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Environmental Impact Statement
On Changyang Xujiaping Hydropower
Project in Hubei Province

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Evaluation unit: Wuhan Institute of Environmental Medicine, Tongji Medical College, Huazhong University of Science and Technology (Seal)

Project Leader: Wu Hongjuan

Information on personnel of evaluation		
Name	Job No. of Environmental Assessment	Signature
Wu Hongjuan	B26040006	
Yang Jiakuan	B26040008	
Hu Yonggang	B26040007	
Huang Zheng	B26040001	

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Attachment:

1. Power of Attorney of Xujiaping Hydropower Project Environmental Impact Assessment
2. Approval of Environmental Protection Bureau of Changyang Tujia Autonomous County on the Applied Standards for Environment Assessment of Xujiaping Hydropower Station Engineering Construction Project
3. Opinion of Technology Review Experts on Environmental Impact Statement of Xujiaping Changyang Hydro-power Project of Yichang City in Hubei Province
4. List of Experts at Environment Assessment Review Meeting of Hubei Changyang Xujiaping Hydropower Station
5. Approval on “Report of Development and Planning of Hydraulic Power of Yaozhan River of Changyang in Hubei Province”
6. Air Quality Monitoring Report of the Location of the Proposed Changyang Xujiaping Hydropower Station
7. Surface Water Environmental Quality Monitoring Report of the Location of the Proposed Changyang Xujiaping Hydropower Station
8. Sound Environment Quality Monitoring Report of the Location of the Proposed Changyang Xujiaping Hydropower Station
9. Xujiaping Hydropower Project Public Participation Questionnaire

Attached Figure:

1. Xujiaping Hydropower Project Location Map
2. Yaozhan River Basin Planning Map
3. Xujiaping Hydropower Project Hub Layout
4. Xujiaping Hydropower Project Construction Layout
5. Xujiaping Hydropower Project Monitoring Points Distribution Map
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Foreword

Xujiaping Hydropower Project that is planned to be constructed, located in Duzhenwan Town of Changyang County, is the key project on the hydraulic power development and utilization of Yaozhan River. The dam site of the project is located at Liulinzi in the middle reaches of Yaozhan River, 58km to Zhuangxi River, 135km to Changyang County and 195km to Yichang City; the Powerhouse is located in Xujiaping, 48km to Zhuangxi River, 125km to Changyang County and 185km to Yichang City, therefore, the project boasts convenient traffic conditions.

Yaozhan River, located at the south of Changyang, originates in the south and the north of Gaofeng Village of Wufeng Bailuzhuang Township and belongs to the Grade One branch of Qingjiang River. The total drainage area of the river is 128.6 km²; the length of the main channel of the river is 20.6 km; the total elevation of the river is 1952.7m; the average weighted river slope of the main channel of the river is 17.3‰; the multi-year average precipitation is 1445.7mm and the multi-year average flow is 3.2m³/s. The theoretical storage quantity of Yaozhan River is 1.55×10^4 kW and the hydraulic power in the corresponding year is 136 million kWh. The development on the hydraulic power of the trunk of the river plans to adopt the program of one reservoir and nine stations, namely, Sifangdong hydropower station (built, 2×2500kW), Houziyan hydropower station (built, 2×40kW), Taizi hydropower station (2×125kW), Chengwuhe hydropower station (built, 2×75kW), Huilongguan hydropower station (built, 2×500kW), Xujiaping reservoir (the normal water level of 437m and the total reservoir storage of 2.17×10^6 m³) and the reservoir power station (5,000 +3200 kW), Wangjiacao hydropower station (2×160kW), Erhekou hydropower station (2×125kW), Xiangshuidong hydropower station (built, 500+250 kW), the total installed capacity is 16,000kW. The hydraulic power development of the branch of the river plans to adopt the Grade I development program, namely, the Zhongxi hydropower station (2×160kW) with the tail-water into the reservoir area of Xujiaping Hydropower Project. The development on the Chongxi hydraulic power of the branch plans to apply the three-station development program, namely, Erchakou hydropower station (2×320kW), Xujiaping Hydropower Project (Capacity Enlargement of 800kW) and Chongxi Hydropower Station (built, 2×125kW). Yichang Water

Resources & Hydropower Office approved the above planning with the document numbering X.S.S. [2005] No. 112 in June 2005.

According to the "Eleventh Five-Year" planning, the electricity consumption load of Changyang County in 2010 will be 1.67×10^5 kW; however, the existing installed capacity of Changyang County is only 7.63×10^4 kW, indicating that the power shortage will be increasingly obvious. Based on the existing states of the socio-economic development and the power system, the development of Yaozhan River is imperative. In July 2005, Yichang Water Resources & Hydropower Office held the meeting on the review of "The development and planning report of Yaozhan River hydraulic power of Changyang in Hubei Province", and finally obtained the conclusion that the fundamental information of the planning report was detailed, the content was comprehensive and the analysis was reasonable, furthermore, the report met the depth and requirements on planning, therefore, the planning program is feasible.

In accordance with the relevant requirements of "Environmental Impact Assessment Law of People's Republic of China" and "Regulations on the Administration of Construction Project Environmental Protection" and entrusted by Yichang Changfeng Hydropower Development Co., Ltd., Huazhong University of Science and Technology implemented the environmental impact assessment on the project. With the spot survey and the preliminary identification and screening on the environmental impact of the project, Huazhong University of Science and Technology, based on the analysis on the project characteristics and the environmental characteristics of the evaluation area, carried out full discussion with the construction units and the design units, furthermore, after consulting the opinions of the local environmental protection department of the project, the "Environmental Impact Statement on Hydro-power Project of Changyang Xujiaping in Hubei Province" has been developed in accordance with the relevant requirements of State Environmental Protection Management Department. The statement has been submitted to the construction units and also reported to Hubei Province Environmental Protection Bureau for approval.

During the preparation of the project environmental impact statement, Changyang County Environmental Protection Bureau, Changyang County Environmental Monitoring Station and the Owner Unit have given great support, we hereof express sincere gratitude for their kindness.

1. General

1.1 Evaluation Purpose and Evaluation Principle

1.1.1 Evaluation Purpose

Environmental Impact Evaluation Purpose of the Project:

(1) The construction of Xujiaping Hydropower Project is a public welfare project of significant social benefits. Its construction will be beneficial to the sustainable development of local society-economy and the environmental improvement, but also it will create and bring the relevant environmental issues. The evaluation will be made by taking full account of the influence scope and degree on the society, economy and environment of the relevant areas of Yaozhan River due to the construction of the project, and furthermore, the quantitative projections and qualitative analysis and evaluation on the key environmental impact factors will be focused (including the favorable and adverse effects). Besides, the demonstration on the feasibility of project construction will be made from the point of view of environmental protection, so as to provide the reference for the decision-making of the competent authorities.

(2) To implement the objective evaluation on the impacts to the natural and social environment of the reservoir area, the construction area and the downstream of the dam site due to the project construction; and put forward practical and feasible environmental protection measures and countermeasures; and minimize the negative impact on the environment due to the project construction.

(3) To implement the investment estimation and the profit and loss analysis on the proposed environmental protection measures to integrate the construction of environmental protection of the project and the investment into the project construction while putting forward the environmental monitoring and management plans on the construction period and operation period of the project, thus realizing the harmonious development between the economy and the environment.

1.1.2 Evaluation Principle

To comprehensively implement the national and local laws, regulations and policies on environmental protection, the evaluation should comply with the following principles:

- (1) Principle of the protection to the regional biodiversity;
- (2) Principle of the protection to surface water environmental quality of the reservoir area and the downstream of the dam site;
- (3) Principle of prompting the sustainable development of the regional ecology and economy;
- (4) Principle of overall planning and laying stress on key points;
- (5) Principle of prevention first, combining management and protection, and laying equal stress on construction and management.

1.2 Preparation Basis

1.2.1 Laws, Rules and Regulations

- (1) "Environmental Protection Law of the People's Republic of China" (December 26, 1989);
- (2) "Environmental Impact Assessment Law of the People's Republic of China" (October 28, 2002);
- (3) " Law of the People's Republic of China on Prevention and Control of Water Pollution" (May 15, 1996);
- (4) "Law of the People's Republic of China on the Prevention and Control of Atmospheric Pollution" (April 29, 2000);
- (5) "Environmental Noise Pollution Prevention and Control Law of the People's Republic of China" (October 29, 1996);
- (6) "Law on the Prevention and Control of Environmental Pollution by Solid Wastes of the People's Republic of China" (October 30, 1995);
- (7) "Law of the Peoples Republic of China on the Prevention and Treatment of Infections Diseases" (August 28, 2004);
- (8) "Water Law of the People's Republic of China" (August 29, 2002);
- (9) "The Law of Land Administration of the People's Republic of China" (August 29, 1998);

- (10) "Law of the Peoples Republic of China on Water and Soil Conservation" (June 29, 1991);
- (11) "Law of the People's Republic of China on the Protection of Wildlife" (November 8, 1988);
- (12) "Regulations of the People's Republic of China on Wild Plants" (September 30, 1996);
- (13) "Regulations on the Administration of Construction Project Environmental Protection" (GWYL No. 253);
- (14) "Classified Index of Environmental Protection Management in Construction Projects" (GJHBZJL No. 14);
- (15) "Regulations on the Protection of Basic Farmland" (GWYL No. 257);
- (16) "Fisheries Law of the Peoples Republic of China" (August 28, 2004);
- (17) "Lists of wildlife under special state protection";
- (18) "Lists of wildlife under special state protection (The first batch)";
- (19) "Management method on soil and water conservation program of development and construction projects of Yichang City";
- (20) "Notice on the strengthening of environmental protection of hydropower construction", Ministry of Environmental Protection of the People's Republic of China, National Development and Reform Commission, HF [2005] No. 13, January 2005;
- (21) Ministry of Environmental Protection of the People's Republic of China, HF [2004] No. 24 "Opinion on the strengthening of the supervision of ecological and environmental protection of resources development";
- (22) Document of General Office of Hubei Provincial People's Government EZBF [2000] No. 10 "General Office of the Provincial People's Government Transmitting the Notice of Provincial Environmental Protection Bureau on Surface Water Environmental Function Classification of Hubei Province";
- (23) Ministry of Environmental Protection of the People's Republic of China HF [2006] No. 28 "Temporary Measures of the Public Participation in Environmental Impact Assessment";

(24)"Large and Medium-sized Hydropower Engineering Land Requisition Compensation and Resettlement Regulations"

(25) Ministry of Environmental Protection of the People's Republic of China, HF [2006] No.4 "Technical guidelines on environmental impact assessment of ecological use of water, low-temperature water and fish passage facilities of the river of hydropower project construction (for trial implementation) ";

(26) Ministry of Environmental Protection of the People's Republic of China, HF [2006] No. 93"Notice on order development of small hydro power and protection to the ecological environment"

(27) Hubei Provincial People's Government EZF [2006] No. 25 "Opinions on the strengthening of the management on the development and utilization of hydraulic power resources".

1.2.2 Technical Guidelines and Norms

(1) "Technical Guidelines on Environmental Impact Assessment-General principles" (HJ/T2.1-93);

(2) "Technical Guidelines on Environmental Impact Assessment-Atmospheric Environment" (HJ/T2.2-93);

(3) "Technical Guidelines on Environmental Impact Assessment-Surface Water Environment" (HJ/T2.3-93);

(4) "Technical Guidelines on Environmental Impact Assessment-Sound Environment" (HJ/T2.4-1995);

(5) "Technical Guidelines on Environmental Impact Assessment-Non-polluted Ecological Impact" (HJ/T19-1997);

(6) "Technical Guidelines on Environmental Impact Assessment-Water and Hydropower Project" (HJ/T88-2003);

(7) "Technical regulation on water and soil conservation plan of development and construction projects" (SL204-1998);

(8) "Technical specifications on the comprehensive control over oil and water conservation" (GB/T164531 ~ 6-1996);

- (9) "Technical specification on "surface water and waste water monitoring" (HJ/T91-2002);
- (10) "Specification for planning and design of reservoir submergence treatment of hydroelectric engineering" (DL/T5064-1996).

1.2.3 Main Technical Documents and Power of Attorney

- (1) Power of Attorney on Environmental Impact Assessment Project;
- (2) Letter of Changyang Environment Protection Bureau Relevant to the Executive Standard on Environmental Assessment of Xujiaping Hydropower Station;
- (3) "Xujiaping Hydropower Project Feasibility Study";
- (4) "Water Resources Appraisal Report on Xujiaping Hydropower Station of Changyang Tujia Autonomous County";
- (5) "Soil and Water Conservation Program Report on Changyang Xujiaping Hydropower Project of Hubei Province"
- (6) "Surface water environmental quality monitoring report on the planned construction site of Changyang Xujiaping hydropower station"
- (7) "Air quality monitoring report on the planned construction site of Changyang Xujiaping hydropower station"
- (8) "Sound environment monitoring report on the planned construction site of Changyang Xujiaping hydropower station"
- (9) "Ecological survey report on Changyang Xujiaping hydropower station"

1.3 Evaluation Standard

In accordance with the regulations of Document of General Office of Hubei Provincial People's Government EZBF [2000] No. 10 "General Office of the Provincial People's Government Transmitting the Notice of Provincial Environmental Protection Bureau on Surface Water Environmental Function Classification of Hubei Province" and the Letter of Changyang Environment Protection Bureau Relevant to the Executive Standard on Environmental Assessment

of Xujiaping Hydropower Station, the applicable standards of the environment impact assessment of the project are as follows, see Table 1-1.

Table 1-1 Standards for Environmental Impact Assessment of Xujiaping Hydropower Project

Category	Standard No.	Standard Name	Grade/Class
Quality Standard	GB3838-2002	Environmental Quality Standards for Surface Water	Class II
	GB3095-1996	Ambient air quality standard	Grade II
	GB3096-93	Standard of environmental noise of urban area	Class II
Emission Standard	GB12523-90	Noise Limits for Construction Sites	Relevant Limits

1.4 Environmental Protection Objectives

Based on the characteristics of the project construction, the environmental protection objectives of the main protection targets of the project are as follows:

(1) Ecological Environment

Due to the project construction, the hydrological regimen will be changed, resulting in that the river dry-up section and the water reducing section from the downstream of the dam of Xujiaping Hydropower Project to the tail water outlet of the powerhouse will appear, therefore, it shall discharge the ecological flow of a certain amount to meet the basic need of the ecological environment on water.

By the application of a variety of prevention and control measures, it shall ensure that the new water and soil erosion caused by the activities relevant to the project within the project construction scope is under control and it meets the objectives of local government on the water and soil conservation prevention, furthermore, it shall ensure that the water and soil erosion of the construction scope and especially the waste residue yards is basically under control.

Minimize the destruction of project construction to vegetation, and after the completion of the project, the vegetation of the bare soil surface within the construction scope shall be recovered. It shall ensure that vegetation coverage rate will recover over 95%, the coverage rate of trees and grass within the accountability scope will be higher than 30% and the ecological environment within the construction scope will be improved.

(2) Surface Water

As for the water bodies within the reservoir area and from the downstream of the dam to 5km at the downstream of the power house, ensure the water environment function zoning objectives are maintained or improved, and ensure that the surface water environmental functions will not be damaged due to the project construction. At present, the water is mainly used for agriculture and landscape, which plans to be used for landscape and entertainment; furthermore, the water quality shall follow the requirements of Class II requirements of "Environmental Quality Standards for Surface Water" (GB3838-2002).

(3) Sound Environment

The sound sensitive points are distributed as follows: one household 50m at the south side of the powerhouse and 3 households about 100m at the west side, totally 4 points, and the sound environment quality shall reach the requirements of Class II of "Standard of environmental noise of urban area" (GB3096-93).

(4) Resettlement

The main objects of the resettlement are the residents within the construction areas. The resettlement shall follow the principle of keeping the existing standard of living, protecting the rights of residents and not lowering the quality of life of the residents within the resettlement areas.

(5) Population Health

Protect the health of residents, construction workers and other people involved into the resettlement relevant to the project, and meet the requirements on the relevant disease prevention and control and the public health requirements regulated by the state health departments (Including infectious diseases, endemic diseases, epidemics, etc.).

Based on the environmental investigation on the project area, the main environmental protection objects and the aims are shown in Table 1-2.

Table 1-2 Main Environmental Protection Objects and Aims

Environmental factors	Protection Objective	Affected area	Influencing Factors
Ecological Environment	River dry-up section and the water reducing section	Totally 7.8km from the downstream of the dam to the powerhouse	Blocked by the dam
	Water and soil erosion	Project construction area, soil quarrying site and waste residue yard	Excavation, quarrying and waste residue, etc.
Water Environment	Yaozhan River	Totally 14.97km from the reservoir area and the downstream of the dam to the downstream of the powerhouse	Wastewater of the project construction and the project operation
Sound Environment	4 households within 100m at the southwest side of the powerhouse	Within the project construction scope	Construction noise, traffic noise
Air	Scattered residential area	Around the project construction and both sides of the building materials transportation roads	Dust, vehicle exhaust
Social Environment	Duzhenwan Town	Relevant Villages	Land utilization, population health, rights of people of resettlement, and society& economy, etc.

1.5 Evaluation Work Grade

In accordance with regulations of "Classified Index of Environmental Protection Management in Construction Projects" (G.J.H.B.Z.J.L. No. 14), because Xujiaping Hydropower Project is the hydro-electric project, the environmental impact statement shall be prepared for the overall evaluation on the pollution caused by the project and the environmental impact evaluation.

(1) Ecological Environment

The adverse impact of the proposed project on the environment is mainly on the ecological environment, belonging to the non-polluting type, the impact scope of the project is the non-sensitive area. By the preliminary analysis on the engineering and the environment of the engineering, the backwater length of the proposed engineering is 1165m, the reservoir capacity at the normal water level is $2.13 \times 10^6 \text{m}^3$ and the directly affected scope is $(1.40 \times 10^5 \text{m}^2) < 20 \text{km}^2$. The total submerged area involved into the engineering is 14.61hm^2 , the area of the house submerged is 1050m^2 and the arable land area is 1.23hm^2 , of which the paddy field area is 1.15hm^2 , the dry land area is 0.08hm^2 , the tea garden area is 0.95hm^2 , the timber production forest area is 1.92hm^2 , the fuel forest area is 3.36hm^2 , the barren hill area is 4.33hm^2 , the river flat area is 1.90hm^2 and the road area is 0.86hm^2 , furthermore, there are a bridge and 16 telegraph poles, the reduction of the biomass of the biome flooded is less than 20%, the heterogeneity degree and the relative homogeneity have little change, and the species diversity is lower than 50% and the number of regional environmental green is lower than 20%, the environment connectivity degree is poorer, and the physical and chemical properties of the water and the soil are changed. In accordance with the grading principle of HJ/T19-1997 "Technical Guidelines on Environmental Impact Assessment-Non-polluted Ecological Impact", the ecological environment impact assessment work grade is Grade III.

(2) Surface Water

The multi-year average flow of Xujiaping Hydropower Project is $1.92 \text{m}^3/\text{s}$, and the river for the project is a small one with the water body environmental function of Class II and the reservoir of Class II. The engineering construction can only produce the waste water and a small amount of domestic sewage during the construction period of time, and there will be 11 workers during the operation of the project with the domestic sewage amount of less than $1000 \text{m}^3/\text{d}$, which can be used for watering plants after the treatment, and the water quality complexity degree is simple, in accordance with the grading requirements of the HJ/T2.3-93 "Technical Guidelines on Environmental Impact Assessment-Surface Water Environment", the surface water environment impact assessment work grade is Grade III.

(3) Air

The engineering itself does not produce any air pollutants, and the few air pollutants relevant to

the engineering mainly come from the construction machinery and the transport vehicles, and a small amount of dust, SO₂ and other pollutants are produced by the living stoves of construction staff, the emission of all pollutant is much lower than the standard of 2.5×10⁷m³/h. According to the grading regulations of HJ/T2.2-93"Technical Guidelines on Environmental Impact Assessment-Atmospheric Environment", the air environmental impact assessment work grade is briefness.

(4) Noise

The engineering during the operation period will not produce the noise basically, but it will produce the noise during the construction period due to the rock blasting, the concrete mixing, the transportation of vehicle and other activities required, but most of which are intermittent and temporary. And the engineering construction area is located in the non-sensitive area, and no residents are within 200m of the construction area. The existing function of the sound environment of the construction area is Class 2, and in accordance with the grading regulation of HJ/T2.4-1995 "Technical Guidelines on Environmental Impact Assessment-Sound Environment", the sound environment impact assessment of the engineering is briefness.

1.6 Evaluation Scope and Period of Time

There is no water for irrigation at the downstream of the reservoir within the evaluation area of the engineering, and there is little amount of water for drinking of residents and domestic animals; furthermore, the engineering construction requires the relocation of 21 people. Then the scope of the environmental impact assessment of Xujiaping Hydropower Project is as follows:

(1) Ecological Evaluation Scope

In accordance with the engineering design, the total land area required during the engineering construction period will be 22.54hm², of which, the land for temporary use of the engineering will be 5.26hm² and the land for permanent use of the engineering will be 17.28hm², including 14.61hm² submerged by the reservoir and 2.67hm² land for the permanent use of the engineering buildings. After the commencement of the engineering, the most landforms within the engineering scope will be damaged of different degrees by the construction activities, such as excavation, disturbance, roller compaction and occupancy and other forms, its original water retention and the soil conservation functions will be lowered.

Because the engineering construction will change the existing state of the land utilization of the area and the connectivity of the different landscape ecology spaces, the indirectly affected scope will be expanded from the surrounding area of the reservoir to the area of residents of resettlement to fully analyze the integrity of the landscape of the area.

The ecological evaluation scope will be 200m more based on the above area, totally 530hm².

(2) Water Environment Evaluation Scope

The water environment evaluation scope for the construction period is as follows: 2km at the upstream of the dam site to the 5km at the downstream of the powerhouse, totally about 14.8km.

The water environment evaluation scope for the operation period is as follows: 1km at the upstream of the backwater section of the reservoir to the 5km at the downstream of the powerhouse, totally about 14.97km.

(3) Air and Sound Environment Evaluation Scope

Xujiaping Hydropower Project during the operation period only produces a very small amount of exhaust gas due to the running of machines, and the air and sound environment evaluation mainly focuses on the construction period, therefore, the evaluation scope is the scope including the construction area of the hydropower station (including the plant area of the dam site, the auxiliary engineering area, the waste residue disposal area and the storage yard exploration area) and 200 meters at the surrounding areas.

1.7 Evaluation Content and Evaluation Focus

1.7.1 Evaluation Content

Based on the information collection and investigation relevant to the surrounding environment of the construction project and the analysis on the engineering, furthermore, by the application of the identification and screening of the environmental impact factors relevant to the engineering, the main contents of the evaluation include:

To implement the detailed analysis and the evaluation on the main environmental impact factors such as ecological environment, surface water environment, environmental impact during the construction period, water and soil conservation, reservoir inundation and resettlement; at the same time, the brief analysis and evaluation on the general evaluation factors shall be made, such

as silt, population health and environmental geology.

Based on the analysis and evaluation and combined with the operation experiences of similar domestic engineering facilities, it will put forward and design the applicable environmental protection measures and countermeasures; put forward the requirements on the settings of the environment management organizations and the detailed contents of the environment monitoring plan; analyze the investment on the environmental protection measures and its operating costs; evaluate the economic benefits; and investigate and implement the statistics on the public comments and suggestions on the powerhouse construction.

Finally, it shall prove the feasibility of project from the point of view of environmental protection and present the conclusion of the comprehensive evaluation.

1.7.2 Evaluation Focus

The evaluation focus of the engineering is the eco-environmental impact assessment, soil and water conservation, surface water environmental impact assessment and the environmental impact of reservoir inundation and resettlement.

1.8 Evaluation Method and Procedures

1.8.1 Evaluation Method

In accordance with the requirements of "Technical Guidelines on Environmental Impact Assessment" and "Technical Guidelines on Environmental Impact Assessment- Water and Hydropower Project" (HJ/T88-2003), the following evaluation techniques will be applied.

Investigation on the Existing State of the Environment

Apply of data collection, site investigation and monitoring and other techniques.

Engineering Analysis

Apply analog analysis, inquiry relevant information and implement entire process analysis and other techniques.

Environmental Impact Prediction and Evaluation

Apply the analogy analysis and necessary mathematical models for the predication and evaluation.

Economic Gain or Loss Analysis on Environmental Impact

Apply the environmental economics methods and the analogy analysis as well as other analysis.

Public Participation

Apply filed investigation, questionnaire survey and other methods of public participation.

1.8.2 Evaluation Procedures

In accordance with the requirements of “Management Procedures for Environmental Protection of Construction Projects” and "Technical Guidelines on Environmental Impact Assessment", the evaluation work can be divided into the following steps:

(1)Collect the basic information and the design result information on the comprehensive utilization and planning of Yaozhan River, the Changyang socio-economic development planning of Yichang City, the environmental protection planning and relevant environment function planning and the engineering feasibility study reports; implement the preliminary investigation on the ecological environment within the area; to carry out the identification on the nature of the environmental factors within the engineering area, the degree of influencing and the importance; and screen the important environmental factors and the general environmental factors affected. Identify the environment monitoring and the investigation project as well as the layout of the monitoring sites.

(2)Prepare the outline of the engineering environmental impact assessment and submit the outline for approval.

(3)Monitoring and investigation on the existing state of environment. To implement the monitoring and investigation on the land ecological environment and the water ecological environment, the hydrology, the water quality, the air quality, the sound environment and the pollution sources; and collect the weather, the climate, the soil, the population health, the society and economy, and the public opinion and other information relevant to the evaluation area.

(4)To implement the influence prediction and evaluation on the main environmental factors during the engineering construction

(5)To put forward the environmental protection measures relevant to the engineering construction

and implement the relevant investment estimation.

(6)To implement the economic gain or loss analysis on environmental impact

(7)To put forward the environment monitoring and management plan on the engineering construction.

(8)To put forward the evaluation conclusion; develop the engineering environmental impact statement and submit the statement to the competent authorities for approval

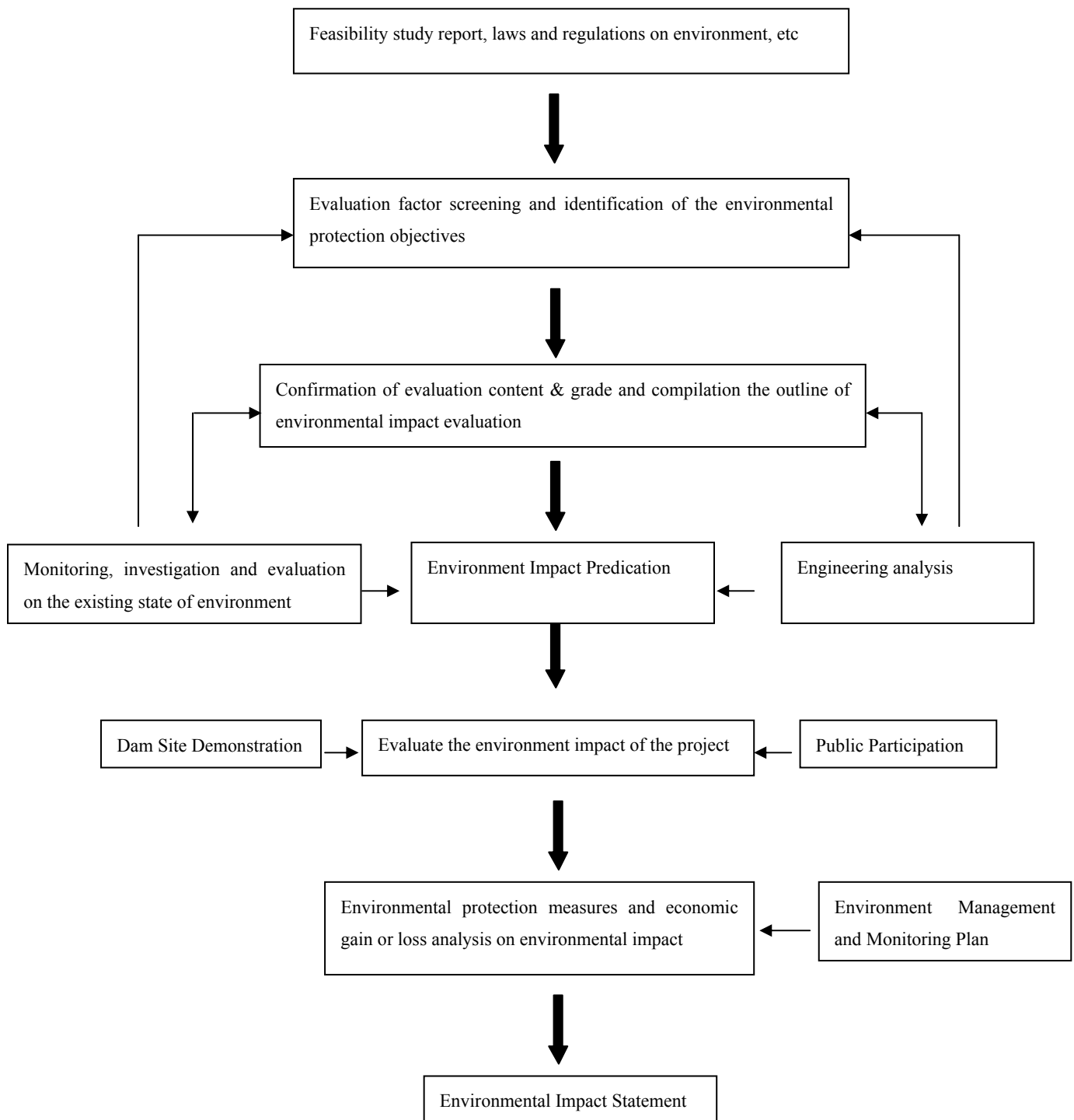


Figure 1-1 Work Procedure of Environment Impact Evaluation

2 Engineering Overview

(1) Project Name: Changyang Duzhenwan Xujiaping Hydropower Project of Yichang City in Hubei Province.

(2) Construction Location: the dam site is located at Liulinzi, in the middle reaches of Yaozhan River, 58km to Zhuangxi River, 135km to Changyang County and 195km to Yichang City; the powerhouse is located in Xujiaping, 48km to Zhuangxi River, 125km to Changyang County and 185km to Yichang City. The dam covers the east longitudes of $110^{\circ}30' \sim 54'$ and the north latitudes of $30^{\circ}15' \sim 24'$ (See Figure I for the engineering location), the location is the area of Yaozhan River, belonging to the Grade One Branch of Qingjiang River.

(3) Nature: new engineering.

(4) Total investment to the engineering: RMB 59.4907 million Yuan (Including the environment protection investment).

2.1 Information on Yaozhan River Planning

The Yaozhan River, located at the south of Changyang Tujia Autonomous County, belongs to the Grade One Branch of Qingjiang River. The total drainage area of the river is 128.6 km^2 ; the multi-year average flow is $3.2 \text{ m}^3/\text{s}$ and the multi-year average runoff volume is $1.01 \times 10^8 \text{ m}^3$. The theoretical storage quantity of Yaozhan River is $1.55 \times 10^4 \text{ kW}$ and the hydraulic power in the corresponding year is $1.36 \times 10^8 \text{ kWh}$. The development on the hydraulic power of the trunk of the river plans to adopt the program of one reservoir and nine stations, namely, Sifangdong hydropower station (built, $2 \times 2500 \text{ kW}$), Houziyan hydropower station (built, $2 \times 40 \text{ kW}$), Taizi hydropower station ($2 \times 125 \text{ kW}$), Chengwuhe hydropower station (built, $2 \times 75 \text{ kW}$), Huilongguan hydropower station (built, $2 \times 500 \text{ kW}$), Xujiaping reservoir (the normal water level of 437m and the total reservoir storage of $2.17 \times 10^6 \text{ m}^3$) and the reservoir power station ($5,000 + 3200 \text{ kW}$), Wangjiacao hydropower station ($2 \times 160 \text{ kW}$), Erhekou hydropower station ($2 \times 125 \text{ kW}$), Xiangshuidong hydropower station (built, $500 + 250 \text{ kW}$), the total installed capacity is 16,000kW. The hydraulic power development of the branch of the river plans to adopt the Grade I

development program, namely, the Zhongxi hydropower station (2×160kW) with the tail-water into the reservoir area of Xujiaping Hydropower Project. The development on the Chongxi hydraulic power of the branch plans to apply the three-station development program, namely, Erchakou hydropower station (2×320kW), Xujiaping Hydropower Project (Capacity Enlargement of 800kW) and Chongxi Hydropower Station (built, 2×125kW). Yichang Water Resources & Hydropower Office approved the above planning with the document numbering XSS [2005] No. 112 in June 2005.

According to the "Eleventh Five-Year" planning, the electricity consumption load of Changyang County in 2010 will be 1.67×10^5 kW; however, the existing installed capacity of Changyang County is only 7.63×10^4 kW, indicating that the power shortage will be increasingly obvious. Based on the existing states of the socio-economic development and the power system, the construction of the key powerhouse with the adjustment function is imperative. Therefore, Changyang County Government decided to construct Xujiaping Hydropower Project by the form of investment invitation.

See Attached Figure II “Yaozhan River Hydraulic Power Development Planning Figure” for the details on Yaozhan River.

2.2 Necessity of Engineering Construction and Development Task

(1) Necessity of engineering construction

Due to the acceleration of the development of industry and agriculture, the demand for electricity will continue to increase, while the existing electric power can not meet the needs of production and living, which has been the key factor restricting the economic development of Changyang, therefore, accelerating the development of hydropower resources is the important measure for the economic development of Changyang.

As the gradual realization of the “Tenth Five-Year Plan”, the electricity consumption load of Changyang County in 2005 was 9.74×10^4 kW, however, the existing installed capacity of Changyang is only 7.63×10^4 kW, indicating that the power shortage will be increasingly obvious, and the contradiction between the flood season and the dry season will be more prominent. With the industrial and agricultural development, especially the high-speed development of the industry

and the improvement of people's living standard, the demand for electricity will be greater and the requirements on the electricity supply quality will be higher, it is expected that until 2010 the electricity consumption load of the county will be $1.67 \times 10^5 \text{ kW}$, and the power shortage will be more obvious. Based on the existing states of the socio-economic development and the power system, the construction of the key powerhouses with the regulation function is imperative. The construction of Xujiaping Hydropower Project will improve the power supply quality of Changyang electricity grid to a greater extent; increase the power supply; adjust the electricity distribution during the flood season and the dry season; and promote the socio-economic development of Changyang. The main task of the engineering is to generate electricity to provide the electricity for living and production of urgent demand.

2.3 Engineering Size and Characteristics

The normal water level of Xujiaping Hydropower Project is 437m and the corresponding storage capacity is $1.9938 \times 10^6 \text{ m}^3$, and the storage capacity at the dead water level of 418m is $3.3338 \times 10^5 \text{ m}^3$, the regulation storage capacity is $1.661 \times 10^6 \text{ m}^3$ and the storage capacity coefficient is $\beta = 2.74\%$. The reservoir is an incomplete annual regulation reservoir. By the calculation of flood regulation, the checked flood level is 438.86m and the total storage capacity is $2.1956 \times 10^6 \text{ m}^3$.

Xujiaping Hydropower Project is a diversion type hydropower station, and in the dry season, the project is mainly used for peak load dispatching and backup. By the technical and economic comparison, the installed capacity is 5000 + 3200 kW, the multi-year average electric power generation is $2.59138 \times 10^7 \text{ kWh}$ and the annual utilization hours shall be 3160h. The guaranteed output (P = 85%) is 1369kW.

According to the regulations of "Standard for flood control of People's Republic of China" (GB50201-94) and "Standard for Classification and Flood Control of Water Resources and Hydroelectric Project" (SL252-2000), the size of the engineering is the Small (1) Type.

See Table 2-1 for the main characteristics of Xujiaping Hydropower Project.

Table 2-1 Table of Xujiaping Hydropower Project Characteristics

Item	Unit	Quantity	Remark
I. Hydrology			
1. Drainage area			
Whole basin	km ²	128.6	
Over the dam	km ²	77.3	Including the supplementary water-resource
2. By the application of the hydrological serial year limited	Year	44	
3. Multi-year average runoff	10 thousand m ³	6069.21	
4. Representative flow			
Multi-year average flow	m ³ /s	1.92	
Measured Maximum Flow	m ³ /s		Measured Date
Measured Minimum Flow	m ³ /s		Measured Date
Designed flood flow (P = 2%)	m ³ /s	639	
Checked flood flow (P = 0.33%)	m ³ /s	897	
Construction diversion flow (P = 5%)	m ³ /s	77	Dam Site
5. Flood amount			
Measured Maximum Flood Amount	100million m ³		Measured Date
Designed flood amount	10 thousand m ³	1958	
Checked flood amount	10 thousand m ³	2775	
6. Mud and sand			
Multi-year average sediment concentration	kg/m ³	0.14	
Multi-year average suspended sediment concentration	10 thousand t	0.83	

Multi-year average bed-load sediment concentration	10 thousand t	0.17	
7. Natural Water Level			
Measured Lowest Flood Level (Corresponding Flow, m ³ /s)	m		
Measured Highest Flood Level (Corresponding Flow, m ³ /s)	m		
Invested Highest Flood Level (Corresponding Flow, m ³ /s)	m		
II. Reservoir			
1. Water level of the reservoir			
Checked flood level	m	438.86	
Designed flood level	m	437.00	
Normal water level	m	437.00	
High water level of flood control (P=%)	m		
Limited water level for flood control	m		
Dead Water Level	m	418.00	
2. Reservoir area at the normal water level	10 thousand m ³	14.03	
3. Backwater length	m	1165	
4. Reservoir volume			
Total storage capacity	10 thousand m ³	219.56	
Storage capacity below the normal water level	10 thousand m ³	199.38	
Regulating storage capacity	10 thousand m ³	166.1	
Flood-control storage	10 thousand m ³	20.18	

capacity			
Storage capacity for users	10 thousand m ³	166.1	
Dead storage capacity	10 thousand m ³	33.28	
5. Coefficient of reservoir storage capacity	%	2.74	
6. Regulation characteristics		Incomplete Annual Regulation	
7. Utilization coefficient of hydrology		93.0	
III. Let-down flow rate and corresponding downstream water level			
1. Maximum outflow volume at the designed flood level	m ³ /s	639	
Corresponding downstream water level	m	403.80	
2. Maximum outflow volume at the checked flood level	m ³ /s	845	
Corresponding downstream water level	m	404.44	
3. Regulated discharge (P=%)	m ³ /s		
Corresponding downstream water level	m		
4. Minimum Flow	m ³ /s		
Corresponding downstream water level	m		
IV. Engineering efficiency indicators			
1. Flood Control Efficiency			
Land area protected (P=%)	10 thousand mou		

Area of town and industry and mine area protected	Km ²		
2. Power generation efficiency			
Installed capacity	kW	3200+5000	
Guaranteed output (P = 85%)	kW	1369	
Multi-year average power generation	10 thousand kW.h	2591.38	
Annual Utilization Hours	h	3160	
3. Irrigation efficiency			
Area (P= %)	10 thousand mou		Separated listing of irrigated lands, dry lands and grasslands
Maximum utilized flow	m ³ /s		
Total annually water consumption (P= %)	100 million m ³		
4. Flood control efficiency			
Area (P= %)	10 thousand mou		
Quantity of water discharged	m ³ /s		
5. Water supply efficiency			
Maximum utilized flow (P= %)	m ³ /s		
Total annually water consumption	100 million m ³		
6. Efficiency from shipping and log-lock			
Improve the of seaway length	km		
Tonnage of ships	t		
Designed annual volume of freight traffic	t		
Size of bamboo raft	m		
Designed annual volume of bamboo transported	m ³		

7. Cultivation efficiency			
V. Inundation losses and permanent land occupation for engineering			
1. Arable land	Mou	18.46	
2. People of resettlement	People	21	
3. Submerged House	m ²	1050.00	
4. Tea Garden	Mou	14.21	
5. Woodland	Mou	144.2	
6. Highway	Mou	12.95	
7. Bridge	Set	1	
8. Permanent occupation (excluding the area inundated by the reservoir)	Mou	40.00	
VI. Main buildings and equipment			
1. Water retaining structure			
Type	Roller Compacted Concrete (RCC) Dam		
Groundwork lithology	Silurian system Luoreping formation sand mudstone		
Crest elevation	m	440.06	
Maximum height	m	46.06	
Crest length	m	110	
Basic seismic intensity/ earthquake fortification intensity	VI/VI		
2. Release structure			
Type			Open weir
Groundwork lithology			Sand mudstone
Crest elevation	m	428.40	
Length of Overflow Section (or Gateway pore size and pore number)	m	12	
Unit width flow rate	m ³ /(s.m)	70.4	
Energy dissipation approach			Trajectory bucket type
Gate Size	m	12×9	

Headstock gear type			Winch Type Headstock gear
Weight of Headstock gear	t	13.5	
3. Diversion structure			
Designed water diversion flow	m ³ /s	5.2	
Maximum water diversion flow	m ³ /s	5.5	
Intake type			Shaft well
Groundwork lithology			Silurian system Luoreping formation sand mudstone
Floor Elevation	m	413.70	
Gate type			Flat Wheel Type Steel Valve
Gate Weight	t	2.5	
Headstock gear type			Screw type
Catch-water type			Round pressure water diversion culvert
Groundwork lithology			Sand mudstone, quartz sand, siltstone
Length	m	6068.38	
Excavation section size	m	D2.6	
Lining section size	m	D2.0	
Designed water head	m	41.66	
Pressure-regulated well type			Impedance Type Structure
Well Inner Diameter	m	4.0	
Well Height	m	57.55	
Pressure pipe type			Steel Pipe
Groundwork lithology			Sand mudstone, quartz sand, siltstone, shale

Main pipe length	m	423.97	
Inner Diameter of the Main Pipe	m	1.2	
Number of pipelines and length	m	1×9+1×16	
Inner diameter of branch pipe	m	0.8/0.6	
Bifurcated pipe type			Bifurcated pipe strengthened inside with crescent rib
4. Plant			
Type			Ground Type
Groundwork lithology			Scree, quartz sand, siltstone
Main plant dimensions (L*W* H)	m	30.4×12×15.58	
Turbine installation Elevation	m	206.01	
5. Switching station			
Type			Ground Type
Groundwork lithology			Mudflat and farmland
Area (L × W)	m ²	22.3×15.1	
6.Main mechanical and electrical equipment			
A. Turbine Model		HLA351-WJ-95 HLA351-WJ-84	
Number	Piece	Each	
Rated output	kW	5624/3404	
Rated speed	r/min	1000	
Rated flow	m ³ /s	3.01/1.98	
Maximum gross head	m	232.44	
Minimum gross head	m	213.00	

Draft height	m		
Rated head	m	194.14	
B. Generator Model	SFW 5000-6/1730 SFW 3200-6/1730		
Number	Piece	Each	
Rated Current	A	572.7/366.5	
Rated speed	r/min	1000	
Rated voltage	V	6300	
Rated power factor	cosφ	0.8	
C. Main transformer	Type	S9-12500/35	
Number	Piece	1	
Rated capacity	kVA	12500	
Voltage Ratio	kV	38.5±.5%/6.3	
D. Inlet valve Model	Z941H-25-φ800 Z941H-25-φ600		
Diameter	m	0.8/0.6	
Maximum head	m	232.44	
E. Plant hoisting machine model	QD 30/5		
Span	m	12	
Lifting capacity	t	30/5	
7. Transmission line			
Voltage	kV	35	
Loop		1	
Transmission destination		Switching Station of Shibampo	
Transmission distance	km	1	
8. Navigation structure			
Type			
Main Size	m		
Tonnage of ships	t		

Annual volume of freight traffic	10 thousand t		
Navigation discharge	m ³ /s		
9. Bamboo raft structure			
Type			
Main Size	m		
Annual volume of freight traffic	10 thousand t		
Flow of bamboo raft	m ³ /s		
10. Other Structure			
VII. Construction			
1. Main engineering quantity			
Earth excavation	m ³	45034	
Stonework excavation	m ³	40577	
Masonry block stone	m ³	45653	
Curtain grouting	m ³	1840	
Consolidation grouting	m ³	1518	
Backfilling grouting	m ³	7580	
Steel production	t	534.8	
Template	m ²	32820	
Construction area	m ²	746	
Concrete	m ³	21691	
2. Main construction materials			
Cement	t	13732	
Reinforcing steel bar	t	676.2	
Steel	t	287.35	
Timber	m ³	100	

Explosives	t	98.71	
Detonators	10 thousand	13.53	
Fuse	m	26.19	
Gasoline	t	39.93	
Diesel	t	44.91	
Rock Block	m ³	50377	
Pebble	m ³	24274	
Sand	m ³	38766	
3. Required labor			
Total Man-day	Man-day	163865	
Average number of workers	Worker	91	
Peak number of workers	Worker	200	
4. Temporary house for construction			
5. Construction Energy			
Power supply	kVA	5×100,2×250	
7. External transport	km	135	To Changyang County
8. Construction diversion			
Diversion method		Cofferdam, open channel	
Structure Type		Earth rock cofferdam	
Main Dimensions	m		
9. Construction area	mou	105.8	
10. Construction duration			
Minimum Construction Period	Month	22	
Total duration	Year	2	
VIII. Economic indicators			
1. Static Investment	10 thousand Yuan	7241.13	

2. Total investment	10 thousand Yuan	7522.85	
Architectural engineering	10 thousand Yuan	3724.35	
Mechanical & Electrical equipment and installation engineering	10 thousand Yuan	880.57	
Metal structures equipment and installation	10 thousand Yuan	488.88	
Interim engineering	10 thousand Yuan	230.37	
Compensation for Reservoir Inundation Treatment	10 thousand Yuan	441.51	
Independent cost	10 thousand Yuan	891.39	
Basic reserve	10 thousand Yuan	372.93	
Reserve for price difference	10 thousand Yuan		
Financial cost	10 thousand Yuan	281.72	
Resettlement and environmental protection investment	10 thousand Yuan	235.13	
3. Main economic indicators			
Investment to unit KW	Yuan/kW	8830	
Investment to unit Kilowatt-hour	Yuan/kWh	2.80	
Cost of power generation	10 thousand Yuan		
Economic internal rate of return (EIRR)	%	8.59>8	
FIRR of all investment	%	7.56>7	All investment before financing and taxes

FIRR of self-owned capital	%	11.72>10	Self-owned capital after financing
Loan repayment period	a	25	

2.4 Project Components

Xujiaping Hydropower Project is consisting of the main engineering, the supportive engineering, the auxiliary engineering, the utility engineering and the environmental protection engineering and others, see Table 2-2 for details.

