conducive to irrigation. It is recommended that waterlogging control measures should be taken to prevent soil gleyization of the arable land in the reservoir area that has been submerged by underground water.
4	Zhongxiang Municipal Bureau of Aquatic Products	Supportive	The complex project development will benefit Zhongxiang. Zhongxiang has the national reserves of *Elopichthys bambusa*, *Ochetobius elongates*, and *Luciobrama macrocephalus*. Large investment will be made in the complexes every year. Fish breeding and releasing serves to restore fish stocks. However, construction of the complexes blocks the passageway through which Asian carps migrate to release egg, so during the spawning season, the quantity of water discharged downstream shall be increased and joint ecological operation shall be implemented so as to restore the spawning conditions.
5	Zhongxiang Municipal Administration of Culture, Sports, Press, Publication, Radio, Film and Television	Supportive	Cultural relics shall be prospected and protected throughout the construction of the complexes.
6	Zhongxiang Forestry Bureau	Supportive	During the construction of the complexes, the reservoir may inundate some of the forestry resources and disrupt the wild animal and plant protection efforts, especially wetland resources and migratory bird protection. Therefore, we need to double our efforts to protect wild animals and plants as well as wetland resources.
7	Zhongxiang Land and Resources Bureau	Supportive	A rising water level will cause inundation. Drainage for arable land in the reservoir area shall be well designed; A requisition-compensation balance of farmland should be made and maintained.
8	Zhongxiang Water Authority	Supportive	The representatives have listed some of the existing environmental problems. After impoundment of Xinglong Complex, in February and March, algal blooms occurred downstream from Xinglong Complex. According to the results of water quality monitoring in the corresponding period, the total nitrogen and phosphorus concentrations exceeded the standards; water environmental capacity decreased; a rising underground water level caused the surrounding farmland to be inundated, thus crop yields lowered. During the dry season, urban tap water was once difficult to be pumped. It is recommended that ecological compensation measures should be developed and implemented to mitigate these adverse impacts.
9	Zhongxiang Maritime Safety Administration	Supportive	After the construction of the complexes began, water discharged downstream may erode the downstream river course and embankment. The downstream river course and embankment should be monitored more frequently in order to ensure navigation safety. A navigation control center shall be established for jointly controlling navigation in the Han River. It is recommended that vessels should be equipped with wastewater treatment facilities and waste collection devices as a way to protect the quality of Han River water. When the vessels are passing

No.	Organization	Attitude	Opinions
			through a ship lock, the waste produced on the vessels should be moved ashore and collectively treated there.
10	Qianjiang Municipal People's Congress	Supportive	Different departments and areas should be communicated and coordinated more frequently.
11	Qianjiang Environmental Protection Agency	Supportive	With regard to the existing algal blooms and underground water submerging arable land, relevant parties shall ensure the ecological flow of water discharged downstream from the complexes and arrange water logging grooves to mitigate the relevant impacts.
12	Villagers' representatives	Supportive	Hopefully the construction of the complex begins at an early date. It is recommended that Nianpanshan project owner and Yakou project owner jointly develop a resettlement compensation plan and define arable land and tidal flats so as to prevent the causes of social instability.

Besides the aforesaid representatives, other representatives at the meeting also shared their opinions. They believe that raising the water level of the reservoir area serve to obtain water and improve agricultural irrigation while having insignificant impacts on the terrestrial ecosystem and others. The persons who are displaced due to the implementation of the project have been properly resettled; their living and working conditions are better than they were before the project was implemented. However, construction of the complexes has adversely affected aquatic ecosystem, water, sewerage, and urban drainage.

12.5 Information Disclosure

Since preparation for the project began, project information and documents including full text RAP and supplemental EA reports have been disclosed to the residents in the affected areas.