Table 2-2 Xujiaping Hydropower Project Components

Project Name		Location	Project Content and Parameter	
Main Engineering	Dam	Gate dam type overflow dam	The middle of the main stem	The crest elevation of the overflow dam is 428.40m; the crest applies the open overflow dam surface curve; the maximum head at the crest is 10.46m; and the weir surface head of template design is 7.85m. The bottom side of the weir surface curve is connected with the 1:0.75 slope, a R = 8.0m ogee section is connected with the deflector bucket at the dam toe. The elevation of the deflector bucket is 405.00m and the flip shot angle is 22°.
		Left bank non-overflow gravity dam	Located at the left side of the dam section, connected with the left-bank mountain massif	The dam section has the length of 39.0m, and the dam type is the RCC gravity dam
		Right bank non-overflow gravity dam	Located at the right side of the dam section, connected with the right-bank mountain massif	The dam section has the length of 59.0m, and the dam type is the RCC gravity dam
		Diversion tunnel	Located at the right bank	The diversion tunnel will be the round pressure water diversion culvert, and the tunnel has the length of 6068.38m, the longitudinal tunnel of 3/1000 will be taken
				The non-overflow dam crest has the elevation of 438.96m and the width of 4.0m. The wave-proof wall is provided to the upstream side and the railings are provided to the downstream side. The wave-proof wall top has the elevation of 440.06m, the thickness of 0.5m, integrated with the dam. Below the 430.42m elevation, the upstream dam slope is 1: 0.1 and the downstream dam slope is 1:0.76.

				into account and the excavation diameter of the tunnel is 2.60m.
	Main plant		At the right side of the downstream riverbed	The planar dimension of the main plant is $30.4 \times 12.0 \text{ m}^2$
	auxiliary plant		At the rear of the main plant	Plane dimensions of $30.4 \times 5.1 \text{ m}^2$
	Booster Station		At the left side of the main plant	Planar dimensions of $22.30 \times 15.10 \text{ m}^2$
Supportive engineering	Supportive production plant for office and living facilities		At the right bank of the downstream side of the dam	600m for temporarily
Auxiliary engineering	Sand Yard	1 #	At the downstream side of Xiangshi Village, 1100m from the dam site	Both banks are steep, and the exposed bedrock is under good condition, the exposed Silurian system Luoreping formation (S2lr2) gray red quartz sandstone can be use for producing artificial aggregate, the thickness of the useful layer is 35-40m in the medium and thick form, dense and hard.
		2 #	About 2.5 km at the downstream side of the dam site	The exposed part contains S_{3sh}^2 quartz sandstone, D_{2y} quartz sandstone and D_{3h} quartz sandstone, the total thickness is 100 ~ 150m, the part can be used as the artificial aggregate yard with the rich reserves, basically meeting the demands of the engineering.
	Block Stone Yard		At Tangzuo, about 3.5 km at the downstream side of the dam site	The lithology is P2q2, containing flint limestone, in the thick form and with hard texture, the mechanical properties are well and the reserves are rich.
	Waste	1#	At the downstream side of the water intake works	Located about 250 m at the downstream of the water intake dam, and area of the mudflat for temporary occupation is 0.67hm^2 ; $6.05 \times 10^4 \text{ m}^3$ residue volume of the water intake engineering can be held.
		2#	1# branch tunnel	Located at the downstream side of 1# branch tunnel, and the area of valley and

	residue Yard		grassland occupation is 0.28hm^2 , for holding the waste excavated half from 1# tunnel and half from 2 # tunnel, totally $1.17 \times 10^4\text{m}^3$.	
		3#	2# branch tunnel	Half at the 2# tunnel and half at the 3# tunnel, for holding the waste excavated of totally $5.70 \times 10^3\text{m}^3$.
		4#	3# branch tunnel	Located opposite to the 3 # branch tunnel, and the area of grassland occupied is 0.18hm^2 , for holding the waste excavated half from 3# tunnel and half from 4 # tunnel, totally $6.00 \times 10^3\text{m}^3$.
		5#	4#Tunnel Exit	At the downstream side of the pressure regulation well, the area of the grassland occupation is 0.38hm^2 , for holding the waste of $1.19 \times 10^4\text{m}^3$. It also is used for holding the waste of about $1.80 \times 10^3\text{m}^3$ of the previous pipeline.
		6#	Middle of the pipeline	For holding about $4.1 \times 10^3\text{m}^3$ wastes from the middle of the pipeline, and waste is placed dispersedly at both sides of the pipeline, occupying the grassland area of 0.17hm^2 .
		7#	At the downstream of the plant	The yard occupies the mudflat area of 0.12hm^2 for holding the waste of $8.60 \times 10^3\text{m}^3$. The total waste excavated within the plant is $2.50 \times 10^3\text{m}^3$, which will be send to the waste year about 170m at the downstream of the plant; at the same time, it can also hold the waste of $6.1 \times 10^3\text{m}^3$ near the lower part pipeline of the plant.
		8#	Intake of the Supplementary Water Source	Located at the downstream side of the intake of the supplementary water resource, covering 0.08hm^2 mudflat area, for holding the waste excavated by the water intake engineering and half of the wastes excavated by the supplementary water diversion tunnel, totally $3.80 \times 10^3\text{m}^3$.
		engin Utility	Water Supply System	River Water

	Power Supply System	10kV power supply	The transformer shall be S9-100/10 model
Environmental protection engineering	Water and soil conservation	Dam Site and the Excavation are of the soil storage yard, etc.	Investment of RMB 1.6257 million Yuan
	Reservoir Bottom Clean-up	Reservoir Inundation Area	14.61 hm ² area is inundated
	Environment protection measures during the construction period	Construction Area	Noise, atmosphere, water quality, and population health protection and others
	Environment Monitoring	The upstream part and the downstream part of the dam site	Water quality, environment, air and noise monitoring

2.5 Engineering Level and Design Flood Control Standard

(1) Engineering Level

Xujiaping Hydropower Project is located within Changyang Duzhenwan of Hubei Province, and at the middle and lower reaches of Yaozhan River, the branch of Qingjiang River. The hub engineering is mainly consisting of the dam, the power generation and water diversion tunnel, the pressure pipeline, the power plant and booster stations and others. Xujiaping Hydropower Project is a reservoir regulation power station with the total capacity of $2.20 \times 10^6 \text{ m}^3$ and the installed capacity of 5000+3200 kW. In accordance with the regulations of “Standard for flood control of People's Republic of China” (GB50201-94) and “Standard for Classification and Flood Control of Water Resources and Hydroelectric Project” (SL252-2000), the size of the engineering is the Small (1) Type and the other engineering level is IV. The level of the main structures, namely, water retaining structure, release structure, diversion structure, and plant and booster station is Level 4, and the level of other structures and temporary structures is Level 5.

(2) Flood Control Standard

In accordance with the engineering grades, the relevant flood control standards are as follows:

The design flood control standard of the water retaining structures and the release structures is

once for 50 years (upper limit), and the corresponding peak flow volume is $639\text{m}^3/\text{s}$; Because the water retaining structure of the engineering is the RCC gravity dam, and the dam is located at the place of few population and full of mountains and canyons, furthermore, the reservoir storage capacity is not large and the residents at the downstream side are few, as a result, the checked flood control standard at the stage is determined as Once for 300 Years (medium limit) with the corresponding peak flow of $897\text{m}^3/\text{s}$. In accordance with the regulations of “Standard for Classification and Flood Control of Water Resources and Hydroelectric Project” (SL252-2000) and “Design code for spillway” (SL253-2000), and with the reference of “Design specification for concrete gravity dams” (DL5108-1999), it is finally determined that the design flood control standard of the energy-dissipating facilities is Once for 20 Years with the corresponding peak flow of $344\text{m}^3/\text{s}$.

The plant and the boost station are located at the right bank of Yaozhan River, their flood control standard is Once for 50 years with the corresponding peak flow of $730\text{m}^3/\text{s}$; and the checked flood standard is Once for 100 years with the corresponding peak flow of $851\text{m}^3/\text{s}$.

2.6 Overall Layout of the Engineering

2.6.1 Main Engineering

Xujiaping Hydropower Project is consisting of the dam, the diversion tunnel, the pressure pipeline, the plant and the booster station, and on-grid lines and others.

(1) Masonry gravity dam

The length of the crest is 110m; the right bank non-overflow gravity dam has the length of 59m; the river bed overflow dam has the length of 12m and the left bank non-overflow gravity dam has the length of 39m. The elevation of the foundation base of the riverbed is 394.00m, the elevation of the wave-proof top is 440.06m, the dam height is 46.06m, the normal water level is 437.00m and the checked flood control level is 438.86m. The upstream slope of the dam is 1:0.1 and the downstream slope is 1:0.76.

The crest elevation of the overflow dam is 428.40m; the crest applies the open overflow dam surface curve; the maximum head at the crest is 10.46m; and the weir surface head of template

design is 7.85m. The bottom side of the weir surface curve is connected with the 1:0.76 slope, a R = 8.0m ogee section is connected with the deflector bucket at the dam toe. The elevation of the deflector bucket is 405.00m and the flip shot angle is 22°. Since the overflow dam section of the project is short and the checked peak flow is designed as Once for 300 years, the water level before the dam is 438.86m, 10.46m higher than that of the crest of the overflow dam, therefore, the flood discharge gate is provided.

The non-overflow dam crest has the elevation of 438.96m and the width of 4.0m. The wave-proof wall is provided to the upstream side and the railings are provided to the downstream side. The wave-proof wall top has the elevation of 440.06m and the thickness of 0.5m, integrated with the dam. The gate pier and the guide wall are provided between the overflow dam and the non-overflow dam. The elevation of the gate pier top is 438.96m and the length is 20.5m. The guide wall has the height of 4.0m, with the top connecting with the tail of the gate pier and the bottom connecting with the deflector bucket. The gate pier and the guide wall are applied the reinforced concrete structure with the thickness of 1.8m.

(2) Diversion Structure

The diversion structure is mainly consisting of the dam type water intake, the pressure tunnel, the pressure-regulation well and the pressure pipeline and others.

The foundation of the dam water intake is integrated with the dam foundation, which is constructed by the application of C20 (2) concrete with the thickness of 2m, the width of 7.5m and the length of 5m. The water intake bearing adopts the frame mix structure and the water intake applies the rectangular cross with the orifice size of 2.0 × 2.0m. The gate applies the plane steel gate.

The diversion tunnel for power generation is located the right bank and applies the round pressure form with the total length of 6068.38m. The longitudinal tunnel of 3/1000 is applied and the excavation diameter of the tunnel is 2.60m. In accordance with the available geological information, the lining length shall be 60%, that is 3630m, and the C20 (b) lining with the thickness of 0.30m is applied, furthermore, the double-layer reinforced steel bars shall be arranged to the III rock with the length of the dilatation joint of 12m.

The total length from the water intake to the center of the pressure-regulation chamber is 6068.38m; and the total length from the center of the pressure-regulation chamber to the center of the bifurcated pipe is 423.97m; the length from the bifurcated pipe to the 1 # branch pipeline is 9m, of which, the internal diameter of the branch pipe is 0.8m; the length from the bifurcated pipe to the 2# branch pipeline is 16m, of which the internal diameter of the branch pipeline is 0.6m. The pressure-regulation chamber applies the impedance structure and the reinforced concrete lining. The internal diameter of the pressure-regulation chamber is 4.0m and the thickness of the lining is 0.40m. The internal diameter of the impedance hole is 2m and the thickness of the plate is 1.5m. The elevation of the surge level of the pressure regulation chamber is 448.84m at the normal pool level of the reservoir when all loads are suddenly thrown away under the circumstances of the 5% percent rated load more, and the highest water level is 451.89m under the checked working condition, and the elevation of the top of the pressure regulation chamber is 453m.

The Chongxi supplementary water source is arranged at the bottom trash rack dam with the length of the trash rack dam of 15m, the length of the overflow dam of 12m and the crest width of 1.4m, the crest elevation is planned to be 455.16m; and the length of the bottom trash rack of 3m, the crest width of 1.6m and the crest elevation of 454.26m. The width of the grit chamber is 3.0m and the length is 20m, furthermore, the flushing gate is provided to the end of the grit chamber. The total length of the non-pressure diversion tunnel is 1900m. The water of Chongxi after the treatment of the grit chamber enters the non-pressure tunnel and then is injected in the pressure regulation chamber.

The pressure pipeline is located at the northwest side of Puling syncline. The length of the pressure pipeline from the pressure regulation chamber to the center of the bifurcated pipe is 423.97m with the diameter of 1.2m; the length from the center of the bifurcated pipe to the 1# machine tube is 9m with the pipe diameter of 0.8m; and the length from the center of the bifurcated pipe to the 2 # machine tube is 16m with the internal diameter of 0.6m.

(3)Plant and Booster Station

The plant here is mainly consisting of the primary plant and the auxiliary plant and the booster station. The plant is located at the right bank of Yaozhan River, outside Xujiaping Chongxi power

station. The plant is the diversion-type ground-based plant. And the installed capacity of the power station is 5000+3200 kW. In accordance with the requirements on the electrical and mechanical equipment layout, the main plant has the length of 30.40m and the width of 12.00m. The machine is installed at the left side of the plant, and the distance between the center of the 1# machine unit and the center of the left wall is 4.15m; the distance between the centers of the machine units is 11.00m; and the installed evaluation of the machine unit is 206.01m; Due to the different models of the applied hydro-electric power generating unit, the ground evaluation of the 2 # unit is 0.17m higher than that of the 1 # unit. To create convenient inside transport, the ground evaluation of the main machine chamber is regarded as 205.19m, and the 2 # machine unit foundation is 0.17m outside the foundation of the main machine chamber in the form of machine stand.

The auxiliary plant is located at the rear of the main plant with the length of 30.40m, the height of 5.40m and the floor elevation of 208.19m. The high voltage switching chamber is located at the left side, covering an area of $12.00 \times 5.10 \text{ m}^2$. The centre control chamber is located at the middle with an area of $12.00 \times 5.10 \text{ m}^2$ and in the single-line form and provided with the twelve control panels. The air compressor chamber, the water supply chamber and the machine servicing room are provided to the bottom of the installation field, specifically, the machine servicing room is located at the upstream side with an area of $4.20 \times 6.00 \text{ m}^2$ and the floor elevation of 205.19m; the air compressor chamber is located at the middle with an area of $3.60 \times 6.00 \text{ m}^2$ and the floor elevation of 205.19m; and the water supply chamber and the water collection well chamber are integrated to be located at the downstream side with an area of $4.20 \times 6.00 \text{ m}^2$ and the floor elevation of 205.10m.

The booster station is located near the access road and at the left side of the plant with the floor elevation of 209.50m. The booster station has the length of 22.30m and the width of 15.10m, covering an area of 337 m^2 .

2.6.2 Auxiliary Engineering

2.6.2.1 Material Yard Selection and Exploitation

In accordance with the design, the concrete volume consumed by the engineering is $5.76 \times 10^4 \text{ m}^3$, the masonry block stone volume is 667 m^3 , and the crushed stone of $6.24 \times 10^4 \text{ m}^3$, the sand of

$3.88 \times 10^4 \text{ m}^3$ and the block stone of 700 m^3 are required, of which, the total amount of concrete for the dam area, the No.1 tunnel and the No.2 tunnel is $4.97 \times 10^4 \text{ m}^3$, the required aggregate shall be mined for the material yards, and the aggregate required by the concrete for the other engineering parts can be the tunnel excavation materials.

1# gravel yard: Located at the downstream side of the dam site, both banks are steep, and the exposed bedrock is under good condition, the exposed Silurian system Luoreping formation (S2lr2) gray red quartz sandstone can be use for producing artificial aggregate, the thickness of the useful layer is 35-40m in the medium and thick form, dense and hard. The place can be used for backup material yard.

2 # gravel yard: About 2.5 km at the downstream side of the dam site, The exposed part contains S_{3sh}^2 quartz sandstone, D_{2y} quartz sandstone and D_{3h} quartz sandstone, the total thickness is 100 ~ 150m, the part can be used as the main artificial aggregate yard with rich reserves.

3 # block stone material: at the left side of the upper reaches of the dam site, the lithology is the sand mudstone, and the stones by the overflow excavation can also be used.

2.6.2.2 Waste Residue Yard Planning and Layout

(1) Waste Residue Yard Planning of Intake Works

The waste residue volume of the construction of intake works (Including 1# tunnel entrance) is $6.25 \times 10^4 \text{ m}^3$ (excluding the waste residue of the intake dam of the supplementary water source and the entrance part of the diversion tunnel), the waste residue can be used for the field leveling and the maintenance of construction roads and others within the intake work scope, consuming $2.00 \times 10^3 \text{ m}^3$ totally and the rest of $6.05 \times 10^4 \text{ m}^3$ shall be sent to the 1# waste residue yard, about 250m at the downstream of the intake dam, the area of the mudflat for the waste residue of temporary use is 0.67 hm^2 .

(2) Waste Residue Yard Planning of the Main Diversion Tunnel Engineering

The main diversion tunnel engineering part includes 1 #, 2 #, 3 # and 4 # tunnels. The waste residue excavated is $3.78 \times 10^4 \text{ m}^3$ totally, and the engineering of the preliminary consideration will be provided with a total of 3 waste residue yards numbering 2 #, 3 # and 4 # respectively, of which,

the 2 # waste residue yard is located at the downstream side of 1# branch tunnel, and the area of valley and grassland occupation is 0.28hm^2 for holding the waste excavated half from 1# tunnel and half from 2 # tunnel, totally $1.17 \times 10^4\text{m}^3$; the 3# waste residue yard is located half at the 2# tunnel and half at the 3# tunnel for holding the waste excavated of $5.70 \times 10^3\text{m}^3$ totally; and the 4# waste residue yard is located opposite to the 3 # branch tunnel, and the area of grassland occupation is 0.18hm^2 for holding the waste excavated half from 3# culvert and half from 4 # culvert totally $7.20 \times 10^3\text{m}^3$, because the residue can be easily transported to the original township roads located between the power plant and the dam site for the road maintenance, consuming a total of 1200 m^3 , as a result, the final residue of the waste residue yard will be about $6.00 \times 10^3 \text{ m}^3$; the 4 # tunnel exit section of the $5.40 \times 10^3 \text{ m}^3$ waste residue will be transported to the 5# waste residue yard at the side filed of the pressure-regulation well, the residue yard covers 0.18hm^2 grassland area.

(3) Waste Residue Yard Planning of the Pressure Regulation Well

The waste residue amount excavated relevant to the pressure regulation well is 900m^3 , and in accordance with the actual information, the waste residue will be transported to the 5# waste residue yard at the side filed of the pressure-regulation well, of which, the 5# waste residue yard occupies 0.38 hm^2 grassland for holding the waste of $1.19 \times 10^4\text{m}^3$.

(4) Waste Residue Yard Planning of the Pressure Pipeline

The waste residue amount relevant to pressure pipeline excavation is $1.22 \times 10^4 \text{ m}^3$, and in accordance with the actual terrain situation, the concentrated stacking of waste residue is inapplicable, therefore, the initial program decides to transport $1.80 \times 10^3 \text{ m}^3$ waste residue produced by the upper pipeline excavation to the 5# waste residue yard and $4.10 \times 10^3 \text{ m}^3$ produced by the middle pipeline excavation to the both sides of the pipeline (Called as #6 waste residue yard), and the effective engineering measures shall be taken for the effective protection of each residue yard, the grassland occupied for the waste residue yards is about 0.17hm^2 ; and the waste residue produced by the lower pipeline excavation near the plant is about $6.1 \times 10^3 \text{ m}^3$, all of which is transported to the 7# waste residue yard of the plant.

(5) Planning of the Waste Residue of the Plant

The plant area (Including the booster station and the access roads) has the total waste residue excavated of $2.50 \times 10^3 \text{ m}^3$, the initial program plans to transport the waste residue to the 7# waste residue yard, about 170m at the downstream of the plant, of which, the 7# waste residue yard covers 0.12 hm^2 mudflat area and the actual waste residue holding capacity is $8.60 \times 10^3 \text{ m}^3$.

(6) Waste Residue Planning of the Supplementary Water Source Engineering

The supplementary water source engineering includes the intake dam and the diversion tunnel, the waste residue excavated is about $7.60 \times 10^3 \text{ m}^3$, the initial program plans to transport the waste residue to the 5# waste residue yard at the pressure regulation well, and the waste residue excavated from the intake dam and the tunnel entrance section to the 8# waste residue yard at the downstream side of the intake dam of the supplementary water resource, of which, the 8# waste residue yard covers 0.08 hm^2 mudflat area for holding all the waste by the water intake engineering excavation and half of the supplementary water diversion tunnel excavation, totally $3.80 \times 10^3 \text{ m}^3$. See Table 2-3 for the detailed specific values of each waste residue yard.

Table 2-3 Waste Residue Yard Characteristics Table

No.	Location	Holding Capacity($\times 10^4 \text{ m}^3$)	Waste Source	Area(hm^2)
1#	Downstream of the intake work	6.05	Intake work and 1#tunnel	0.67
2#	1#Branch Tunnel	1.17	1#Tunnel, 2#Tunnel	0.28
3#	2#Branch Tunnel	0.57	2#Tunnel, 3#Tunnel	0.16
4#	3#Branch Tunnel	0.60	3#Tunnel, 4#Tunnel,	0.18
5#	4#Culvert tunnel	1.19	4# and supplementary tunnel, pressure regulation well and the upper section of the pipeline	0.38
6#	Middle of the pipeline	0.43	The middle of the pipeline	0.17
7#	At the downstream of	0.86	The lower part of the pressure pipeline and	0.12

	the plant		the plant area	
8#	Intake of the Supplementary Water Source	0.38	The intake dam of the supplementary water source and the diversion tunnel	0.08
Total	Songfang	11.25		2.04

2.6.2.3 Construction Site and Warehouse

The shed, machine servicing, warehouse and concrete batching & mixing plant are located at the valley and the second bench at the left and right banks of the upper reaches. The plant construction can use the nearby resident houses rented. And there is a flat field at the downstream of the dam site where is provided with the rural roads, featuring broad terrain. The elevation here is 400m, therefore, the shed, machine servicing, warehouse and concrete batching & mixing plant can be set up here.

2.6.2.4 Construction Road

The transportation of the engineering is mainly completed by roads and the external transport is completed by the use of the existing road network. However, due to the flood's influence, the road of 20km shall be repaired.

Transportation within the construction site: the road of 0.5km to the dam will be constructed at the right bank of the dam, which at the same time connects with the rebuilding road of the reservoir area, meeting the requirements of the material and equipment transport required by the engineering; furthermore, the new temporary construction roads for the construction areas shall be made, that is, 1 # branch tunnel, 2# branch tunnel and 3# branch tunnel, pressure regulation chamber and Chongxi Intake Dam with the length of 1km, 1km, 1km and 2km respectively, totally 5km.

2.6.3 Utility Engineering

The main plant shall be provided with the fire hydrants, and the two machine units involved into the engineering shall be provided with the fire pipelines, in addition, by taking into account of the living demands of staff of the powerhouse, one 40m³ fire water tank is provided to the outside of the main plant with the water from the steel pressure pipeline at the front of the intake valve of the

powerhouse. Besides, the outlet pipe of the fire water tank should be provided with a rotary water filter to filter the water for fire prevention. Furthermore, one connecting valve shall be provided to the place between the trunk of the fire pipeline and the technical water supply pipes to backup the water for fire prevention. Besides, a $\phi 80$ water supply trunk for living and fire prevention throughout the whole plant is provided in the main plant, directing to the fire pipeline of the generators and the fire hydrants. The generator here is applied the manual fire-fighting approach.

The booster station is provided with a 12500kVA transformer. The booster has the length of 22.30m, the width of 15.10m and the construction area of 337m².

2.6.4 Content of Environmental Protection Engineering

(1) Soil and water conservation measures

In accordance with the requirements of "Law of the People's Republic of Soil and Water Conservation" and "Implementation of the Law of the People's Republic of Soil and Water Conservation" and the requirements of local laws and regulations, the engineering sticks to the principles on the soil and water conservation of "Prevention first, overall planning, comprehensive prevention and control, in line with local conditions, management strengthening and actual effect emphasis" and follow the requirements of the simultaneous design, construction and acceptance with the main engineering to implement the engineering step by step and in a planned manner, so as to minimize the destruction to the original vegetation. Furthermore, in accordance with the principle of "suiting measures to local conditions and putting protection according to harm", plan the soil and water conservation measures, and aim to integrate the engineering measures with the grass& forest measures. The soil and water conservation engineering shall be fixed in accordance with the layout of the main structures and the engineering size of Xujiaping Hydropower Project, here the engineering measures can be implemented to four zones, that is, the dam zone, the tunnel zone, the pipeline zone and the powerhouse zone. Furthermore, the prevention and control measures shall be applied to the water residue yard, the material yard, the permanent occupation area for the engineering and the temporary site for construction of each zone, of which, more attention shall be paid to the treatment of the waste residue yard.

Preliminary design of water and soil conservation measures

a. Slope protection engineering

The engineering protection measures shall be applied to the unstable sloped formed due to the excavation and backfilling. As for the earth slope with the height of larger than 4m and the gradient greater than 1:1.5, the straight line slope-cutting excavation method shall be applied, and if the slope contains the loose layers, the reinforcement measures shall be taken to ensure the stability of the slope after excavation; the rock slope gradient after cutting shall be lower than 1:1. As for the soil or sandy slope with the gradient less than 1:1.5, the plant slope protection engineering shall be applied, specifically, grow the plant to the slopes, here the plant shall be the low creeping one and the direct seeding to the common soil slope shall be used and the pit planning to the compacted soil slope shall be used, the necessary closing measure and raising measures shall be made within 1 to 3 years after the planting. As for the slope with the gradient between 1:1 and 1:2 or the slope facing to the gully bank, its lower part may be subject to water erosion, and for the protection section greatly influenced by the flood, the M7.5 masonry slope protection shall be applied.

b. Masonry retaining wall engineering

The calculating scope is between 1.0m and 2.0m, belonging to the low-height retaining walls. The cross section of the retaining wall is confirmed in accordance with the empirical formula. The $0.3 \times 0.3 \text{m}^2$ barrel-drains are provided to the junction between the top of the waste yard and the mountain.

Plant Treatment Measures:

The requirements on the slope protection engineering and the masonry retaining walls shall be the same to the requirements on the dam area.

The construction roads to the powerhouse shall be stable and the landscaping shall be made; to control the water and soil erosion, trees shall be planted to both sides of the roads, specifically, one camphor with the spacing of 4m shall be planted.

(2) Sand Scouring and Accretion of Reservoir

In accordance with the sand scouring and accretion calculation of the reservoir, the accretion

before the dam is 411.50m. And on the hydraulic arrangement, the sand removal measures shall be taken and also the operation mode of storing clearness and releasing muddy, specifically, no sand is removed during the non-flood season and the sand is emptied during the flood season, that is, during June and July to keep the water level of the reservoir at the normal water level.

(3) Health and epidemic prevention measures

1. Auxiliary Room

According to the actual needs and easy-to-use principle, an office building and a dormitory should be provided.

In accordance with the grading requirements of "Hygienic standards for the Design of Industrial Enterprises" (TJ38-79), the engineering is Grade 4, therefore, no dedicated cloakrooms will be provided within the plant, and the uniform can be placed at the lockers of the central control room.

A public toilet is set up in the powerhouse, divided two part based on the number of the staff, one for men and one for women, and the sewage of the toilet will be used as fertilizer through the septic tanks.

2. Health and Safety Management Organization and Setup

In accordance with the engineering size and the number of employees engaged into Xujiaping reservoir powerhouse, the specific health and safety management agency will not be set up, and the health and safety management work will be the responsibilities of the relevant operators and a part-time safety and health administrator shall be assigned.

The safety and health machines, in accordance with the characteristics of the engineering, shall be provided with the monitoring devices and equipment, the publicity column and other security publicity devices, furthermore, there should be provided with the brooms, the sprayers, the disinfectants, the raticides and other tools and supplies, furthermore, the regular clean-up, disinfection and rat eradication shall be made at the plant area, the office zone, the dormitory and the surrounding. Besides, the health and safety management manual should be given to each one, and the education and publicity on the employers' health and safety shall be enhanced.

2.7 Reservoir Inundation and Resettlement

2.7.1 Reservoir Inundation Scope and Physical Indicators

Xujiaping Hydropower Project is the hydro-power engineering of incomplete annual regulation. The reservoir is located at Liulinzi, in the middle reaches of Yaozhan River, which is mainly used for water storage. The dam site is 135km away from Changyang County and the water retaining structure is the RCC gravity dam with the maximum dam height of 46.06m. Xujiaping reservoir is mainly used for power generation, which plays a positive role in economic development and the new rural construction of Changyang. The normal water level of Xujiaping reservoir is 437m, the checked flood level is 438.86m and the water surface area of the reservoir is $1.40 \times 10^5 \text{ m}^2$. Below the checked flood level, the most of the fields of the right bank and the left bank belongs to the woodland, and there are no minerals of exploitation value within the reservoir area and no other inundation loss. The total submerged area due to the reservoir engineering is 14.61 hm^2 . In accordance with the national and provincial estimation methods on land acquisition and compensation and the physical indicators of the reservoir inundation approved by each level, the physical indicators of the reservoir inundation of Xujiaping Hydropower Project (Excluding the area of the permanent occupation of the engineering construction and the area of the temporary occupation of the engineering construction) are as follows: 1.23 hm^2 arable lands; 0.95 hm^2 tea gardens; 1.92 hm^2 timber lands; 3.36 hm^2 firewood lands; 4.33 hm^2 barren hills; 1.90 hm^2 beaches; 0.86 hm^2 highways and 1050 m^2 submerged houses, one small bridge, 16 telegraph poles and 21 people involved into the relocation. The total compensation cost is RMB 1.5704 Million Yuan.

2.7.2 Reservoir Inundation Treatment and Resettlement

In accordance with the requirements of (E.S.L.S.D.H.[2006] No.523"Review opinion on the preliminary design report of Changyang Xujiaping Hydropower Project" of provincial Water Resources Department, 7 households, totally 21 people are involved into the resettlement of the engineering due to the reservoir inundation.

In accordance with the national and provincial land requisition compensation standards for projects, Changyang Tujia Autonomous County belongs to the Class VI, therefore, the minimum annual production value regulated is RMB 700 Yuan/household and the minimum resettlement

subsidy standard is RMB 6000 Yuan/per person. The land requisition compensation program of the project is as follows: annual output value of cultivated lands is RMB 1450 Yuan/per mou, the land compensation fee is 8 times, the resettlement compensation fee is 8 times and the fee for the compensation of crops is 1 time; the woodland output value is RMB 700Yuan/per mu, the land compensation fee is 8 times and the resettlement compensation fee is 8 times, too; the annual production value of the construction land is RMB 1450 Yuan/per mu, and both the land compensation fee and resettlement compensation fee are 8 times; the annual output value of the wasteland is RMB 700 Yuan/per mu and the land compensation fee is 8 times. The compensation to the Ground attachments and young crops is made in accordance with the actual situation.

2.8 Reservoir Operation and Dispatching Models

The reservoir of Xujiaping Hydropower Project is the one of the incomplete annual regulation, the regulation storage capacity is $1.66 \times 10^6 \text{ m}^3$, characterized in that the normal pool level is 437m, the dead water level is 418m, the design flood level is 437m and the checked flood level is 438.86m.

In accordance with the requirements of “Hydropower design code for small hydro power projects” (SL76-94), the duration method under the conditions of ascertaining incoming water is applied to the power plant of Xujiaping Hydropower Project for the development of the basic dispatching lines and of the reservoir dispatching chart.

Dispatching chart developing: select the year with the runoff near to 85% from the runoff series and implement the amendment, and then carry out the regulation calculation on the water supply and the water storage periods, of which, the water supply period is from October to April and the water storage period is from May to September. The regulation calculation starts from May when the water level of the reservoir is at the dead water level and the water within the reservoir during the water storage period is below the normal pool level, and the water supply period starts from October, since then, the water level gradually lowers and the water level at the end of the water supply period lowers to the dead water level. The power is generating during the water storage period based on the guaranteed output, and the upper limit line and the lower limit line of the water supply period and the water storage period of the reservoir of each year shall be made, of which, the upper limit line is the upper critical guide curve and the lower limit line shall be the

lower critical guide curve, and the reservoir dispatching chart shall be developed.

Reservoir dispatching and operation manner: when the reservoir is under the normal circumstances, the reservoir operation shall focus on the control conditions, and the reservoir dispatching is made in accordance with the reservoir dispatching map.

□ When the water level of the reservoir is within the firm output area, the powerhouse can power in accordance with the firm output and the dispatching line will not be exceeded.

□ When the water level of the reservoir is within the increased output area, the power generation output of the powerhouse is larger than the firm output and the maximum output is restricted by the output of the machine unit. When the water storage level of the reservoir is normal and the incoming water is more, the normal water level should be maintained, and power generation shall be made by the full utilization of the incoming water and the abandoned water shall be minimized; when the inbound traffic flow is more than the maximum flow of the machine unit, the water will have to be abandoned.

□ When the water level of the reservoir is within the decreased output area, the powerhouse cannot guarantee the output and the operation lower than the output shall be made, and the uniform destruction is allowed.

The dispatching map shall be supplemented and amended based on the actual experience.

2.9 Construction Organization Design

2.9.1 Construction Conditions

The outbound traffic of Xujiaping Hydropower Project can be divided into the land transportation and the water transportation. The dam site is located at Liulinzi, 135km to Changyang County and 195km to Yichang City; the powerhouse is located at Xujiaping, 125km to Changyang County and 185km to Yichang City. In addition, the dam site is 37km to Xiwan Dock and 83km away from Heyan Dock; and the power plant is 27km from Xiwan Dock and 73km away from Heyan Dock. Therefore, it boasts very convenient transportation.

The width of the river bottom at the dam site is about 25m, where the construction site is not appropriate, but there is a flat field at the downstream of the dam site where is provided with the

rural roads, featuring broad terrain. The elevation here is 400m, therefore, the shed, machine servicing, warehouse and concrete batching & mixing plant can be set up here. The pneumatic machines and others for the tunnel construction can be placed to the air compressor station of each branch tunnel, and the air compressor station for the dam excavation can be located at the flat filed of the right side at the upstream side of the dam. The plant construction can use the nearby resident houses rented.

1.37×10^4 tons of cements are required by the engineering, and now there are two cement factories in Changyang with the annual production capacity and quality meeting the requirements of the engineering. The reinforced bars and the steel materials required by the engineering can be purchased from Yichang or Wuhan, or also be supplied by the county material supply company. The local timber can be used directly. The fire material can be supplied by the county chemicals and construction companies or the local police office. The oil material can be supplied by the county oil company or be purchased by the construction unit to meet the demands of the construction machinery.

The power to the construction of the dam and the tunnel entrance can make use of the existing 10kV transmission line, with branches to each working site, a 250kVA transformer should be provided to the dam construction area and a 250kVA transformer to the concrete system; a 100kVA transformer to each construction area such as the No. 2, No.3 and No. 4 branch exits, the pressure regulation chamber and Chongxi Intake dam; and power to the pressure pipeline for construction and the power to the power plant can use that of Chongxi Power Station.

2.9.2 Construction Diversion

In accordance with the requirements of “Specifications for Construction Planning of Water Resources and Hydropower Engineering”, the engineering is a Grade IV one and the grade of the corresponding diversion level is Grade V. The flood control standard of the diversion buildings shall be 20 years (return period) and the dry season is from October to April and the flood flow is $77\text{m}^3/\text{s}$. The engineering applies the cofferdam damming and the channel diversion. The cofferdam at the upper reaches is located at 20m of the upstream of the dam axis with the crest elevation of 407.00m, 4.5m higher than the original river, and the crest length of 56m, the width of

3m and the gradient of both the upstream and downstream slopes of 1:2. The cofferdam at the down reaches is located at 60m of the downstream of the dam axis, with the crest elevation of 402.50m, 3.5m higher than the original river, and the crest length of 28m, the width of 3m and the gradient of both the upstream and downstream slopes of 1:2. The length of the channel for diversion is 105m, the elevation of the access bottom plate is 402.00m and the elevation of the exit bottom plate is 399.90m and the bottom slope gradient is 0.02. The cross section is the rectangular form with the bottom width of 3.0m and the wall height of 3.0m. The well is provided to the upstream pits of the riverbed, where the 150QJ10 submersible pump is applied for drainage and pumping.

2.9.3 Overall Construction Layout and Land Occupation for Engineering

As for the engineering, with the exception of the concentrated construction of the dam, other structure construction is relatively dispersed, according to relatively independent features of the dam, the diversion structures, the power house and others, the construction layout is relatively decentralized.

The construction layout shall stick to the principle of no or less occupation of farmlands, the construction assistant enterprises of the engineering shall also be located dispersedly. In addition to the gravel aggregate processing system, the concrete mixing system, the reinforced steel bar and wood processing plant, and the construction machinery servicing plant required by the engineering, the steel model, the non-standard products and others can be provided and processed by the specialized manufacturers, and the only the maintenance place at the construction site is provided.

By taking into account of the shorter construction period of the engineering, to lower the fees required by the land requisition and the temporary engineering, the residents' houses rented are used and the temporary sheds are set up, with the exception of the new living rooms for the construction staff and assistants.

According to the engineering characteristics, with the exception of $1.48 \times 10^4 \text{ m}^3$ tunnel wastes used by the engineering, other earth and stone are the wastes. There are 8 waste residue yards provided to the engineering, covering 2.04 hm^2 area of the barren hill.

The permanent land occupation of the engineering includes the land for structures, the land of

reservoir inundation and the land for management. To guarantee the safe operation of the project, the area of 50m surrounding the structures is the management scope of the powerhouse. See 2-4 for the details of the land occupation of the engineering.

Table 2-4 Permanent and Temporary Land Occupation of the Engineering

No.	Item		Temporary Land Occupation (hm ²)			Permanent Land Occupation (hm ²)					Total
			Arable Land	Barren hill	Beach	Arable Land	Barren hill	Firewood	Beach	Other	
1	Water retaining structure	Gravity Dam				0.07	0.47		0.07		0.61
2	Diversion structure	Branch Tunnel					0.20				0.20
		Pressure Regulation Chamber						0.07			0.07
		Pressure Pipeline				0.14	0.33	0.67			1.14
3	Reservoir Inundation					1.23	4.33	3.36	1.90	3.79	14.61
4	Plant and booster station					0.13			0.07		0.20
5	Access Road					0.13		0.33			0.47
6	Waste Residue Yard			2.04							2.04
7	Temporary Land Occupation	Dam Area	0.13	1.12	0.11						1.37
		Material Yard		0.31							0.31
		Water diversion Area	0.16	0.09							0.25
		Plant Area	0.08	0.08	0.08						0.24
8	Construction Road			1.07							1.07
9	Total		0.36	4.71	0.19	1.70	5.33	4.43	2.03	3.79	22.54

2.9.4 Construction of the main engineering

(1) Dam Construction

As for the dam excavation, the bank slope shall be excavated first with the elevation of 400 ~ 440m and the application of the 100 model down-the-hole drill, pre-splitting blasting and 1m³pull-shovel and 3m³ loader for waste removal, and the waste is transported to waste residue yards by vehicles. As for the dam foundation excavation, the 1m³ pull-shovel shall be applied with the material excavated for the direct loading and transport; as for the excavation of the protection layer to the dam foundation, the air pick shall be applied. The consolidation grouting shall be implemented after the concrete pouring on the bedding course with the hole depth of 5m, the plum-shaped form and the row spacing of 3m. The curtain grouting applies the once-through

methods and the bottom-up subsection grouting.