Table 12-10 Yakou Navigation Complex Project Information Disclosure

No.	Content	Organization	Time	Website
1	Project description; channels for public consultation, grievance and complaint	EIA organization &project owner	April of 2016	http://www.hbghj.gov.cn/
2	RAP draft, supplemental ESIA, CEA draft, Environmental & Social Management Reports (Chinese)	EIA organization &project owner	June 20 of 2016	http://www.yichengnews.com/ http://www.xfhbj.gov.cn/
4	Notice on disclosing the complete information of RAP and EA online	EIA organization &project owner	June 20 of 2016	http://xfrb.hj.cn/
5	Revised draft RAP, supplemental ESIA, CIA and ESMP reports (Chinese)	EIA organization &project owner	June 25 of 2016	http://www.yichengnews.com/ http://www.xfhbj.gov.cn/

Figure 12-5 First-time disclosure of Yakou Navigation Complex Project information

Figure12-6 Second-time disclosure of Yakou Navigation Complex Project information

12.6 Grievance Mechanism

12.6.1 Grievance Mechanism for Environmental Issues

In order to timely detect and deal with the possible grievance of the public in connection with the environmental issues of the project and reduce the project risks, a grievance mechanism designed to solve the environmental issues has been set up. In the local context, the grievance about environmental and social issues will be solved through different ways.

Under such mechanism environment, it is agreed to set up a public grievance department in the environmental management department of the project owner and set up a grievance mechanism for environmental issues. Figure 12-7 shows the procedure and requirements.