The concrete mixing is completed by the HZ75.0A type mixing station and transported by dump trucks. The manual paving is applied and the plate vibrator or the poker vibrator is applied. And the 1500×150×55 steel mould is applied for the site assembly. And the reinforced steel bars are produced and installed at the construction site.

The masonry block stone applies the pull-shovel and the manual masonry and the mortar required is mixed by the mortar mixer.

(2) Tunnel Construction

As for the excavation of the intake shaft well, it shall be made from the bottom to the up, so as to facilitate the disposal of slag, the excavation method is to apply the 100 model down-the-hole drill for inverse-induced shaft holes for the once-through and the subsection blasting, the hand-held air drill is applied for expanding the holes and the slag is taken out through the diversion tunnel at the bottom of the well. The stones excavated shall be sent to the waste residue yard outside the tunnel manually by the application of rubber-wheel push vehicles. The shaft is applied the shaft concrete pouring, furthermore, the mixers are provided to the 441m platform for pumping the concrete placing, and the combined climbing formwork is applied.

The adit excavation applies the air-feed leg pneumatic drill and the smooth blasting. The disposal of slag is made manually and by the application of the narrow gauge locomotive battery or 0.5m³anti-vatus head motor vehicles for slag transpiration. The ventilation inside the tunnel can be achieved by the application of reversible axial flow fan (37kW), placed at 20 m of the excavating face. The power is supplied by the transformers at the mouth of the tunnel. And the concrete lining is mainly concentrated at the exits and the entrances of tunnels and the place of poor geological conditions, the required concrete is mixed outside the tunnel, furthermore, the hydraulic piston type concrete pump is used for concrete placing and the poker vibrator is applied. The grout holes should be reserved for the concrete pouring pipes burying. In course of concrete pouring, the expansion joints per 12m should be provided. As for the concrete jetting and protection, the wet-jetting shall be applied with the back-step construction, furthermore, the 0.25m³ forced mixer shall be used for mixing and the concrete sprayer shall be used for the

spraying and protection, as for the concrete of resilience, the manual method shall be applied to pave the concrete to the bottom.

(3) Construction of Pressure Regulation Chamber and Pressure Pipeline

As for the excavation of the intake shaft well, it shall be made from the bottom to the up, so as to facilitate the disposal of slag, the excavation method is to apply the 100 model down-the-hole drill for inverse-induced shaft holes for the once-through and the subsection blasting, the hand-held air drill is applied for expanding the holes and the slag is taken out through the diversion tunnel at the bottom of the well. The stones excavated shall be sent to the waste residue yard outside the tunnel manually by the application of the rubber-wheel push vehicle. The shaft is applied the shaft concrete pouring, furthermore, the mixers are provided to the 441m platform for pumping the concrete placing, and the combined climbing formwork is applied.

The adit excavation applies the air-feed leg pneumatic drill and the smooth blasting. The disposal of slag is made manually and by the application of the narrow gauge locomotive battery or 0.5m³ anti-vatus head motor vehicles for the transpiration of the slag. The ventilation inside the tunnel can be achieved by the application of the reversible axial flow fan (37kW), placed at 20 m of the excavating face. The power is supplied by the transformers at the mouth of the tunnel. And the concrete lining is mainly concentrated at the exits and the entrances of the tunnel and the place of poor geological condition, the required concrete is mixed outside the tunnel, furthermore, the hydraulic piston type concrete pump is used for concrete placing and the poker vibrator is applied. The concrete pouring pipes buried should be reserved with the grout holes. In course of the concrete pouring, the expansion joints per 12m should be provided. As for the concrete jetting and protection, the wet-jetting shall be applied with the back-step construction, furthermore, the 0.25m³ forced mixer shall be used for mixing and the concrete sprayer shall be used for the spraying and protection, as for the concrete of resilience, the manual method shall be applied to pave the concrete to the bottom.

(4) Construction of Plant and Tail Water

The plant excavation applies the excavating with backhoe excavator, which is the main form of the excavation, supported by the hand-hold pneumatic drill for drilling hole and blasting, the slag is sent to the waste residue yard by vehicles or tractors, as for the stones excavated, they are

stacked to nearby place for the masonry.

The excavation of the booster station of the plant applies the 80 down-the-hole drill for getting holes and the pre-splitting blasting is applied to get the neat slope, the stones excavated shall be sent to the waste residue yard by tricycles. As for the required concrete: it shall apply the 0.8m³ forced mixer for mixing and the tricycles for transportation, furthermore, the manual pavement shall be applied, and also the plate vibrator or the poker vibrator, and the manual smoothing shall be applied. The formwork applies the 1500×150×55 steel formwork for site assembly. The reinforced steel bars are made by the plant and the site installation is applied. The upper part applies the conventional construction methods.

2.9.5 Construction progress

The duration of the engineering is 2 years, which is planned to generate electricity in April 2008.

From July to September, 2006, the preparation phase. The main responsibilities during the phase are to complete the construction of the construction roads; the construction of the wind, water, electricity, communication systems; the construction of the sand and concrete systems; the construction of the rooms for construction and living; and the installation of tower cranes.

From October 2006 to April 2008, the construction phase of the main engineering. The main responsibilities during the phase are to complete the diversion engineering; the dam excavation, concrete pouring and foundation treatment; the diversion tunnel excavation and lining; the excavation and lining of pressure regulation chamber and the pressure pipe; the excavation and lining of plant foundation; the plant construction; the installation and debugging of electrical and mechanical equipment; furthermore, the engineering of the phase shall be equipped with the power generation functions.

From May to June 2008, the round-off work stage of the engineering. The main responsibilities during the phase are to complete the civil engineering of the working bridge of the overflow spillway; the installation and debugging of arc gates; the initial water storage observation; and the improvement of the operation and the management of the powerhouse.

3. Engineering Analysis

3.1 Engineering Feasibility Analysis

3.1.1 Industrial Policy Compliance Analysis

The energy development is the key of the industrial policies relevant to the engineering and the hydropower development is the important project of the energy engineering. The project is a hydropower one, a clean production and an industry with the state support on the development and investment as well as the production promotion. The construction of Xujiaping Hydropower Project can develop a wealth of water resources; improve the flood control capacity of the region; provide the cheap, clean and renewable energy for Xujiaping; and as the same time, it can replace the corresponding thermal electric generation; play an important role in reducing the environmental pollution and the damage of acid rain and others; and feature obvious economic and environmental benefits. The project construction can apply various effective measures; rationally use the natural resources; prevent the environmental pollution and ecological damage; and be consistent with requirements of national environmental policies.

3.1.2 Planning Compliance Analysis

The proposed Xujiaping Hydropower Project is located at Duzhenwan Town of Changyang County, is the key project on the hydraulic power development and utilization of Yaozhan River. Yaozhan River is located at the south of Changyang Tujia Autonomous County, belongs to the Grade One Branch of Qingjiang River. The total drainage area of the river is 128.6 km²; The multi-year average flow is 3.2m³/s and the multi-year average runoff volume is 1.01×10⁹m³. The theoretical storage quantity of Yaozhan River is 1.55×10⁴kW and the hydraulic power in the corresponding year is 136 million kWh. In May 2005, Hubei Zhanghe Civil Engineering Design Institute has implemented the development planning on the hydraulic power, of which, the program of one reservoir and nine stations was going to be adopted, Xujiaping Hydropower Project is one of projects. Yichang Water Resources & Hydropower Office in June 2005 approved

the above planning with the document numbering Y.S.S. [2005] No.112.

3.1.3 Economic Development Compliance Analysis

After the completion of this engineering, adequate water will be provided to Changyang, the development of the electric power industry and the township enterprises will be promoted; the local revenue of Changyang County will be increased; the resource accumulation will be expanded; the local economic will be more flourish; the rural industrial structure will be improved and standard of living of the people will be higher. After the electricity is provided to each household, the village and household power-on ratios will be increased and the ratio of the electric furnace application will be increased, as a result, the electricity will gradually replace the application of the firewood, thus reducing the wood cutting amount, realizing the virtuous circle of “Protecting the forest by electricity, storing water by the forest and generating power by the water” and improving the ecological quality of vegetation in the reservoir area. Therefore, the engineering construction shall be in line with the local economic development.

3.1.4 Feasibility analysis on the Project Site Selection

On the environmental protection, the brief analysis on the rationality of the project site selection, the construction layout and the waste residue yard selection is made.

(1) Dam site selection

During the feasibility study phase, the upper and the lower dam sites are selected near to the planned dam site for comparison, of which, the upper dam site is located at Liulinzi and the lower dam site is located at Xiaoji Town of Linxiangshi. In accordance with the river planning, the requirements of the hub building layout, the topographic and geological condition of the engineering area, the comparison is made from the geological, economic and environmental indicators relevant to the engineering:

a) On geological conditions, the two dam sites are only 400m from each other; therefore, the geological conditions are similar to each other.

b) On economic investment, as for the investment to the water retaining structure, the lower dam site is RMB 3.2734 million Yuan more than that of the upper dam site; as for investment to diversion tunnel, the lower dam site is RMB 961.2 thousand Yuan less than that of the upper dam

site; as for the investment to the reservoir inundation, the lower dam site is RMB 913.9 thousand Yuan more than that of the upper dam site; on engineering benefit, the storage capacity of the lower dam site is $1.43 \times 10^6 \text{m}^3$ more than that of the upper dam site, and the electricity generation is increased by 875,800 kWh and the revenue is increased by RMB 245,200 Yuan. Based on the program of upper dam site, the internal revenue rate under differential investment of the lower dam site is $4.37 < 10\%$, therefore, on economy, the upper dam site is better than that of the lower dam site.

c) On environmental impact, the number of people involved into the resettlement at the lower dam site is 27 more than that of the upper dam site and the 1350m^2 more area of the house is covered and 5.2hm^2 more land is involved into the land requisition, the length of the road rebuilt is 800m; and on the area of reservoir inundation, the lower dam site is larger than that of the upper dam site, and the vegetation destruction is more serious and the ecological environment impact on the animals and plants around the reservoir area is greater. Therefore, on the ecological environment impact, the upper dam site is better than the lower dam site.

The power station is a regulation one, and at the dam site, there are no important mineral deposits, natural monuments, cultural sites, nature reserves, scenic spots, rare and old trees protection bases, basic farmland protection areas, forest parks, densely populated areas and culture & education areas and other objectives requiring protection. Based on the above analysis, the selection of the upper dam site is feasible.

(2) Material Yard Selection

Sand material yard: there are no good gravel yards near the engineering, therefore, it is suggested that the coarse aggregate uses the artificial aggregate and the fine aggregate is purchased or uses artificial aggregate. The 1 # material yard and 2 # material yard are near the dam site, of which, 1 # yard is located at the lower dam site with steep both banks, and the exposed bedrock is under good condition, the exposed Silurian system Luoreping formation (S2lr2) gray red quartz sandstone can be use for producing artificial aggregate; and 2# yard is located about 2.5 km at the downstream side of the dam site, the exposed part contains S_{3sh}^2 quartz sandstone, D_{2y} quartz sandstone and D_{3h} quartz sandstone, the yard can be used as the artificial aggregate yard with rich reserves, basically meeting the demands of the engineering.

Block stone material: the engineering adopts the rock-fill dam, the right bank of the upper reaches of the upper dam site can be used as the material yard, the lithology here is the sandy mudstone, furthermore, part of the stones produced by the overflow spillway excavation can be used for the engineering. The water tunnel of the engineering has the length of more than 6000 meters; part of the tunnel slag can be used to the engineering for rock-fill dam construction. The waste stone materials excavated by the engineering construction can effectively reduce the damage to the surface vegetation due to the quarry mining of the engineering. If the engineering requires a large amount of stones, the 3# material yard can be used, which is located at Tangzuo, about 3.5 km at the downstream side of the dam site with the lithology of P_{2q2}, containing flint limestone, in the thick form and with hard texture, the mechanical properties are well and the reserves are rich.

(3) Waste Residue Yard Selection

As for the diversion tunnel engineering of Xujiaping Hydropower Project, the water diversion construction has the total length of 6082.36m, along with the Chongxi supplementary water resource, the area has steep terrain and long working surface. With the exception of 3 # and 4 # tunnels, the gravels and aggregates for supplementary resource water tunnel and the pressure regulation well come from the slag due to the tunnel excavation, if the rest cannot meet the requirements of the engineering construction, they shall be sent to the nearby waste residue yards, the slag amount of the engineering is larger.

During the engineering construction period, the branch tunnel excavation and the entrance and exit branch tunnel excavation cause the partial surface vegetation destruction of the branch, furthermore, the long-distance waste residue transport causes the damage to the ecological environment along the engineering, unfavorable to the water and soil conservation. In accordance with the dispersion characteristics of the working surface of the engineering structures, there are totally eight waste residue yards, of which, there are two waste residue yards for the intake engineering, 4 waste residue yards for the diversion tunnel engineering, one for upper section of the pipeline engineering and one for the plant engineering, see the construction layout for the detailed location of each waste residue yard.

The layout of the eight waste residue yards, in accordance with the topographic and geological

conditions, the engineering layout and the overall layout of the construction, shall stick to the principle of proximity to shorten the slag transportation distance as far as possible and minimize the damage to the ecological environment along the engineering due to the slag transportation. Based on the principle of minimizing the occupation of the cultivated land and woodland, the eight waste residue yards are constructed on the grassland, covering an area of 2.04hm².

By the application of appropriate drainage measures, engineering measures and vegetation restoration measures, the flood flowing of river is affected; the land occupied belongs to the grassland, and no rare or endangered reeds and plants are found and the area does not belong to the main geological hazard area, therefore, the selection of the waste residue yard is reasonable.

(4) Construction Site Layout

The width of the river bottom of the dam site is about 25m, where the construction site is not appropriate, but there is a flat field at the downstream of the dam site where is provided with the rural roads, featuring broad terrain. The elevation here is 400m, therefore, the shed, machine servicing, warehouse and concrete batching & mixing plant can be set up here. The pneumatic machines and others for the tunnel construction can be placed to the air compressor station of each branch tunnel, and the air compressor station for the dam excavation can be located at the flat filed of the right side of the upstream of the dam. The land for the temporary occupation within the construction site is mainly the flat slope, the excavation amount is less, and there are no villages, drinking water intakes and other sensitive targets surrounding the construction site, therefore, the layout of the construction site is reasonable.

By the above analysis, the project selection will affect the local environment, but some are temporary and some are not very important, therefore, the project site selection is feasible.

3.2 Analysis on the environmental impact during the construction period

During the construction of the hydro-power project, the diversion engineering, the main engineering construction, the local building materials exploitation, the construction of inside and outside traffic roads and others require a large amount of earth excavation, concrete mixing, dam pouring, the application of all kinds of construction machinery and transport vehicles as well as the activities of construction staff, all of which will impact the environment within the

construction area with different degrees.

(1) Analysis on the Water and Soil Erosion Impact Due to Engineering Construction

a) Analysis on the original geomorphic destruction, and the land and vegetation damaged

In accordance with the information relevant to the design of Xujiaping Hydropower Project and the land requisition scope, the area involved into the original geomorphic destruction and the damage to land and vegetation during the construction shall be calculated and measured.

The area of the permanent occupation of the engineering is 17.28hm², including 2.67hm² land for the permanent use of the engineering buildings, 0.47hm² cultivated land; 1.00hm² barren hills and 1.07hm² firewood; and the area of the temporary occupation of the engineering is 5.26hm², including 0.36hm² cultivated land; 4.71hm² barren hills and 0.19hm² beaches; and the area for the reservoir inundation is 14.61hm². In accordance with “Soil and Water Conservation Report of Xujiaping Hydropower Project”, the land occupation details relevant to the engineering are shown in Table 3-1.

Table 3-1 Statistics on the area involved into the original geomorphic destruction, and the land and vegetation damaged Unit (hm²)

Forecasting Zone	Number of the Classified Area					Subtotal
	Cultivated terrace land	Cultivated Sloping Land	Woodland	Grassland	River and Road, etc.	
Main Construction Zone	0.50		1.13	0.90	0.14	2.67
Reservoir Zone	0.37	0.86	6.23	4.34	2.81	14.61
Temporary occupation zone	0.06	0.31		1.67		2.04
Access road zone				2.67		2.67
Material				0.32		0.32

Yard Zone						
Waste Residue Yard Zone				2.14		2.14
Total	0.93	1.17	7.36	12.04	2.95	24.45

By the statistics on the land type of the original topography in the construction site, the area of soil and water conservation facilities damaged due to the engineering construction is 7.74hm^2 , including 0.78hm^2 cultivated land, 1.00hm^2 woodland, 5.84hm^2 grassland and 0.12hm^2 highway and house sites, see Table 3-2 for details. At the same time, due to the vegetation and the topsoil damage, the water and soil erosion is caused, furthermore, the capacity of solidifying soil and scouring prevention is weakened, resulting in the water and soil erosion.

Table 3-2 Statistics on the area involved into damaged soil and water conservation facilities
Unit (hm^2)

Forecasting Zone	Cultivated terrace land	Cultivated Sloping Land	Woodland	Grassland	House and Road, etc.	Total
Main Construction Zone	0.44		1.00	0.92	0.12	2.48
Temporary occupation zone	0.06	0.28		1.50		1.84
Access road zone				1.07		1.07
Material Yard Zone(3#material zone)				0.31		0.31
Waste Residue Yard				2.04		2.04
Total	0.50	0.28	1.00	5.84	0.12	7.74

b) Engineering Slag Volume

The earth and stone excavation volume of the key engineering of the project is $8.91 \times 10^4 \text{ m}^3$, including $1.88 \times 10^4 \text{ m}^3$ earthwork by open excavation, $3.06 \times 10^4 \text{ m}^3$ stonework by open excavation

and $3.97 \times 10^4 \text{ m}^3$ stonework by tunnel excavation; the usable volume of the earthwork is $8.40 \times 10^3 \text{ m}^3$, and the earthwork abandoned (natural earthwork) is totally $8.07 \times 10^4 \text{ m}^3$, the loosening earthwork converted is $1.16 \times 10^5 \text{ m}^3$, and the weight of the residue is $1.90 \times 10^5 \text{ t}$. Because the water residues are too many, the engineering is provided with the waste residue yards for placing the residues, however, if no effective protective measures are taken, the serious water and soil erosion will be caused, which will endanger the downstream of the river and the ecological environment. See Table 3-3 for the calculation of earthwork balance.

Table 3-3 Earthwork excavation and utilization balance calculation

Project	Earthwork Engineering($\times 10^4 \text{ m}^3$)			Stonework Engineering ($\times 10^4 \text{ m}^3$)			Total Abandoned Earthwork ($\times 10^4 \text{ m}^3$)	Weight ($\times 10^4 \text{ t}$)
	Excavated	Used	Discarded	Excavated	Used	Discarded	Natural	
Intake Work	1.46		1.46	2.36	0.05	2.31	3.77	8.40
1#Tunnel				1.01		1.01	1.01	2.53
2#Tunnel				0.79		0.79	0.79	1.98
3#Tunnel				0.36	0.13	0.23	0.23	0.56
4#Tunnel				1.18	0.47	0.71	0.71	1.78
Supplementary Tunnel				0.54	0.05	0.49	0.49	1.23
Pressure regulation well				0.09	0.03	0.06	0.06	0.15
Pressure Pipeline	0.20		0.20	0.64	0.02	0.62	0.82	2.05
Plant Zone	0.22	0.03	0.19	0.06	0.06		0.19	0.34
Total	1.88	0.03	1.85	7.03	0.81	6.22	8.07	19.02

(2) Water Pollution Source

The wastewater and sewage produced during the construction period of time mainly come from

the production and living, including the waste water from the aggregate processing, the waste water from concrete mixing, the waste water from pits, the oily wastewater and the domestic sewage, etc.; the main pollutant is SS, and the most wastewater is from the aggregate processing; the pit wastewater and the wastewater from concrete mixing are applied the intermittent emission and others are applied the continuous emission.

Based on the analysis of the monitoring data relevant to the wastewater from the hydropower engineering construction, the concentration of the suspended substances in the wastewater of concrete mixing is 3000~5000mg/L and the pH value is 11 ~ 12. In accordance with the engineering analysis, the concrete volume for the dam engineering is 45095m³, of which, the peak intensity of the concrete of the main engineering (dam) construction is 150m³/h. And the concentration of SS contained in the wastewater for the aggregate washing is 2.5×10⁴ mg/L.

The average number of workers of each day involved into the engineering construction is 91, and in accordance with the general rules relevant to the water consumption for living of the hydropower engineering construction staff, the daily water consumed is about 120L, of which, 80% is discharged as the form of wastewater, the drainage indicator is 96L/d, the peak sewage emission volume of each day is 8.74m³, and the total volume of sewage during the construction period (two years) is 6.4×10³ m³. The main pollutants of the domestic sewage are BOD₅ and COD with the respective concentration of 200mg/L and 400mg/L, see Table 3-4 for the waste (sewage) water emission information.

Table 3-4 Waste (sewage) water emission information

Type	Emission Period	Emission Mode	Emission Intensity	Emission concentration of main pollutant
Waste water from the aggregate processing	Construction Period	Intermittent emission	324 m ³ /h	SS: 25000mg/L
Waste water from concrete mixing	Construction Period	Intermittent emission	Wastewater from washing: 0.5 m ³ /per time. Wastewater from concrete tank	SS: 5000mg/L pH value of 11 ~ 12

			maintenance: 0.35 m ³ / m ³	
Waster water from pits	Construction Period	Intermittent emission	22 m ³ /h	SS: 2000mg/L
Domestic sewage	Construction Period	Continuous emission	8.74m ³ /d	BOD5: 200mg/L COD: 400mg/L
Oily wastewater	Construction Period	Intermittent emission	4.9 m ³ /d	SS: 300 mg/L Oil:30 ~ 150mg/L

(3) Air pollution sources

The air pollution sources during the construction period mainly come from the dust produced by the concrete production system, the temporary material preparation yard and the handling of the materials for dam construction and the tail gas produced by the fuel machines.

The concrete mixing and pouring system is mainly used for the concrete placement, of which, the cement, by the screwing machine and the hoist is sent to the mixing station from the storage; in course of cement handling and concrete mixing, the feeding materials are under the dry state and are not sealed well, resulting in that the cement in the storage entrance and at the material feeding layers and the transport layer of the mixing plant is easy leaked, thus causing the local air pollution.

During the construction period, the soil, sand and gravel materials and cement have to be got from the outside, so the traffic amount is great, the transport dust and the tail gas of vehicles have an impact on local air quality.

(4) Noise source

The construction noise is mainly from the excavation, drilling, blasting, aggregate crushing, concrete pouring and the running of construction machines, vehicles and the processing and servicing of machines, etc.

a) Traffic Noise Source

The vehicles used in the engineering construction area are mainly the oversize vehicles with the maximum noise of 90dB (A) and the sound source is in the linear distribution. The intensity of the source has the close relations with the speed and flow of vehicles. According to construction planning, the vehicle flow within the construction site is 8vehicles/h.

b) Noise at Dam Site and Material Yard

The noise at the dam site and the material yard construction area is mainly from the running of machines and the excavation of rocks and other construction activities, such as drilling, blasting, shovel operation, concrete pouring and others. The drillers of various models produce the paroxysmal sound source, featuring higher audio frequency and greater source strength of over 90dB (A); and the blasting produces the paroxysmal sound source, featuring higher sound intensity, and the noise value of each embrasure is between 130 ~ 140dB (A); furthermore, there are lots of concrete mixing plants built in the construction area with all the noise values larger than 80dB (A).

Table 3-5 Main Noise Sources of the Construction

Sound Source Type	Equipment and System Name	Noise Level [dB(A)]
Fixed Source	Large-scale ball mill	120
	Mixer	75 ~ 88
	Crusher	105 ~ 110
	Screen Machine	105 ~ 110
	Windlass	95 ~ 105
	Compressor	98 ~ 105
Mobile source	Heavy-duty truck	88 ~ 93(84 ~ 94)
	Medium truck	85 ~ 91(79 ~ 85)
	Light truck	82 ~ 90(76 ~ 84)
	Bulldozer	78 ~ 96
Blasting noise		130 ~ 140

(5) Population health impact analysis

The construction duration of the engineering is 22 months and the most number of people during the construction period is 200. Because a number of construction workers lives in the construction

site during the construction period, the population density is increased, furthermore, because most of which are temporary residents and live in the temporary sheds where the standard of the living facilities is relatively low and the hygienic conditions are poor, the infection incidence rate will be higher.

3.3 Environmental Impact Analysis during the Operation Period of Time

The factors that impacting the water environment during the operation period of the engineering are from the domestic sewage produced by the workers, the oil and wastewater from the operation and servicing of machines of the powerhouse, and the impact to the ecological environment due to eutrophication and the hydrological changes of the waster storage of the reservoirs. During the operation of the engineering, no pollutants are allowed to be emitted to the surrounding environment, but the impact to the environment due to the permanent occupation of land involved into the engineering is also irreversible. The environment impact during the operation period is as follows:

(1) Impact on Hydrological Regime and Sediment

After completion of Xujiaping reservoir, the power is generated by the water diversion through the diversion tunnel with the length of 6068.38m to Xujiaping powerhouse, resulting in the dry-up section or the water reducing section with the length of 7.8km from the downstream of the dam of Xujiaping Hydropower Project to the river section of the powerhouse. Therefore, it shall discharge the ecological flow of a certain amount; the minimum ecological flow shall be fixed in accordance with the requirements of “Water Resources Argumentation of Construction Project”. The multi-year average flow of Xujiaping intake work is $1.92\text{m}^3/\text{s}$, and based on 10% of the multi-year average flow of the dam site, the required discharge of ecological flow is $0.19\text{m}^3/\text{s}$ and the ecological water demand is $5.99 \times 10^6 \text{m}^3$.

The operation of the engineering will impact the spatial and time distribution of the sediment in the reservoir area, the detailed analysis on the sediment accumulation of the reservoir area is presented as follows. And because the sediment measurement information on Yaozhan River is unavailable, the sediment measurement information of Yuyanguan Station can be used. In accordance with the sediment measurement information of Yuyanguan Station, the average

sediment transport modulus of the suspended substances is $145\text{t}/\text{km}^2$, so the suspended substance at Xujiaping dam site is:

$$M_{\text{suspended}}=145\times 57.2=8294\text{t}$$

The multi-year average flow at the dam site is $1.92\text{m}^3/\text{s}$, and the sediment concentration in the suspended substance at Xujiaping Hydropower Project is $0.14\text{kg}/\text{m}^3$.

Due to the lack of measured bedload data, it has to be estimated by the percentage of the suspended sediment, in accordance with the requirements on the sediment calculation standard, the percentage of the engineering is 20%, so the bedload of the dam site of Xujiaping Hydropower Project is:

$$M_{\text{bedload}}=8294\times 20\%=1659\text{t}$$

The dry-bulk densities of the suspended and bedload sediment are $1.3\text{t}/\text{m}^3$ and $1.5\text{t}/\text{m}^3$ respectively. The sediment trapped rate, estimated by the coefficient of reservoir storage capacity, is 80%. The multi-year average sediment amount to the reservoir is $6.00\times 10^3\text{m}^3$.

According to the content of article 4.7.4 of "Design code for small hydropower station" (GB50071-2002), the sediment accumulation duration of the engineering is fixed as 20 years preliminarily, and the sediment amount to the reservoir is $1.20\times 10^5\text{m}^3$. The sediment accumulation will have an impact on the normal operation of the power plant and the return of the reservoir tail water.

(2) Impact on water quality

After the reservoir starts to be used for water storage, the flow of the reservoir area will be slow and the nutrients (nitrogen, phosphorus, etc.) are easy to accumulate, resulting in enrichment, which will cause the eutrophication, furthermore, the change of the water volume discharged by the reservoir and the water quality will also affect the water quality at the downstream side of the river.

(3) Analysis on the impact on biodiversity and ecosystem integrity

The main impact on the ecological environment after the reservoir starts to store water includes

the vegetation loss and the change of the number of plants due to the increasing of the reservoir area. Due to the hydrological changes caused by the reservoir dispatching and operation, the original river ecosystem within the reservoir sections will become a reservoir ecosystem, the population structure and the biomass of aquatic organisms and fishes will change. The reservoir inundation will cause the habitat loss of wild animals and plants, resulting in the change of the number of wildlife species and their distribution scope.

At the same time, the integrity of the landscape will also be affected due to the engineering construction, which will cause the change of the biological productivity and the stability of the natural system.

(4) Impact on Population Health

At the initial stage when the reservoir starts to store water, the mouse and mosquitoes are forced to move to the edge of the reservoir and the residents' places, therefore, the density of mouse in the residential area will be increased, and at the same time, with the expansion of the scopes of shallow water areas and the stagnant area, the mosquito density will be higher, causing the increasing of the incidence of malaria and others.

(5) Socio-economic Impact

After the completion of the hydropower station and being put into use, it will provide the multi-year average power generation of 29.1616 million kW • h, not only bringing the direct financial revenue to Duzhenwan of Changyang, but also to greater extent improving the power supply quality of Changyang electricity grid, enhancing the degree of ensured power supply, regulating the quantity of electricity during the flood season and the dry season and promoting the socio-economic development of Changyang. At the same time, the small waters formed by the reservoir are available for irrigation, creating the favorable conditions for agricultural and economic development surrounding the reservoir and playing a positive role in the shaking off poverty and becoming rich of Duzhenwan.

4. Overview on Environment of Project Area

4.1 Natural Condition

4.1.1 Location

Changyang Tujia Autonomous County is located in Wuling mountain, southwest of Hubei and the middle and upper reaches of Yangtze River, at east longitude of $110^{\circ}21' \sim 111^{\circ}20'$ and north latitude of $30^{\circ}12' \sim 30^{\circ}46'$. The place has the length of 94.5km from east to west and the width of 63.0km from north to south. The total land area of the place is 3430km^2 by the aerial survey (Source from “50 years of Changyang socio-economic development” (1949 ~ 1999), the same below.), and the above is changed to 3418.82km^2 (341881.74hm^2) in the detailed land investigation and the modified registration in 1999. And Qingjiang River, the second largest branch in the upper and middle reaches of Yangtze River is through the county from west to east with the length of 148km. The east side of the county is connected with Yidu city, and south side with Wufeng Tujia Autonomous County, the west with Badong County and the north is adjacent to Zigui County and Dianjun District.

4.1.2 Topography

The Changyang Tujia Autonomous County is the tail of Yunnan-Kweichow Plateau at the east and the remainder of Wuling Mountain as well as the extension of Wushan Mountain. The range has the north and south ones, with the boundary of Qingjiang River, the south is Wuling Mountain and the north is Wushan Mountain, the surface slopes down from west to east. Due to the two remainders have the complex branches, diversifying by hills and mountains, continuous ups and downs of mountains, deep gorges and various ravines. The Bengjianzi of Yinduzui with the sea level of 2259.1m is the highest one in the county, and the Xikou of Xiangjia with the sea level of 48.7m is the lowest in the country, the difference of the two is 2210.4m. Divided by the terrain, the area of the high mountains (with the sea level higher than 1200m) is 71589.50hm^2 , the area of the medium mountains (with the sea level between 800~1200m) is 103563.80hm^2 , the area of the lower mountains (with the sea level between 500~800m) is 66570.10hm^2 and the area of shallow hill and valley (with the sea level below 500m) is 100158.40hm^2 . At the east side, there are few hills, and the north, west and south side are full of high mountains, the top is the highland,

furthermore, the medium mountains are embedded the flat dams, trickling fields and basins.

4.1.3 River Basin Overview

Yaozhan River basin, located in the southwest of Changyang Tujia Autonomous County, covering the east longitude of 110°30-54' and the north latitude of 30°15-24', is Grade One Branch of the middle reaches of Qingjiang River at the south bank. The river originates from Shizinao with the sea level of 2152m at Gaofeng Village, Bailuzhuang Township of Wufeng County; flows into the ground at Zhongzhuwan; exposes at Sifangdong; crosses Diaoshuiyan, Chengwuhe, Shuangmatou, Huilongguan, Xiangshi, Xiangshuidong, Shibanpo, Wangjiacao and Xujiaping, and finally flows to Qingjiang River Geheyuan Hydro-power engineering reservoir are at Shuanghekou (with the elevation of 200m). The length of the main channel is 20.6km; the total height difference is 1952.7m; the weighted average gradient of the main channel is 17.3 ‰; and the drainage area is 128.6km².

Yaozhan River is located in the middle and high terrain of southwest mountainous area of Hubei, and the surface slopes down from south to north. Within the scope of Yaozhan River, the mountain is steep, the mountain body is thick and the plants are lush. The river is narrow; the deeply cut valley is in the V form; the width of the river bed is generally 10 ~ 40m; the rock of both banks of the river is exposed and the terrain is steep and part of the place is formed the steep cliffs.

4.1.4 Hydrology

There is no a hydrological station within the scope of Yaozhan River basin and the hydro-meteorological zoning is Zone VII. However, the Yuguan hydrological station adjacent to Yaozhan River basin has the 1961-2004 runoff information, which is the Grade I national hydrological station with the controlling area of 465km², here the multi-year average precipitation is 1610.9mm; the multi-year average flow is 12.9m³/s and the multi-year average runoff is 410 million m³.

The drainage area under control over Xujiaping Hydropower Project is 77.3km² and the multi-year average precipitation is 1445.7mm, here the hydrologic area analogy method and the rainfall revision method are applied to calculate the designed runoff of Xujiaping Hydropower Project.

The multi-year average flow at the dam site of Xujiaping Hydropower Project is $1.92\text{m}^3/\text{s}$; the multi-year average runoff is 60.692 million m^3 and the runoff modulus is $0.0248\text{m}^3/(\text{s}\cdot\text{k}\text{m}^2)$.

4.1.5 Meteorology

Changyang Tujia Autonomous County has the subtropical humid monsoon climate, featuring rich heat resources, good water conditions, distinct four seasons, sufficient sunlight, rain and heat in the same quarter, early spring, wet summer, late autumn, warm winter and longer frost-free period and so on.

The whole county, located at the middle of the Qingshuiwan rainstorm area and Lvcongo rainstorm area of the remainder of Wuling Mountain, is one of the rainy areas of Qingjiang River in the middle and lower reaches. Here the multi-year average temperature is 16.8°C ; the highest temperature was 42.1°C (June 8, 1966) and the lowest temperature was -12.0°C (January 30.); the monthly average highest temperature was 30.8°C (Aug., 1959) and monthly average lowest temperature was 1.3°C (Jan. 1997). The multi-year average rainfall was 1312.1mm , the maximum daily rainfall was 144.8mm (August 1, 1980) and the maximum monthly rainfall was 429.1mm (July, 1983).

Affected by topography, the temperature and sunshine of the county have the vertical difference, featuring the vertical climate distribution. The annual average temperature of Qingjiang and Danhe valleys is 16°C and the active accumulated temperature of the one $\geq 10^\circ\text{C}$ over years is 5281.7°C ; and the average annual temperature of the high mountain areas is 12°C , and active accumulated temperature of the one $\geq 10^\circ\text{C}$ over years is around 3000°C ; the number of frost-free days at the low mountain area is $275\sim 300$ and at the high mountain area is below 200; the annual average sunshine hours at the low mountain area is 1571h and at the high mountain area is 1875h ; the sunshine radiation volume at the low mountain and valley area is 101.7 thousand k/cm^2 and at the high mountain is 98.9 thousand k/cm^2 .

4.1.6 Water System

Qingjiang River is the largest one throughout the county with the total length of 423km and the total area of 16472km^2 . The length of the river in the county is 148km ; the cutting depth is $100\sim 1000\text{m}$ and the multi-year average precipitation within the basin is 1418.9mm . The gradient of

Qingjiang River is great and the total difference is 1430m, and the difference within the basin is 140m, indicating that the flood peak is easy to be formed. In accordance with the statistics of Changyang Chengguan hydrological station and Banyuzui hydrological station, the multi-year average flow is $427\text{m}^3/\text{s}$ and the largest peak flow is $18900\text{m}^3/\text{s}$.

The surface water system within the county is as follows: the Qingjiang River is the trunk and a total of 428 rivers of different size, forming a pinnate shape, of which, there are 32 Grade One Qingjiang River branches. The number of rivers with the catchment area over 5km^2 is 32; the catchment area over 100km^2 is 9 and the number of rivers with the perennial flow over $0.5\text{m}^3/\text{s}$ is 17. Danshui is the largest river, followed by Zhaolai River, Tianchi River, Siyang River and Dongxi River, etc. Danshui, commonly known as Houhe River, is the largest branch of Qingjiang River in the county with the area of 548km^2 and the total length of 71.75km, crossing Hejiaping, Gaojiayan and Longzhouping; and Zhaolai River originates from Wawazha of Badong with the length of 50.1km and the catchment area of 808.4km^2 .

The area is also rich in the groundwater resources and there are 11 rivers with the river bed over 10km, such as Xianchi River, Zhizheping River, Huangyanchuan River, Tanshuidong River, Longquan River, Baishuidong River, Xiangshuidong River and Nanchaxi River, therefore, the area is rich in water storage.

4.1.7 Sediment

Because there is no measured information on the sediment of Yaozhan River basin, the relevant information from Yuguangzhan hydrological station has to be used; here the average sediment transport modulus of the suspended substances is $145\text{t}/\text{km}^2$. The sediment concentration in the suspended substance at the intake work is $0.14\text{kg}/\text{m}^3$. The dry-bulk densities of the suspended and bedload sediment are $1.3\text{t}/\text{m}^3$ and $1.5\text{t}/\text{m}^3$ respectively. The sediment trapped rate, estimated by the coefficient of reservoir storage capacity, is 0.8, the multi-year average sediment amount to the reservoir is $6.00 \times 10^3 \text{m}^3$ and the sediment in two years will be $1.20 \times 10^5 \text{m}^3$.

4.1.8 Engineering Geology

The engineering is located in the region with weak seismicity, the stability of the area is good and

the basic earthquake intensity is VI.

The dam site and the reservoir area of the engineering are made of the sand mudstone of lower Luoreping group of Silurian system, indicating the water storage condition is good. The place for the intake work is flat and has equipped with good construction field conditions. The lands with the lithology in the dam site are mainly the Silurian siltstone, mudstone and shale, featuring weak permeability of water, which is the natural impermeable layer.

The stratum that the water tunnel has to pass is made of Permian limestone, Carboniferous limestone, Devonian limestone with shale, Silurian mudstone, shale, quartz sandstone and others. The terrane that the tunnel has to pass is fresh and the mechanical conditions of the rock is generally good, with the exception of the entrance, the branch section, part crannies and place with the dense distribution of shale break, causing poor tunnel shaping, most of which belong to the II-III wall rock, indicating the tunnel shaping conditions are good.

The place that the pressure pipelines and the plant have to pass belong to the karst erosion middle-low mountain area with the surface covered with the residual slope accumulated gravelly soil of different thickness and the underlying bed rock of Silurian mudstone. The area of the plant is flat and the exposed rock is good, part of which is covered with the alluvial layer of the thickness of 1 ~ 3m.

4.1.9 Main Resources

(1) Land Resource

Changyang Tujia Autonomous County covers the total land area of 341881.74hm^2 , accounting for 1.83% of total area of the province. The following is the detailed land information: 53951.73hm^2 agricultural land area, accounting for 15.78%; 244667hm^2 forestry land, accounting for 72.57%; 2830.12hm^2 grassland, accounting for 0.83%; 10877.71hm^2 water area, accounting for 3.18%; 8958.19hm^2 barren hills and slopes, accounting for 2.62%, 8861.03hm^2 non-production area, accounting for 2.59%; and 11726.03hm^2 area difficult to use, accounting for 3.43%. The land resource within the county is mainly the mountainous areas; the per capita land area is 0.82hm^2 , indicating that the land resources are relatively abundant and it has the overall development potential. At present, the utilization of land resources is mainly for agriculture and forestry, and

the excessive utilization of farmlands and insufficient woodland exist, of which, the main form of the farmland is the dry-land, covering an area of 51064.73hm^2 , accounting for 94.65% of the total cultivated land area; and the leading land area is only 11625.52hm^2 with the per capita amount less than 0.03hm^2 ; and the slope farmland area with the degree over 25 is 8455.86hm^2 , accounting for 13.76% of the total slope land, furthermore, there are 12933.33hm^2 low-yielding fields and 7333.33hm^2 arable land in the high mountains, from the above information, it is indicated that the soil environmental conditions are poor and the obstacles factors are too many. As for the woodland, the total area is only 244677hm^2 , and the percentage of forest cover is only 47.9%. Besides, there are still large lands for open forest and grass, and 8958.19hm^2 lands are covered by barren hills and slopes.

(2) Water Resource

The water resources in Changyang County can be divided into cross-border foreign water, surface runoff and groundwater, the total amount is about 14.1~14.2 billion m^3 and the water resource reserve is about 1.5389 million kw; Qingjiang River is the only cross-border foreign water source with the multi-year average cross-border water flow of 10.324 billion m^3 ; As for Phase I and Phase II engineering of Qingjiang River of cascade development, the Geheyan power station with the installed capacity of 1.2 million kw and the Gaobazhou hydropower station with the installed capacity of 252 thousand kw have been completed, forming the pattern of “One dam and Two reservoirs” in Changyang, increasing the water area of the entire County to 108km^2 , of which, the effective storage capacity of Geheyan power station is 3 billion m^3 ; the cascade development of Qingjiang River not only brings opportunities for the economic development of Changyang, but also improves the climate and environment.

The surface runoff of Changyang Tujia Autonomous County is 3.126 billion m^3 with the runoff coefficient of 0.69 and the runoff modulus of 913 thousand m^3/km^2 and the hydraulic power reserves of 338.9 thousand kw, of which, there are 36.6 thousand hydraulic power has been developed and utilized to provide the power resources to the industrial and agricultural production of the county; and the total groundwater of the county is 680 ~ 750 million m^3 with the runoff modulus of 200~ 220 thousand m^3/km^2 , mainly distributed in the basins of the high mountain areas and in the sand and gravel layer of the alluvial cones of valleys.

Changyang Tujia Autonomous County has a small (I) reservoir, and seven small (II) reservoirs with the total capacity of 3 million m³. The length of the small diversion canals within the county is 306km, covering 3933.33hm² effectively irrigated area. According to the analysis on the supply and demand balance of water resources, 97 million m³ water is required during the drought year for the industrial and agricultural production and living all around the county, and the foreign water and the external water are not needed. The county boasts rich water resources, however, due to the developed karst, the geological features of higher land and lower water basin, the irrigation is difficult and the utilization of the water is hard, furthermore, because of the backwardness in economy and uneven distribution of water resources, part of the areas of the county has serious water shortages, and the development and utilization of water resources are extremely inadequate.