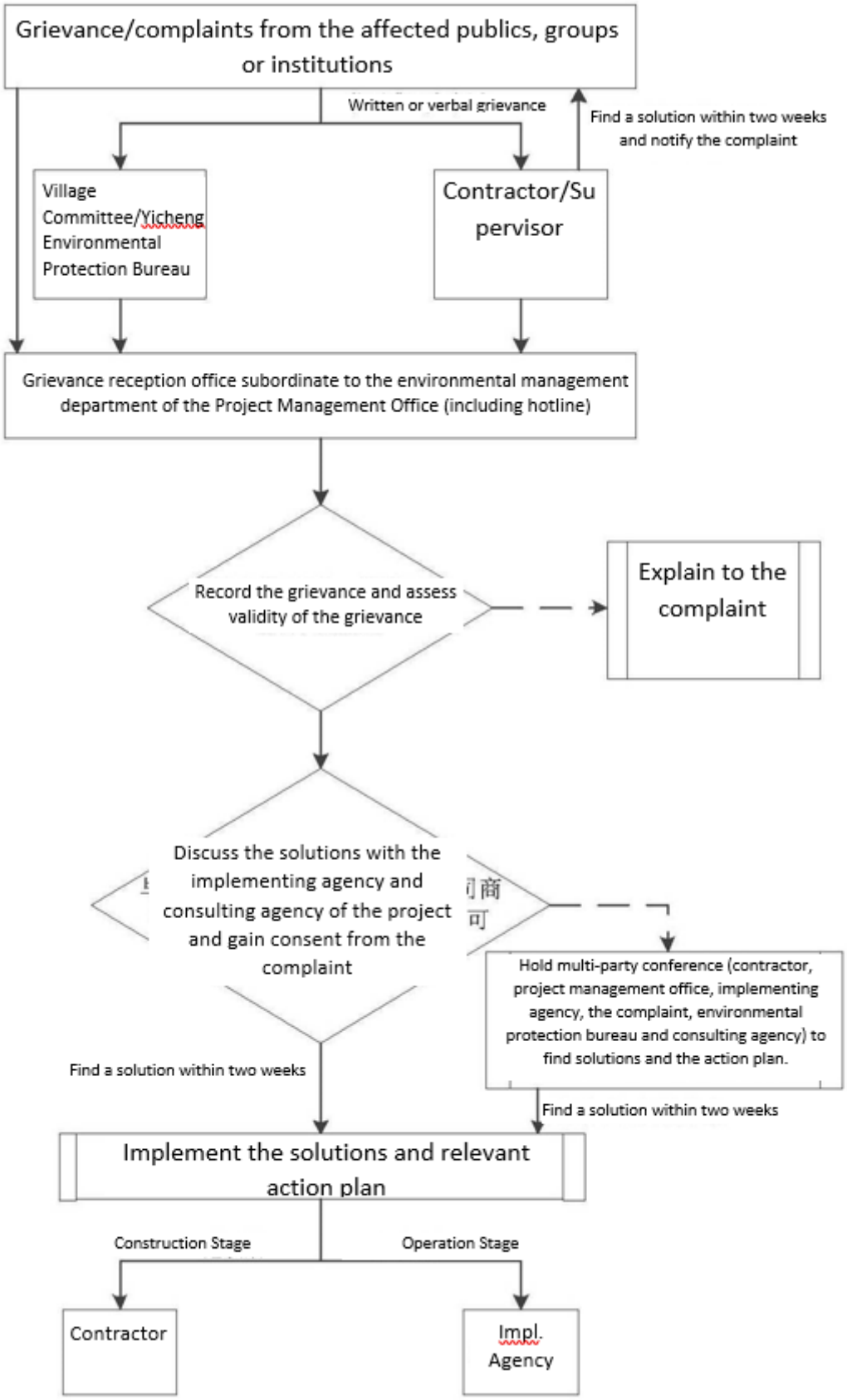


Figure 12-7 Grievance mechanism about environmental issues of Han River Yakou Project

Such grievance mechanism will be open to all local residents, including women and other vulnerable people. Any affected persons, group or institutions can appeal through phone, letter, E-mail and through other media. The contacts of various grievance reception links (such as cadre of the Village Committee, Contractor, environmental management personnel of the implementing agency and officials of the local environmental protection bureau and so on) will be determined before commencement of the project. The specific contact information (such as phone number, address and E-mail and so on) will be disclosed on the InfoBar of the construction site or portal of the local government.

Environmental management department of the project management office will set up a complete tracking and recording system of grievance mechanism so as to:

(1) Set up the follow-up form and procedures to collect information from the project staff and the complaint;

(2) Appoint a person to regularly update the information in the database;

(3) Set up information analysis system, identify the cause of grievance, improve the transparency of grievance handling procedures and regularly assess overall operation of the mechanism.

(4) Set up procedures to notify the relevant party to deal with the grievance;

(5) Regularly report the grievance handling information to the project management office, implementing agency and World Bank.

12.6.2 Grievance Mechanism for Social Issues

When grievance about social issues has something to do with the legitimate rights and interests of the displace persons, they have the right to appeal. A special grievance mechanism for this project has been set up:

(1) If any displace person is dissatisfaction with the resettlement, he/she can submit verbal or written grievance to the Village Committee or the resettlement office of the township level. If it is verbal grievance, the Village Committee or resettlement office of the township level should deal with it and keep the written records. Such grievance should be solved within two weeks.

(2) If the displaced person is dissatisfaction with the results of the first stage, he/she can file a grievance to the resettlement office of the county level after receiving the results. Such grievance should be dealt with in two weeks.

(3) If the displaced person is still dissatisfaction with results of the second stage, he/she can file a grievance to the Dimensional Stability or Office for Letter and Calls of the county level. Dimensional Stability or Office for Letters and Calls of the county level should organize the displaced persons, resettlement direction department of the county level, Bureau of Land and Resources, Bureau of Housing and Urban-Rural Development, Human Resources and Social Security Bureau, Bureau of Civil Affairs and other functional departments to hold a coordination meeting and solve the problems.

(4) If the problems are still not solved in the third stage, the displaced person can lodge an action to the People's Court of county level in accordance with Civil Procedural Law of the People's Republic of China.

(5) In addition, the displaced persons can also file a grievance to the supervising and management departments of the project which will coordinate with the project owner and

solve the problems.