(3) Plant Resources

Changyang County has warm and humid climate, different land forms, fertile soil and diversified microclimate environment, suitable for the growing of a wide range of plants, therefore, the plant types here are quite lot. In accordance with the survey and statistics of Forestry Bureau of Changyang Tujia Autonomous County on the plant species, the higher and lower plants here cover 561 species including varieties of 253 genera in 90 families, of which, there are 320 species of arbors, 229 species of shrubs and 12 species of vines.

□Arbors:

Castanea, *Quercus*, *Paulownia Sieb.et Zucc*, *Platanus orientalis L*, *Camptotheca Decne*, *Castanea mollissima Blume*, *Toona sinensis Roem*, *Populus tomentosa Carr*, *Liquidambar formosana Hance*, *Litsea hupehana Hemsl*, *Pinus tabulaeformis Carr*, *Pinus armandi Franch*, *Betula luminifera H.Winkl*, *Quercus spinosa David*, *Cercidiphyllum Sieb, et Zucc*, *Emmenopterys henryi Oliv.*, *Taxus chinensis var.mairei Cheng et L.K.Fu*, *Torreya fargesii Franch*, *Corylus chinensis Farnch*, *Sabina chinensis (L.) Ant.*, etc.

□Bamboo:

Phyllostachys sulphurea Riviere, *Potamogeton cristatus Regel et Maack*, *Phyllostachys glauca McClure*, *Phyllostachys nigra Munro*, *Sinarundinaria nitida Nakai*, *Bambusa emeiensis Chia et H.L.Fung*, *Phyllostachys nidularia Munro*, *Bambusa multiplex*, etc.

Grass:

Saccharum fallax Balansa, *Eulaliopsis binata* C.E.Hubb, *Bidens bipinnata* L, *Portulaca oleracea* Lin, *Helianthus tuberosus* L, *Acorus calamus* L, *Aplinia japonica* Miq, *Arisaema heterophyllum* Bl., *Oenanthe javanica* (Bl.) DC., *Lilium brownie var.viridulum* Baker, etc.

Fungus, fern:

Lentinus edodos Pegler, *Flammulina velutipes* Kar, *Volvariella volvacea* Sing, *Pteuororus ostreatus*, *Stenolom chusanum* Chin, *Aleuritopteris argentea* Fee, etc.

(4) Animal Resource

Changyang County has warm and humid climate, and the forest coverage rate is high, conducive to the growth and reproduction of animals, therefore, the animal species are rich here. However, with the increasing development of mountain areas, the forest area is increasingly few, the activity area of animals is narrower, along with the illegal killing, many precious animals have become extinct.

Mammalia:

Hystrix hodgsoni , *Arctonyx collaris* , *Meles meles*, *Hydropotes inermis*, *Muntiacus muntjak*, *Sus scrofa moupinensi*, *Petaurista elegans*, *Callosciurus erythraeus bonhotei*, etc.

Aves:

Bambusicola thoracica, *Francolinus pintadeanus*, *Hydrophasianus chirurgus*, *Coturnix coturnix*, *Chrysolophus pictus*, *Upupa epops*, *Alcedo atthis*, *Rallus aquaticus*, *Amaurornis phoenicuru*, *Egretta garzetta*, *Ardea cinerea*, *Phalacrocorax carbo*, *Eurasian Cuckoo*, *Streptopelia orientalis*, *Aix galericulata*, *Anser cygnoide*, *Psittacula derbiana*, *Hirundo rustica*, *Garrulax canorus*, *Leiothrix lutea*, *Pica pica*, *Parus major*, *Passer rutilans*, *Corvus macrorhyncho*, *Passer montanus*, *Acridotheres cristatellus*, etc.

Reptilia, Amphibia:

Gekko chinensis , *Lacerta agilis*, snake, frog, *Bufo*, etc.

Pisces:

Ctenopharyngodon idellu, *Mylopharyngodon piceus*, *Misgurnus anguillicaudatus*, *Varicorhinus angustistomatus*, *Gymnodiptychus pachycheilus*, *Pelteobagrus fulvidraco*, *Squaliobarbus curriculu*, *Carassius auratus*, *Elopichthys bambusa*, etc.

□ Arthropod and others:

Scolopendra, *Thereuopoda clumifera*, *Chryso; pulcherrima*, *Nepa chinensis*, etc; , *Semiothisa cinerea*, *Sachalinobia koltzei*, *Tenodera aridifolia*, *Anax parthenope*, *Popillia quadriguttata*, *Gryllus testaceus*, *Oxya chinesi*, *Blattidae Handlirsch*, *Lyristes sp*, etc. *Margarya melanioide*, *Anodonta*, *Pheretima* ,*Leech*, *Haemadipsa*, etc.

(5) Mineral resources

Changyang Tujia Autonomous County is also rich in mineral resources. The area has 14 kinds of main mineral deposits, accounting for 26.9% of the total kinds of the province, the ferrous metals include iron, manganese and vanadium (molybdenum) ores and the non-ferrous metals include lead, zinc and mercury ores and the non-metallic limestone, phosphate, barite ore, etc. The iron ore reserves of the area is up to 374 million tons and the coal reserves is up to 38 million tons, but only the coal, barite and pyrite have been developed or are developing.

4.2 Socio-economic Overview and Development Planning

4.2.1 Socio-economic Overview

The engineering is located in Duzhenwan town, at the western side of Changyang, of which, the town has 16 villages, 105 groups and 14,527 households. The total population here is 55,108, of which the one involved into the agriculture is 52,148, the rural labor force is 28,213 and the natural population increase rate is -2.32 %. The land area is 524.9km², of which the arable land is 4464hm². The grain output is 23.5 thousand tons, the total agricultural output value is RMB 74.4 million Yuan and the net income per capita is RMB 1626 Yuan.

4.2.2 Development Planning

(1) Enterprise development planning

The township enterprises of the project area with the selection of the market economy and the improvement of the system reformation are full of new vigor and vitality, now the enterprises expand constantly and the overall economic strength is increased gradually, in 2004, the overall

output of enterprises is RMB 76 million Yuan, an average annual increase of 10.38 %.

Now the enterprise mechanism made by the township government is inflexible, the structure is not good and the development potential is poor, furthermore, the growth is quite hard, therefore, it requires the adjustment of thought, the vigorous implementation of investment invitation and the cultivation of key enterprises. Now the completion of Huilongguan hydropower station, the preparation of Xujiaping power station and Zhongxihe Power Station will enhance the economic strength of the township industry.

(2) Agricultural development planning

With the core of increasing the income of farmers, the town government aims to improve the living standard of people; focuses on the development of agriculture and rural economy; perfects the household contract responsibility system; establishes the market economy mechanisms; strengthens the social service systems; optimizes the rural industrial structure and product structure; stabilizes the food production; and vigorously develops the production of a variety of economic crops. It should, under the premise of keeping food production, positively develop and expand the economy.

4.3 Main environmental problems of the project location

The main environmental problem within the evaluation area is the water and soil erosion, embodied in that the water erosion, gravity erosion, water surface erosion and serious gully erosion, of which, the gravity erosion is more serious due to the unreasonable socio-economic activities of humans, resulting in the severely damaged ecological environment. The engineering area within Duzhenwan Scope is 52474m^3 , where the area of water and soil erosion is 25048m^3 , accounting for 47.73% of the drainage area.

5. Investigation and Evaluation on Present Environmental Condition

5.1. Investigation and Evaluation on Present Ecological Environmental Condition

5.1.1 Land Plant

5.1.1.1 Plantage

Based on the national forest zoning, Changyang County is a district with subtropical evergreen and deciduous broad-leaved mixed forests, due to the affect of the natural and geographical conditions, it finally forms the mixed forest with the main form deciduous broad-leaf more prefer to warm and wet conditions, and mixed with the evergreen broad-leaf more prefer to cold conditions.

5.1.1.2 Vegetation Types

The alpine zone is distributed with needle-leaved evergreen forest and deciduous broad-leaved forest, mainly consisting of conifers and deciduous oaks, and the main species include *Pinus tabulaeformis* Carr, *Pinus armandi* Franch, *Cyclobalanopsis biauca*, *Quercus spinosa* Davi, *Populus davidiana* Dode, *Betula platyphylla* Suk, etc, and the undergrowths include *Lespedeza* Spp and *Rhododendron* spp.

The medium mountain are is distributed with deciduous broad-leaved forest, mainly including *Castanea mollissima* Blum, *Toona sinensis* Roem, *Populus tomentosa* Carr, *Liquidambar formosana* Hance, *Litsea hupehana* Hemsl, etc.

And the evergreen oaks are distributed in the middle and upper parts of the mountain, in the ridges or steep cliffs such as *Quercus spinosa*, and the undergrowths include *Lespedeza* sp, *Rhus chinensis*, *Chimonanthus pyaecos*, raffia palm tree, peach tree, crab tree, dogwood tree, kudzu, *Mukdenia rossii* Koid, etc.

The low-mountain valley zone is distributed with the needle-leaved evergreen forest and the deciduous forest containing subtropical evergreen broad-leaved species, mainly located at the place below 800m. The *Quercus* was the main initial specie, after the natural vegetation is

destroyed, the *Quercus* is replaced by *Pinus massoniana* Lamb, *Cunninghamia lanceolata*, acacia and others, the common forms are the massoniana and oak mixed forest or massoniana, *Cunninghamia lanceolata*, *Vernicia fordii* and mourning cypress forests, mixed with few arbors such as, paulownia, chinar, cortex meliae, oriental white oak, sago cycad, boxtree, microtropis discolor, purpus privet, paramichelia baillonii and others, and the main shrubs are spicebush, *platycarya strobilacea*, *Coriaria sinica*, yellow wood, *Pteroacantha* spp, *Lespedeza bicolor*, bamboo and others, and the common vines are *Pueraria lobata* Ohwi, *Vitis longii* Prince, *Holboellia* Wall, *Mukdenia rossii* Koidz, *Berchemia kulingensis* Schneid, *Celastrus gemmatus* Loes, etc.

The area from the reservoir area to the power plant belongs to the lower mountain valley area, the scene investigation is mainly focused on evergreen coniferous forest and the deciduous forest with subtropical evergreen broad-leaved species, which are mainly distributed at the place below 500m, now the species are mainly replaced by *Pinus massoniana* Lamb, acacia and *Vernicia fordii* and others, the common massoniana Lamb is scattered in the evaluation area and mixed with *Chukrasia tabularis* var. *velutina*. There are no forests distributed in the evaluation area and even the original ones are now replaced by the farmlands.

The shrub layer mainly is consisting of *Coriaria sinica*, spicebush and *platycarya strobilacea* and others, and the grass layer is mainly consisting of *Saccharum fallax* Balansa, *Eulaliopsis binata* C.E.Hubb, *Bidens bipinnata* L, *Portulaca oleracea* Linn, *Lilium brownii* var. *viridulum* Baker, etc.

Due to the special geographical conditions of the reservoir area, the gentle slope below 500m has already been developed into farmlands, and the steep areas where the development cannot be made are provided with the shrubs, mixed with a small number of massoniana and *Vernicia fordii*. Based on the field survey, there are no key wild plants under state protection below the reservoir inundation line.

5.1.2 Terrestrial Animals

b. Animals

With the increasing development of mountain areas, the forest area is increasingly few, the activity area of animals is narrower, along with the illegal killing, many precious animals have become extinct. And now there are no state-level protected animals within the engineering

evaluation scope.

□Beast: mainly *Arctonyx collaris*, *Meles meles*, *Sus scrofa moupinensis*, *Petaurista elegans*, *Callosciurus erythraeus bonhotei*, etc.

The medium and large beasts live in the grass and the shrubs of the high and medium altitude areas (Over 600m) within the evaluation area, and in autumn and winter, beasts find food and water at the inundation area, and other small and medium-sized animals and rat-shapes animals are located in different levels of the evaluation area.

□Aves: mainly, *Acridotheres cristatellus*, *Hirundo rustica*, *Garrulax canorus*, *Cyanopica cyana*, Eurasian Cuckoo, *Streptopelia orientali*, *Passer rutilans*, *Corvus macrorhynchos*, *Passer montanus*, etc.

□Arthropod: mainly including Myriapoda, Crustacea, arachnid and insecta, etc.

Myriapoda includes *Scolopendra* and others, Crustacea includes *Caridinophila unidens* and others; arachnid includes *Chrysso pulcherrima*; insecta include *Semiothisa cinerea* and *Sachalinobia koltzei*, etc.

□Reptiles and Amphibians mainly include *Gekko chinensis*, *Lacerta agilis*, *Chinemys reevesii* and others.

5.1.3 Aquatic Resources

Based on the information provided by environment monitoring station of Changyang Tujia Autonomous County, the main aquatic biological resources within the project area are as follows:

□Phytoplankton

There are totally 116 species of phytoplankton within the project area, belonging to 69 genera and 8 families, of which, there are 21 species of 11 genera of Cyanophyta; 32 species of 27 genera of Chlorophyta; 51 species of 23 genera of Chrysophyta; 2 species of 2 genera of Pyrrophyta; 3 species of 2 genera of xanthophyta; 3 species of 1 genera of Chrysophyta; 3 species of 1 genera of Cryptophyta and 1 specie of 1 genera of Euglenophyta, of which the Chlorophyta and the Chrysophyta are the main types. The average density of phytoplankton is 107.2835×10^4 ind/L and

the biomass is 0.2929mg/L. The dominant species are Melosira Fragilariaceae and Fragilaria, and the secondary dominant specie is Ceratium, characterized in the river phytoplankton community structure.

The phytoplankton of Geheyan reservoir is Cyclotella, Chroococcus and Fragilaria, the secondary dominant species are Ceratium and Coelosmopedia, and the cyanophytes, chlorella and Cryptophyta as well as others are the main type, characterized in the lake phytoplankton community structure.

□ Zooplankton

There are 132 kinds of zooplankton with the average annual density of 656.6ind/L and the biomass of 0.2811mg/L, of which, there are 50 genera (species) protozoan, 22 genera (species) Sarcodina, and 28 genera (species) infusorium, the dominate types are difflugia, mesodinium and strombidium with the average density of 547.5 ind/L and the biomass of 0.0227 mg/L. There are 53 species of 13 section, the Brachionidae (21 species) is the main type, and the dominate types are pedalia mira, keratella.valge, polyarthra euryotrta, conochilus unicornis and chromogaster sp with the average density of 96.3 ind/L and the biomass of 0.0164mg/L; the cladocera and copepods cover 29 species of 19 genera in 8 sections, of which the cladocera covers 17 species of 10 genera in 5 sections and the copepods covers 12 species of 9 genera in 3 sections of 3 families. Among the cladocera, the Chydoridae is the dominate type with 11 species in 4 genera, accounting for 64.71%; and among the copepods, *Cyclopoida* is the dominate type with 8 species in 5 genera, accounting for 66.67%, and its average density is 12.8 ind/L and the biomass is 0.2424 mg/L.

□ Zoobenthos

There are 23 species (genera) of reservoir zoobenthos, of which there are 5 species of oligochaeta, accounting for 21.8%; 15 species of aquatic insects, accounting for 65.2% and only 1 molluscs, accounting for 4.3%, and the rest two accounts for 8.7%. The average density of zoobenthos is 470.2 each/ m² and the biomass is 1567.3mg/m². The density of oligochaeta is 411.8 each/ m², accounting for 87.6% and the biomass is 1508.5 mg/m², accounting for 96.2%; the density of aquatic insects is 58.3 each/ m², accounting for 12.4% and the biomass is 58.8 mg/m², accounting for 3.8%. The tubifex is the dominant type of oligochaeta which is the dominate type of

zoobenthos, therefore the tubifex is the dominate type of reservoir zoobenthos.

□Fish

The fishes involved are: *Varicorhinus angustistomatus*, *Gymnodiptychus pachycheilus*, *Pelteobagrus fulvidraco*, *Mylopharyngodon piceus*, *Ctenopharyngodon idellus*, *Misgurnus anguillicaudatus*, *Squaliobarbus curriculus*, *Carassius auratus*, *Elopiichthys bambusa* and so on.

The engineering zone and the surrounding are mainly effected by the humans' activities for a long time, the habitat of wild animals is changed greatly, at present, the types and the quantities of the wild animals are greatly reduced, with the investigation and verification, there are no rare animals in the area.

5.1.4 Utilization of Land within Evaluation Zone

Table 5-1 Utilization of Land within Evaluation Zone

Village	Agricultural land (hm ²)	Construction land (hm ²)	Unused land (hm ²)
Machi	2206.12	105.26	58.31
Puling	3583.01	91.30	72.46
Xiangshi	2226.70	58.16	42.28
Chengwuhe	2755.51	90.60	67.93
Zhulishan	1080.84	38.95	40.24
Chongxi	1732.54	45.17	44.59
Xiwan	689.78	17.09	17.92

The information in Table 5-1 indicates that the total area within the evaluation scope is $1.51 \times 10^4 \text{ hm}^2$, of which the agricultural land is $1.43 \times 10^4 \text{ hm}^2$, accounting for 94.75%; and the construction land is 446.54 hm^2 , accounting for 3.0%; and the unused land is 343.73 hm^2 , accounting for 2.25%.

5.1.4 Overall Evaluation of Ecological Environment Quality

The main natural vegetation at the project site is the forest and the main artificial vegetation at the project site is the plant-based agriculture. The area has warm and humid climate, different land

forms, fertile soil and diversified microclimate environment, suitable for the growing of a wide range of plants, therefore, the plant types here are quite lot. In accordance with the survey and statistics on the plant species, the higher and lower plants here cover 561 species including varieties of 253 genera in 90 families; and in accordance with the survey on the special plant classification, the plants cover 1438 species of 718 genera in 207 families of 6 categories. As for the forest, among the 561 species, there are 320 species of arbors and 229 species of shrubs. Below the low mountain area, the forest area accounts for about 31.3 % of the total area, and the main plants here are the evergreen broad-leaved mixed forest and the scattered massoniana, bamboo and cypress trees. At the medium mountain area, the forest area accounts for about 22.0 % of the total area, and the main plants are the evergreen broad-leaved and coniferous mixed forest. And at the high mountain area, the forest area accounts for about 16.0% of the total area, and the main plants are the evergreen broad-leaved, dark coniferous forest. In accordance with the survey of Environmental Protection Station of Changyang Tujia Autonomous County, there are no animals, plants and ancient, large, rare and endemic plants and species of the state protection within the area below the reservoir inundation line. In accordance with the statistics, there are seven kinds of provincial-level protected animals within the project evaluation scope, belonging to the beast type and the Aves.

There are totally 116 species of phytoplankton within the project area, belonging to 69 genera and 8 families, of which, the xanthophyta and the Chrysophyta are the main types. The average density of phytoplankton is 107.2835×10^4 ind/L and the biomass is 0.2929mg/L. There are 132 kinds of zooplankton with the average annual density of 656.6ind/L and the biomass of 0.2811mg/L, of which, there are 50 genera (species) protozoan, 22 genera (species) Sarcodina and 28 genera (species) infusorium. There are 23 species (genera) of zoobenthos, of which there are 5 species of oligochaeta, accounting for 21.8%; 15 species of aquatic insects, accounting for 65.2% and only 1 molluscs, accounting for 4.3%, and the rest two accounts for 8.7%.

The upstream of the project site has the fast water flow and low water temperature, and the main fish types are *Silurus soldatovi meridionalis* Chen, *Siniperca scherzeri* Steindacher, *Pelteobagrus fulvidraco*, *Opsariichthys bidens*, *Schizothorax taliensis* (eastern subspecies), *Phoxinus oxycephalus*, *Scaphesthes macrolepis*, *Homalopterida* and so on.

The elevation results on the land utilization shows that the total area within the evaluation scope of the engineering site is $1.51 \times 10^4 \text{ hm}^2$, of which the agricultural land accounts for 94.75%, the construction land accounts for 3.0% and the unused land accounts for 2.25%. Here the forest is the main type, followed by the arable land, and there are hardly other types.

Bengjianzi, at the southwest of the project site is the top of Changyang County, and the Bengjianzi Nature Reserve is located at 2200m above the sea level, while the impact scope of the engineering is about 200-450m, furthermore, there are no nature reserves, scenic spots and cultural relics and others within the evaluation area.

5.2 Water Environment Investigation and Evaluation

5.2.1 Pollution Source Survey and Evaluation

According to the field investigation, the domestic sewage around the reservoir area mainly comes from the daily domestic sewage of residents of both banks. The upstream and the downstream regions of the dam site and the relatively dispersed residents, the centralized disposal of human and animal feces is applied to use the feces as fertilizer. Therefore, the quantity of sewage discharged is small and scattered, no significant effect on river water quality. The field investigation also shows that there are no any industrial pollution sources within the power inundation area.

5.2.2 Water Environment Quality Survey and Evaluation

(1) Monitoring points:

To meet the requirements of water quality prediction and evaluation, there are five water quality monitoring sections provided within the evaluation area: the samples from reservoir entrance, dam site, plant site and Qingjiang River and one sample from Chongxi Plant Power reservoir area.

See Table 5-3 and the Attached Figure for the location of each monitoring sections and the layout significance.

Table 5-3 Surface water environment monitoring sections and sampling points

No.	Monitoring Section Location	Sampling Points	Layout Significance

1#	Reservoir Entrance Section	On the central vertical line and 03.m below the water surface	Comparison Section
2#	Xujiaping Power Plant Dam Site	On the central vertical line and 03.m below the water surface	Control Section
3#	Xujiaping Power Plant Site	On the central vertical line and 03.m below the water surface	Control Section
4#	Chongxi Reservoir Area	On the central vertical line and 03.m below the water surface	Control Section
5#	Qingjiang Entrance	On the central vertical line and 03.m below the water surface	Control Section

(2) Monitoring time and frequency

On May 24 and 25, 2006, and in accordance with the requirements of environmental impact assessment, the monitoring shall be made twice. Each section shall be provided with the surface layer sampling points on the central vertical line.

(3) Monitoring Items and Methods

The items include water temperature, pH, suspended substances, DO, permanganate index, total phosphorus, chemical oxygen demand, biochemical oxygen demand (5), nitrate nitrogen and oil, etc. The water sample collection, preservation and analysis method shall be implemented in accordance with the requirements of GB3838-2002, and the detailed monitoring methods on each item are shown in Table 5-4.

Table 5-4 Analysis Methods on Items relevant to Yaozhan River Water Environment

No.	Item	Analysis Method	Source
1	Water temperature	Thermometer method	GB13195-91
2	pH	Glass electrode method	GB6920-86
3	Suspended substances	Gravimetric method	GB11901-89
4	DO	Iodometry	GB7489-89

5	Permanganate index		GB 11892-89
6	Total phosphorus	Ammonium molybdate Spectrophotometer method	GB 11893-89
7	Chemical oxygen demand	Potassium dichromate method	GB 11914-89
8	Biochemical oxygen demand (5)	Dilution and inoculation method	GB 7488-87
9	Nitrate nitrogen	Gaseous molecular absorption spectrum method	HJ/T 198-2005
10	Oil	Infrared spectrometry method	GB/T 16488-1996

(4) Evaluation Standard

Based on "Environmental Quality Standards for Surface Water" (GB3838-2002) and "Letter of Changyang Environment Protection Bureau Relevant to the Executive Standard on Environmental Assessment of Xujiaping Hydropower Station" of Changyang Environment Protection Bureau, the II class is applied to the project.

See Table 5-5 for the water quality monitoring results

Table 5-5 Yaozhan River water environment monitoring results

(Unit: mg/L, excluding pH value)

Section Item	Entrance Section		Dam Site Section		Plant Section		Chongxi Engine Chamber		Qingjiang Entrance Section	
	24/5	25/5	24/5	25/5	24/5	25/5	24/5	25/5	24/5	25/5
pH Value	8.06	8.13	8.22	8.30	8.33	8.15	8.21	8.19	8.34	8.28
Water temperature	16	16	16	16	16	16	16	16	18	20
Permanganate index	1.01	0.985	1.01	1.02	1.04	0.996	1.02	0.997	1.06	1.04
DO	10.1	9.85	9.56	10.1	9.66	9.86	9.64	9.58	9.57	9.62

Suspended substances	5L	5L	5L	5L	5L	5L	5L	5L	5L	5L
Total phosphorus	0.02L	0.02L	0.02L	0.02L	0.02L	0.02L	0.02L	0.02L	0.02L	0.02L
Chemical oxygen demand	2L	2L	2L	2L	2L	2L	2L	2L	2L	2L
Nitrate nitrogen	0.256	0.262	0.258	0.265	0.263	0.278	0.271	0.276	0.280	0.284
Biochemical oxygen demand (5)	0.60	0.53	0.58	0.64	0.57	0.62	0.53	0.56	0.63	0.59
Oil	0.01L	0.01L	0.01L	0.01L	0.01L	0.01L	0.01L	0.01L	0.01L	0.01L

Notes:

1. With "L", minimum detection limit of the item, indicating the item is in fact not detected;
2. With the exception of pH without unit and the temperature with the unit of °C, the remaining monitoring items have the unit of mg/L.

(5) Water Quality Status Evaluation

The evaluation on the monitoring results by the application of the standard indicator of each item is made based on the Nemerow average value of the water quality parameters monitored and the relevant requirements in "Environmental Quality Standards for Surface Water"(GB3838-2002), and the judgment on the water quality category of each section shall be made, that is,

Standard index at Jth Point of i, the single water quality parameter

Standard index of DO is:

$$S_{DO,j} = \frac{DO_f - DO_j}{DO_f - DO_s} \quad DO_j \geq DO_s$$

$$S_{DO,j} = 10 - 9 \frac{DO_j}{DO_s} \quad DO_j < DO_s$$

$$DO_f = 468 / (31.6 + T)$$

Standard index of pH is:

$$S_{pH,j} = \frac{7.0 - pH_j}{7.0 - pH_{sd}} \quad pH_j \leq 7.0$$

$$S_{pH,j} = \frac{pH_j - 7.0}{pH_{su} - 7.0} \quad pH_j > 7.0$$

If the standard index of the water quality parameter is > 1, indicating that the water quality parameters are higher than the water quality standard and it cannot meet the application requirements. See Table 5-5 for the water quality monitoring results and see Table 5-6 for the evaluation results.

Table5-6 Evaluation Results on Water Quality of Xujiaping Hydropower Engineering

Item	Standard Value	Entrance Section	Dam Site Section	Plant Section	Chongxi Engine Chamber	Qingjiang Entrance Section
pH	6-9	0.556	0.640	0.645	0.605	0.665
BOD5	3	0.194	0.208	0.203	0.184	0.207
Permanganate index	4	0.251	0.255	0.257	0.254	0.264
DO	6	0.042	0.023	0.019	0.054	0.058
Nitrate nitrogen	0.5	0.522	0.526	0.548	0.55	0.566
Total phosphorus	0.1	0.2	0.2	0.2	0.2	0.2
COD	15	0.133	0.133	0.133	0.133	0.133
Oil	0.05	0.2	0.2	0.2	0.2	0.2

From the water quality evaluation results of Table 5-6, we know that:

Before the construction project, the water quality of five evaluation section was good with each item meeting the Class II standard of "Environmental Quality Standards for Surface Water"(GB3838-2002), indicating that the water quality of the project site is good.

5.3 Sound Environment Quality Status Survey and Evaluation

According to the site survey, there are a few residents and no industrial and mining enterprises

within the evaluation area, and there are no major sources of noise. The noise of the area mainly comes from the river flow, and there are hardly other sources of noise, and at the same time, the noise intensities are different due to the different river section and different water flow. The noise monitoring focuses on the background value of the area affected by the noise during the construction period and the operation period.

5.3.1 Monitoring points and monitoring time

According to the functions of the evaluation area and the features of the project layout as well as the layout of the sensitive points of the project site, there are eight noise monitoring points involved into the evaluation. See Table 5-9 for details. The monitoring is made at daytime, once totally.

5.3.2 Monitoring instruments and methods

See Table 5-7 for monitoring instruments and methods.

Table 5-7 Noise Monitoring Method

Item	Monitoring Method	Monitoring Instrument	Remark
Noise	Apparatus Method	AWA6218C Sound level meter	GB/T14623-93

5.3.3 Monitoring Standard and Result

See Table 5-8 for the noise monitoring standard.

Table 5-8 Noise Evaluation Standard Unit: db(A)

Item	Daytime	Nighttime	Remark
Standard Value	60	50	Class II of GB3096-93

See Table 5-9 for the noise monitoring results.

Table 5-9 Noise Monitoring Results Unit: db(A)

Item	Location	Result	Remark
1#	Dam site, 5 meters from river	64.0	Sound of water flow, no man-made noise source

2#	Dam site, 10 meters from river	63.2	Sound of water flow, no man-made noise source
3#	Dam site, 20 meters from river	59.5	Sound of water flow, no man-made noise source
4#	Plant site, 5 meters from river	61.0	Sound of water flow, no man-made noise source
5#	Plant site, 10 meters from river	56.7	Sound of water flow, no man-made noise source
6#	Plant site, 25 meters from river	52.1	Sound of water flow, no man-made noise source
7#	1 meter outside Chongxi Power Plant	60.5	Sound of water flow and the noise from the engine room of Chongxi Power plant
8#	10 meters outside Chongxi Power Plant	58.2	Sound of water flow and the noise from the engine room of Chongxi Power plant

The sound environment sensitive points of Xujiaping Hydropower Project are the four households of the power plant, of which, one household is located 10 meters outside Chongxi Power Plant, that is the 8# monitoring point, in addition, the rest three households are located 25 meters outside Chongxi Power Plant, that is the 6# monitoring point.

The noise monitoring of the area shall follow Class II of "Standard of environmental noise of urban area"(GB3096-93). The standard index method is used for evaluation. See Table 5-10 for the monitoring and evaluation results.

Table 5-10 Sound Environment Evaluation Results

Item	8# Monitoring Point	7# Monitoring Point	6# Monitoring Point	5# Monitoring Point	4# Monitoring Point	3# Monitoring Point	2# Monitoring Point	1# Monitoring Point
------	------------------------	------------------------	------------------------	------------------------	------------------------	------------------------	------------------------	------------------------

Monitoring Result	Leq	64	63.2	59.5	61.0	56.7	52.1	60.5	58.2
Class II Standard Value of GB3096-93	Leq ₀	60	60	60	60	60	60	60	60
Standard Index Method for Evaluation	Pi= Leq/ Leq ₀	1.067	1.053	0.992	1.017	0.945	0.868	1.008	0.97
Reaching Standard		Below standard	Below standard	Reaching Standard	Below standard	Reaching Standard	Reaching Standard	Below standard	Reaching Standard

From the above content, the sound environment within the evaluation area can meet the requirements of the functional area, in accordance with the environmental conditions within the evaluation area, the source of noise is mainly the water flow and there are no man-made noises. The monitoring and evaluation results indicate that the existing sound environment within the proposed engineering area can meet the Class II standard basically.

6. Environmental Impact Prediction and Analysis

6.1. Ecological Environment Impact Prediction and Analysis

6.1.1 Impact of Hydrological Changes on Aquatic Resources

6.1.1.1. Impact on Plankton

The reservoir area has lots of branches, and the main bottom material of the reservoir area is limestone, and here the vegetation is good and the water is clear, furthermore, the riverbed is mostly consisting of gravels and rocks, and the organic sediments are fewer and the plankton in the water is also fewer. After the reservoir starts to store water, the water flow is slow, resulting in that the water in the reservoir is clearer, beneficial to phytoplankton for photosynthesis; at the same time, due to the soluble substances appeared in the inundation area and the nutritional substances collected by the surface runoff, which stay longer time in the reservoir area, providing the rich material foundation for the proliferation of phytoplankton within the reservoir area. Compared with the primary ecological river, the community structure and the community numbers of phytoplankton within the reservoir area will be significantly increased. The distribution density and the location of phytoplankton will also be changed, and the zooplankton biomass will be increased, and at the same time, the Cladocera and the copepods suitable to live in the retarded flow area or standing water will appear in the reservoir area.

The construction of the dam will form a water-reduction section with the length of 7.8km from the dam site to the power generation plant, due to the sharp reduction of the living space, the distribution space of the plankton at the water-reduction section will change and the plankton biomass will also be reduced.

6.1.1.2. Impact on Zoobenthos

After the reservoir is used for water storage, the water level before the dam will be higher, changing the water exchange capacity of natural rivers, and the sediment deposition will change the bottom materials and damage the habitat of zoobenthos, it is expected that after the completion of the engineering, the community structure of the zoobenthos will be changed and the species prefer to moving water in the original river will be gradually reduced, and the community structure in the shallow water in the reservoir area is consisting of mollusks and oligochaetes.

Due to the reduction of the water amount within the reservoir, the water-reduction section with the length of 7.8km will be formed at the downstream of the river, resulting in the change of the hydrological regime of the river and the reduction of the living space of zooplanktons and of the food resources required by the living of zooplanktons, thus reducing the number of zooplanktons of the river section.

6.1.1.3 Impact on Fishes

Yaozhan River is a mountainous stream, where the fish resources are not abundant and the output is low. After the completion of the power plant, the section with the water slowing down will change from the river ecological characteristics to the lake ecological characteristics. The deposition of a large number of nutrients and the great increasing of planktonic plants and animals provide good living and breeding conditions for the filter-feeding fishes prefer to slack water such as carp, bastard carp and *Pelteobagrus fulvidraco*, resulting in the great increasing of the fishes.

After the completion of Xujiaping Hydropower Project and being put into use, the water-reduction section with the length of 7.8km from the dam site to the plant site is formed, narrowing the river and reducing the water amount, thus affecting the living space of fishes. Therefore, the power station during the operation period of time will affect the diversity of the species and the habitat diversity of the water-reduction section to a certain extent.

6.1.2. Impact on Terrestrial Plants

The impact on the terrestrial plants due to the engineering construction is the land occupation and the damage of the construction activities to the surface vegetation.

The total area of Xujiaping Hydropower Project is 22.54hm², of which, and the land for permanent use of the engineering will be 17.28hm², including 14.61hm² submerged by the reservoir and 2.67hm² land for the permanent use of the engineering buildings; and the land for temporary use of the engineering will be 5.26hm². The main forest type occupied by the engineering is the secondary forest and the shrub forest, consisting of the common species such as pipe threes and oaks and others, and there are no rare species. Bengjianzi of Machi, at the southwest of the project site is the top of Changyang County, and the Bengjianzi Nature Reserve is located at 2200m above the sea level, while the impact scope of the engineering is about

200-450m, therefore, the engineering construction and operation will not affect the plants

The vegetation to the construction zone and the soil storage yard is the shrubs and bushes, which will be affected by the construction activities at the initial stage of the construction, and the surface vegetation will be affected in a short period of time, the disappearance or extinction of plant species due to the partial inundation or the excavation will not appear.

The timber production forest area submerged by the engineering is 1.92hm² and the fuel forest area is 3.36hm², the inundation of vegetation due to the reservoirs is irreversible, and the vegetation within the inundation scope, the construction area, the soil storage yard and the resettlement area is the common one, and no plants of state protection are involved, so the inundation effect is small, and the disappearance or extinction of plant species due to the partial inundation or the excavation will not appear.

The normal water level during the engineering operation period of time doesn't fluctuate obviously, and the vegetation within the reservoir area above the normal water level will not be affected.

The vegetation within the resettlement area will be affected in a short period of time by the land occupation due to the resettlement of residents and the relocation and the houses construction, after the completion of new houses, more trees and forests will be provided to the front and the rear of the houses, until then, the living environment of residents will be improved.

6.1.3 Impact on terrestrial animals

6.1.3.1 Impact during the Construction Period

In accordance with the investigation on the construction site, the land for temporary use of the engineering will be 5.26hm² and the land for permanent use of the engineering will be 17.28hm².

The vegetation to both banks within the construction area is good, providing a better living environment for wildlife. With the entrance of construction staff and the machinery and equipment, the activities of staff, the noise of machinery, the blasting, the resettlement and the house construction and the re-construction of public facilities and other activities will directly affect the quality of life of terrestrial animals near the construction site, forcing the beasts and birds and other animals to migrate to a new environment, and the habitats of the animals will be narrower,

unfavorable to animals in a short period of time, and the effect scope is within the engineering construction area and the affected animals are the common species, furthermore, there are no animals of state protection within the area. However, the unfavorable effect is temporary, after the vegetation within the temporary land acquisition recovers, the animals can return to their areas.

6.1.3.2 Impact during the Operation Period

The river here is a mountainous stream with flash flood, the animals in the original valley have adapted to the migration habitat for a long time, after the completion of the reservoir, the instable river form will be changed to the stable water storage manner. Although the habitats below the submerged line have been submerged, after the reservoir has been put into use for a period of time, the small animals of the provincial protection such as hog badger and badger can enjoy the stable living environment, after the reservoir is put into use, the river will be broadened, and the change of the bank habitats will be benefit to the feeding of animals.

Because a few people live at both banks of the reservoir area, the level of agricultural production is lower and the fewer chemical fertilizers and pesticides are used, furthermore, there are no industrial pollution sources surrounding the reservoir, after the reservoir is put into use, the water level will be higher and the water area will be larger, providing suitable living environment to the amphibians prefer to slack water, the change of the shore habitats will be beneficial to the feeding of animals within the area and bring stable living environment to existing animals, which may increase the type and quantity of animals within the area, thus forming the natural environment conducive to the living of swimming birds and Aves, it will finally attract more swimming birds and Aves of different types to winter here.

6.2 Hydrology and Sediment

6.2.1 Hydrology

6.2.1.1 Hydrological regime of the region

The construction activities relevant to Xujiaping Hydropower Project, the water storage, the water diversion and other activities during the operation period will change the natural properties of the water body, resulting in the change of the water level, flow, flow rate and sediment erosion and deposition of the reservoir area, the downstream of the dam and the river mouth, finally directly or indirectly affecting the environment. The multi-year average flow of Xujiaping Hydropower

Project is 1.92m³/s and the multi-year average runoff is 60.6921million m³ and the runoff modulus is 0.0248m³/(s.km²), C_v = 0.28, C_s = 2C_v. The hydrological year is from April to March of the following year, and the flood season is from April to October, during the period of time, the multi-year average flow is 2.72m³/s, accounting for 82.8 % of the runoff of the whole year; and the dry season is from November to March of the following year with the multi-year average flow of 0.80m³/s, accounting for 17.2% of the runoff of the whole year. When P = 85%, the fixed flow is 0.35m³/s. See Table 6-1 for the runoff distribution within the year.

Table 6-1 Average Annual and Monthly Flow and Distribution of the Dam Site of Xujiaping Hydropower Project

Item	April	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	March	Average
Flow (m ³ /s)	2.27	2.79	3.51	1.93	2.92	3.82	1.84	0.84	0.73	0.50	0.75	1.18	1.92
Runoff (10 thousand m ³)	588.71	746.51	910.38	515.88	782.93	989.28	491.61	218.49	194.21	133.52	182.08	315.60	6069.21
Distribution Rate (%)	9.70%	12.30%	15.00%	8.50%	12.90%	16.30%	8.10%	3.60%	3.20%	2.20%	3.00%	5.20%	100.00%

6.2.1.2 Hydrological Regime Impact Analysis

(1) Hydrological characteristics of the reservoir

Runoff

The reservoir is an incomplete annual regulation one. And there is no water for irrigation at the downstream of the river, and there is little amount of water for drinking of residents and domestic animals, and after the completion of the reservoir, the flow to the reservoir is still the natural water, and the annual flow to and from the reservoir is basically balanced.

Water Level

After the reservoir is used for water storage, the influence on the water level of the river is obvious,

in accordance with the design, the normal pool level of the reservoir is 437.00m, 43m higher than that of the original riverbed; the dead water level of the reservoir is 418m; the largest regression degree of the reservoir is 19m, and the multi-year average water level change of the reservoir area will increase.

□ Flow Velocity

In accordance with the analysis on the topography of the river bed, the running water level, the dead water level and the sediment accumulation, and after the reservoir starts to store water, the velocity will be slower than that of the old times.

(2) Hydrological Regime of the Downstream of the Dam

After the completion of Xujiaping reservoir, the water diversion with the length of 6082.36m provides the water to Xujiaping power plant for the power generation, resulting in the dry-up section or the water reducing section with the length of 7.8km from the downstream of the dam of Xujiaping Hydropower Project to the tail water outlet of the powerhouse.

Therefore, it shall discharge the ecological flow of a certain amount, and there are no rare aquatic organisms of national and provincial key protection at the downstream of Xujiaping Reservoir and no water consumption requirements on production, living and landscape, either, and the minimum ecological flow shall be fixed in accordance with the requirements of “Water Resources Argumentation of Construction Project”. The multi-year average flow of Xujiaping intake work is $1.92\text{m}^3/\text{s}$, and based on 10% of the multi-year average flow of the dam site, the required discharge of ecological flow is $0.19\text{m}^3/\text{s}$ and the ecological water demand is $5.99 \times 10^6 \text{m}^3$.

6.2.2 Sediment

Because there is no measured information on the sediment of Yaozhan River, the relevant information from Yuguangzhan has to be used; here the average sediment transport modulus of the suspended substances is $145\text{t}/\text{km}^2$. After calculations, the sediment concentration in the suspended substance at the dam site of Xujiaping Hydropower Project is $0.14\text{kg}/\text{m}^3$, showing that the river contains fewer sands. However, the reservoir of Xujiaping Hydropower Project is a canyon-type reservoir, its depth of deposit before the dam is higher, directly impacting the life of the reservoir.

The normal pool level of Xujiaping Hydropower Project is 437m and the corresponding storage capacity is $1.99 \times 10^6 \text{m}^3$, and the storage capacity at the dead water level of 418m is $3.33 \times 10^5 \text{m}^3$, belonging to small (I) reservoir, its multi-year average sand amount in the suspended sediment to the reservoir is $8.30 \times 10^3 \text{t}$ and the sand amount in the bedload to the reservoir is $1.70 \times 10^3 \text{t}$; and the sediment trapped rate, estimated by the coefficient of reservoir storage capacity, is 80%, therefore, the multi-year average sand amount to the reservoir within 20 years is $1.20 \times 10^5 \text{m}^3$. After calculations, the vertical accumulation of the reservoir is in the strip form and the horizontal accumulation form is at the same elevation.

6.3 Water Environmental Impact Prediction and Evaluation

6.3.1 Prediction of the impact on water quality within the reservoir area

The power plant is located at the transition zone from the mountainous region to the plain and the change of the topography is great. Due to the impact of geological structure, the geomorphology form is complex and the following seven villages are involved, that is, Machi, Puling, Xiangshi, Chengwuhe, Zhulishan, Chongxi and Xiwan, in accordance with the information provided by Environment Protection Bureau of Changyang Tujia Autonomous County, the area around the reservoir is mainly used for planting, and the domestic sewage is mainly used for irrigation, furthermore, there are no concentrated outfalls, and there are no industrial pollution sources within the inundation area of the power plant, either, therefore, the current water quality in the reservoir area is good.

After the completion of the reservoir, the living and the production of the residents within the reservoir area will not be changed greatly, therefore, the point source input will not be increased greatly. As a result, it's expected that after the completion of the reservoir, the water quality can keep the level of Class II.

6.3.2 Water environmental Impact Prediction during the Construction Period

The waste water and sewage produced during the construction period of time mainly come from the production and living, including the waste water from the aggregate processing, the waste water from concrete mixing, the waste water from concrete pouring and maintenance, the waste water from pits, the waste water from equipment washing and the domestic sewage, etc.; the main pollutant is SS, and the most wastewater is from the aggregate processing; the pit wastewater, the

wastewater from concrete mixing and the waste water from concrete pouring and maintenance are applied the intermittent emission and others are applied the continuous emission.

(1) Waste water for washing of aggregate processing system

The work flow of aggregate processing system is as follows: material mining → raw material → sieving → semi-finished products → sieving station → finished aggregate → sand making → mixing → finished sand. Under normal circumstances, 1 ton concrete aggregates consume about 2.7m³water, the sand content in the aggregate is by 8% on average, and based on the material balance principle, the suspended substances concentration in the waste water produced by aggregate washing is about 2.5×10⁴mg/L. In course of aggregate processing, due to the moisture remained in material surface, the evaporation and the seepage, the water loss accounts for 20% of the total water consumed, and the rest 80% is the production wastewater, in accordance with the engineering analysis and calculation, the total waste water for the aggregate processing required by the concrete pouring for the dam engineering during the entire period is about 4.8×10⁴m³, and the peak intensity of the discharge of wastewater from aggregate washing is 324m³/h.

(2) Alkaline wastewater

The alkaline wastewater mainly consists of the wastewater from concrete maintenance, the wastewater from mixer washing and the wastewater from pits, the alkaline wastewater features higher concentration of suspended substances, small amount and intermittent but central drainage. Its pH value can be 11 ~ 12.

In accordance with the feasibility research information and engineering analysis, 1m³ concrete for maintenance produces 0.35m³alkaline wastewater, and during the construction, the concrete pouring and maintenance for the dam engineering produces about 2469m³alkaline waste water.

(3) Oily wastewater

The washing and maintenance of transport vehicles and construction machinery produce a large amount of oily waste water. The optional drainage of the oily wastewater will lower soil fertility, change soil structure and is unfavorable to the recovery of the construction site to the original form.

In accordance with the feasibility research information and engineering analysis, the lifting

machinery, excavators and cars require the regular cleaning, totally 49 (units), based on the assumption of 0.6m³ waste water produced by each unit and the washing frequency of once for each three days, and the washing water of 50%, 4.9m³ oily wastewater will be produced for each single day and a total of 0.37×10⁴m³ oily waste water will be produced throughout the construction period.

(4) Domestic sewage

The worker number of each day for the engineering construction is 91 on average, and according to the general rules of the water consumption of the construction staff for hydropower engineering, the daily water consumption is about 120L on average, of which, 80% is discharged as the form of wastewater and the drainage indicator is 96L/d, the peak sewage emission volume of each day is 8.74m³, and the total volume of sewage during the construction period (two years) is 6.4×10³m³. The main pollutants of the domestic sewage are BOD₅ and COD with the respective concentrations of 200mg/L and 400mg/L.

6.3.3 Prediction on water environmental impact during the operation period

6.3.3.1 Analysis of reservoir water temperature

The evaluation applies the discriminant recommended in "Regulation for hydrologic computation of water resources and hydropower projects" (SL278-2002) for determining the water temperature distribution of water bodies in the reservoir:

$$\alpha = \text{multi-year average annual runoff (m}^3/\text{a)} / \text{the total storage capacity (m}^3\text{)}$$

Table 6-2 Reservoir Water Temperature Type Determining

a Value	< 10	10 ~ 20	> 20
Reservoir water temperature type	Layering	Transition	Mixing

The normal pool level of Xujiaping reservoir is 437.00m and the corresponding storage capacity is 1.99×10⁶m³, and the multi-year average annual runoff is 6.07×10⁷m³/a, after calculation, the value is 30.44 >20, and in accordance with the principle of the division of water temperature structure, the water temperature structure of the reservoir is a mixed one, and the temperature between the water into the reservoir and the water from the reservoir is basically the same, therefore, there will be no influence on the water temperature at the lower reaches of the river and

no influence on the sensitive protection objectives such as aquatic organisms and farmlands and others, either.

6.3.3.2 Prediction of reservoir eutrophication

According to the environmental status investigation, the power plant is located at the transition zone from the mountainous region to the plain and the change of the topography is great, due to the impact of geological structure, the geomorphology form is complex and the following seven villages are involved, that is, Machi, Puling, Xiangshi, Chengwuhe, Zhulishan, Chongxi and Xiwan, and the area around the reservoir is mainly used for planting, and the domestic sewage is mainly used for irrigation, furthermore, there are no concentrated outfalls and no industrial pollution sources within the inundation area of the power plant, either, therefore, the current water quality in the reservoir area is good.

□ Pollution load

The soluble nutrients such as nitrogen, phosphorus, organic matter and others in the soil will affect the water quality after entering the reservoir area by water and soil erosion, and its prediction model is as follows:

$$E = aS_{N,P} + bcdF_{N,P}$$

Where:

E –Total volume of soil nitrogen and phosphorus in the soil to the reservoir;

SN, P-Total volume of nitrogen and phosphorus to the water body and soil, which can be obtained by the total volume of soils to the reservoir multiplied by the total volume of nitrogen and phosphorus;

a –Coefficient of nitrogen and phosphorus to water body, the consumption coefficients of nitrogen and phosphorus along the way are 70% and 95% respectively and the coefficients to the water system are 30% and 5% respectively.

b - Average nitrogen and phosphorus concentration in fertilizer, in a standard fertilizer, the nitrogen and phosphorus are 23% and 15% on average;

c – Utilization rate of fertilizer by crops, and the utilization rates of nitrogen and phosphorus are 30% and 15% respectively;

d – Fertilizer lose rate after entering the soil and water, 10% for nitrogen and 6% for phosphorus;

FN,P- Total fertilizers.

The total land area within the evaluation scope relevant to the engineering is $1.51 \times 10^4 \text{hm}^2$, of which, there are $1.43 \times 10^4 \text{hm}^2$ agricultural land areas, here the fertilizer application is at a lower level, compared with that in other counties and cities of Hubei Province, the nitrogen fertilizer amount of each farmland per year in Duzhenwan is 30kg and the phosphate fertilizer amount is 15kg, and the total nitrogen fertilizer used within the area is 6435t, phosphate fertilizer is 3217.5t, if the pure nitrogen and phosphorus contents are required, then N and P loads within the reservoir area of each year is 1480t/a and 482.6 t/a.

In accordance with the feasibility research information, the total volume of water and soil erosion within the reservoir area is $1.0 \times 10^4 \text{t}$, calculated based on the average sand transport amount; the N and P contents in the soil are 0.12% and 0.035% respectively; and the total volume of N and P to the reservoir area is 12.0 t/a and 3.5t/a.

Putting the above parameters into (1), and the total N and P load can be calculated as follows:

$$EN = 46.92 \text{ t/a}$$

$$EP = 4.51 \text{ t/a}$$

□ Prediction of reservoir eutrophication

Evaluation model: Dillon model

$$C = \frac{L(1 - R)}{\rho \cdot H}$$

Where:

C - Phosphorus (nitrogen) concentration in the reservoir, g / m³.a

L – Annual phosphorus (nitrogen) load per unit area in the reservoir g/(m²·a);

H - Average depth of the reservoir, m

ρ- Hydraulic erosion coefficient, l/a, $\rho = Q / V$;

Q- Annual water inflow

V - Storage capacity

The phosphorus (nitrogen) retention coefficient can be obtained by the empirical equation:

$$R = 0.42 \exp(-0.271Q_i) + 0.574 \exp(-0.00949Q_i)$$

Where: Q_i is the hydraulic loading, m/a; ($Q_i = Q / A$)

Q- Annual water inflow

A - Reservoir surface area

See the following table for each parameter

Table 6-3 Parameters for reservoir eutrophication prediction

Item	Q(m ³)	V(m ³)	A(m ²)	H(m)	ρ	Q _i	R
Parameter	6069.21×10 ⁴	199.38×10 ⁴	14.03×10 ⁴	14.21	30.44	432.59	9.513×10 ⁻³

From the above information, the nitrogen and phosphorus concentrations in the reservoir can be predicted as 0.766mg/L and 0.074 mg/L respectively.

In accordance with the national standard on the water body nutrition type classification of lakes (See the following table), the eutrophication degree of Xujiaping reservoir after being put into use can be fixed.

Table 6-4. Nutrient Types in the Lake Water System Unit: mg / L

Nutrition Type	Index of “Investigating standard of lake eutrophication”		Index of Water Quality Center of Ministry of Water Resources		Taihu Lake Index	
	Total nitrogen	Total phosphorus	Total nitrogen	Total phosphorus	Total nitrogen	Total phosphorus
Inadequate	<0.25	<0.02				

nutrition						
Inadequate nutrition~ middle nutrition			0.2 ~ 0.4	0.005 ~ 0.01	0.16	0.01
Middle nutrition	0.25 ~ 0.7	0.02 ~ 0.05	0.3 ~ 0.65	0.01 ~ 0.03	0.31	0.023
Middle nutrition~ Eutrophication			0.5 ~ 1.5	0.03 ~ 0.1	0.65	0.050
Eutrophication	0.7 ~ 1.3	0.05 ~ 0.09	>1.5	>0.10	1.20	0.110
Heavy Eutrophication	>1.3	>0.09				

Based on the above standards, it is assumed that the content of fertilizer and the soil erosion volume remain the same, Xujiaping reservoir belongs to the middle nutrition type. After the reservoir is put into use, the water system exchange frequency will be lower, if there are no reasonable measures taken, the eutrophication will appear in the reservoir, thus greatly impacting the water system.

6.3.3.3 Predication of Wastewater Impact during the Operation Period

The water for the power generation during the operation period will not pollute the water, and the waster water during the operation period is mainly the domestic sewage generated by power station workers. The main pollutants of living sewages are BOD5 and COD with the respective concentrations of 200mg/L and 400mg/L. Although the pollutant emission is smaller, it still belongs to the excessive emission scope if without any treatment, and also it will pollutes the water environment at the lower reaches of the plant, therefore, the sewage treatment facilities should be built in course of engineering construction. It is recommended to provide dry toilets for effective utilization of the domestic sewage, and furthermore, part of the sewage can be used for watering landscape plants within the plant area. After the treatment by the septic tanks, the sewage can be used as the organic fertilizer for local agricultural production and the direct discharge to the river is forbidden.

6.4 Soil and Water Erosion Prediction

6.4.1 Prediction scope and content

(1) Prediction Scope

According to the principle of “The one for development shall be responsible for the protection and the one for water and soil erosion shall be responsible for the control”, and based on the technical information relevant to development and construction project, the design drawing information and the field survey, the scope within the soil and water erosion prediction of Xujiaping Hydropower Project includes the intake work area of the main water source, the intake work area of the supplementary water source and to the plant, specifically, it includes the main construction area, the reservoir inundation area, the temporary occupied zones for construction, the construction road areas, the material yard areas and the waste residue yard areas, etc., of which, the main construction area includes the intake structure, the release structure, the water diversion structure, the plant and booster station and others.

(2) Predication Content

In accordance with the engineering layout and the construction characteristics of Xujiaping Hydropower Project, the following information shall be obtained first, the surface area involved into the excavation; the extent and area of the vegetation destructed; and the number of slag, rock and slag and their stacking location as well as the stacking form. In accordance with the original erosion modulus of the project location, the erosion modulus of the project during the construction period can be obtained based on the analysis, and it is assumed that if none water and soil erosion control measures have been taken, the engineering construction may cause the water and soil erosion, and even may cause the damage, therefore, the erosion modulus can provide a basis for the effective and scientific water and soil erosion prevention and control.

6.4.2 Prediction Time, Prediction Unit Division and Predication Method

(1) Prediction Time and Prediction Unit Division

According to the requirements of “Technical regulations on water and soil conservation plan of development and construction projects”, the soil and water erosion prediction shall be made for the construction period and the production period.

The prediction time includes the construction period (basic construction period) and the affected

period (Production and operation period), the construction period of the engineering is two years, and the prediction periods of time can be different in accordance with the specific construction period of the main construction zone, the waste residue yard zone, the temporary occupation zone for construction and the construction access roads. The affected period refers to the time required by the surface vegetation recovering to the community diversity with the original water and soil conservation capacity after the human-made intervention is removed, the affected period of the predication is 2 years. See Table 6-3 for the predication and the specific unit division.

Table 6-3 Predication Period of Time on Water and Soil Erosion of Each Area (a)

No.	Predication Area	Predication Period			Predication Time
		Construction period	Affected Period	Subtotal	
I	Main Construction Area	2.0	2.0	4.0	April 2006 ~ March 2010
II	Waste residue yard areas	2.0	2.0	4.0	April 2006 ~ March 2010
III	Temporary occupied zones for construction	2.0	2.0	4.0	April 2006 ~ March 2010
IV	Construction road areas	2.0	2.0	4.0	April 2006 ~ March 2010

(2) Prediction Method

In accordance with the analysis on the local climate, topography, soil, geology, vegetation, water and soil erosion and other information, the type of the water and soil erosion of the construction is mainly the water erosion. And based on the analysis of the characteristics of engineering construction, the predication of the new water and soil loss amount of the damaged surface within the construction area and the impact area shall be made by the application of the analogy method. And the area where may be suffered from the water and soil erosion is the excavation area or the area for burying residue and others which may change the surface area condition and finally lead to the change of the water and soil erosion of the area, that is, the damage to the area with soil and water conservation facilities. As for the area that may be suffered from the water and soil erosion,

it shall be divided into the following two types based on the erosion degree before the construction, that is, the new water and soil erosion area (the surface with hardly water and soil erosion before the construction, such as the terrace land, the woodland and the open forest land with good coverage rate) and the repeated water and soil erosion area (the surface seriously suffering from the water and soil erosion before the construction, such as the slope land, the open forest land without good coverage rate and the grassland).

A) Prediction on Water and Soil Erosion before the Engineering Construction

Within the engineering scope, the original volume of water and soil erosion caused may be obtained by the following equation:

$$W = F \cdot M \cdot T$$

Where: W - Original amount of water and soil erosion (t);

F –Accelerated erosion area (hm²), mainly including the main engineering construction area, the material yard and the waste residue area, the temporary occupation zone for construction, the construction roads area and others with the surface vegetation destroyed, see Table 7-5 for details.

M – The original water and soil erosion modulus before the construction will be different due to the different types of the area with water and soil erosion (t/km²·a). Based on CZW [1994] No. 56 “Report on Comprehensive Prevention and Control of Soil and Water Erosion of Qingjiang River within Changyang County” from People's Government of Changyang Tujia Autonomous County, the sudden erosion modulus of Changyang County on average is 2420t/km²·a, the background average value of the water and soil erosion within the engineering area is 2240 t/km²·a;

T - Erosion Time (a), in unit of a year

b) Prediction on the Volume of Water and Soil Erosion after the Surface is Damaged

The accelerated erosion area of the project is 7.74hm², and the amount of the water and soil erosion during the prediction period is made by the following equation (By the introduction of the equation applied in the water and soil conservation programs of Hurong Expressway, Zhaolaihe Hydro-power Project and other projects)

$$W_1 = (F \cdot M \cdot A \cdot T) \quad (t)$$

Where: W_1 –Amount of water and soil erosion during the prediction period (t);

M – Actual evaluation erosion modulus of the original surface, see Table 7-4 for details;

A - Accelerated erosion coefficient. The accelerated erosion coefficient has a close relation with the local slope and the composition of the surface materials, after the surface is excavated, its dense structure is changed; the cohesion and angle of internal friction are smaller; and the wind resistance and erosion capacity decline significantly. Because the erosion of the exposed surface will increase, the erosion modulus may be increased to 3-7 times of the original surface. The coefficient of the project is finally fixed based on the actual information on the geology, the landform and the applied value of other projects, see Table 6-4 for details.

Table 6-4. Accelerated Erosion Coefficient

Surface Type of Accelerate Erosion	Slope Land	Terrace land from slope land	Woodland	Grassland	Uncultivated slope
Accelerated Erosion Coefficient	8	7	6	5	3

6.4.3 Prediction on the Land Changed, the Surface of Water and Soil Conservation Facilities Changed and the Amount of Waste

(1) Area and Type of Land Changed

The statistics on the surface land changed due to excavation, the land occupied and the land with the vegetation damaged during the construction period of the project is made based on the main engineering area, the material area, the water residue area, the area of temporary occupation and the construction road areas and others.

Table 6-5 Statistics on Landform Changed, Land Damaged and Land with Vegetation Damaged (hm²)

Predication Area	Area of Each Section					Subtotal
	Terrace land	Slope land	Woodland	Grassland	Road and River, etc.	
Main Construction Area	0.50		1.13	0.90	0.14	2.67

Reservoir Area	0.37	0.86	6.23	4.34	2.81	14.61
Temporary occupied zones for construction	0.06	0.31		1.67		2.04
Construction road areas				2.67		2.67
Material Yard Zone				0.32		0.32
Waste residue yard areas				2.14		2.14
Total	0.93	1.17	7.36	12.04	2.95	24.45

(2) Area and Type of Damaged Soil and Water Conservation Facilities

Within the engineering construction land scope, the excavation required by the construction or the burying of waste residue damage the original landform, the surface structure and the surface vegetation of different degrees; lower or lose the original oil and water conservation function; and accelerate the occurrence and development of the water and soil erosion. The surface area damaged due to the engineering construction is regarded as the damaged area with soil and water conservation facilities, which does not include barren hills, uncovered rocks, river beaches and reservoir inundation areas and others. Based on the survey and statistics on the land utilization type used by the engineering, the damaged area with soil and water conservation facilities is 7.74hm², of which there are 0.78hm² cultivated lands, 1hm² woodlands, 5.84hm² grasslands and 0.12hm² lands for highways and houses, see Table 6-6 for details.

Table 6-6 Statistics on Damaged Area with Soil and Water Conservation Facilities (hm²)

Predication Area	Terrace land	Slope land	Woodland	Grassland	Road and House	Total
Main Construction Area	0.44		1.00	0.92	0.12	2.48
Temporary	0.06	0.28		1.50		1.84

occupied zones for construction						
Construction road areas				1.07		1.07
Material Yard Zone (3# Material Yard)				0.31		0.31
Waste residue yard areas				2.04		2.04
Total	0.50	0.28	1.00	5.84	0.12	7.74

(3) Prediction on Waste Amount

The abandoned stone, soils and slag of the project are mainly the rest soils and stones from foundation excavation and slope cutting that cannot be used.

The coefficient converted the natural earthwork to the solid earthwork is 0.85 and to loose earthwork is 1.33, and the coefficient converted the stonework to the loose earthwork is 1.53. In accordance with the description of geological reports, the main stonework within the power plant engineering area is the mudstone with the natural wet bulk density of 2.5t/m³, and the earthworks are the loam soil with the natural wet bulk density of 1.8 t/m³. The total amount of the earthwork and stonework of the project construction is 8.91×10⁴m³. Based on the principle of Reasonable Utilization, 8.40×10³m³ earthwork and stonework are involved into the engineering and 8.07×10⁴m³ natural earthworks area abandoned, equaling to 1.16×10⁵m³ loose earthwork, and the waste disposal bulk density is 1.90×10⁵t.

6.4.4 Analysis and prediction of new water and soil erosion

(1)Waste Loss Amount Prediction

The waste soils, stones and slag during the construction are the essential reason for water and soil erosion, and not all of the residues can be involved into the erosion, which should be transported to the rivers to be a part of the water and soil erosion. The amount of the waste loss of the project

can be calculated by the following formula:

$$W_{S2} = \sum D_{ei} W_i$$

Where: W_{S2} - Loss volume of the waste discharged ($\times 10^4$ t)

D_{ei} - Waste volume of each waste residue yard ($\times 10^4$ t)

W_i - Loss coefficient of each waste residue yard

There are many factors affecting the waste and the ratio of the waste discard and waste loss, and the following four factors are the main ones, that is, the location for placing the waste, the rainwater runoff and other dynamic conditions, the composition of the waste and the prevention and control measures. Because the slopes of the main construction area of the power plant and the runoffs of the rainstorm are different, the different ratios of the waste discard and waste loss shall be applied to the different waste residue yards, it is expected that the amount of the water loss is 2.39×10^4 t. See Table 6-7 for details.

Table 6-7. Waste Loss Amount Prediction and Calculation

Item	Discard Amount ($\times 10^4$ t)	Loss Coefficient	Loss Amount($\times 10^4$ t)
Intake Work	8.40	0.10	0.84
1# Main Diversion Tunnel	2.53	0.15	0.38
2# Main Diversion Tunnel	1.98	0.20	0.01
3# Main Diversion Tunnel	0.56	0.20	0.11
4# Main Diversion Tunnel	1.78	0.15	0.27
Diversion Tunnel of Supplementary Water Source	1.23	0.15	0.19
Pressure-regulation Well	0.15	0.15	0.02
Pressure Pipeline	2.05	0.25	0.51

Plant Area	0.34	0.10	0.03
Total	19.02	1.45	2.39

(2) Prediction of Damaged Land with Water and Soil Conservation Facilities

The area with the damaged water and soil erosion and the area of accelerated erosion are 7.74hm² due to the construction of the engineering, and the construction period here is 2 years and the affected period is 2 years.

a) Water and Soil Erosion before the Engineering Construction

In accordance with the regulations of “Technical regulation on water and soil conservation plan of development and construction projects” SL204-98 and “Standards for classification and gradation of soil erosion” SL190-96, along with the actual topography of the engineering area, the background values of the soil erosion modulus are shown in Table 6-8.

Table 6-8 Background values of the soil erosion modulus within the project area

Land Type	Land Features	Landform Type	Erosion Intensity	Erosion Modulus
Arable land	Gradient <5°	Flat	Slight	500
Sloping land	Gradien<15°	Flat	Average	1000
Woodland and Grassland	Gradien<25°, Coverage Rate >30%	Mountainous region	Medium	2500
Wasteland	Gradien<25°, Coverage Rate >30%	Mountainous region	High	5000

The loss amount of the original soil and water erosion within the project area is 189.90t for each year, from which, the average erosion modulus of the project area can be obtained, that is 2454 t/km²·a, larger than that of the average background value of the water and soil erosion within the project area of 2240 t/km²·a. See Table 6-9 for details.

Table 6-9 Water and Soil Erosion of the Project Area

Item		Land area (hm ²)					Soil Loss Amount (t/hm ² .a)
		Terrace land	Slope land	Woodland	Grassland	Subtotal	
Main Construction Period	Intake Work	0.02		0.45		0.47	11.4
	Tunnel Project			0.05		0.05	1.2
	Pressure-regulation Well, Pipeline	0.02		1.19		1.21	29.9
	Plant	0.28				0.28	1.4
	Permanent Road	0.12		0.35		0.47	9.4
	Subtotal	0.44		2.04		2.48	53.3
Temporary occupied zones for construction		0.06	0.28	1.50		1.84	40.6
Waste residue yard areas				2.04		2.04	60.0
Material Yard Zone				0.25	0.06	0.31	9.3
Construction road areas				1.07		1.07	26.7
Total		0.50	0.28	6.90	0.06	7.74	189.9

The accelerated erosion area of the project is 7.74hm², and the amount of the water and soil erosion in the prediction period is 2.80×10³, of which the new water and soil erosion volume is 2.00×10³t. See Table 6-10 for details.

Table 6-10 Water and Soil Erosion Prediction within the Project Area

Item	Accelerated Erosion Area	Loss amount of the original surface	Erosion Modulus (t/hm ² .a)	Prediction period(a)	Loss Coefficient (A)				Loss Amount in prediction period	New Loss Amount (t/a)
					The 1 st Year	The 2 nd Year	The 3 rd Year	The 4 th Year		
Main Intake Work	0.47	11.4	24.26	4	6.0	4.0	3.0	2.0	171	125

Tunnel Project	0.05	1.2	24.00	3	5.0	3.0	2.0	1.5	14	9
Pressure-regulation Well, Pipeline	1.21	29.9	24.71	3	6.0	4.0	2.0	1.5	404	284
Plant	0.28	1.4	50.00	3	7.0	5.0	3.0	1.5	23	18
Permanent Road	0.47	9.4	20.00	2	6.0	3.0	2.0	1.0	103	66
Subtotal	2.48	53.3	142.97						715	502
Temporary occupied zones for construction	1.84	40.6	22.07	4	7.0	3.0	2.0	1.5	548	386
Waste residue yard areas	2.04	60.0	29.41	4	6.0	5.0	3.0	2.0	960	720
Material Yard Zone	0.31	9.3	30.00	4	5.0	4.0	3.0	2.0	130	93
Construction road areas	1.07	26.7	24.95	4	6.0	5.0	3.0	2.0	427	320
Total	7.74	189.9	249.4						2780	2021

(3) Prediction on total erosion

The erosion amount increased by the water discharged during the engineering construction is $2.39 \times 10^4 \text{t}$ and the erosion amount due to the change and damage to surface is $2.80 \times 10^3 \text{t}$, based the above information, the total amount of water and soil erosion in the prediction period is $2.67 \times 10^4 \text{t}$, of which, the amount of new soil and water erosion is $2.59 \times 10^4 \text{t}$.

From the above information, we know that if none treatment has been made to the damage of vegetation and a large number of water slag and residues in course of engineering construction, the loose stacking will cause the soil and water erosion.

6.4.5 Prediction and Analysis on the Hazard of Water and Soil Erosion

During the construction of Xujiaping Hydropower Project, the surfaces within the engineering scope have been suffered from the damage of different degrees, and the change to some parts will be great, and if none water and soil conservation measures are taken, the new soil and water

erosion volume within the project area will be 2.59×10^4 t, resulting in the impact of different degrees on the land productivity, the river sedimentation and the change of the ecological environment within the area.

(1) Destruction and Influence on Land Resources

The burying of a large number of waste slag, stones and soils, the excavation and the change of surface with vegetation are required by the engineering construction, which destroy the original landform, the soil structure and the surface vegetation of the area.

(2) Destruction of Ecological Environment

The engineering construction causes the damages to surface vegetation; exposes the and; weakens the corrosion resistance and erosion resistance; and greatly lowers the capacity of water storage and soil conservation, thus leading to the serious water and soil erosion and frequent natural disasters and resulting in a vicious circle.

(3) Impact on the Power Station

The water and soil erosion will affect the construction of the engineering and the operation of the hydropower station. If there are no timely and effective methods are taken for the disposal of the waste soil within the engineering construction area, the lost water and soil will enter the construction site, thus affecting the construction progress and the safe operation during the production period, and endangering the personal safety.

6.5 Evaluation on the Impact of Reservoir Inundation and Resettlement

6.5.1 Prediction on the Impact of Reservoir Inundation

(1) Reservoir inundation indicators

Xujiaping Hydropower Project is the hydro-power engineering of incomplete annual regulation. The reservoir is located at Liulinzi, in the middle reaches of Yaozhan River, which is mainly used for water storage. The dam site is 135km away from Changyang County and the water retaining structure is the RCC gravity dam with the maximum dam height of 46.06m. The normal pool level of Xujiaping reservoir is 437m and the checked flood level is 438.86m. Below the checked flood level, the most fields of the right bank and the left bank belong to the woodland, and there are no minerals of exploitation value within the reservoir area and no other inundation loss.

The physical indicators of the reservoir inundation (Excluding the area of the permanent occupation of the engineering construction and the area of the temporary occupation of the engineering construction) are as follows: the total submerged area involved into the engineering is 14.61hm², the area of the house submerged is 1050m² and the arable land area is 1.23hm², of which the paddy field area is 1.15hm², the dry land area is 0.08hm², the tea garden area is 0.95hm², the timber production forest area is 1.92hm², the fuel forest area is 3.36hm², the barren hill area is 4.33hm², the river flat area is 1.90hm² and the road area is 0.86hm², furthermore, there are a bridge and 16 telegraph poles.

(2) Environmental Impact Analysis of Reservoir Inundation

After the construction of the reservoir, the vegetation now below the normal water level will be completely submerged, which is irreversible. However, the vegetations within the inundation scope of the project are the normal species and there are no plants under the state protection, therefore, the impact of the reservoir inundation on vegetation is smaller.

6.5.2 Resettlement Plan

(1) Resettlement Goal

Compared with other hydropower engineering of the project, the basic objectives of the resettlement proposed by the evaluation is as follows:

- Ensure the land area for production involved into the resettlement is not smaller than the area per capita currently, that is, 1.34 mou.
- Ensure the house area for people involved into the resettlement: as for rural house (Including the ancillary facilities), ≤ 140 m² for each household with cultivated land and ≤ 200 m² for each household without cultivated land; as for the non-arable land for each resettlement area, 60 m² for each one and 200 m² for each household on average.
- Improve the levels of the public infrastructure, education, health care, social welfare, traffic conditions and natural environment and other factors within the resettlement areas, for example, as for the water supply: one well or spring or one cistern should be provided for the people of decentralized resettlement; and the electricity supply should be the same with the pervious level.
- Ensure the living standards of people involved into the resettlement are at least the same with

the previous or improved.

(2) Resettlement Number and Method

Because the inundation loss of Xujiaping Hydropower Project is small, and in accordance with the requirements of (ESLDH[2006] No.523"Review opinion on the preliminary design report of Changyang Xujiaping Hydropower Project" of provincial Water Resources Department, 7 households, totally 21 people are involved into the resettlement of the engineering. And the resettlement program is as follows: Based on the actual support capacity of relocated households and the holding capacity of the engineering, it in principle agrees the program of "surrounded by the hills and scattered resettlement" proposed by the township and village governments. The county government will urge the village leaders to arrange the location of each house, organize the arable land reclamation and implement the land expropriation and park establishment to ensure and improve the living standard of each household.

(3) Resettlement compensation

The land requisition compensation is made in accordance with the C.Z.B.F. [2003] No.12 Land requisition and resettlement compensation on Yichang expressway engineering, Wuhan gas pipeline engineering and Changyang section engineering, the relevant regulations of similar projects, the national and provincial standard estimation on land requisition compensation and the indicators on actual loss due to the reservoir inundation concluded in the feasibility study report, as well as the national and provincial engineering land requisition compensation standards.

According to the indicators on actual loss due to the reservoir inundation and the compensation standard as well as the requirements on the recovery of each facility, it is estimated that when the reservoir of Xujiaping Hydropower Project is at the normal pool level of 437m, the submerged compensation is RMB 1.5704 million Yuan, Yichang Changfeng Hydropower Development Co., Ltd., will be responsible for contracting the project valuing RMB 1.5704 million Yuan to the town government of the project, and the town government will organize the village leaders and the group leaders for the work relevant to the resettlement of each household.

6.5.3 Prediction on the Environmental Impact of Resettlement

(1) Impact on Land Resources within the Reservoir Area

The area of permanent occupation of Xujiaping Hydropower Project is 17.28hm^2 , among the lands expropriated, 2.06hm^2 land areas are inundated and belong to arable lands, and the proportion to the land resources of Duzhenwan town is very small. Due to the reduction of land resource, the grain yield will be affected to a certain extent; however, because the occupation of cultivated land areas is fewer, the project will not affect the local economic development. By the appropriate adjustment and land reclamation, the level of per capita arable land after resettlement will remain basically unchanged.

(2) Impact on Water and Soil Erosion

In course of new population centre planning and the new housing construction, the land leveling and the house construction will change the original topography and produce a certain amount of slag and waste soils. In addition, the soil erosion modulus of the resettlement areas is $2454\text{t}/\text{km}^2 \cdot \text{a}$, belonging to the light erosion area, if it is suffered from heavy precipitation or during the rainy season in course of excavation and waste leveling and if there are no protective slopes to roads, the large amount of water and soil erosion will be caused. But it can only happen in the construction period, and it will disappear after the completion of the construction.

(3) Impact on Woodland Submerged

The area of the woodland of the engineering affected by the reservoir inundation is 5.28hm^2 , of which, the timber production forest area is 1.92hm^2 and the fuel forest area is 3.36hm^2 , the main forest type occupied by the engineering is the secondary forest and the shrub forest and there are no rare plant species. However, the reduction of woodland will greatly affect the existing energy structure for drinking and cooking of farmers with the main cooking materials of shrubs, leaves and grasses. Therefore, it's better to change the structure of energy consumption of local residents in the reservoir area as soon as possible to minimize the negative impact due to the woodland inundation, which is one of the urgent tasks of local government.

(4) Impact on Resettlement Area

The trees are required by the land leveling and house construction for resettlement. Therefore, in order to save wood and protect forest resources, the conventional wood structure cannot be used for the house construction of the resettlement. According to the requirements of national "Forest

Law" and relevant laws and regulations on disafforestation prohibition, the main form of the new houses will be the brick-concrete structure, and multi-layer is allowed, which is not only beautiful and solid but also saves lands. According to the planning, the doors and windows for brick-concrete structure house will be 0.2m^3 /per person, requiring 0.42 m^3 timbers, based on 60% timber-produced rate, about 0.7m^3 standing trees will be consumed. In addition to the re-application of the wood materials from the old houses, the trees that have to be cut down due to the land leveling and that are below the inundation level can be made full use of to meet the requirements on the wood materials for the new house construction. While cutting down the forest below the inundation level, the wood material demands of each household should be distributed, the new timber stands are not allowed to be cut down. In course of resettlement, local government shall guide the people of resettlement to develop the methane gas and reduce the firewood demands.

(5) Impact on Population Health

After the completion of the reservoir, due to the expansion of the water area and the slowing of water flow, the area will be more conducive to the growth of float grass along the banks and will a place of good breeding conditions for water-borne germs, insect-borne pathogens and natural focal pathogens, thus increasing the incidence of infectious diseases.

A few peoples are involved into the resettlement of the engineering, therefore, the resettlement applies to the way of nearby and decentralized relocation, however, the resettlement of residents, the limited drinking water conditions and the poor drinking and hygiene habits, a small number of infectious disease carriers may cause the transmission to other places or the disease infection scope may be expanded. At the same time, it may speed up and expand the transmission of infectious diseases.

Therefore, we must strengthen the health and epidemic prevention publicity, while drilling wells for providing water, it shall ensure that the well site shall not be close to the garbage station and toilets, if possible, the running water system should be provided to the place with more residents and the new resettlement center, furthermore, more attention should be paid to the hygiene and disinfection of drinking water and the isolation and treatment of infectious diseases, so as to

minimize the number of people infected by the infectious and epidemic diseases.

(6) Impact on Local Society and Economy

The construction of Xujiaping hydropower engineering can not only ensure the efficient use of water for power generation, but also play an important role in increasing the power capacity of Changyang County, improving the local economic condition and shaking off poverty. The construction of the project not only brings the employment opportunities for the people within the reservoir area and improves their standard of living, but also perfects the local infrastructure and creates better production and living conditions for local residents. The expansion of the reservoir area is the channel to promote the people to construct new houses, open up new lands, adjust the agricultural planting structure, improve the economic returns per unit area, develop the secondary and tertiary industries and increase the incomes, in this way, local residents can shake off poverty and be rich as soon as possible.

6.6 Analysis and Prediction on Other Impact due to the Engineering Construction

6.6.1 Analysis and prediction of atmospheric environment

The prediction on atmospheric environmental impact should focus on the powder and raise dust by the foundation excavation of main engineering, the backfilling of earthworks, the processing and screening of aggregates, the material handling and others during the construction period; the raise dust and the tail gas caused by the running of construction machinery and the inside and external transport; the exhaust gas produced by the running of excavators and the explosion of gunpowder; and the exhaust gas produced by the coal required by living, both of which will affect the surrounding air, and main pollutants of the exhaust gas are TSP,SO₂,NO₂ etc.

(1) Blasting and Excavation of Earth and Stone

The blasting of the engineering that will cause the air pollution initially determines to be made in the following two material yards:

1# material yard below the dam site and the 2 # material yard about 2.5km at the downstream of the dam site. The earthwork volume excavated of $4.5 \times 10^4 \text{ m}^3$ indicates that it will produce a large amount of dusts in a short time, unfavorable to the on-site construction personnel and local

inhabitants. The engineering practice shows that, the pollutants discharged by the construction blasting are intermittent and the pollution to air is slight.

(2) Aggregate Processing and Concrete Mixing

The aggregate processing and concrete mixing will produce dust. In light of the measured data on the construction period of Gezhouba hydro-project and the engineering analysis, the TSP concentration from the operation sites within the construction area will be $150\text{mg}/\text{m}^3$. The dust concentration of each operation site will be higher than that required in the Class II emission standard of GB3095-1996 "Ambient air quality standard", and the daily average output of TSP is $12\text{kg}/\text{m}^3$.

The dust pollution is intermittent, temporary and unorganized non-point source emissions. The planning of the aggregate processing and concrete mixing stations within the construction area will not affect the nearby residents; however, the influence to on-site staff is unavoidable, therefore, the prevention measures shall be taken, such as wearing masks, so as to lower the extent of hazards to the health of on-site construction staff.

(3) Fuel Combustion Pollution

The oil during the construction period is mainly for powering various types of machines and equipment. According to the engineering analysis, the total amount of oil consumed is 84.84t, according to the arrangement of the engineering construction organization, there are 382 main construction machines with the NO_2 and CO as the main tail gas, which will have a negative impact on the local atmosphere environment during the construction period, however, the impact is local and temporary, which will disappear with the completion of construction activities.

(4) Exhaust Gas from Coal for Living

The exhaust gas amount from coal in the living area of construction staff has close relations with the number of construction staff. And the maximum number of construction staff is 200 and 91 of each day on average. The main components in the tail gas are particulate matters, SO_2 , CO , NO_2 , etc. Because the engineering construction area is close to the living area, the dust and fuel exhaust will affect the construction personnel and nearby residents, therefore, the exhaust funnels within

the construction living area shall be up to the required height, so as to improve the dilution ability and avoid the short-range pollution to the living area, after the measures have been taken, the affect on local atmospheric environment in the living area is not serious.

6.6.2 Analysis and Prediction of Sound Environment Impact

The sound environment impact prediction shall focus on the intensity, time and the effect on the sensitive point objects of the noise generated by the running of construction machines, the gravel aggregate processing, the concrete mixing system, the drilling, the blasting and the motor vehicle transportation.

6.6.2.1 Noise sources and source intensity analysis

According to the engineering analysis, the drilling and blasting, the concrete pouring, the reinforced steel bar processing, the running of on-site machines and other construction activities produce the noise of different levels. See Table 6-12 for the noise source and source intensity.

Table 6-12. Main Construction Noise Sources

Sound Source Type	Equipment and System Name	Noise Level [dB(A)]
Fixed Source	Large-scale ball mill	120
	Mixer	75 ~ 88
	Crusher	105 ~ 110
	Screen Machine	105 ~ 110
	Windlass	95 ~ 105
	Compressor	98 ~ 105
Blasting noise		130 ~ 140

6.6.2.2 Sound Environment Impact Prediction

No residents live within 200m of the dam site construction area; There is one household at 50 m of

the south side of the power plant and 4 households at 100m of the west side of the power plant, both of which are the noise sensitive objectives. During the construction period, the point sound source sound is the main form and the corresponding prediction formula can be used for calculation.

(1) Fixed-point sound source

□ Fixed-point sound source prediction formula:

$$L_A(r) = L_{WA} - 20 \lg r - 11$$

Where: $L_A(r)$ - A sound level (dB) r (m) from the sound source;

L_{WA} - A Sound Power Level (dB);

r - Distance between the prediction point and the sound source

□ Prediction results and analysis

By taking into account of the most negative factors, select the maximum of sound source intensity, then the prediction results are shown in Table 6-13. The sound source intensity can be listed in accordance with Table 6-12. Based on the overall construction layout of Xujiaping reservoir, the construction noise is scattered due to the terrain restrictions, and within the point sound source noise area, there are no environmental noise sensitive points. See Table 6-13 for the calculation results on the fixed and continuous point source noise within the construction site.

Table 6-13. Prediction value of fixed and continuous point source noise

Sound Source	Sound Intensity dB(A)	Noise Prediction Values at Different Places to the Sound Source (dB(A))							Object distance *
		20	50m	100	150	200	250	300	
Aggregate processing	110	79.9	68.4	60.6	56.0	52.7	50.1	47.9	200
Pit	112	81.9	70.4	62.6	58.0	54.7	52.1	49.9	300
Mixer	95	64.9	53.4	45.6	41.0	37.7	35.1	32.9	100
Aggregate processing system, concrete mixing system	95	64.9	53.4	45.6	41.0	37.7	35.1	32.9	100
Blasting noise	130	99.9	78.4	80.6	76.9	72.7	70.1	67.9	250

* The noise limit of the object distance is nighttime 50 dB (A), of which the blasting noise is the instantaneous noise with the object distance of nighttime 70 dB (A).

From Table 6-13, we can know that the main noise pollution during the construction period is the fixed and continuous point source and the noise scope is 200m around the construction area, unfavorable to the short-range construction staff.

No residents live within 200m of the dam site construction area, the environment sensitive points within the construction scope are the construction living area and the four households 100 meters from the power plant, therefore, the impact of the noise from construction machinery on the sensitive points is small.

The noise impact scope of the mixer, the aggregate processing system and the concrete mixing system as well as others construction machinery is around 100 meters, and no residents live within 200m of the dam site construction area, therefore the noise of construction machinery affects the construction workers.

The blasting noise is mainly from the foundation excavation of the main engineering and the quarry excavation, with the fixed-point and instantaneous features, and the instantaneous noise can

reach 130dB (A), in course of blasting, the peak instantaneous noise value within 250m around the blasting point can be over 70dB (A), and no residents live within 200m of the dam site construction area, therefore, the blasting noise only affects the construction workers.

6.6.3 Analysis and Prediction of Solid Waste

The main waste pollution sources during the construction period include the engineering slag, the construction waste, the lime and gravel and others. If no proper measures on the treatment of the solid waste are taken during the construction period, it will affect the water quality, the air and the population health, but also will destroy the local natural landscape.

(1) Engineering Slag

The waste amount from the earthwork excavation of the engineering is $8.07 \times 10^4 \text{ m}^3$, once the waste is crushed into the river, the river will be blocked, resulting in the sluggish river flow, increasing the difficulty of construction, delaying the construction progress, destroying the surrounding natural landscape and causing water and soil erosion and landslides, thus finally affecting the ecological balance of the local rivers. In addition, the disorder stacking of residues will also damage the landscape along the bank and affect the water quality, before the application of the earth and stones excavated for backfilling, it may produce the dust in sunny and windy days, and pollute the surface water in rainy days and endanger the health of humans.