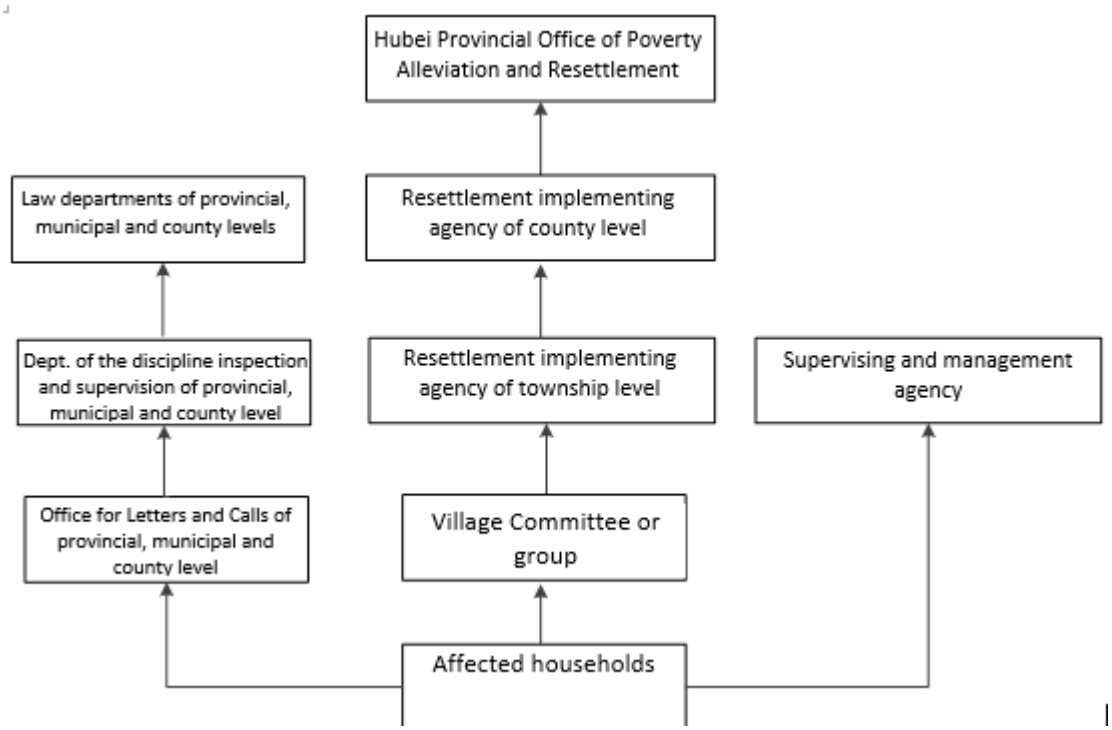


Figure 12-8 Grievance mechanism about social issues of Han River Yakou Navigation Complex Project

In addition, a report meeting will be held before commencement of all construction activities to inform the affected persons of the potential environmental and social impacts of the project.

13 Conclusions and Recommendations

Yakou Navigation Complex Project is the sixth complex among navigation complexes along Han River in Hubei Province. It is 52.67km away from Cuijiaying complex and 59.38km away from the planned Nianpanshan complex and is an integrated project with navigation as the main function and power generation, irrigation and tourism as the auxiliary functions. The normal water level of Yakou reservoir is 55.22m, corresponding to capacity of 350.2 million cubic meters. The reservoir has daily regulating capacity. Grade III waterway of 52.67km will be channelized and the design navigation capacity of ship lock is 1000t ship. The installed capacity of power station is 75.0MW and the average annual energy output is 252 million KWH. Yakou Navigation Complex Project is the communication and water conservancy project encouraged by National Development and Reform Commission of PRC in *Catalogue for Guiding Industry Restructuring* (2011 edition) (revised in 2013) and meets the industry policy of the state, the layout as specified in *National Inland Waterway and Port Layout Planning* and requirements of navigation planning of Yangtze River and inland navigation development plan of Hubei Province.