There are eight waste residue yards involved into the engineering construction of the power station, covering an area of 2.04 hm^2 . According to soil and water conservation program, after the construction of the slag wall and barrel-drain on the waste residue yards, the waste from the engineering will not have an impact on the river and the normal operation of the reservoir, as well as the sediment accumulation at the downstream of the river, either. From an environmental perspective, the construction of waste residue yards is feasible. In order to reduce the amount of residues and to reduce the damage to the ecological landscape, part of the engineering residues can be used for the engineering facility construction of the local agriculture or for the road maintenance and so on.

(2) Living Garbage

The power station construction zone is consisting of the dam site and the power station, in accordance with the engineering analysis, the construction period lasts for 24 months and the average number of workers of each day during the construction period is 91, it is assumed that the daily garbage per capita is 1kg, the daily garbage during the construction period is 0.091 t and 65.52 t throughout the construction period.

The throwing of living garbage may be smelly and produce dust and pollute the air, and it may pollute the surface water and soil in rainy days, thus adversely affecting the environment. Under a certain circumstances, it may cause the breeding of mosquitoes, flies and rats, which may increase the risk of the spread of various diseases, thus endangering the health of construction personnel.

6.7. Population Health

(1) Construction Period

High-intensity field work may lower the immunity of construction personnel, if the domestic sewage and production wastewater and living garbage cannot be disposed in time, it may cause the breeding of mosquitoes, flies and rats, leading to the occurrence of insect-borne infectious diseases and water-borne infection and others. Therefore, it should strengthen the sanitation and environment of the construction area and the hygiene quarantine and health check of construction personnel, furthermore, it needs to implement the water source management; carry out the control and inspection of external personnel and improve the medical conditions of the construction area. In addition, it must pay attention to the management on food hygiene to prevent the mass food poisoning incidents.

(2) Operation Period

In course of reservoir inundation and water storage, the submerged pollutant in the barren hills, garbage and dejecta and other will flow into the water, bringing the pathogens to the water, which will result in the increase of organic pollutants in the water and the deterioration of health status. After the completion of the reservoir, the water area will be larger and the water flow will be slow down, the change of the microclimate is more conducive to the survival and reproduction of bacteria, viruses and eggs, therefore, the cleaning of the reservoir bottom shall be made before the water storage, and the water quality of the reservoir at the initial stage may be polluted, which will

cause the outbreak of the gastro-intestinal diseases around the reservoir area.

In accordance with the field investigation, there are no natural focal pathogens around the reservoir area, in course of reservoir inundation and water storage, the rats will live to higher place, therefore, the disease spread by the media of rates will increase; after the completion of the reservoir, the local climatic conditions and water environment will be changed, some local climate will be more conducive to the growth and breeding of mosquitoes; the expanding of the surface and slowing of the water flow will make the place be the habitat of more mosquitoes, resulting in the increase of mosquito density, thus increasing the insect-borne infectious diseases. To prevent the mosquito from increasing, the complete removal of weeds and shrubs shall be made at the lower part of the reservoir before the water storage, so as to eliminate the breeding conditions for mosquitoes and flies.

6.8 Society and Economy

Changyang County is relatively backward among the counties in Yichang City, the project area belongs to the quasi-high mountain area with weak industrial and agricultural foundations. Since reform and opening up, with the improvement of traffic conditions, the national economy strength gradually increases, however, due to the restrictions of natural conditions and the relatively slow development growth compared with other regions, the national economic indicators have been a relatively backward position for a long term. In accordance with the "Eleventh Five-Year" plan, the electricity consumption load of Changyang County in 2010 will be 1.67×10^5 kW; however, the existing installed capacity of Changyang County is only 7.63×10^4 kW, indicating that the power shortage will be increasingly obvious. Based on the existing states of the socio-economic development and the power system, the development of several key power stations with the regulation performance is imperative. The construction of Xujiaping Hydropower Project will improve the power supply quality of Changyang electricity grid to a greater extent; increase the power supply; adjust the electricity distribution during the flood season and the dry season; and promote the socio-economic development of Changyang.

(1) The construction of Xujiaping Hydropower Project promotes the industrial and agricultural development of the town; increases the gross national product; increases the national and local

fiscal revenue; expands the accumulation; prospered the local economy; improves the rural industrial structure and the living standard of people.

(2) The construction of Xujiaping Hydropower Project will improve the structure of rural labor force and increase the employment chances, thus stabilizing the social order.

(3) Xujiaping Hydropower Project is an adjustable power station, the construction of the station will promote and improve the capacity of flood control and drought resistance, and bring very good social benefits to the town and Changyang County.

7. Environmental Protection Measures

7.1. Ecological Protection and Restoration Measures

7.1.1 Eco-Management

Ecological environment management is the administrative work of the ecological environment department to implement the effective management on the ecological impacts of the development and construction projects in accordance with national and local relevant laws, regulations, ordinances, technical specifications and standards.

(1) Ecological Management Ordinance on Project Area

Based on the national and local relevant laws, regulations, ordinances, technical specifications and standards, develop the ecological protection code for construction staff during the construction period and reservoir workers during the operation period, the main contents are as follows: comply with the laws and regulations on natural resource conservation and ecological protection; avoid to participate into the activities detrimental to the local ecological environment; and take good care of forests, grasslands and animals.

(2) Ecological Protection and Management

Soil and Water Conservation Supervision and Management

Organize and implement ecological restoration measures of the soil and water conservation program of the engineering; and inspect and supervise the implementation effect of the above measures.

Ecological Management of Resettlement Areas

Improve the natural environment of resettlement areas; encourage people within the resettlement areas to plant the fast growing tree species around the new houses and the open areas to build the "Four sides" green; use the feces of humans and animals to develop the clean energy of biogas and improve the quality of life of people involved into the resettlement.

7.1.2 Protective Measures on Ecological Environment

(1) Protective measures on terrestrial animals

□ To lower the impact of construction staff on wildlife, it is planned to mark stakes and delimit the construction area; in accordance with the water storage features and the wildlife distribution features during the construction area and the reservoir area, set up the eye-catching wild animal protection tags at the dam site, the both banks of the reservoir and the power plant, in particular, strengthen the protective measures management on the provincial protected animals such as hog badgers, badgers, house swallows and azure-winged magpie and others; forbid the hunting of construction personnel, the fishing at the river section within the construction area and engaging into the other activities unfavorable to ecological environment protection.

□ During the engineering construction period, it needs to use the brochures and notices and other forms to strengthen the publicity and education on the ecological protection of construction personnel and nearby residents; and by the establishment of strict systems, forbid construction staff to participate into the illegal hunting of frogs, snakes, birds, beasts and other wild animals to lower the impact of the construction team on local terrestrial animals.

□ Implement the reasonable arrangements on the operation modes and service time on construction machinery; apply the bench blasting way to the engineering construction and strictly control the amount of explosives to reduce the harm to animals due to the instantaneous blasting sound.

(2) Vegetation restoration and protection measures

□ According to the topography, climate and vegetation characteristics of the engineering site, along with the programs on the natural forest protection and soil and water conservation of the engineering, plant the trees and grasses suit to the local conditions, so as to recover the vegetation of the engineering-affected zones; here the key areas include the temporary occupied zones of construction, the sand and gravel yards, the water residue yards and both sides of roads.

□ Take effective measures to prevent forest fires, particularly in the engineering construction period, it should strengthen the protection, taking the measures such as providing the fire warning

signs to the temporary residential area, the surrounding hills and the construction zones to prevent and put a stop to forest fires.

(3) Measures on retarding the impact on aquatic life

The fish farming is not allowed within the reservoir area to protect water quality and control of eutrophication of water within the area. After completion of Xujiaping reservoir, the power is generated by the water diversion through the diversion tunnel with the length of 6068.38m to Xujiaping powerhouse, resulting in the dry-up section from the downstream of the dam of Xujiaping Hydropower Project to the river section of the powerhouse. Therefore, it shall discharge the ecological flow of a certain amount. It is proved that there are no rare aquatic organisms of national and provincial key protection at the downstream of Xujiaping Reservoir and no water consumption requirements on production, living and landscape, either, and the minimum ecological flow shall be fixed in accordance with the requirements of “Water Resources Argumentation of Construction Project”. The multi-year average flow of the Xujiaping intake work is $1.92\text{m}^3/\text{s}$, and based on 10% of the multi-year average flow of the dam site, the required discharge of ecological flow is $0.19\text{m}^3/\text{s}$ and the ecological water demand is $5.99 \times 10^6 \text{m}^3$.

7.1.3 Eco-restoration Measures

(1) Soil and water conservation scope and divisional prevention system

The water and soil erosion scope of Xujiaping hydropower engineering is consisting of the project construction area and the directly affected area, of which, the project construction area includes the area of permanent occupation for construction and the area of temporary occupation for construction; and the directly affected area includes the area damaged and changed due to the engineering construction and the area of vegetation destroyed, the area of reservoir inundation and the resettlement area, etc.

Based on calculations, the area of the water and soil erosion of the project is 1.63hm^2 , of which 1.50hm^2 for the construction area and 0.13hm^2 for the directly affected area.

(2) Soil and water conservation prevention divisions

The water erosion is the main type within the water and soil erosion prevention and control scope

of the project construction area, along with fewer mixed eroded area with gravitational erosion. Therefore, in accordance with the characteristics of water and soil erosion of the project construction area, the prevention of water erosion and gravitational erosion is the main task of the water and soil erosion prevention and control within the project area. Based on the water and soil erosion control and prevention scope, and the layout of main engineering and the possible hazards caused by water and soil erosion, the water and soil prevention and control scope can be divided into the following five zones, that is, the main construction zone, the material yard zone, the water residue yard zone, the temporary occupied zone of construction and the construction roads zone.

(3) Overall layout of soil and water conservation measures

The detailed information on the water and soil conservation prevention and control measures are as follows:

- Soil and water conservation measures for main construction zone:

The main soil and water conservation prevention and control measures for the main construction zone during the construction area are as follows: provide the temporary drains to the place surrounding the main structures in the construction area (with the total length of 435m); provide the temporary protective measures to the surface excavated for the engineering in the rainy season; arrange the temporary stacking of wastes; provide the bagged stones for temporary protection; and implement the protection with temporary covers to the material storage for the temporary engineering within the construction area, etc.

- Soil and water conservation measures for waste residue yard zone

-Engineering measures

In accordance with the topographical features of each waste residue yard and the regulations of “Technical regulation on water and soil conservation plan of development and construction projects” SL204-98, the design principle for the engineering measures is as follows:

- By providing the masonry debris retaining walls to the lower edges of the waste residue yard or providing the placed rock-fill protective slop to the side slopes of wastes, aim at preventing the slope land erosion and the instability of states due to the erosion of Baoyuhe River.

- By providing the drains to the edges of the waste residue yards, of which, the bottom of the drains shall be provided with the sedimentation tank, aim at preventing the wastes from being washed during the rain-storm period.
- By controlling the slope gradient of wastes, ensure the stability of waste slope and prevent the partial collapse.
- As for the area where the centralized processing cannot be made, the appropriate measures shall be taken for protection.

(1) Dammed-up measures

The design is made by taking the retaining wall within the 1# waste residue yard as an example, and the details are as follows:

The debris retaining wall of 1# waste residue yard has the length of 164.0km and the height of 6.0m; the width of the wall top is 0.5m; the gradient of the strong surface is 1:0.1; the gradient of the wall back is 1:0.4; and the width of the wall bottom is 3.5m. The wall is applied the M7.5 masonry blocking structure; the foundation excavation shall be made to the bedrock or solid clay layer with the minimum depth of not less than 0.7m; and the width of the foundation of the debris retaining wall is 4.0m. In accordance with the geological conditions, a settlement joint of every 15.0m should be set up with the joint width of 0.01. A row of drainage holes should be provided to the place 0.3m above the ground elevation with both of vertical and horizontal distances of 2.0m and in plum-shaped layout, the cross-section dimension of the drainage hole should be 0.15m×0.15m and the gradient of 0.1; and the waste slope gradient above the top of the waste residue yard is 1:2.0.

(2) Typical design on drainage measures

The typical design on drainage measures is made by taking 2 # waste residue yard as an example. The 2# waste residue yard is located at the low ground of the mountain region where is flat. Inside the waste residue yard is insequent valley with the barrel drains provided along the hillside at both sides of the debris retaining wall to discharge the water from the hillside inside the waste residue yard. The total length of the drains is 180.0m with the longitudinal slope of 1/50, the cross-section of the drains designed is $b \times h = 0.5\text{m} \times 0.5\text{m}$; the side wall is the masonry block structure with inside finishing and the bottom of the drain is the C15 concrete structure. See Table 7-1 for the specific sizes of the debris retaining walls and the barrel drains.

Table 7-1 Engineering Measures Design of Waste Residue Yard

No.	Debris retaining wall size (m)						Barrel drain size (m)			sedimentation basin size (m)			
	Wall Length	Wall Height	Top Width	Bottom Width	Outer Slope	Inner Slope	L	W	D	Location	L	W	D
1# waste residue yard	164	6.0	0.5	3.5	0.1	0.4							
2# waste residue yard	116	4.0	0.5	2.5	0.1	0.4	180	0.5	0.5	2	2.0	1.5	1.5
3# waste residue yard	78	3.0	0.5	2.0	0.1	0.4	106	0.5	0.5	2	2.0	1.5	1.5
4# waste residue yard	46	3.0	0.5	2.0	0.1	0.4	184	0.4	0.4	2	2.0	1.5	1.5
5# waste residue yard	32	3.0	0.5	2.0	0.1	0.4	268	0.5	0.5	2	2.0	1.5	1.5
6# waste residue yard	220	2.0	0.5	1.5	0.1	0.4							
7# waste residue yard	134	6.0	0.5	3.5	0.1	0.4							
8# waste residue yard	62	5.0	0.5	3.0	0.1	0.4	98	0.4	0.4	2	2.0	1.5	1.5
Total	852						836			10			

□Vegetation measures

In accordance with the overall layout of soil and water conservation program, while applying the debris retaining and drainage engineering measures, the vegetation measures shall be applied to the water residue yards to recover the vegetation at the yards and ensure they are equipped with the water conservation function.

The waste residue yards are the place where the water and soil erosion is easy to happen, therefore, the selection of tree species should comply with the following main principles:

- a. The trees with the well-developed roots, powerful soil conservation capacity, vigorous growth and rich defoliations can be used to the engineering, furthermore, it shall ensure that the soft leaf litter can be formed easily, propitious to improve the soil properties and the capacity of water and fertilizer retaining of soil.
- b. The grass with strong adaptive capacity, well-developed roots, rapid growth capacity and lush

stems and leaves can be used to the engineering; furthermore, it shall ensure that the grass applied is easy to breed. Based on the actual situation of the engineering, the Manila grass is the best choice, featuring powerful drought resistance capacity.

In accordance with the principle of “Providing suitable trees and grasses to suitable places”, the acacia featuring powerful cold resistance capacity, the thinness resistance and fast growing speed is the suitable trees to the waste residue yards of the project. It is a perennial leguminous sheepberry with powerful adaptable capacity and has the easy-to-breed feature, in fact, it is also the excellent species for improving soil. At the same time, the local perennial grass can be applied to the waste residue yards of the project.

□ Conservation measures design for quarry yard area

The total quarry area of the project is 0.31hm^2 , mainly used for stone exploitation, sand and aggregate processing required by the engineering measures of the dam site. The main measures on the prevention and control of soil and water conservation for the quarry yard are the engineering measures and the vegetation measures.

a. Engineering measures

The engineering measures for the quarry yard include the temporary and concentrated stacking and protection of surface soil and weathered material (The bagged soil is provided around the earth deposits for protection), the water drainage at the upstream side around the excavation openings of the quarry yard to prevent the stones from washing away. The length of the drains is 170m, the cross-section of the drains is $0.4*0.4\text{m}^2$, the wall of the drains is M5 masonry block structure and the bottom of the drains is the C15 concrete structure.

b. Vegetation measures

The water and soil erosion of the surface of the quarry yard is serious due to the damage of the stones to the ground and the attachment. The water conservation here mainly focuses on the vegetation measures, that is, after the material obtaining required by the engineering completes, the clean-up, leveling, earth-up, hole opening, tree planting and grass planting should be made to the excavated surfaces, and the restoration of vegetation should be made to the material yard lands. The green area of the material yard is 0.26hm^2 .

□ Prevention and control measures for the temporary occupied area of the engineering

The temporary occupied area of the engineering is 5.26hm^2 , mainly used for the shed construction

for the construction staff of the construction production and daily life of the engineering, and for the temporary stacking of engineering materials and machines & equipment, etc.

a. Engineering measures

Among the area of temporary occupation, only the land for sands and stones requires the engineering measures, that is, provide the temporary drains around the material yard to discharge the foreign water around the material yard and prevent the sands and stones from washing away. The cross section of the drains is $0.4 \times 0.4 \text{m}^2$, the wall of the drains is M5 masonry block structure and the bottom of the drains is the C15 concrete structure.

The preliminary plan decides to provide ten temporary sand & stone yards (2 at the dam site of the engineering, 4 at the tunnel engineering, 3 at the pipeline engineering and 1 at the plant engineering). The total length of the drains is planned to be 540m.

b. Vegetation measures

The water and soil erosion of the surface of the quarry yard is serious due to the damage of the stones to the ground and the attachment. The water conservation here mainly focuses on the vegetation measures, that is, after the completion of the engineering, the temporary buildings on the ground should be removed and the construction garbage should be cleaned up, then the earth-up, hole opening, tree planting, grass planting and second ploughing should be made to recover the vegetation and the ecological environment of the land of temporary occupation. The green area of the land of temporary occupation is 1.02hm^2 .

□ Prevention and control measures for the construction roads zone

a. Residue treatment of the construction road zone

In course of construction road building, it should ensure the balance between digging and filling as far as possible, furthermore, the residues are produced inevitably at part sites, which is not allowed to be stacked intensively, therefore, the decentralized treatment on the residues to the suitable places along the roads shall be made, furthermore, the placed rock-fill retaining wall or the bagged stones shall be provided to protect the residues.

b. Vegetation measures design

Because many trees are provided along the roads and the trees are under good condition, this program design is not to plant trees at both sides of roads and only the grass is planned to be plant to the affected areas at both sides of the roads for protection and control.

7.2 Water Environment Measures

7.2.1 Water Quality Protection within Reservoir Area

The water quality management objective of the section from Xujiaping reservoir to Xujiaping outlet is the same with that of Qingjiang River, both of which is Class II. To prevent the eutrophication and deterioration of water quality after the water storage of the reservoir, the following measures shall be taken:

1. Strengthen the waste water treatment of the river. In order to reduce the nutrient substances of the reservoir, the establishment of the township industries and other industries that may pollute the water quality within the reservoir area and the upper reaches is not allowed; the domestic sewage from rural residents shall be discharged to the septic tanks for farmlands or vegetable fields directly after the bio-fermentation, the directly discharge to the river is not allowed.
2. Implement the state measures relevant to returning land for farming to forestry around the reservoir and its upstream region; focus on the water and soil conservation; reduce the sediment amount to the storage and the area source pollution; and strengthen the water and soil erosion treatment at the catchment area of the reservoir to lower the nutrient substances of the soil to the reservoir.
3. Promote the scientific farming and reduce the amount of chemical fertilizer and pesticide to the reservoir. Appropriately increase the utilization proportion of organic fertilizers; promote the application of slow available fertilizers and the control release fertilizer; and improve utilization coefficient of fertilizers.
4. The cleaning of reservoir bottom. To ensure the water quality and prevent the pollution, the cleaning of the reservoir bottom shall be made in accordance with the “Reservoir Bottom Cleaning Method” before the water storage of the reservoir.
5. Reasonably control and adjust the operation of the reservoir. Under the premise of not affecting the water body application function of the reservoir, discharge the high nutrient water to the reservoir during the flood and the level periods as much as possible; accelerate the cycle of water bodies within the reservoir; lower the background concentration and reserves of water bodies of the reservoir; and control the eutrophication of the reservoir.

7.2.2 Water Environment Protective Measures during the Construction Period

(1) Treatment measures on the wastewater from aggregate processing

□ Treatment Size

Based on the engineering analysis, the waste water from aggregate processing during the construction period of the engineering is about $324\text{m}^3/\text{h}$, the suspended solid concentration in the waste water is high, and therefore the precipitation treatment should be made. Due to the features of larger suspended particles of the aggregate processing wastewater and faster sedimentation speed, the sedimentation tanks shall be provided for the wastewater treatment.

□ Treatment process:

The treatment on the aggregate washing wastewater can apply the natural precipitation method, the flocculation precipitation method and the mechanical accelerated precipitation method. And the natural precipitation method is the best on the maintenance and management and operating costs, the flocculation precipitation method and the mechanical accelerated precipitation method are better on effect and area coverage, and the mechanical accelerated precipitation method covers the fewest area and the flocculation precipitation method requires the fewest amount while its requirements on design, construction and management are higher. Because most of the suspended substances are inorganic particles of fast settlement speed, therefore, the flocculation precipitation method is the best one for the wastewater treatment of the aggregate processing system of the project.

In accordance with the water supply design of the engineering during the construction period, the process on the wastewater treatment of the aggregate processing system applied in the engineering is shown in Figure 7-2.

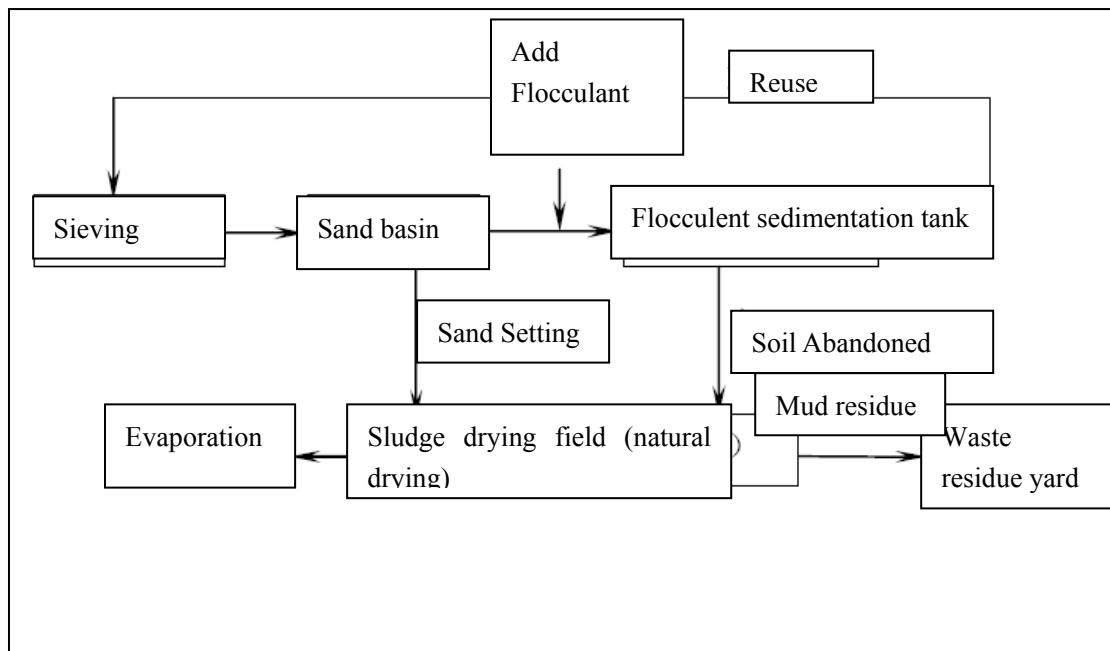


Figure 7-2 Wastewater treatment process of aggregate processing system

The wastewater from sieving and sand producing workshop flows to the sand basin, and after the treatment in the flocculent sedimentation tank, over 98% suspended solids can be removed, and the upper clean liquid can be re-used for production and the wastewater is not discharged to the outside, under normal circumstances, the water is re-used for washing aggregate in the sieving and sand producing workshop. The abandoned soils from the sand basin and the flocculent sedimentation tank are sent to the drying field and finally sent to the waste residue yard after drying. In accordance with the features of Xujiaping Hydropower Project and the construction layout, the natural drying is applied for the treatment of abandoned soil which will be sent to the waste residue yard after drying.

□ Program design

The sizes of the proposed sand basin and the sedimentation tank are as follows: the area of the sand basin is 20m^2 with the size of $10 \times 2 \times 3\text{m}^3$; the area of the sedimentation tank is 150m^2 with the size of $30 \times 5 \times 4\text{m}^3$. The applied flocculant is olyacrylamide (PAM), and the flocculating tank is not the necessary.

The sand basin and the sedimentation tank are located near the aggregate processing system, specifically, at the downstream side of the aggregate processing system. The drying field is located near the wastewater treatment tank, the specific location arrangement is flexible in accordance with the amount of sludge and the existing terrain conditions.

(2) Alkaline wastewater

The alkaline wastewater of the engineering is mainly from the concrete mixing and maintenance. A concrete mixing station is provided to the left bank and the fixed mixing station should be provided with the wastewater collection system, furthermore, because the pH value of the waste water is higher, it needs to add an appropriate amount of acid into the sedimentation tank to adjust the pH value before the precipitation treatment.

The pit wastewater treatment is planned to provide the collecting sump to the pit, the wastewater of the pit with regular discharge has the higher suspended solid content and the higher pH value, of which, the concentration of suspended solids is generally about 2000mg/L and the pH value is around 11 ~ 12. After more than 2 hours' precipitation and the SS concentration below 300mg/L, apply two 6B13A pumps to pump the wastewater to lower the impact of pit wastewater on environment.

Compared with the pit wastewater monitoring results of the hydropower station, we know that after two hours' precipitation, the SS concentration can meet the discharge requirements. In course of precipitation, it needs to add the acid to neutralize, so as to greatly reduce the alkalinity of the water for concrete maintenance.

The amount of flocculants is determined by the test at the construction site, so as to prevent the secondary pollution caused due to too many flocculants. The treatment method features simple structure, low cost and easy management, by the application of the methods, only the regular tank cleaning is required, the water quality monitoring should be made on the yielding water and the precipitation time should be adjusted, the wastewater after meeting the requirements by treatment shall be re-used completely for watering the construction roads, for water and soil conservation and for vegetation measures, etc.

(3) Oily wastewater

The discharge amount of the oily wastewater is about $4.9\text{m}^3/\text{d}$, the wastewater cleaning and collection trenches with simple structures are provided to the machine parking, and in accordance with the terrain, a rectangular treatment tanks should be provided with the size of $4 \times 2.5 \times 1.5\text{m}^3$, after the oily wastewater is collected, add the flocculants and wait for 12 hours for the flocculation precipitation treatment before the discharge. Assign the person in charge of flocculants adding on

the oily wastewater which can be used for washing aggregate after meeting the relevant requirements. See Figure 7-2 for the treatment process. Furthermore, it should enhance the maintenance and management on the transport machinery for construction to reduce the discharge of the oily wastewater and prevent the oil leakage of machines.

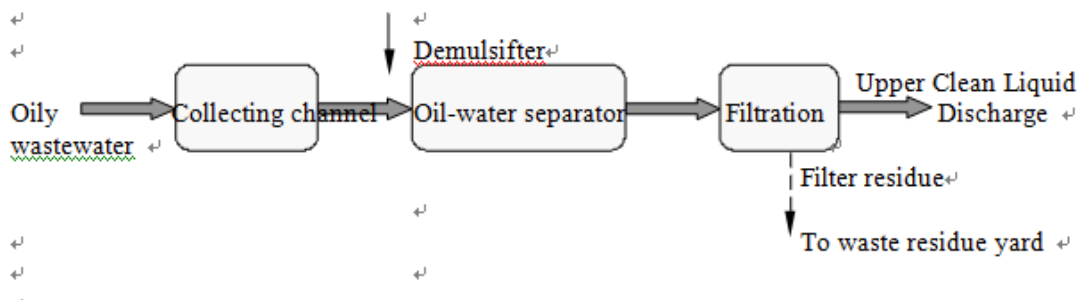


Figure 7-3 Oily Wastewater Treatment Process

(4) Domestic sewage

One construction encampment is provided to the right banks of the dam site of the engineering and one construction encampment is provided to the power station. The peak sewage emission volume of each day is 8.74m^3 during the engineering construction, and the total volume of sewages during the construction period (two years) is $6.4 \times 10^3 \text{m}^3$. The main pollutants of the domestic sewage are BOD_5 and COD with the respective concentration of 200mg/L and 400mg/L .

The domestic sewage produced by the construction personnel should be collected for treatment, the discharge to the river is strictly forbidden. In accordance with the principle of comprehensive utilization of wastes and along with the survey results on the existing hydropower construction sites, 4 simple drying toilets are provided to the two construction encampments for collecting the domestic sewage of construction personnel, the cleaners are responsible for the timely collection in accordance with the utilization to use it for organic fertilizer in agriculture, in course of collection, the environment of the drying toilets shall be strictly controlled, and the overflow and the random placement are strictly prohibited.

7.2.3 Water Environment Protective Measure during the Operating Period

The main wastewater during the operation period of the project is the domestic sewage, and the sewage discharge amount during the operation period is $2.2\text{m}^3/\text{day}$. The main pollutants of the domestic sewage are BOD_5 and COD with the respective concentration of 200mg/L and 400mg/L . Although the pollute emission is smaller, it still belongs to the excessive emission scope without

any treatment, therefore, the sewage treatment facilities should be built in course of engineering construction.

Two simple drying toilets are provided to the two construction encampments for collecting the domestic sewage of construction personnel, the cleaners are responsible for the timely collection in accordance with the utilization to use it for organic fertilizer in agriculture, in course of collection, the environment of the drying toilets shall be strictly controlled, and the overflow and the random placement are strictly prohibited.

7.3. Sound Environment Protection

(1) Noise source control

The construction unit shall use the construction equipment meeting the requirements of relevant state noise standards and give priority to the equipment and technologies of low noise; furthermore, it shall strengthen the equipment maintenance.

The aggregate processing system must be equipped with the rubber mesh, the plastic-steel plate and the damping materials for gravel sieving, so as to lower the noise.

Apply the vibration decreasing base to the equipment with large vibration to lower the noise, or provide the soft materials of elasticity to the place between the equipment foundation and other structures, such as blankets, rubber plate and others to decrease the vibration transmission, thus playing in a role in vibration isolation. The working hours of the comprehensive processing plant should be strictly regulated. And when vehicles pass through the population centre at both banks of the construction zone and the construction encampment at both banks, the horns shall not be used if not necessary, and the reasonable arrangement on the transport time shall be made to avoid the noise of vehicles from affecting the residents near Shadixiang Street.

(2) Labor protection to construction staff

The shift system shall be applied to the concrete mixer operators and the bulldozer drivers and others, and the noise protective equipment should be provided to the above staff, and the equipment of low noise should be given priority to, furthermore, it shall strengthen the equipment maintenance.

In the tender contract, it should clearly describe the labor protection articles on the noise

protection on construction staff, and the contractor should provide the anti-noise earplugs, earmuffs or anti-noise helmets and other anti-noise protective equipment to construction staff affected by the noise.

(3) It shall apply the appropriate explosives and blasting methods to minimize the impact of the instantaneous blasting noise on wildlife. The blasting activities are not allowed on evenings and early mornings.

7.4 Air Protection

The construction unit shall apply the construction machinery and transport with the waste gas emission complying with the relevant state standards and the drilling machine shall be provided with the dust remove device.

It's better to provide the offices and living areas for the construction personnel to the windward direction of the dominant wind direction of the dust operation area and the stoves; as for the construction staff contacting with much dust, the dustproof shall be provided in accordance with relevant state labor protection regulations, such as the dustproof masks.

It should strengthen the monitoring on the effect of the dust removal equipment of the concrete mixing plants, if it fails to meet the requirements, the two-level dust removal equipment should be applied with the first level of cyclone dust removal and the second level of bag dust removal, or other efficient dust removal device can be applied. Besides, it should water the place near the processing systems to reduce the dust pollution.

It should strengthen the management on the large-scale construction machinery and vehicles, furthermore, the machinery and equipment should be provided with the corresponding smoke removal components and the transport vehicles should be provided with the exhaust purifiers. Besides, it needs to implement the regular inspection and maintenance to ensure each environmental index on the construction machinery and vehicles meets the exhaust emission requirements. And only the high-quality and low pollution fuel can be applied.

In course of material handling and transportation such as cement, it should use the storage tanks for sealing transport, and it should ensure the storage tanks are under the well sealed conditions, furthermore, when transport vehicles pass through the residential areas, the speed should be controlled. Besides, it needs to strength the vehicle servicing and maintenance to prevent the

leakage of gasoline and diesel and ensure the smoothness of the inlet system and the outlet system.

The sprinkler should be provided during the construction period with the frequency of three times every day, that is, each one for evening, midday and morning to reduce the dust amount and shorten the affected period of the dust pollution.

7.5 Solid Waste Disposal

7.5.1 Household Garbage Disposal

There are four dustbins provided in the construction staff living zone for collecting the household garbage. The cleaners shall be arranged for the daily garbage cleaning, and the garbage can be buried, however, the anti-seepage measures shall be made before the burying. After the completion of the construction, the sheds should be removed in time, and the cleaning of the household garbage, the simple toilets and the cesspools shall be made, and also the leveling shall be made, furthermore, the carbolic acid and calcium oxide should be applied for disinfection. The dustbins within the construction area should be applied the aminocarb and others to prevent the reproduction of flies and other vectors of infection, so as to reduce the negative impact of the household garbage on the environment and the health of construction workers.

The domestic sewage during the operation period is discharged to the drying toilets for the centralized collection, which can be used as the fertilizer. The cleaner shall be arranged for cleaning the household garbage which can be buried after collection, while the anti-seepage measures shall be taken before burying. Besides, the centralized collection and treatment shall be applied to the waste oil produced by the equipment servicing within the power plant during the operation period, and the random discharge to the reservoir and other places is not allowed.

7.5.2 Disposal of Construction Waste and Production Waste

After the completion of the engineering, the temporary facilities within the construction area should be removed, and as for the construction sites such as the site of concrete mixing systems, the site for parking construction machinery, the site for stone materials and the integrated warehouse should be applied the site cleaning to remove the construction debris and others, furthermore, the carbolic acid and calcium oxide should be applied for disinfection. Besides, the contractor shall arrange the worker to be responsible for the collection of scrap iron, scrap steel

and other production wastes, and the random packing is not allowed.

7.5.3 Disposal of Transport Garbage

In course of building materials transport, the cover shall be applied to the goods of transport to avoid the falling of sands, soils and others, furthermore, the regular cleaning on the trunks roads shall be made.

7.6 Protective Measure on Resettlement Environment

(1) Implement the resettlement plans and policies

Develop the resettlement plans as soon as possible; compensate in accordance with the land occupation standard, which should be implemented under the monitoring of local governments; and lower the impact on the ecological environment of resettlement areas; in accordance with the physical indicators of the engineering investigation, the resettlement compensation agreement shall be entered into to reduce the loss of the people involved into the resettlement due to the construction of the engineering; implement the resettlement plans and ensure the quality of life of people is the same with or is higher than that before.

(2) Environmental Protection in the Resettlement Area

Before moving to the new place, people should made the cleaning first, such as the removal of construction waste, weeds and wastewater around the house, and the leveling of waste sumps, furthermore, the lining for drains shall be made, the household garbage shall be placed to the fixed points to reduce the habitats of mosquitoes and flies. Besides, the eradication of rats at the new place shall be made to cut down the channels of natural focal infectious diseases and insect-borne infectious diseases.

It shall control the surface source pollution and protect the water environment. In course of transformation of low-yield fields, it should strictly control the application of fertilizers and organo-phosphorus pesticide, and promote the application of organic manure to prevent the residues of chemical fertilizers and pesticides from flowing into the river along with the surface flow.

(3) Improve the living conditions and the quality of life

People of resettlement shall plant the citrus, tea, sasanqua and fast-growing tree species around the new houses and nearby open areas, raise pigs and chickens with the manures to the methane tank which can be the energy for life and can improve the energy structure of the resettlement project, the local government must guide people of resettlement to development the ecological agriculture with the core of methane, taking the roads of "Pig - methane - farmers," "Pig - methane - fruit," or "Pig - methane - vegetables" and other efficient eco-agriculture ways, implement the eco-home construction strategy of main content of "One tank drives three reforms" (namely, building the methane tank, reform the kitchen, the toilet and the animal yard); reduce the deforestation; protect the ecological environment of people of resettlement; improve the quality of life; increase their income and improve the environment condition of the engineering area; form civilized way of life and improve the health level.

7.7 Population Health Protection

7.7.1 Population Health Protection during the Construction Area

(1) Hygiene cleaning

Before the construction personnel enters the construction site, the site hygiene cleaning and disinfection should be made first. The rat destruction, mosquito destruction and fly destruction within the construction area should be made once of each quarter, and more attention should be paid to the rat destruction, besides, the monitoring management work shall be strengthened to reduce the vector of infection.

(2) Hygiene Supervision and Management

More attention shall be paid to the drinking water hygiene during the construction period. The water from the river can only be drunk after the disinfection treatment and meeting the requirements of the hygiene standard on drinking water, and the groundwater can only be used for life after the disinfection. Besides, the regular monitoring on the source water and the drinking water shall be made in accordance with relevant regulation, and the water quality of the water supplied shall be in line with the regulations of "Standards for Drinking Water Quality" (GB5749-85) to prevent the water-borne infection.

The regular food hygiene inspection and supervision on the catering enterprises of the

construction area shall be made, and the staff engaged in catering must obtain health permits before taking the jobs, and the operators directly contacting with the food must comply with the "health card" system and be able to take effective control measures in case of food poisoning immediately to prevent the expansion of the disease.

(3) Health agency and disease prevention

Each construction unit and the engineering management department must assign the specific staff for the epidemic prevention, who will be responsible for the epidemic prevention within the construction management scope and for the publicity and education on the construction hygiene and health on construction personnel through radio, wall newspaper and brochures and other forms, so as to improve the health awareness of disease prevention of construction staff.

Provide the medical center to the place with more construction staff, where the commonly used drugs should be available, and staff of the medical center should be able to carry out simple treatment and the first aid for the industrial accidents and shall be responsible for the health and epidemic prevention work during the construction period.

Before construction personnel enters the construction zone, the hygiene and quarantine inspection shall be made to prevent the people with communicable diseases from entering the construction zone and prevent the spreading of the diseases. At the same time, it should establish the health files on each construction work; ask construction workers to take preventive medication and accept the immunization and other measures regularly; uphold the epidemic reporting system; implement the random inspections among construction workers and master the dynamic change of all kinds of epidemics.

The health and epidemic prevention and the regular physical examination on construction staff shall be made throughout the engineering work. In accordance with the health information of the staff during the construction period, the population health prevention and physical examination can be carried out in phases. Furthermore, a first-aid station should be provided to the living area to be responsible for treatment of general diseases, the first-aid treatment of industrial accidents and epidemic prevention work.

(4) Hygiene facilities

4 temporary drying toilets are provided to the construction zone with simple brick-wall structure

and the asphalt felt or the waterproof cloth at the top, the place should be flat and easy to be cleaned, workers shall be specifically assigned for the disinfection and the regular cleaning and the overflow is strictly forbidden; furthermore, the dustbins should be provided to the construction area, and the garbage shall be disposed regularly and buried, and the anti-seepage measures shall be taken before the burying.

7.7.2 Population Health Protection within Resettlement Area

The health promotion work shall be made within the resettlement areas, and many forms are applicable here, furthermore, it needs to publicize the knowledge on infectious diseases prevention and on prophylactic immunization and improve the level of people of resettlement on health knowledge and awareness of health care.

Implement the targeted environmental sanitation cleaning and disinfection and the immunization on people of resettlement, in accordance with the current disease prevalence within the area, pay more attention to the inspection on the people within the resettlement area regularly and the random inspection scope shall be 20% of the total population of the resettlement area.

7.7.3 Relics Protection Measure

In case of relics is found in the construction, the earthwork excavation should be stopped immediately and the relevant information shall be reported to the local cultural relics department. Before the completion of the relics' identification of the competent authorities and the application of the necessary protective measure, the excavation is not allowed.

7.8 Technical and Economic Analysis on Countermeasures

See Table 7-4 for the technical and economic analysis on the environmental protection measures of Xujiaping Hydropower Project.

Table 7-4 Technical and economic analysis on the environmental protection measures of Xujiaping Hydropower Project

Type		Environmental protection measures	Technical and economic analysis
Water Environment Protective Measures	Water Quality Protection within Reservoir	The water and soil conservation within the reservoir area shall be made in accordance with the relevant state measures applied around the reservoir and the upstream region	By the effective management means, realize the aim of using water resource while protecting the water quality.

	Area	<p>to reduce the sediment amount to the storage and the area source pollution;</p> <p>To ensure the water quality and prevent the pollution, the cleaning of the reservoir bottom shall be made in accordance with the “Reservoir Bottom Cleaning Method” before the water storage of the reservoir.</p>		
Waste water and sewage treatment within the construction area	Wastewater from aggregate processing	Apply the sedimentation tank for treatment, with the upper clean liquid to the clean water box and to be re-used for production completely, the wastewater is not discharged to the outside. The natural drying is applied for the treatment of abandoned soil which will be sent to the waste residue yard after drying.	The method features simple construction and low cost, over 98% suspended solids can be removed after treatment, feasible technologically and economically.	
	Oily wastewater	Collect the oily wastewater; add the demulsifier, realize the aim of separating oil from water after filtration.	The method is feasible economically; the oil content within the oily wastewater after the treatment will be below 5mg/L, which can be re-used for washing aggregate.	
	Alkaline wastewater	Provide the wastewater collection system; add the acid of appropriate amount to adjust the pH value until it is neutral and implement the sedimentation treatment.	The alkaline wastewater is discharged separately and the concentrated treatment by the application of the equipment is hard, and the treatment method features simple structure, low cost and easy management, only the regular tank cleaning is required, feasible technologically and economically.	
	Domestic sewage	Drying toilets are provided to the two construction encampments, the cleaners are responsible for the timely collection, which can be used for organic fertilizer in	The sewage can be used as the organic fertilizer in agriculture, realizing the comprehensive utilization of wastes. The discharge to the outside is allowed under the	

			agriculture, and the discharge to the outside is allowed.	circumstances of timely cleaning and no overflow.
Ecological Protection and Restoration Measures	Ecological Management	Ecological Management Ordinance on Project Area	Based on the national and local relevant laws, regulations, ordinances, technical specifications and standards, develop the ecological protection code for construction staff during the construction period and the reservoir workers during the operation period; avoid participating into the activities detrimental to the local ecological environment; and take good care of forests, grasslands and animals.	Standardize the construction activities with scientific and strict rules and regulation to ensure the ecological management of the construction period is made in accordance with rules.
		Ecological Protection and Management	Soil and Water Conservation Supervision and Management: organize and implement ecological restoration measures of the soil and water conservation program of the engineering; and inspect and supervise the implementation effect of the above measures. Ecological Management of Resettlement Areas: improve the natural environment of resettlement areas; encourage people within the resettlement areas to plant the fast growing tree species around the new houses and the open areas.	There are no urban water supply systems within the water function planning area. Implement the "three simultaneous" system on water and soil conservation and rationally arrange the water and soil conservation measures. Build the "Four sides" green around the reservoir area; use the feces of humans and animals to develop the clean energy of biogas and improve the quality of life of people involved into the resettlement.

Type	Environmental protection measures		Technical and economic analysis
	Protective Measures on Ecological	Protective measures on terrestrial	Construction workers are not allowed to implement other activities rather than
			Effectively prevent the unreasonable construction manner of the construction

	Environment	animals	the construction activity beyond the construction area; forbid hunting animals; implement the reasonable arrangements on the operation modes and service time on construction machinery, in particular the stone exploration and foundation excavation, apply the bench blasting way to the engineering construction and strictly control the amount of explosives to reduce the harm to animals due to the instantaneous blasting sound.	personnel; strictly control the amount of explosives; reduce the hunting and terrifying to animals to terrestrial animals.
		Protective measures on land plant	The damage to the vegetation other than land acquisition area is not allowed, and protective measures shall be taken to species of state protection or the transplanting shall be applied.	Protect the existing vegetation and control the damage of the construction activities on vegetation and the water and soil erosion in the project area
		Protective measures on aquatic life	After completion of Xujiaping reservoir, the power is generated by the water diversion through the diversion tunnel with the length of 7928m to the powerhouse, resulting in the dry-up section from the downstream of the dam of Xujiaping Hydropower Project to the river section of the powerhouse. The multi-year average flow of the Xujiaping intake work is $1.92\text{m}^3/\text{s}$, and based on 10% of the multi-year average flow of the dam site, the required discharge	Protect water quality of the reservoir and control the eutrophication of water of the reservoir and lower the impact of the engineering on aquatic life.

			of ecological flow is 0.192m ³ /s and the ecological water demand is 5.99×10 ⁶ m ³ .	
	Eco-restoration Measures	Soil and water conservation ecological restoration and compensation	<p>Engineering measures: <input type="checkbox"/> Spray the concrete to the steep rock surface; <input type="checkbox"/> Provide the latticework slope to the soil slope; <input type="checkbox"/> Provide drains to the outside; <input type="checkbox"/> Implement the concrete hardening within the plant; <input type="checkbox"/> Implement the reclamation on the waste residue yard.</p> <p>Plants and reclamation measures: plant shelterbelts at the dam area, of which, plant shelterbelt to the steep slope above the excavation line; implement the plant greening; implement the forest planting after the reclamation of temporary land; plant the production forest in the resettlement area.</p>	Effectively protect the surface cultivated soil occupied by the construction; ensure the effective restoration of vegetation at the waste residue yard. At the same time, effectively prevent the new water and soil erosion within the resettlement areas.
Sound Environment Protection	Noise control	<p>(1) The construction unit shall use the construction equipment meeting the requirements of relevant state noise standards and give priority to the equipment and technologies of low noise; furthermore, it shall strengthen the equipment maintenance. It should apply the vibration decreasing base to the equipment with large vibration to lower the noise and The working hours of the comprehensive processing plant should be strictly regulated.</p> <p>(2) The contractor should provide the anti-noise earplugs, earmuffs or anti-noise helmets and other anti-noise protective equipment to construction staff affected by the noise.</p>	Effectively reduce the intensity of construction noise and block the channel for noise transmission. These measures and equipment feature low investment, easy installation and operation and great effect, feasible technologically.	

		(3) It shall apply the appropriate explosives and blasting methods to minimize the impact of the instantaneous blasting noise on wildlife. The blasting activities are not allowed on evenings and early mornings.	
Air Protection	Exhaust Control measures	<p>(1) The drilling machine shall be provided with the dust remove device;</p> <p>(2) The dustproof shall be provided to construction workers;</p> <p>(3) When dust removal equipment of the concrete mixing plants fails to meet the requirements, other dust removal equipment should be provided; it should water the place near the processing systems to reduce the dust pollution.</p> <p>(4) The machinery and equipment should be provided with the corresponding smoke removal components and the transport vehicles should be provided with the exhaust purifiers.</p> <p>(5) In course of material handling and transportation such as cement, it should use the storage tanks for sealing transport;</p> <p>(6) The sprinkler should be applied to both sides of the construction roads to reduce the dust.</p>	These measures can control pollution emissions, but also protected the affected targets, and they are easy to operate, feasible technologically and economically.
Solid Waste Disposal	Household Garbage Disposal	<p>Dustbins are provided to the construction staff living zone for collecting the household garbage, which should be buried nearby.</p> <p>After the completion of the construction, the cleaning of the household garbage, the simple toilets and the cesspools shall be made, and the leveling shall be made, furthermore, the carbolic acid and calcium oxide should be applied for disinfection.</p> <p>The dustbins within the construction area should be applied the aminocarb and others to prevent the reproduction of flies and other vectors of infection, so as to reduce the negative impact of the household garbage on the environment.</p> <p>The domestic sewage during the operation</p>	After the implementation of the measures, it can effectively prevent the random discharge of household garbage and waste production materials, conducive to maintaining the environmental hygiene, preventing the diseases and protect the population health.

		<p>period is discharged to the drying toilets for the centralized collection, which can be used as the fertilizer. The cleaner shall be arranged for cleaning the household garbage which can be buried at Changyang County Waste Landfill Site after collection. Besides, the centralized collection and treatment shall be applied to the waste oil produced by the equipment servicing within the power plant, and the random discharge to the reservoir and other places are not allowed.</p>	
	Disposal of Construction Waste and Production Waste	<p>The production waste shall be placed at the designed place, and the random placement is not allowed. After the completion of the engineering, the temporary facilities within the construction area should be removed, the construction sites should be applied the site cleaning to remove the construction debris and others, furthermore, the construction site recovery shall be made.</p>	
	Disposal of Transport Garbage	<p>In course of building materials transport, the cover shall be applied to the goods of transport to avoid the falling of sands, soils and others, furthermore, the regular cleaning on the trunks roads shall be made.</p>	
Environmental Protection for Resettlement	Implement the resettlement plans and policies	<p>Develop the resettlement plans; compensate in accordance with the land occupation standard, which should be implemented under the monitoring of local governments; and lower the impact on the ecological environment of resettlement areas; in accordance with the physical indicators of the engineering investigation, the resettlement compensation agreement shall be entered into.</p>	<p>Reduce the loss of the people involved into the resettlement due to the construction of the engineering; implement the resettlement plans and ensure the quality of life of people is the same with or is higher than that before.</p>
	Environmental Protection in the Resettlement Area	<p>Before the moving to the new place, people should made the cleaning first, such as the removal of construction waste, weeds and wastewater around the house, and the leveling of waste sumps, furthermore, the lining for drains shall be made, the household garbage shall be placed to the fixed points to reduce the habitats of mosquitoes and flies. It should strictly control the application of</p>	<p>Cut down the channels of natural focal infectious diseases and insect-borne infectious diseases to the minimum to ensure the safety of drinking water.</p>

		fertilizers and organo-phosphorus pesticide, and promote the application of organic manure to prevent the residues of chemical fertilizers and pesticides from flowing into the river along with the surface flow.		
	Improve the living conditions and the quality of life	People of resettlement shall plant the citrus, tea, sasanqua and fast-growing tree species around the new houses and nearby open areas, develop the methane for the energy for life to improve the energy structure of the resettlement project, the local government must guide people of resettlement to development the ecological agriculture with the core of methane, taking the roads of "Pig - methane - farmers," "Pig - methane - fruit," or "Pig - methane - vegetables" and other efficient eco-agriculture ways, implement the eco-home construction strategy with the main content of "One tank drives three reforms" (namely, building the methane tank, reform the kitchen, the toilet and the animal yard).		Protect the ecological environment of people of resettlement; improve the quality of life; increase their income and improve the environment condition of the engineering area; from civilized way of life and improve the health level.
Population Health Protection	Health Protection during the Construction Area	Hygiene cleaning	Before the construction personnel enters the construction site, the site hygiene cleaning and disinfection should be made first. The rat destruction, mosquito destruction and fly destruction within the construction area should be made.	Reduce the cause of disease and the vector of infection and prevent the spreading of diseases, feasible economically.
		Hygiene Supervision and Management	More attention shall be paid to the drinking water hygiene, disinfection and management, the regular monitoring shall be made and the food hygiene shall be focused.	Prevent the water-borne infection, the food poisoning and intestinal communicable disease
		Health agency and disease prevention	Define the staff responsible for the epidemic prevention and the publicity and education	Technologically, it can prevent the people with communicable diseases from entering the

		<p>on the construction hygiene; provide the medical center, where the commonly used drugs should be available, and staff of the medical center should be able to carry out simple treatment and the first aid for the industrial accidents; carry out the epidemic prevention during the construction period and take the preventive medication and the immunization and other measures; and carry out the regular physical examination on construction staff.</p>	<p>construction zone and prevent the spreading of the diseases; Master the dynamic change of all kinds of epidemics and protect the health of construction staff.</p>	
		<p>Hygiene facilities</p>	<p>Drying toilets are provided to the construction zone, workers shall be specifically assigned for the disinfection and the regular cleaning, and the sewage should be collected for fertilizer.</p>	<p>By applying the temporary hygiene facilities to the construction zone, build good environmental hygiene and avoid the spreading the diseases.</p>
	<p>Population Health Protection within Resettlement Area</p>	<p>The health promotion work shall be made within the resettlement areas, and many forms are applicable here, furthermore, it needs to publicize the knowledge on infectious diseases prevention and on prophylactic immunization and improve the level of people of resettlement on health knowledge and awareness of health care. Implement the targeted environmental sanitation cleaning and disinfection and the immunization on people of resettlement, in accordance with the current disease prevalence within the area, pay more attention to the inspection on the people within the resettlement area regularly and the random inspection scope shall be 20% of the</p>	<p>Immediately master the information on the change of the population health within the resettlement area; after applying the relevant measures, the energy structure for the people of resettlement area can be improved and the quality of their life can be improved and their income will be increased, and the way of life shall be civilized and the health level shall be improved.</p>	

		total population of the resettlement area.	
Relics Protection Measure	Construction area and resettlement area, etc.	In case of relics is found in the construction, the earthwork excavation should be stopped immediately and the relevant information shall be reported to the local cultural relics department. Before the completion of the relics' identification of the competent authorities and the application of the necessary protective measure, the excavation is not allowed.	Effectively and immediately the unknown relics

8. Environment Monitoring and Environment Management Plan

8.1 Environment Monitoring

8.1.1 Monitoring Purpose

To ensure the environmental protection work of the engineering, verify the evaluation and prediction results of the environmental impact, prevent the sudden incidents from harming the environment and provide the scientific basis for the environment pollution control and the environment management during the engineering construction period and the operation period and for the environmental protection of the cascade development of the river, it is necessary to implement the environment monitoring and master the information on the change of ecological environment during the engineering construction period and the operation period.

8.1.2 Principle on the Monitoring Point Layout

(1) Principle of closely integrated with the engineering construction

The scope, object and key on the monitoring work shall be combined with the characteristics of the engineering construction and operation to fully reflect the change of surrounding environment during the engineering construction and operation processes and reflect the impact of the environmental changes on the construction and operation.

(2) Principles of pertinency

Based on the engineering characteristics, environmental status and environmental impact prediction results, the monitoring shall be made on the main factors that play a control and significant role in the environmental impact on the area or the river, and it shall reasonably select the monitoring points and the monitoring items to ensure the monitoring program is targeted and representative.

(3) Economic and operational principles

In accordance with the relevant professional and technical norms, the monitoring item, frequency, period of time and method shall be fixed on the premise of completing the main tasks required by

the monitoring system; furthermore, it needs to make full use of results of the monitoring organizations and to ensure the operable features of the setup of new sites, so as to obtain the more complete environment monitoring data with the minimum input.

8.1.3 Environment Monitoring during the Construction Period

8.1.3.1 Construction wastewater (sewage) monitoring

(1) Layout of monitoring points

On the premise of meeting the requirements of the technical specifications on environment monitoring, set the monitoring points at the main production wastewater and domestic sewage outfalls. Based on the construction organization design information and the construction process, the monitoring objects on the production wastewater are determined as follows: gravel & aggregate production wastewater, wastewater from concrete mixing system and pit wastewater, and the domestic wastewater monitoring points are mainly located at the construction encampments.

(2) Technical requirements of monitoring

The water sample collection and analysis shall be made in accordance with the requirements of “Technical Specifications Requirements for Monitoring of Surface Water and Waste Water” HJ/T91-2002 and “Technical Requirements for Monitoring of Total Amount of Pollutants in Waste Water” HJ/92-2002.

Confirm the monitoring items, the monitoring cycle, the monitoring period of time and the monitoring frequency, shown in Table 8-1, which is fixed in accordance with the different characteristics of construction waste water.

Table 8-1 Construction wastewater (sewage) monitoring technical requirements

Object	Monitoring Location	Monitoring Parameters	Monitoring Frequency and Time	Remark
Pit wastewater	Pit Outfall	SS, wastewater flow, emission frequency	Twice during the pit wastewater discharge period	The first dry season and the second dry season at the pit excavation period of time

Gravel & aggregate production wastewater	Outfall of gravel and aggregate processing plant	SS, wastewater flow, emission frequency	Once for the peak period of construction	The first and the second years of the construction
Wastewater from concrete mixing system	Outfall of the mixing system	pH value, SS, wastewater flow, emission frequency	During the period of the concrete mixing wastewater discharge, annually at the construction peak period of time	The first and the second years of the construction
domestic Sewage	Outfall of domestic sewage	DO, COD _{cr} , BOD ₅ , total bacteria, fecal coliform, sewage flow	annually at the construction peak period of time	The first and the second years of the construction

8.1.3.2 Water Quality Monitoring on Rivers within the Construction Zone

(1) Monitoring point layout

To reflect the water environment quality from and to Yaozhan River and master the impact on the water quality of the river due to the engineering construction, each water quality monitoring section shall be provided to the upper reaches and the lower reaches of the river within the construction area. See Table 8-2 for the specific location.

(2) Technical requirements of monitoring

The monitoring on the water sample collection and analysis shall be made in accordance with the methods of GB3838-2002 "Environmental Quality Standards for Surface Water", see Table 8-2 for the monitoring items, the monitoring cycle, the monitoring period of time and the monitoring frequency.

Table 8-2 River water quality monitoring technical requirements

Cross Section	Monitoring Parameters	Monitoring Frequency and Time	Remark
Upstream of Yaozhan River Dam Site (300m away from the dam site)	DO, pH value, SS, permanganate index, BOD ₅ , oil, total bacteria, fecal coliform	Annually at the peak period of time during the construction and monthly during normal operation	Timely monitoring data analysis and timely treatment of problems found

About 1km at the downstream of the dam site		period	
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8.1.3.3 Sound Environment Monitoring of the Construction Zone

(1) Monitoring point layout

To monitor the impact of the engineering construction on the sound environment of the environmentally sensitive points, and in accordance with requirements of "Technical Specification for Environmental monitoring", the sound environment monitoring points are set up at the resident center near the dam site for the sound environment monitoring.

(2) Technical requirements of monitoring

The monitoring shall be made in accordance with the requirements of "Technical Specification for Environmental monitoring". See Table 8-3 for the monitoring items, the monitoring cycle, the monitoring period of time and the monitoring frequency.

Table 8-3 Noise monitoring technical requirements of the construction zone

Object	Monitoring Location	Monitoring Parameters	Monitoring Frequency and Time	Remark
Sensitive zone	Resident Points of the Powerhouse	Environmental noise	Annually during the construction period with each of two day, one for daytime and one for nighttime	Peak period of the construction

8.1.3.4 Population Health Monitoring

The local health and epidemic prevention department shall be responsible for the health monitoring on the construction staff in accordance with the relevant requirements of Ministry of Health (10% 10% ratio). Implement the statistics on the pollution diseases and the natural foci diseases quarterly. Uphold the epidemic reporting system, if any communicable diseases are found, timely reporting shall be made and the immediate measures shall be taken to control the development of diseases.

8.1.4 Environment Monitoring during the Operation Period

8.1.4.1 Water Quality Monitoring

See section 8.1.3.2 for the monitoring point layout and technical requirements.

8.1.4.2 Population Health Observation

In accordance with the resettlement program in the reservoir area, the census on the population health and the sample survey in the typical zone within the reservoir area and the resettlement areas shall be made.

8.1.4.3 Ecological Environment Monitoring

(1) Investigation on cross-section layout

To master the impact on ecology after the completion of engineering and to verify the results of prediction, it is planned to implement the terrestrial biological resources survey around the reservoir and the main construction area; to implement the living aquatic resources investigation and monitoring within the reservoir area and the downstream section, here the aquatic organisms sampling is made at two cross sections, 200m in the upper reaches of the reservoir and about 1km at the downstream of the dam site, furthermore, the monitoring deposition at the cross section of the reservoir area shall be made.

(2) Period of time and frequency

The monitoring shall be made annually before the water storage and once at the third year after the water storage and once at the sixth year, totally three times. The monitoring cycle shall be a year, and the terrestrial biological monitoring period of time shall be from April to June and from August to October of each year and the aquatic organism monitoring period of time shall be August, July and December of each year.

(3) Monitoring method

The biological investigation shall be made in accordance with relevant regulations.

8.1.5 Water and Soil Erosion Monitoring

Xujiaping Hydropower Project is a small development and construction project, the damage to land and vegetation as well as other soil and water conservation facilities during the construction of the hydropower station will cause the water and soil erosion, therefore, while implementing the water and soil conservation measures, the real-time track and monitoring on the water and soil

erosion during the construction of the hydropower station shall be strengthened and the observation on the effect of the water and soil conservation measures after the completion of the project shall be carried out.

(1) Monitoring content

□ Soil and water vector erosion monitoring: the amount of water and soil erosion and the soil erosion modulus and others caused by the channel erosion, surface erosion and landslides due to the excavated surface, waste residue yard and roads, etc.

□ Disastrous monitoring of water and soil erosion: mainly including the impact of the downstream siltation, desertification and economic and social development of the surrounding areas, etc.

□ Monitoring on the effect of soil and water conservation facilities: it mainly including the monitoring of the prevention effect of the soil and water conservation facilities; the extent on the control of the water and soil erosion and the stability of the control engineering and others applied in the program

(2) Monitoring technical methods and main monitoring objects

Apply the fixed-point monitoring method and the used monitoring techniques and methods shall be in line with the SL277-2002 “Technical code of practice on water and soil conservation monitoring” and the main monitoring objects are the waste residue yard, the stone yards and the large excavated surfaces and others during the construction period, therefore, the fixed-point observation, monitoring and investigation shall be made at one point of the waste residue yard, the stone yards and the typical excavated surface.

(3) Monitoring period of time and frequency

The water and soil erosion monitoring of the project shall be made before the commencement of the engineering, during the construction of the engineering and after the completion of the engineering, one for each time. And during the first three years of the operation period, the monitoring shall be made before the flood season and after the season once a year.

(4) Monitoring Implementation

The construction unit should entrust the water and soil conservation monitoring unit with the qualification for the monitoring who shall also be responsible for the development of the

monitoring plan in accordance with the monitoring requirements of the program and for the submission of the monitoring results of the higher administrative department on a regular basis as well as for the submission of the special monitoring reports after the completion of the construction of the soil and water conservation facilities.

8.2 Environmental Supervision during the Construction Period

8.2.1 Supervision Objective

During the construction period, it should, in accordance with the requirements of the environmental protection design, carry out the environmental supervision on the construction period; fully supervise and inspect the implementation and effect of the environmental protection measures applied by each construction unit; and immediately handle and settle the sudden environmental pollution incidents.

8.2.2 Supervision Content

By complying with the principles, policies, decrees and regulations of environmental protection made by national and local government, supervise the contractors to implement the environmental protection contents contracted with the construction units. And the main responsibilities are as follows:

- (1) Develop the environment supervision plan and plan the environmental supervision project and content;
- (2) Supervise the engineering contractors to prevent or lower the environmental pollution or the damage to vegetation and wildlife and the forest fires due to the engineering construction;
- (3) Carry out the overall supervision and inspection on the implementation and actual effect of the environmental protection measures applied by each construction unit; and immediately handle and settle the sudden environmental pollution incidents.
- (4) Implement the comprehensive inspection on the cleaning and recovery of the waste residue yards and the construction site applied by the construction unit, mainly including the slope stability, land restoration and greening as well as the greening rate, etc.;
- (5) Supervise the implementation of the environment monitoring; examine relevant environmental statements; and in accordance with the monitoring results on the water quality, air, noise and other

factors, put forward relevant requirements on the engineering construction and management to minimize the adverse environmental impact due to the engineering construction.

(6) Implement the supervision records and reports in the daily work; and participate the completion acceptance.

8.2.3 Environmental Supervision Agency

The environmental supervision agency shall be fixed by the engineering owner among the units with the corresponding qualification in course of tender invitation.

8.3 Environment Management Plan

8.3.1 Objective

Ensure the smooth implementation of environmental protection measures relevant to the engineering; control and weaken the adverse effects of the engineering construction on the environment; protect the ecological environment of the evaluation area to ensure the benign development of the ecosystem of the engineering area.

8.3.2 Tasks

8.3.2.1 Environment Management during the Construction Period

(1) Environment Management Tasks of the Owner

The owner shall be responsible for the environmental protection management from the commencement of the construction to the completion of the construction, and the main contents are as follows:

- a) Develop the environment protection implementation planning and the management methods for the construction period;
- b) Be responsible for the development and review on the environmental protection articles of the tender documents and the project contracts;
- c) Develop the annual plans for environmental protection work;
- d) Be responsible for the audit and arrangements on the cost for the annual environmental protection work;
- e) Supervise the contractor's implementation of environmental protection measures;

- f) Supervise the implementation of environmental protection measures during the resettlement;
- g) Ensure the contact between the environmental protection unit and other relevant departments;
- h) Handle the environmental pollution accidents and pollution disputes of the engineering and immediately report to the relevant department in charge of the situation;
- i) Develop the annual environmental report and submit the monthly, quarterly and annually statements;
- j) Organize the environmental protection propaganda, education and training.

(2) Environment Management Tasks of Contractors

The contractor shall be responsible for the environmental protection work of the enterprises and the construction & production activities, and the main contents are as follows:

- a) Develop the annual environmental protection work plan;
- b) Inspect the construction progress, quality, operation and inspection of the environmental protection facilities and handle the relevant issues during the implementation;
- c) Audit the use of annual environmental protection funds;
- d) Report the implementation of environmental protection of the contracts.

8.3.2.2 Environmental Protection and Management during Operation Period

During the operation period, the environmental protection work of the engineering management unit includes the following main contents:

- (1) Implement the national and local laws, regulations and guidelines and policies on environmental protection;
- (2) Implement the environmental protection measures during the engineering operation period;
- (3) Be responsible for the implementation of environment monitoring during the operation period and the statistical analysis on the results;
- (4) Supervise the impact of the surrounding environment change on engineering; report the information to the relevant departments and urge the settlement of the problems.

In addition, the local environmental protection administrative departments should strengthen the supervision and management of environmental protection, especially the supervision and management under the circumstances of guaranteed ecological basic flow.

Table 8-4 Acceptance Examination of the Environment (Construction Period)

Type		Protective measures	Implementation Agency	Supervision Agency
Water Environment Protective Measures	Water Quality within Reservoir Area	Do well in the water and soil conservation in the reservation are, and the cleaning of the reservoir bottom shall be made in accordance with the requirements “Reservoir Bottom Cleaning Method” before the water storage of the reservoir.	Yichang Changfeng Hydropower Development Co., Ltd.	Changyang Environment Protection Bureau
	Wastewater from aggregate processing	Apply the flocculent sedimentation tank for treatment,		
	Pit wastewater	Add acid for the regulation and precipitation treatment		
	Oily wastewater	Add the demulsifier and then filter, and then separate the oil and water		
	Domestic sewage	Apply the septic tank for nitrification and sterilization and use for organic fertilizer after the collection		
Sound Environment		See 7.3 for details	Yichang Changfeng Hydropower Development Co., Ltd.	Changyang Environment Protection Bureau
Air Protection		See 7.4 for details		
Solid Waste	Household Garbage	Collect by dustbins and apply the burying method	Yichang Changfeng Hydropower Development Co., Ltd.	Changyang Environment Protection Bureau
	Construction Waste and Production Waste	Carry out site cleaning and disinfection and implement the site recovery. Collect the production waste and forbid the random stacking.		

	Transport Garbage		Put covers to the goods for transport and implement the regular cleaning on roads		
Ecological Protection and Restoration Measures	Ecological Management	Ecological Management Ordinance on Project Area	Based on the national and local relevant laws, regulations, ordinances, technical specifications and standards, develop the ecological protection code for construction staff during the construction period and the reservoir workers during the operation period;	Yichang Changfeng Hydropower Development Co., Ltd.	Changyang Environment Protection Bureau
		Ecological Protection and Management	Soil and Water Conservation Supervision and Management: organize and implement ecological restoration measures of the soil and water conservation program of the engineering; Ecological Management of Resettlement Areas: improve the natural environment of resettlement areas; encourage people within the resettlement areas to plant the fast growing tree species around the new houses and the open areas.		

	Protective Measures on Ecological Environment	Terrestrial animals	Forbid hunting animals; implement the reasonable arrangements on the operation modes and service time on	Yichang Changfeng Hydropower Development Co., Ltd.	Changyang Environment Protection Bureau
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			<p>construction machinery, strictly control explosive quantity in a sound to reduce the harm to animals due to the instantaneous blasting sound.</p>		
		Land plant	<p>The damage to the vegetation other than land acquisition area is not allowed, and protective measures shall be taken to species of state protection or the transplanting shall be applied.</p>		
	Eco-restoration Measures	Soil and water conservation ecological restoration and compensation	<p>Engineering measures: <input type="checkbox"/> Spray the concrete to the steep rock surface; <input type="checkbox"/> Provide the latticework slope to the soil slope; <input type="checkbox"/> Provide drains to the outside; <input type="checkbox"/> Implement the concrete hardening within the plant; <input type="checkbox"/> Implement the reclamation on the waste residue yard. Plants and reclamation measures: plant shelterbelts at the dam area, of which, plant shelterbelt to the steep slope above the excavation line; implement the plant greening; implement the forest planting after the reclamation of temporary land; plant the production forest in the resettlement area.</p>	Yichang Changfeng Hydropower Development Co., Ltd.	Changyang Environment Protection Bureau
Environmental	Implement the resettlement plans		Develop and implement	Yichang	Changyang

Protection for Resettlement	and policies		the resettlement plans; compensate in accordance with relevant standards and ensure the quality of life of people is the same with or is higher than that before.	Changfeng Hydropower Development Co., Ltd.	Environment Protection Bureau
	Environmental Protection in the Resettlement Area		Before the moving to the new place, people should made the cleaning first; Implement the rat destruction; Cut down the channels of natural focal infectious diseases and insect-borne infectious diseases; and control the surface source pollution and protect the water environment.	Yichang Changfeng Hydropower Development Co., Ltd.	Changyang Environment Protection Bureau
	Improve the living conditions and the quality of life		The local government must guide people of resettlement to development the ecological agriculture with the core of methane, implement the eco-home construction strategy with the main content of “One tank drives three reforms” and construct the eco-home.	Yichang Changfeng Hydropower Development Co., Ltd.	Changyang Environment Protection Bureau
	Health Protection during the Construction Area	Hygiene cleaning	Before the construction personnel enters the construction site, the site hygiene cleaning and disinfection should be made first. The rat destruction, mosquito destruction and fly destruction within the	Yichang Changfeng Hydropower Development Co., Ltd.	Changyang Environment Protection Bureau

			construction area should be made.		
		Hygiene Supervision and Management	More attention shall be paid to the drinking water hygiene, disinfection and management, the regular monitoring shall be made and the food hygiene shall be focused.		
Population Health Protection		Health agency and disease prevention	Define the staff responsible for the epidemic prevention and the publicity and education on the construction hygiene; provide the medical center, where the commonly used drugs should be available, and staff of the medical center should be able to carry out simple treatment and the first aid for the industrial accidents; carry out the epidemic prevention during the construction period and take the preventive medication and the immunization and other measures; and carry out the regular physical examination on construction staff.		
		Hygiene facilities	Drying toilets are provided to the construction zone, workers shall be specifically assigned for the disinfection and the regular cleaning, and the sewage should be		

		collected for fertilizer.		
	Population Health Protection within Resettlement Area	<p>The health promotion work shall be made within the resettlement areas, and many forms are applicable here, furthermore, it needs to publicize the knowledge on infectious diseases prevention and on prophylactic immunization and improve the level of people of resettlement on health knowledge and awareness of health care.</p> <p>Implement the targeted environmental sanitation cleaning and disinfection and the immunization on people of resettlement, in accordance with the current disease prevalence within the area, pay more attention to the inspection on the people within the resettlement area regularly and the random inspection scope shall be 20% of the total population of the resettlement area.</p>	Yichang Changfeng Hydropower Development Co., Ltd.	Changyang Environment Protection Bureau
Relics Protection Measure	Construction area and resettlement area, etc.	In case of relics is found in the construction, the earthwork excavation should be stopped immediately and the relevant information shall be reported to the local cultural relics	Yichang Changfeng Hydropower Development Co., Ltd.	Bureau of Cultural Relics of Yichang City

		department. Before the completion of the relics' identification of the competent authorities and the application of the necessary protective measure, the excavation is not allowed.		
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Table 8-5 Environment Protection and Management Plans (Operation Period)

Item		Protective Measure	Implementation Agency	Agency in charge
Water Environment Protection	Reservoir Water Quality	Prohibit new sources of pollution and the tourism, farming and other development activities in the reservoir area.	Yichang Changfeng Hydropower Development Co., Ltd.	Changyang Environment Protection Bureau
	Water-reduction Section			
Ecological Environment Protection		1. Take effective measures to protect the existing woodland recover the vegetation around the construction site after the completion of the construction; 2. Forbid the construction of any a structures within the reservoir area and to both banks of the river; 3. Discharge 0.19m ³ /s ecological flow and ensure the ecological environment of the water-reduction section, by the application of providing the steel pipes to the bottom of the overflow dam and providing the flat gat to the inlet for control.	Yichang Changfeng Hydropower Development Co., Ltd.	Changyang Environment Protection Bureau
Sound Environment and Soil Wastes		1. Provide the dustbin and the solid waste collection system; 2. Specifically assign staff for the disposal of the solid waste at the dam site and around the power plant, aim at removing the waste produced every day.	Yichang Changfeng Hydropower Development Co., Ltd.	Changyang Environment Protection Bureau
Environment Monitoring		Develop the monitoring plan and implement in accordance with the relevant state standards	Local Monitoring Station	Changyang Environment Protection Bureau

Table 8-5 Engineering Environment Protection and Management Agency and Responsibilities

Stage		Organization Agency	Supervision Agency	Working Responsibility
Feasibility study stage	Feasibility study report	Zhanghe Civil Engineering Design Institute of Hubei Province	Hubei Environment Protection Bureau, Yichang Environment Protection Bureau, Changyang Environment Protection Bureau	Project environmental and economic feasibility study
	Environmental impact report	Wuhan Institute of Environmental Medicine, Tongji Medical College, Huazhong University of Science and Technology	Hubei Environment Protection Bureau, Yichang Environment Protection Bureau, Changyang Environment Protection Bureau	Fix the environmental impact; prove the feasibility of engineering construction environmentally and put forward environmental protection measures
Construction Period	Environmental elements protection measures and soil and water conservation measures	Construction Unit	Hubei Environment Protection Bureau, Yichang Environment Protection Bureau, Changyang Environment Protection Bureau	Implement the construction in accordance with the environmental protection measures of the project to ensure the implementation of the environmental protection measures and ensure the realization of the "three simultaneous" system
	Environmental Supervision	Owner, supervision unit with qualification	Hubei Environment Protection	Supervise the implementation of the environmental protection

			Bureau, Yichang Environment Protection Bureau, Changyang Environment Protection Bureau	measures and ecological protection projects; report the implementation, the existing problems and the improvement of the environmental measures
	Environmental Monitoring	Changyang Environment Monitoring Station	Changyang Environment Protection Bureau	Complete the environmental monitoring tasks in the construction period
	Environmental acceptance	Owner, environment protection acceptance unit	Hubei Environment Protection Bureau, Yichang Environment Protection Bureau, Changyang Environment Protection Bureau	Inspect the implementation of the environmental protection measures
Operation Period	Daily Management of Environmental Protection	Owner	Hubei Environment Protection Bureau, Yichang Environment Protection Bureau, Changyang Environment Protection Bureau	Ensure the normal running of environmental protection facilities and the concentration of pollutant emissions meets the local environmental requirements
	Environmental Monitoring	Changyang Environment Monitoring Station	Changyang Environment Protection Bureau	Complete the environmental monitoring tasks proposed in the environment assessment report

8.3.3 Environment Management Agency

8.3.3.1 Agency Organization

According to the relevant provisions of (87) GHZ NO.2 "Stipulation for environment protection design of construction projects" and "Environmental Protection Management Method of Electric Power Industry" (Ministry of Electric Power Industry, 1996 NO.9), the engineering should be provided with the environment management agency to complete the environment management tasks required during the engineering construction period and the operation period. Based on the environment characteristics of the engineering, it is recommended to suggest the engineering management agency to set up the environmental protection office.

8.3.3.2 Staffing

In accordance with the environment management tasks of the engineering, the environmental protection office during the engineering construction period and the operation period should be consisting of a director (full-time) and several part-time workers engaged into the health and epidemic prevention, environment monitoring, water and soil conservation, and biology and others. Under the guidance of local environmental protection department, the staff with the office shall have close cooperative relations with the engineering construction unit and the supervision unit to ensure the smooth implementation of environmental protection required by the engineering.

9. Environmental Risk Analysis

The analysis on dam safety is made based on geological conditions, reservoir leakage, stability of reservoir bank and design & construction of the dam and others relevant to the engineering; the analysis and evaluation on the environmental risks under the accident circumstances (flood risk, risk of dam-break and stability of reservoir banks) are made; and the corresponding supervision, prevention and emergency measures are put forward, especially the emergency mechanisms for the environmental impact under the dam-break condition.

9.1 Construction Period Risk Analysis

9.1.1 Construction Risk

Xujiaping Hydropower Project is consisting of the dam, the diversion tunnel, the pressure pipeline, the plant and booster station, and on-grid lines and others. In course of engineering implementation, the main risks are the stone blasting at the stone yard, the stone transport and the tunnel excavation.

Because the open-air stone blasting is applied for the stone collection, the gravel splashing is inevitable. To avoid the damage to the construction staff and the passers-by, the following measures are mainly taken: regulate the blasting time, the evening or the morning is the best choice; provide the safety warning signs to the exit and entrance of the material yard with the clear information of the blasting engineering and the blasting time; provide the helmets to construction staff; implement the training on security and prevention knowledge before the construction; and provide the anti-inflammatory and analgesic drugs and others to construction staff.

The engineering construction is mainly made at the river beach and the mountain slopes, where the rolling of stones and other materials in course of handling or piling up is inevitable, resulting in the damage to the construction staff at the lower part, therefore, it should enhance the security awareness of construction staff and provide the helmets, gloves and other safety facilities to them; furthermore, the construction of medical facilities shall be provided to the engineering area, where should be equipped with the conventional medicines, so that, in case of casualties, the nursing work can be made immediately, thus creating a secure operating environment for construction

staff.

The hidden tunnel failure may happen in course of diversion tunnel excavation, in order to prevent the unnecessary damage to tunnel construction staff, it should not only provide the safety helmets to them and the safety precaution guidance, but also enhance the lighting facilities in the tunnels and provide the oxygen supply equipment to the medial center within the engineering area. In the event of collapse, staff should immediately remove, and if any one is trapped and involved into other dangers, the timely rescue shall be made as soon as possible under the unified command, so as to prevent greater loss due to the poor implementation.

9.1.2 Other Risk

The other risk of Xujiaping Hydropower Project during the construction period is the one from the transportation and the storage of explosives and fuels. Due to the explosive and inflammable features of fuels and explosives, the environmental risks in the transport and storage of fuels and explosives are inevitable. Therefore, it shall strictly comply with the relevant regulations on the transport of dangerous goods, and the mixed transport of explosives and detonators should be forbidden. For safety reasons, the explosives warehouse should be located at the valley in the upper reaches, which will not cause serious damage in case of accidents. Besides, the strict management system must be applied to the explosives warehouse, smoking and lighting fires are strictly forbidden in the warehouse, and the lightning protection facilities should be provided to avoid accidents.

9.2 Risk Analysis of Operation Period

9.2.1 Flood Risk Analysis

The cyclonic rain and the frontal rain are the main types within the area; sometimes the typhoon rain may directly or indirectly affect the area. The rainstorm appears in April earliest and most of which ends in October with the rainfall accounting for about 85% of the total. Most rainstorms are in July and August and in the upper reaches of river; in July, the west-wind circulation weakens and the southwest monsoon strengthens, the temperature is higher and the water vapor is abundant, furthermore, the precipitation intensity generally increases; from the end of July to the beginning of August, the subtropical high belt moves to the north and the equatorial belt of convergence also

moves to the north, during the time, the typhoon, the east dispute and other tropical systems can directly or indirectly affect the area, bringing heavy rain or rainstorm; at the middle and the end of August, the subtropical high belt still strengthens and moves to the north, then the area is completely under the control of the subtropical high belt, during the period, the precipitation is less, but there are exceptions, for example, in August 1975, the typhoon came to the area and caused the rainstorm to Huaihe River Basin in Henan, after it backed to Qingjiang River, the rainstorm center was in Duzhenwan Town with the storm rainfall of 545.6mm in 12 hours and 630.4mm in 24 hours, leading to a larger flood.

The flood of the area is mainly caused by the cyclonic rain and the frontal rain, sometimes it may be caused by the typhoon rain, therefore, the flood volume is more than the surrounding areas. Due to the larger gradient of both banks of the river, the convergence time of flows is short, resulting in the sudden rise and sharp drop of the flood, and the single-peak form is the main type, belonging to the peak & fine type, and even the repeated peak flood appears in the area, the peak power and volume of the secondary peak are small and the lasting time is short. The flood duration usually lasts for 1 to 3 days. It is proved that the river here belongs to the mountainous stream type.

The type of the release structure of Xujiaping Hydropower Project is the banked spillway. According to the hydraulic arrangement, the flood discharge capacity of the spillway by application of the gate for control is taken into account in the flood discharge, and the flood conveying volume of the generating units is relatively small, which can be negligible. To enhance the regulation capacity of the reservoir, the spillway is controlled by the gate. Therefore, the construction of Xujiaping hydropower engineering plays a great role in the prevention of the outbreak of mountain torrents.

9.2.2 Dam-Break Risk Analysis

The retaining structure of the reservoir is designed as the RCC gravity dam with the crest length of 110m; the length of the right bank non-overflow gravity dam of 59m; the length of the river bed overflow dam of 12m and the length of the left bank non-overflow gravity dam of 39m. The elevation of the foundation base of the riverbed is 394.00m and the width of the dam foundation is 32 m, the elevation of wave-proof top is 439.58m and the dam height is 45.58m, the normal pool

level is 437.00m and the checked flood control level is 438.57m. The upstream slope of the dam is 1:0.1 and the downstream slope is 1:0.76.

The crest elevation of the overflow dam is 428.40m; the crest applies the open overflow dam surface curve; the maximum head at the crest is 10.17m; and the weir surface head of template design is 7.82m. The bottom side of the weir surface curve is connected with the 1:0.76 slope, a R = 8.0m ogee section is connected with the deflector bucket at the dam toe. The elevation of the deflector bucket is 405.00m and the flip shot angle is 22°.

Since the overflow dam section of the project is short and the checked peak flow is designed as Once for 200 years, the water level before the dam is 438.57m, 10.17m higher than that of the crest of the overflow dam, therefore, the flood discharge gate is provided.

The non-overflow dam crest has the elevation of 438.38m and the width of 5.0m. The wave-proof wall is provided to the upstream side and the railings are provided to the downstream side. The wave-proof wall top has the elevation of 439.58m and the thickness of 0.5m, integrated with the dam. Below the 430.42m elevation, the upstream slope of the dam is 1:0 and the downstream slope is 1:0.76; above the 430.42m elevation, the gradients of both the upstream slope and the downstream slope are 1:0.

The gate pier and the guide wall are provided between the overflow dam and the non-overflow dam. The elevation of the gate pier top is 438.38m and the length is 16m. The guide wall has the height of 3.0m, with the top connecting with the tail of the gate pier and the bottom connecting with the deflector bucket. The gate pier and the guide wall are applied the reinforced concrete structure with the thickness of 1.8m.

In accordance with the relevant information, so far, a large number of reservoirs are provided to each country of the world, and accidents have happened to hundreds of dams, approximately 35% of which comes from the floods and the dam overtopping. The dam type has close relations with the flood risk, and the earth dam can have the dam overtopping and then the dam-break due to the unexpected flood volume and the concrete dam can only have the dam-break accidents generally.

In accordance with the dispatching operation way analysis of the engineering, the flood control during the flood season is made by the dam gate, specifically, when the inflow volume is smaller than the discharge volume, the gate controls and discharges the volume based on the inflow volume and when the inflow volume is larger than the discharge volume, the gate is opened

completely and discharges based on the discharging capacity.

Xujiaping reservoir is the IV Hydro-power Project with the height of 45.58m, the total capacity of 2.1352 million m³. The dam structure is the RCC gravity dam, and the crest overflow and the ski-jump energy dissipation is applied. Based on the grade and dam type of the retaining structure, it can ensure that even when only one flood appears in 500 years (Checked flood standard), the dam overtopping and the dam-break will not happen. Even the flood volume is over the expectation and the dam overtopping or the dam-break appears, the affect on the downstream side will be not too great.

9.2.3 Oil Spill Risk

After the completion of the hydropower engineering, the waste gas, waste water and industrial residue will not be produced basically and the adverse impact on the environment during the operation period is small, but if the oil spill happens, the downstream water will be affected to a certain extent, therefore, the oil spill of the machine units of the power station is one of the environmental risks of the engineering during the operation period.

The oil system of the hydropower station includes the penetrating oil system and the insulation oil system, of which, the former is mainly providing the oil to the thrust bearing of the generator, the upper and lower guide bearings, the guide bearing of the turbine, the speed control system and the butterfly valve oil-pressure device and other devices; and the latter is mainly used for providing the oil to the transformers and oil switches. Furthermore, the oil volume required by the power plant is great, so the oil spill risk mainly happens to the oil tank.