In consideration of the background of construction of navigation complexes along Han River mainstream and engineering characteristics of Yakou reservoir, this supplemental ESIA covers the areas directly and indirectly affected by the project, including project construction area (dam area, project management area, construction and living areas, access roads, waste dump site and reservoir inundated areas), resettlement area and areas of relevant works (namely, Han River embankment area of Xiangyang City and transmission line project area). In the process of supplemental environmental impacts assessment, the company has investigated the physical culture resources, assessed the environmental impacts of resettlement area, access roads, Han River embankment works in the reservoir area and transmission line project and other supporting projects as well as the mitigation measures, implemented public consultation activities, cumulative effect assessment and due diligence on embankment works and included the main results of supplemental environmental and social impacts assessment into the environmental and social management plan. Upon assessment and analysis, main conclusions of this supplemental environmental impacts assessment are as follows:

• Analysis of alternatives: The development scope of the planned complexes in middle and lower reaches of Han River is the river section from Danjiangkou dam to Xinglong complex. Such river section will be greatly influenced after implementation of South-to-north Water Diversion Project. The service area of Yangtze-Han Water Diversion Project is the section below Xinglong complex. Therefore, construction of complexes in river section from Danjiangkou to Xinglong to form interconnected reservoir system will well compensate the ecology, navigation and water supply upon implementation of South-to-north Water Diversion Project and is also the important integrated compensation means of this river section. Yakou Navigation Complex Project is a part of complexes development along Han River mainstream. Comparison and analysis of different alternatives have been done in the overall planning and design process since the project proposal is put forward and the highly cost-effective design scheme with minimum environmental and social impacts is determined through comprehensive comparison on technical, economic, environmental and social factors of waterway management scheme of Han River mainstream, dam site, water level, fish pass measures and so on.

• Impacts on aquatic ecosystem: With construction of Danjiangkou reservoir, the fish

is unable to swim upwards the reach above Danjiangkou dam and fish spawning in upper reach of Han River is also unable to swim downwards the middle and lower reaches of Han River and even middle and lower reaches of Yangtze River. Aquatic ecological function of Yangtze River originally undertaken by Han River will be undertaken by middle and lower reaches of Han River and the corresponding habitats narrow and weaken. In particular, the temperature of discharged water of Danjiangkou reservoir is lower, delaying the breeding of fishes in middle and lower reaches of Han River in about one month. But there are still many spawning grounds in middle and lower reaches of Han River and these spawning grounds are important location for spawning and breeding of fishes in middle and lower reaches of Yangtze River. With construction of Wangfuzhou complex, Cuijiaying complex and Xinglong complex, some spawning grounds will be inundated, migration channels of fishes will be blocked, the spawning grounds will narrow and the breeding population will decrease. In particular, in the low flow years, small flood peak discharge and attenuation of many complexes will further weaken the function of the remaining Yicheng, Guanjiashan, Zhongxiang spawning grounds and Zekou spawning ground which is located under Xinglong dam. With running of South-to-north Water Diversion Project (Phase I), Danjiangkou dam will discharge less water and temperature of the discharged water will be even lower. This will further exert impacts on these spawning grounds.

If not considering ecological scheduling, construction of Yakou Navigation Complex will further exert adverse impacts on fish producing pelagic eggs in middle and lower reaches of Han River. Even if Yakou Navigation Complex is not built in the middle and lower reaches of Han River, due to blocking of the built complex, baby fishes continuously swim downwards the reaches under Xinglong dam but the mature parent fishes find it hard to swim back to the reaches above Xinglong dam. Hence, quantity of producing pelagic eggs continuously decreases and the function of current spawning grounds further weaken. The relevant studies show that, breeding of fish producing pelagic eggs in the middle and lower reaches of Han River mainly relies on water supply of Tangbai River and flood. Discharge of Danjiangkou reservoir plays a helping role. Therefore, implementing ecological scheduling of Cuijiaying complex, Yakou complex and Xinglong complex in accordance with water inflow of Tangbai River can restore the natural status of river sections in middle and lower reaches where fish spawns and mitigate the adverse impact of hydrological regime changes on breeding of fish producing pelagic eggs. At the same time, ecological scheduling can connect the project located river section with lower reach of Han River and middle and lower reaches of Yangtze River, mitigate adverse impact of Yakou complex and other built complexes along Han River on fish resources and play an important role in protecting and restoring the spawning grounds of fish producing pelagic eggs in middle and lower reaches of Han River and maintaning the function of Yicheng, Guanjiashan and Zhongxiang spawning grounds.

Meanwhile, in order to mitigate the blocking impact of non-flood period, bionic fishway is built to promote communication between fishes above and below the dam and ensure the smooth migration channel of black carp, grass carp, silver carp and bighead carp and completeness of life history of fish. In addition, the habitats protection plan is proposed and fish breeding and releasing measures are also taken. These protective measures can effectively mitigate the impacts of construction of navigation complexes in middle and lower reaches of Han River on fish resources.

• Due diligence on environmental impacts of embankment works in the reservoir area: The company has investigated the project progress, environmental and social management implementing agency, EIA Report and the approvals as well as the implementation of

given environmental and social management plan. In accordance with the survey, preparation and implementation of urban embankment works in Xiangyang complies with requirements of relevant state and local environmental protection laws and regulations and the Contractor has effectively implemented the given environmental management plan in the construction process by virtue of rich construction experiences of water conservancy project. The greening of the built section is good, the surrounding environment is greatly improved, life quality of the local residents are improved and expected environmental and social benefits are obtained.

• Cumulative environmental impact assessment: As part of the supplemental ESIA, this cumulative effect assessment determines in accordance with the development characteristics of this project and the project located basin and the existing data that the main assessment scope is river section along Han River mainstream below Danjiangkou navigation complex and views the hydrological regime, water quality and fish resources as valuable and key ecological factors. But it is required to effectively implement joint scheduling, water quality monitoring, fish resources protection and pollution control and management of the basin as specified in the environmental and social management plan during the implementation and operation process of the project so as to timely track the impact of complex construction of the basin on the river and aquatic ecological environment and try to mitigate the impacts on local fish resources. In addition, it is also recommended to further monitor the hydrological and water quality data below the complexes in Han River under current operation conditions so as to accurately quantify the cumulative effects through model analysis and further detail the corresponding mitigation measures, laying solid foundation for environmental management of the project.

•Physical cultural resources: Through site survey, confirmation of the local cultural heritage bureau and site-investigation of the experts and in accordance with the construction plan of normal water level, the project construction will inundate 12 ground cultural heritage sites. Among them, Wangjiagang tomb is the county-level protected site and protection level of other 11 has not been determined. Survey the heritage sites and implement archaeological excavation to protect these ground cultural heritages. The bottom cleanup will be properly conducted under direction of local forestry department and the tombs affected by inundation will be fully compensated according to local customs and RAP. In addition, for the accidental discovery of cultural heritages in the construction process and the corresponding cultural heritage protection, the relevant measures in the environmental and social management plan will be strictly implemented so as to avoid damages to the physical cultural relics.

•Resettlement: Implementation of the proposed project will have to arrange production for 690 displaced persons and houses for 18 households with population of 91. The resettlement area and production and living of the displaced persons may impose project related social and environmental impacts, mainly including impacts on ecology, sewage, garbage and human health. The original EIA Report has put forward the corresponding mitigation measures, including greening, source water protection, installation of sewage treatment facilities and collection and landfill of the domestic wastes and strengthening sanitation and epidemic prevention of the resettlement area.

•Auxiliary works: Major auxiliary works of Yakou Navigation Complex Project are road works, quarries and waste dump sites and so on as well as restoration and construction of transmission lines. Environmental impacts and mitigation measures of the road works have been considered by combing with the main works. Restoration and construction of

transmission lines will be implemented in the later period. Hence, only the general environmental management framework on this type of project is described in this supplemental ESIA Report and used for reference of the subsequent EIA. Based on the above analysis, as key project of *Report on Comprehensive Planning of the Han River Mainstream* (revised), Yakou Navigation Complex Project complies with the overall planning of the basin and will bring huge benefits in the aspect of navigation, power generation and irrigation. As the fifth complex among complexes along mainstream in middle and lower reaches of Han River, Yakou project will exert both positive and negative impacts on the aquatic ecology. To this end, this report further improves the original environmental and social management plan and serves as the guidance documents of environmental management in the implementation and operation of the project in the future. With implementation of the relevant mitigation measures and monitoring plan, the above main adverse cumulative impacts are expected to be controlled at the acceptable level.