The oil tank is provided at the lower side of the installation field with the Class C fire danger and Grade 2 fire resistance. The oil tank is provided with the oil deflector, the firewall, the emergency oil tank, the ventilation and fire facilities and others. The oil tank is separated from other parts by the firewall and is provided with the independent exits which the outward fire door is arranged. In order to prevent oil spills, the emergency oil tank is provided, here the oil leaked is collected and the oil-water separator is applied for the treatment, after the treatment, the water will be discharged and the oil will be recycled. In addition, two MP6 foam extinguishers are provided at the entrance of the oil tank, the sandbox is provided to the oil processing room with the door hanging one MP6 foam extinguisher.

Therefore, if the equipment selection and the construction are strictly made in accordance with the design, the oil spill will not happen in the normal operation period of the power plant.

9.2.4 Analysis of the Stability of Reservoir Banks

According to the filed survey, the area is formed with Silurian system Luoreping formation gray red quartz sandstone and siltstone, and the part outside the reservoir area is formed with Silurian system and Permian strata. The height of both banks of the valley is 100 ~ 700m, here the valley is the fault valley with the slope angle of $30^{\circ} \sim 40^{\circ}$, the dip angle of the slope of 35° and the slopes here are gentle, after the water storage, it is predicated that the stability of the majority bedrocks and the slopes is good, and the large-scale collapse is impossible.

9.3 Risk Prevention Measures

(1) Perfect the design and construction of the dam; pay more attention to the geological survey, the hydro-meteorological work and the planning design work; reasonably select the various parameters of the acting force and the resisting force; focus on the design relevant to the places with hidden dangers and implement the special analysis and demonstration on some keys, such as the flood peak and volume, the flood regulation and flood discharge capacities of the dam, the capacity of the dam and structures on the resistance of various natural and special disasters and the skid resistance and anti-penetration stabilities of the dam foundation and others. Furthermore, ensure the construction quality and observe the quality inspection on the engineering and the dam monitoring during the construction period, in particular the initially observed value before the water storage.

(2) Enhance the security monitoring on the dam. The monitoring shall be made on a regular basis in accordance with the regulation and also the security inspection and accreditation shall be made regularly. In case of any abnormalities, the timely reinforcement and treatment shall be made to ensure the security of the dam.

(3) Take the risk management measures; develop the flood inundation map on the downstream area where may be affected by the dam-break and the flood discharge, which shall be submitted to the relevant departments; implement the timely water regimen measuring & reporting for the use of the local governments in the flood warning and evacuation plans; and develop the flood

warning and evacuation plans based on the basic information of the area where may be suffered from the inundation, the schedule of flood prediction, the flood inundation map and other relevant information.

10. Environmental Protection Investment and Economic Profit and Loss Analysis of Environmental Impact

10.1 Environmental Protection Investment Estimate

10.1.1 Estimate Principles and Basis

10.1.1.1 Estimate Principles

According to the relevant state regulations and policies and based on the actual information of the engineering, the following investment principles are fixed:

- (1) The principle of “The one for the pollution shall be responsible for the treatment and the one for development shall be responsible for the protection: the environmental protection investment project is fixed by the principle, and if necessary, the principle shall be used for guiding the investment apportionment.
- (2) The principle of “Functional Protection”: that is, the aim of the pollution control is the protection of engineering functions.
- (3) The principle of “Function recovery”: that is, ensure the scale of investment can protect and recover the functions of the ecological environment to the state before the engineering construction.
- (4) The principle of "One-off compensation", implement the one-off compensation to people involved into the loss of the ecological environment caused by the engineering.

10.1.1.2 Estimate Basis

- (1) “Code for development methods and calculation of design estimation of hydropower engineering” (GJJMW2002, No.78);
- (2) “Notice of issues relevant to standardize the environment impact consultation fee” of National Development Planning Commission and Ministry of Environmental Protection of the People's Republic of China (JJG [2002] No. 125);
- (3) “Preliminary computation development norm of environmental protection design of hydropower engineering”
- (4) Environmental protection measure design on Xujiaping Hydropower Project;

- (5) The prices of relevant materials are the market prices of the first half of 2006;
- (6) Temporary fee collection regulation of Hubei Provincial Environmental Protection Bureau and the management methods on the environment monitoring fee collection, etc.

10.1.2 Investment Estimation

(1) Investment target level

The investment estimation of the items of environmental protection project is fixed based on the material price of 2006.

(2) Environmental protection investment during the construction period

The one-off investment is applied for the environmental protection facilities, and investment to the operation and other costs can be 2 years and the construction environmental monitoring cost can also be 2 years.

(3) Environmental protection investment during the operation period

During the operation period of the hydropower station, the main environmental protection investment is used for the routine monitoring on the environmental factors at the initial period of the engineering (including water quality, ecological monitoring) and so on.

The cost for water and soil conservation involved into the engineering has been included into the special investment for soil and water conservation and the special environmental protection investment includes the resettlement environmental protection, environmental protection equipment, environment monitoring measures and temporary environmental protection measures.

See Table 10-1 for the special environmental protection investment.

Table 10-1. Special Environmental Protection Estimate of Proposed Engineering(10 thousand Yuan)

Item	Project Cost and Name	Unit	Quantity	Unit price	Total Price	Remark
				(10 thousand Yuan)	(10 thousand Yuan)	
Part I Environment Protection Measures					0.84	
I	Population health protection to people involved to the resettlement				0.84	
1	Drinking water disinfection	People	21	0.01	0.21	
2	Health and quarantine	People	21	0.01	0.21	
3	Mosquito-killing and rat-killing	People	21	0.01	0.21	

5	Cost for ecological environment construction of the resettlement area	People	21	0.01	0.21	
Part II Environment Monitoring Measures					16.70	
Construction period					8.50	
I	Water Quality Monitoring				4.00	
1	Water Quality				3.00	
2	Pollutant Source				1.00	
II	Noise Monitoring				0.5	
Operation Period					8.20	
I	Water Quality Monitoring				3.00	
II	Ecological monitoring				2.60	
1	Aquatic organism monitoring				0.60	
2	Land plant and land animal monitoring				2.00	
Part III Equipment and Installation					26.20	
I	Environmental protection equipment				38.20	
1	Aggregate wastewater treatment equipment	Set	2	5.00	10.00	
2	Alkaline waste water treatment equipment	Set	1	3.00	3.00	
3	Oily waste water treatment equipment	Set	1	3.00	3.00	
4	Domestic sewage treatment equipment	Piece	6	0.50	3.00	
5	Watering	Year	2	3.00	6.00	
6	Household garbage disposal facilities	Piece	6	0.20	1.20	
Part IV Temporary Environmental Protection Measures					57.12	
I	Wastewater and sewage treatment of the construction area				15.00	
1	Operation costs for gravel wastewater treatment	Stand .Year	2	3.00	6.00	

Item	Project Cost and Name	Unit	Quantity	Unit price	Total Price	Remark
				(10 thousand Yuan)	(10 thousand Yuan)	
2	Operation cost for aggregate wastewater treatment	Stand .Year	1	1.20	1.20	
3	Operation cost for oily waste water treatment	Stand .Year	1	1.00	1.00	
4	Cost for household sewerage collection and treatment	Point. Year	6	0.50	3.00	

II	Ambient air quality protection				5.20	
1	Watering Cost		2	2.50	5.00	
2	Dust mask	Set	200	0.001	0.20	
III	Household garbage treatment during the operation period				3.28	
	Cost for household garbage cleaning	t	65.52	0.05	3.28	
IV	Population health protection during the construction period				3.64	
1	Drinking water disinfection (2 years)	Year)	People· Year	200	0.01	
2	Health and Quarantine (2 years)	People	200	0.01	2.40	
3	Mosquito-killing and Rat-killing (2 years)	Year)	People· Year	200	0.01	
V	Reserved fund for wildlife protection			30.00	30.00	
Total of I~V environmental protection investment					100.86	
Part V Independent Cost					51.26	
I	Environment management cost				3.03	3% of the sum of I~IV
II	Environment supervision cost	People · Year	2	6.00	12.00	
III	Scientific and research investigation & design fees				20.40	
1	Environmental impact assessment fee				6.00	
2	Environmental protection survey and design fee				8.07	8% of the sum of I~IV
IV	Engineering quality supervision fee				0.25	0.25% of the sum of I~IV
V	Publicity and education				1.51	1.5% of the sum of I~IV
Total of I~V environmental protection investment					152.12	
Basic reserve					9.13	6% of the sum of I~IV
Special environmental protection investment					161.25	

Part VI					162.57	
Special cost for Soil and Water Conservation						
I	Engineering measures				94.80	
II	Vegetation measures				14.32	
III	Temporary works				5.96	
IV	Independent cost				20.00	
	Total of I ~IV investment				135.08	
	Basic reserve (3%)				4.05	
	Total static investment				139.13	
	Compensation fee for water and soil conservation facilities				11.61	
V	Listed investment to main projects				11.83	
	Total				323.82	

The total static investment to Xujiaping hydropower project is RMB 72.4113 million Yuan, the financial cost is RMB 2.8172 million Yuan and the gross investment estimated is RMB 75.2285 million Yuan. The investment to transmission lines is RMB 8 million Yuan and the total investment to the project is RMB 83.2285 million Yuan.

The project investment financing program applies the bank loan and the owner's financing, specifically, RMB 6 million Euros (RMB 52.8 million Yuan) of Climate Change Convention Framework Loan from European Investment Bank and RMB 30.4285 million Yuan from owner's financing.

10.2 Economic Profit and Loss Analysis of Environmental Impact

10.2.1 Major Environmental Loss

The reservoir inundation is the main environment loss, specifically, the area of the house submerged is 1050m² and the arable land area is 1.23hm², of which the paddy field area is 1.15hm², the dry land area is 0.08hm², the tea garden area is 0.95hm², the timber production forest area is 1.92hm², the fuel forest area is 3.36hm², the barren hill area is 4.33hm², the river flat area is 1.90hm² and the road area is 0.86hm², furthermore, there are a bridge and 16 telegraph poles, according to the national and provincial land requisition compensation regulations and the reservoir inundation actual loss approved by all levels, Yichang Changfeng Hydropower Development Co., Ltd., will be responsible for contracting the project valuing RMB 1.5704

million Yuan with the township government of the project.

10.2.2 Main Environmental Benefits

(1) Power generation benefit

The main benefit of Xujiaping Hydropower Project is the power generation, and the designed power generation capacity of the power plant is 2,916,160 kWh and the annual utilization hours are 3556h. The power plant is provided with the incomplete annual regulation capacity, the effective power factor here is 1.0, the power consumption rate of the hydropower station is 1%, the grid loss rate is 9%, and the on-grid price shall be 0.30 Yuan /kWh in accordance with the small local hydropower electricity price, and then:

$$\text{Income} = \text{Electricity Consumption} \times \text{on-grid price} = 2592.63 \times (0.3/1.06) = 7.4354 \text{ million Yuan}$$

The financial internal rate of return of total investment of the project is 7.38% and the financial internal rate of return of the own fund is 6.27% and the static payback time is 9.5 years.

(2) Social Benefit

The construction of Xujiaping Hydropower Project will promote the industrial development of the town; increase the gross national product and the national and local fiscal revenue; expand the accumulation; prosper the local economy; improve the rural industrial structure and the living standard of people; improve the structure of rural labor force; increase the employment chances and stabilize the social order. Xujiaping Hydropower Project is an adjustable power station, the construction of the station will promote and improve the capacity of flood control and drought resistance, and bring very good social benefits to the town and Changyang County.

(3) Environmental Benefit

The construction of Xujiaping Hydropower Project can improve the rural energy structure; promote the “Replacing the firewood by electricity and the coal by electricity”; protect the forest & vegetation; purify the air; improve the climate and promote the virtuous circle of the ecology, at the same time, it also beautify the environment and protect the water resources.

10.2.3 Economic Profit and Loss Analysis of Environmental Impact

The report applies the method of economic analysis to implement the quantitative analysis on the

economic gains and losses on environment, see Table 10-2 for details.

Table 10-2 Economic Profit and Loss Analysis of Environmental Impact

Item	Environmental Benefit	(10 thousand Yuan)
Positive Benefit	Power Generation	743.54
	Other benefits	148.71
	Total	892.25
Negative Benefit		- 323.82
Comprehensive Benefit		568.43
Remark	Based on the normal power generation capacity	

From Table 10-2, we know that the comprehensive benefit of the engineering in the past year was RMB 5.6843 million Yuan. With the implementation of the environmental protection measures during the engineering construction period and the operation period, the short-term damage to the ecological environment will be greatly recovered or perfected, as a result, the social and economic benefits of the engineering will be higher than the environmental losses.

11. Public Participation

11.1 Public Participation Overview

Public participation is an important part for the environmental impact assessment, in a sense, the implementation of the project planning and the design is the result of will and decision-making and at the same time is the results of the designer for planning and the public participation. The scope of the environmental assessment work of Xujiaping Hydropower Project is wide and the environmental factors are more, therefore, in order to help the public to master the information on the characteristics of the engineering construction and operation and the major environmental issues relevant to the engineering and to put forward the opinions and suggestions on the proposed project, the environmental assessment unit in May 2006, with the great support of Changyang County Environmental Protection Bureau and relevant departments, posts the notice to the affected area to briefly describe the information on the engineering environment, the extent of environmental impact and the scope. Furthermore, the public participation into the investigation has been made in the affected area. Besides, the discussion with the local authorities and the public within the project area has been made.

11.2 Survey Method and Object

The questionnaire survey method is the main type and totally 50 copies are distributed and 47 copies are returned, the objects of the survey are the farmers within the engineering scope, in particular, the farmer within the reservoir inundation area (Involved into the land requisition, demolition and resettlement) and relevant people. And the survey is made among people with different occupations, different qualifications and different age groups. The questionnaire is filled on the spot, furthermore, the issues reflected by the public beyond the questionnaire are recorded.

11.3 Survey Content and Statistical Results

The public participation questionnaire mainly includes the following contents: the project overview, the basic information of objects, the information on the project, the impact of the project construction on the local economic development and the environment, and the adverse effects, etc. See Table 11-1 for details.

There are 29 males and 18 females involved into the survey, of which, 26 ones are over 40 years old and the rest are below the 40 years old; and 14 people of the education background of high school or above, 33 people of middle school and below; and 3 cadres and 27 farmers, and the rest engaged into other occupations. See 11-2 for the statistical findings. Three effective forms are selected to be attached with the report.

Table 11-1. Xujiaping Hydropower Project Public Participation Questionnaire

Object Information	Name		Nationality	
	Gender		Occupation	
	Age		Educational Background	
<p>Xujiaping Hydropower Project is for water storage, and also for peak load regulating and emergency during the dry season. The engineering is the Small (1) Type and the other engineering level is IV. The level of the main structure is Level 4 and the level of other structures and temporary structures is Level 5. The static investment to Xujiaping Hydropower Project is RMB 63.0934 Million Yuan and the loan interest during the construction period is RMB 2.4193 million Yuan, and the total investment is RMB 65.5127 million Yuan. The normal pool level is 437m and the corresponding storage capacity is $1.9938 \times 10^6 \text{ m}^3$, and the storage capacity at the dead water level of 418m is $3.328 \times 10^5 \text{ m}^3$, the regulation storage capacity is $1.661 \times 10^6 \text{ m}^3$, the checked flood level is 438.28m and the total storage capacity is $2.1352 \times 10^6 \text{ m}^3$.</p>				
Do you agree with the construction of the hydropower station	Agree	Disagree	No idea	
Do you think whether the project is conducive to local economic development	Advantageous	Disadvantageous	No idea	
Do you think whether the project is conducive to improving the local environment	Advantageous	Disadvantageous	No idea	
Do you know the land requisition and relocation compensation policies relevant to the project	Yes	No	No idea	
Are you satisfied with the resettlement	Satisfied	Dissatisfied	Very dissatisfied	
Are you satisfied with the land requisition and relocation compensation policies	Satisfied	Dissatisfied	Very dissatisfied	
Do you think what will be greatly affected by the project construction	Water Consumption	Aquatic organisms	Terrestrial organism	
Do you think what will be greatly affected by the project construction	Water Quality	Noise	Air	
Other comments and suggestions				

Notes: 1. Please use "√" to express your attitude toward each issue.

2. Please use the written form to express other comments and suggestions or detailed

requirements.

Investigated by:

Date: DD/MM/YY

Table 11-2. Public Opinion Statistics

Do you agree with the construction of the hydropower station	Agree	100%	Disagree	0	No idea	0
Do you think whether the project is conducive to local economic development	Advantageous	97.5%	Disadvantageous	2.5%	No idea	0
Do you think whether the project is conducive to improving the local environment	Advantageous	95.0%	Disadvantageous	2.5%	No idea	2.5%
Do you know the land requisition and relocation compensation policies relevant to the project	Yes	38%	No	48%	No idea	14%
Are you satisfied with the resettlement	Satisfied	55%	Average	45%	Dissatisfied	0
Are you satisfied with the land requisition and relocation compensation policies	Satisfied	55%	Average	45%	Dissatisfied	0
Do you think what will be greatly affected by the project construction	Water Consumption	16.67%	Aquatic organisms	30%	Terrestrial organism	0
	Water Quality	23.33%	Noise	30%	Air	0

The detailed analysis on the public opinions is as follows:

(1) The vast majority of respondents are in favor of the project construction and they believe the implementation of the project will be in favor of local economic development and environmental improvement, benefit both the state and the people.

(2) Over 1/3 respondents have the idea of the land acquisition and relocation compensation policies, but fewer farmers have no idea, and at the same time, the vast majority of respondents said they would agree with the land requisition and relocation way.

(3) The respondents suggest giving the compensation fee to each household, and it shall first solve the problems involved into the resettlement, furthermore, they believe that the compensation standard is too low.

(4) The majority of respondents believe that the affect on water, the noise and the aquatic

organisms will be brought by the project construction, and they hope measures can be taken to ease the impact, such as the reasonable construction arrangement and the timely site greening.

(5) The preventive measures on water and soil conservation shall be applied to the area where the water and soil erosion is easy to happen.

11.4 Public Will Analysis

The survey statistics indicates that the project construction has been supported by the majority of the public, they believe that the project after completion will promote local economic development and improve the environment, they can correctly deal with state, collective, and individual interests and they are willing to cooperate with the government on the land acquisition and relocation required by the project construction.

In addition, some people reflect that the land requisition and relocation compensation level is too lower, in particular the unit price of the house. Therefore, the one in charge of the project shall be responsible for the propaganda of the land acquisition and relocation and the development of reasonable resettlement program, so as to ensure the smooth settlement of the land acquisition and relocation problems involved into the project construction.

To address public's opinions put forward in the survey and ensure the implementation of the project is greatly supported by the residents within the affected area, the relevant authorities and construction units have put forward the following suggestions:

(1) Vigorously publicize the national land requisition and relocation compensation policies on project construction to ensure people involved into the land requisition and relocation comply with the overall situation and contribute to the national construction.

(2) Increase the requisition and relocation compensation level to reasonably compensate the people affected.

(3) Agree with and supervise the environmental protection measures in the environment assessment report. At the same time, enhance the environmental protection awareness of the public to minimize the negative impacts of the project construction on the environment.

12. Evaluation Conclusion and Suggestion

12.1 Evaluation Conclusion

12.1.1 Engineering Overview

The proposed Xujiaping Hydropower Project is located at Duzhenwan Town of Changyang County, is the key project on the hydraulic power development and utilization of Yaozhan River. The dam site of the project is located at Liulinzi in the middle reaches of Yaozhan River, 58km from Zhuangxi River, 135km from Changyang County and 195km from Yichang City; the Powerhouse is located in Xujiaping, 48km from Zhuangxi River, 125km from Changyang County and 185km from Yichang City, therefore, the project boasts convenient traffic conditions. Yaozhan River is located at the south of Changyang Tujia Autonomous County, belongs to the Grade One Branch of Qingjiang River. The total drainage area of the river is 128.6 km²; the multi-year average flow is 3.2m³/s and the multi-year average runoff volume is 1.01×10⁸ m³. The theoretical storage quantity of Yaozhan River is 1.55×10⁴kW and the hydraulic power in the corresponding year is 136 million kWh. The program of one reservoir and nine stations is going to be adopted, one of which is the Xujiaping Hydropower Project. Yichang Water Resources & Hydropower Office in June 2005 approved the above planning with the document numbering YSS [2005] No.112.

The normal pool level of Xujiaping Hydropower Project is 437m and the corresponding storage capacity is 1.99×10⁶ m³, and the storage capacity at the dead water level of 418m is 3.33×10⁵ m³, the regulation storage capacity is 1.66×10⁶ m³ and the storage capacity coefficient is $\beta = 2.74\%$. The reservoir is an incomplete annual regulation reservoir. By the calculation of flood regulation, the checked flood level is 438.86m and the total storage capacity is 2.20×10⁶ m³. Xujiaping Hydropower Project is a diversion type hydropower station, and in the dry season, the project is mainly used for peak load dispatching and backup. By the technical and economic comparison, the installed capacity is 5000+3200 kW, the multi-year average electric power generation is 2.87782×10⁷ kWh and the annual utilization hours shall be 3556h. The guaranteed output (P = 85%) is 1675kW. The total investment of the engineering is 59.4907 million Yuan (Including the environmental protection investment). The engineering is the Small (1) Type, and the main task of

the engineering is power generation to provide the electricity to the living and production required by local people.

Xujiaping Hydropower Project is for water storage, mainly consisting of the dam, the diversion tunnel, the pressure pipeline, the plant and booster station, and the on-grid lines and others. The engineering construction lasts for 2 years and the total engineering volume is as follows: 16594m³ earth excavation, 28440m³ stonework excavation, 40577m³ stone tunnel excavation, 45653m³ masonry block stone, 21691m³ concrete, 32820m² template, manufacturing and installation of 534.8t reinforcing steel bar, 1840m curtain grouting, 7680m² backfilling grouting and 746m² house construction (Excluding the welfare building). And the maximum number of construction staff is 200 and it's expected the total labor force used by the engineering is 163,865 worker' day.

The normal pool level of Xujiaping Hydropower Project is 437m and the corresponding reservoir area is 1.40×105m², the backwater length of the proposed engineering is 1165m. The physical indicators of the reservoir inundation of Xujiaping Hydropower Project (Excluding the area of the permanent occupation for the engineering construction and the area of the temporary occupation for the engineering construction) are as follows: 1050m² houses; 1.23hm² arable lands; 1.15hm² paddy field; 0.08hm² dry land; 1.92hm² timber lands; 3.36hm² firewood lands; 4.33hm² barren hills; 1.90hm² beaches; 0.86hm² highways, one small bridge and 16 telegraph poles. The land requisition compensation is made in accordance with CZBF [2003] No.12 Land requisition and resettlement compensation on Yichang expressway engineering, Wuhan gas pipeline engineering and Changyang section engineering, the relevant regulation of similar projects. The compensation to houses, arable lands and others is applied the one-off compensation method, and the submerged roads shall be raised or rebuilt at other places. In course of resettlement, the reconstruction of roads, the reclamation of hilly area and garden plots, and the transportation of building materials will damage the existing topography and the forest as well as the vegetation, thus causing the water and soil erosion, therefore, more attention shall be paid to the ecological protection in course of resettlement. Because the loss caused by the engineering inundation is smaller and the people involved into the resettlement is fewer, the resettlement can be arranged to near places, therefore, the overall impact to the local society and economy is smaller, however, it should ensure the smooth implementation of the resettlement and relocation compensation to safeguard the rights of the people involved into the resettlement.

12.1.2 Engineering Analysis

The main task of the engineering is for hydroelectric power generation, belonging to the non-polluting type. The impact of the engineering on the environment is mainly from the following aspects: the engineering construction, the engineering inundation and resettlement, and engineering operation, etc.

(1) Engineering construction

In course of engineering construction, the diversion engineering, the main engineering construction, the field building material exploitation, the inside and outside traffic roads and others require a large amount of earth excavation, which will impact or damage the ecological environment, change the original landform, damage the earth and vegetation and cause new water and soil erosion; at the same time, the concrete mixing, the dam pouring and the activities of the staff at the construction site in course of construction will produce wastewater and domestic sewage; the dust produced by the concrete production system, the temporary material preparation yard and the transportation and handling of materials for dam construction and also the tail gas by the fuel machines will damage the surrounding air; the operation of construction machinery, the vehicle transportation and the machine processing and servicing and others required by the construction excavation, the drilling, the blasting, the aggregate crushing, the concrete pouring and other construction activities will produce a lot of noise. The population density of the construction site during the construction period is higher and the living and sanitary conditions are poor, which will affect the population health to a certain extent.

(2) Reservoir Inundation and Resettlement

The physical indicators of the reservoir inundation of Xujiaping Hydropower Project (Excluding the area of the permanent occupation for the engineering construction and the area of the temporary occupation for the engineering construction) are as follows: 1050m² houses; 1.23hm² arable lands; 1.15hm² paddy field; 0.08hm² dry land; 0.95hm² tea gardens; 1.92hm² timber lands; 3.36hm² firewood lands; 4.33hm² barren hills; 1.90hm² beaches; 0.86hm² highways, one small bridge and 16 telegraph poles. The reservoir inundation and resettlement will impact the utilization of local land resources, society and economy and social environment. Generally, the amount of the farmland, woodland and people involved into the resettlement is smaller, fewer

local land resources and people are involved, therefore, the engineering construction features small influence scope and extent.

(3) Engineering Operation

After the reservoir is put into use, it will change the temporal and spatial distribution of the runoff of the original rivers, resulting in that the river dry-up section and the water reducing section from the downstream of the dam of Xujiaping Hydropower Project to the tail water outlet of the powerhouse will appear; and at the same time, the water storage of the reservoir will bring the sediment accumulation, which will have an impact on the normal operation of the power plant and the return of the reservoir tail water; and the nutrients (nitrogen, phosphorus, etc.) are easy to accumulate, resulting in enrichment, which will cause eutrophication, furthermore, the water quality of the reservoir area and at the downstream side of the river will also be affected; the reservoir dispatching changes the surrounding ecological environment, the population structures and the biomass of the aquatic organisms and fishes to a certain extent; furthermore, the reservoir inundation causes the loss of habitats of wild animals and plants, thus changing the population structures and distribution scope of wild animals and plant species, etc.

12.1.3 Environment Evaluation

(1) Ecological Environment Status Evaluation

The main natural vegetation at the project site is the forest and the main artificial vegetation at the project site is the plant-based agriculture. The area has warm and humid climate, different land forms, fertile soil and diversified microclimate environment, suitable for the growing of a wide range of plants, therefore, the plant types here are quite lot. In accordance with the survey and statistics on the plant species, the plants here cover 561 species including varieties of 253 genera in 90 families; and in accordance with the survey on the special plant classification, the plants cover 1438 species of 718 genera in 207 families of 6 categories. In accordance with the survey of Environmental Protection Station of Changyang Tujia Autonomous County, there are no animals, plants and ancient, large, rare and endemic plants and species of the state protection within the area below the reservoir inundation line.

There are totally 116 species of phytoplankton within the project area, belonging to 69 genera and

8 families, of which, the Chlorophyta and the Chrysophyta are the main types. The river has the main types of *Schizothorax taliensis* (eastern subspecies), *Phoxinus oxycephalus*, *Scaphesthes macrolepis* and Homalopterida.

The evaluation information on the land utilization state indicates that the total area within the ecological evaluation scope is $1.51 \times 10^4 \text{ hm}^2$, of which the agricultural land accounts for 94.75%; and the construction land accounts for 3.0%; and the unused land accounts for 2.25%. The woodland covers a larger scope, others are arable lands and the rest cover a very small proportion.

(2) Water Environment Evaluation

According to the field investigation, the domestic sewage around the reservoir area mainly comes from the daily domestic sewage of residents of both banks. At the upstream and the downstream regions of the dam site, due to the relatively dispersed residents, the centralized disposal of human and animal feces is applied to use the feces as fertilizer. Therefore, the quantity of sewage discharged is small and scattered, no significant effect on river water quality. The field investigation also shows that there are no any industrial pollution sources within the power plant inundation area.

There are five water quality monitoring sections provided within the evaluation area: the samples from reservoir entrance, dam site, plant site and Qingjiang River and one sample from Chongxi Plant Power reservoir area, the water quality monitoring results indicate that the water quality meets Class II of "Environmental Quality Standards for Surface Water", and the water quality within the area is good (Source from "Surface Water Environmental Quality Monitoring Report of the Proposed Site of Changyang Xujiaping Hydropower Station").

(3) Sound Environment Evaluation

According to the site survey, there are few residents and no industrial and mining enterprises within the evaluation area, and there are no major sources of noise. The noise of the area mainly comes from the river flow, and there are hardly other sources of noise, and the noise monitoring results at the dam site and the plant are in line with Class 2 requirements "Standard of environmental noise of urban area" (GB3096-93), indicating that the overall noise background value of the area is lower and the sound environment of the area is good.

12.1.4 Environmental Impact Assessment

(1) Ecological Environment Impact

Aquatic Plant

The dam construction will change the ecological environment of the original rivers and have an obvious effect on the types and distribution of aquatic plants. And after the reservoir is formed, due to the slowing of water flow and the release of nutrients at the bottom of the reservoir, along with the diversified environment, the area will be more conducive to the growth of float grass. The species of Cyanophyta, Chlorophyta, and other families will increase, and the species of the diatoms prefer to slack water will decrease, generally, the increasing of nutrients will cause the increasing of the types, quantity and biomass of aquatic plants.

Aquatic animals and fish

After the completion of the reservoir construction, the number of planktons will increase, providing sufficient food resources to plankton eaters, thus increasing the amount of the plankton eaters and the piscivorous fishes. Due to the improvement of the primary productivity of phytoplankton of the reservoir and the emergence of the new bentonic organisms, the fish food web of the reservoir area and the food chains will be changed correspondingly and also the fish catch structure of fish of the reservoir will also be changed, but the fish types will be in line with the development of fishes in the reservoir. Generally, with the increasing of nutrients and the increasing of the types, amounts and biomass of planktons, the type and amount of the aquatic animals will increase.

Terrestrial plants

In course of engineering construction, the excavation, blasting and sand stacking and others will damage the surface vegetation of the both banks of the dam site, the surrounding of the plant, the material yards and the construction roads. The arable land area submerged by the engineering is 1.23hm^2 , the timber production forest area is 1.92hm^2 and the fuel forest area is 3.36hm^2 , and the impact is irreversible. The area affected by the inundation, the vegetation in the construction area, the gravel and earth material yards and the resettlement area are the common type, and no plants of state protection are involved, so the inundation effect is small. With the implementation of the water and soil conservation program of the engineering, the vegetation affected will be recovered

basically.

After the construction of the reservoir, the water level will rise, resulting in the inundation of a small amount of forest, and the submerged forest is consisting of the secondary shrubbery and the grassland. At the same time, because the inundation scope of the reservoir is small, the overall impact of the engineering construction on the growth of the vegetation is small.

□ Terrestrial animals

As for engineering construction, there are no rare and endangered wild animals are distributed in the engineering construction zone and the reservoir inundation zone. Due to the interference of activities of construction staff, the machinery and equipment, the mechanical noise, the resettlement, and the re-construction of the public facilities and other activities during the engineering construction period, the types and quantities of the species within the construction area will decrease and may move to other habitats, but after the completion of the construction, with the decreasing of the noise and the activities of people here, the interference will disappear and the population here will recover as soon as possible, therefore, the engineering will not affect the diversity of species.

After the completion of the reservoir, some low-lying part will be submerged, resulting in that the beasts, the amphibians and reptiles and others living in the low-lying place will move to high places.

(2)Hydrological Regime

After the completion of Xujiaping reservoir, the water diversion construction with the length of 6082.36m provide the water to the Xujiaping power plant for the power generation, resulting in the dry-up section or the water reducing section with the length of 7.8km from the downstream of the dam of Xujiaping Hydropower Project to the tail water outlet of the powerhouse.

Therefore, it shall discharge the ecological flow of a certain amount, and there are no rare aquatic organisms of national and provincial key protection at the downstream of Xujiaping Reservoir and no water consumption requirements on production, living and landscape, either, and the minimum ecological flow shall be fixed in accordance with the requirements of “Water Resources Argumentation of Construction Project”. The multi-year average flow of the Xujiaping intake work is $1.92\text{m}^3/\text{s}$, and based on 10% of the multi-year average flow of the dam site, the required

discharge of ecological flow is $0.19\text{m}^3/\text{s}$ and the ecological water demand is $5.99\times 10^6\text{m}^3$.

(3) Sediment

The multi-year average sand amount in the suspended sediment to the reservoir is $8.30\times 10^3\text{t}$ and the sand amount in the bedload to the reservoir is $1.70\times 10^3\text{t}$; and the sediment trapped rate, estimated by the coefficient of reservoir storage capacity, is 80%, therefore, the multi-year average sand to amount to the reservoir within 20 years is $1.20\times 10^5\text{m}^3$. After calculations, the vertical accumulation of the reservoir is in the strip form and the horizontal accumulation form is at the same elevation, and the reservoir can run normally in a short period and not be affected by the siltation.

(4) Water Environment

Engineering construction period: The aggregate processing wastewater treatment is applied the static settlement; the alkaline wastewater treatment applied by the neutralizing treatment, and the static settlement and neutralizing treatment, the dejecta of the domestic water is collected by the dry toilet, which will be cleaner on a regular basis for the fertilizer. Different treatment measures shall be applied to different wastewater system, and the direct discharge to the river is not allowed, therefore, the impact on the water quality function will not be great.

Engineering operation period: the domestic water produced by the staff of the power plant will be treated and then be collected by the cleaner on a regular basis for the fertilizer, and the direct discharge to the river is not allowed, therefore, the impact on the water quality function will not be great.

(5) Water and soil erosion

During the engineering construction, due to the road construction, the excavation of earth and stone and the material yard exploitation and others, the vegetation will be damaged due to the produced residue, therefore, if none water and soil conservation measures are taken, the new soil and water erosion within the project area will result in the impact of different degrees to the land productivity, the river sedimentation and the change of the ecological environment within the area.

(6) Inundation and Resettlement

Below the checked flood level, the most fields of the right bank and the left bank belong to the

woodland, and there are no minerals of exploitation value within the reservoir area and no other inundation loss.

The physical indicators of the reservoir inundation of Xujiaping Hydropower Project (Excluding the area of the permanent occupation for the engineering construction and the area of the temporary occupation for the engineering construction) are as follows: 1050m² houses; 1.23hm² arable lands; 1.15hm² paddy field; 0.08hm² dry land; 0.95hm² tea gardens; 1.92hm² timber lands; 3.36hm² firewood lands; 4.33hm² barren hills; 1.90hm² beaches; 0.86hm² highways, one small bridge and 16 telegraph poles. The total compensation cost is RMB 1.5704 Million Yuan.

The resettlement area is mainly covered by the cultivated land and the wasteland, and no woodland is involved; the new house structure within the resettlement area is brick-concrete, lowering the impact of the house construction on the vegetation and forest; in course of house construction and infrastructure construction, the earth surface will be changed, resulting in the damage to local vegetation, and in course of resettlement, the building waste will be produced, which may cause the local water and soil erosion, but the impact only happens in a short period of time, which can be proved by taking the preventative measures. The impact of the engineering construction is limit.

(7) Air

The impact of the engineering construction on the atmospheric environment is mainly in the construction period, and the atmospheric pollutants are the dust, the oil fired-exhaust gas and the coal fired exhaust gas, etc.

The construction dust will affect the atmospheric environment within the construction area, and after the construction ends, the impact will disappear; and there are no sensitive targets surrounding the material yards, the water residue yard and the aggregate processing system, therefore, no impact will be caused to the surrounding environment, but the produced dust will affect the field construction staff; and the concrete mixing system is far away from the surrounding residential areas, therefore, the impact on the atmospheric environment of the nearby residential areas is small; and the dust during the moving of the vehicle will increase the dust content at both sides of the construction roads; and the emission of the exhaust gas from oil-fired equipment may form the point source pollution near the construction area.

(8) Noise

The sound environment impact is mainly in the construction period. The construction machinery, construction activities and running of vehicles will increase the sound environment impact to the engineering area, however, because the engineering is located far from Ziqiuji Town and also far from the residents within the elevation area, there will affect the living of residents, and after the engineering construction ends, the impact will also disappear.

(9) Solid waste

The soil wastes here are the construction waste and the household waste of the construction staff. The wastes during the engineering construction are the abandoned stone and soils mainly from the foundation excavation, foundation cleaning, slope cutting and surface cleaning of the soil yard and the stone yard. The engineering measures and the vegetation measures applied to the waste residue yard aim to prevent the new soil and water erosion.

The throwing of living garbage may pollute the air and deteriorate the environment, and in certain climatic conditions, it may cause the breeding of mosquitoes, flies and rats, which may increase the risk of the spread of various diseases, thus endangering the health of construction personnel, and once the pollutants enter the river, the water will be polluted and the concentration of pollutants in rivers will be increased. The living garbage of the engineering basically belongs to the degradable organic matters, therefore, the centralized treatment shall be applied to effectively prevent the organic pollutants and bacteria of or others the living garbage from entering the river and pollute the nearby waters.

(10) Population Health

The high-intensity field work may lower the immunity of construction personnel, if the domestic sewage and production wastewater and living garbage cannot be disposed in time, it may cause the breeding of mosquitoes, flies and rats, leading to the occurrence of insect-borne infectious diseases and water-borne infection and others. Therefore, it should strengthen the sanitation and environment of the construction area and the hygiene quarantine and health check of construction personnel, furthermore, it needs to implement the water source management; carry out the control and inspection of external personnel and improve the medical conditions of the construction area. In addition, it must pay attention to the management on food hygiene to prevent the mass food

poisoning incidents.

(11) Society and Economy

The main task of Xujiaping Hydropower Project is power generation, after the completion of the engineering, it will improve the power supply quality of Changyang electricity grid to a greater extent; provide the electricity for living and production of urgent demand; increase the power supply; adjust the electricity distribution during the flood season and the dry season and promote the socio-economic development of Changyang.

12.1.5 Effectiveness of Environmental Protection Measures

Based on the economic profit and loss analysis of environmental impact, the applied water environment protection, ecological restoration and protection, sound environment protection, water and soil conservation measures and other environmental protection measures as well as the applied environmental protection facilities are technically feasible, featuring easy-to-implement and easy-to-use, and they are also feasible economically. The total investment to the environmental protection of the engineering is RMB 3.2382 million Yuan, of which, the special environment protection investment is RMB 1.6125 million Yuan, the special soil and water conservation investment is RMB 1.6257 million Yuan and the total investment of the engineering is RMB 59.4907 million Yuan, then we can know that the environmental protection investment of the engineering is 5.4% of the total investment of the engineering.

12.1.6 Public Participation

The survey statistics indicates that the project construction has been supported by the majority of the public, they believe that the project after completion will promote local economic development and improve the environment, they can correctly deal with state, collective, and individual interests and they are willing to cooperate with the government on the land acquisition and relocation required by the project construction.

In addition, some people reflect that the land requisition and relocation compensation level is too lower, in particular the unit price of the house. Therefore, the one in charge of the project shall be responsible for the propaganda of the land acquisition and relocation and the development of reasonable resettlement program, so as to ensure the smooth settlement of the land acquisition and

relocation problems involved into the project construction.

12.1.7 General Evaluation Conclusion

(1) Main Favorable Effect

After the completion of this engineering, adequate energy will be provided to Changyang, the development of the electric power industry and the township enterprises will be promoted, thus realizing the economic development of Changyang County, After the electricity is provided to each household, the village and household power-on ratios will be increased and the ratio of the electric furnace application will be increased, as a result, the electricity will gradually replace the application of the firewood, thus reducing the wood cutting amount, realizing the virtuous circle of “Protecting the forest by electricity, storing water by the forest and generating power by the water” and improving the ecological quality of vegetation in the reservoir area, and at the same time, the power supply quality of the local of local electricity grid will be improved and the power shortage will be relieved.

After the reservoir starts to store water, the water flow is slow, resulting in that the waste in the reservoir is clearer, and at the same time, due to the soluble substances appeared in the inundation area and the nutritional substances collected by the surface runoff, it provides the rich foods to planktons and fishes, favorable to the breeding of fishes.

(2) Main Adverse Effects

The reservoir inundation and permanent occupation of land will have a certain impact on the land resources and the agricultural production.

During the construction period of the engineering, the SO₂, NO_x and others in the exhaust produced by the construction machinery and the a lot of dust and noise produced by quarrying, excavation, mixing, aggregate crushing and sieving and transportation will have a certain impact on the atmospheric environment of the construction area, especially the on-site operators. Furthermore, the changing of the surface and the damage to vegetation during the construction period will cause the soil erosion easily, thus reducing the water and soil erosion caused by the weakening of the capacity of soil conversation and erosion control. At the same time, the engineering construction will cause a lot of residues, which will block the downstream river

channels, deteriorate environment and cause serious water and soil erosion if they are not placed at the appropriate place.

In addition, after the water storage, the water velocity will decelerate and the spread of pollutants will be lowered while the accumulated volume of the sludge and heavy metals will be more. At the same time, the dam blocking and the runoff regulation will also have a certain impact on the ecological environment.

To sum up, Xujiaping Hydropower Project is a small hydro-power one of Yaozhan River with the main task of power generation, the project features reasonable location and feasible construction program. From the overall analysis, the engineering construction has both advantages and disadvantages on the ecology and environment, as for the disadvantages, with the exception of the permanent occupation of land resources due to the reservoir inundation, others can be prevented and relied by the application of the preventive and improvement measures. And from the environmental protection perspective, there are no the conditioned environmental impacts of the engineering constraints. The construction unit should implement the environmental protection measures and countermeasures put forward in the evaluation reports to reduce the adverse effect. Therefore, under the premise of sufficient environmental protection investment, the project is feasible from the environmental point of view.

12.2. Suggestions

(1) The water and soil erosion is one of the main environmental problems of the engineering area, it is recommended that the water and soil conservation departments strengthen the supervision and management on the construction site of the construction unit; strictly enforce the law; and control and prevent the new water and soil erosion caused by the engineering construction. And it is suggested that the construction units should minimize the destruction to vegetation as much as possible during the construction, after the completion of the engineering, they should be responsible for the surface vegetation restoration of the exposed soil layers within the construction area.

(2) In course of engineering operation, to ensure the normal running of the ecological system at the downstream side of the dam site, it shall discharge the minimum ecological flow of $0.19\text{m}^3/\text{s}$, furthermore, it's recommended that the relevant departments shall strengthen the supervision to

prevent the damage to the downstream ecological environment due to the water interception.

(3) In accordance with the relevant policies and standards of the state and Hubei Province, it should reasonably fix and immediately pay the land requisition and housing relocation compensation fee to ensure the smooth implementation of the resettlement. At the same time, it should strengthen the publicity of the resettlement policies to help the masses to truly understand the significance and importance of engineering construction and know the relevant policies of the state and Hubei Province.

(4) It is recommended that the project shall strictly comply with the “System of the three at the same time” and other environmental protection systems, furthermore, it shall implement the environmental protection measures in course of engineering construction and at the same time, it shall focus on the environmental protection supervision and management to ensure the smooth implementation of each environmental measure.