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1. Yichang Water Conservancy and Hydropower Bureau 2005/No.112 Document "The Official Reply on Changyang Yaozhanxi River Basin Hydro-Energy Development Planning Report of Hubei Province"
2. Bureau of Water Conservancy and Hydropower of Changyang Tujia Autonomous County/2005 No.82"Official Reply on the Preliminary Design Report for Erchakou Hydropower Station by the County Bureau of Water Conservancy and Hydropower"
3. Bureau of Water Conservancy and Gydroelectric Power of Changyang Tujia Autonomous County/2005 No.86 "Suggestion on the demonstration report for the Water Resource of Erchakou Hydropower Station by the County Bureau of Water Conservancy and Hydropower"
4. Changyang Water and Soil Conservancy Bureau 2006/No.1 "Official Reply on Water and Soil Conservation Planning Report of Erchakou Hydropower Station"

5. Yichang Municipal Bureau of Environmental Protection's Letter on the EIA Implementation Standard of Erchakou Hydropower Station Project
6. Letter of Commission on environment impact assessment by Changyang Funeng hydroelectric Development Co.Ltd
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**Erchakou Hydropower Station of
Changyang Tujia Autonomous County of
Hubei Province**

Environmental Impact Report

(For Approval)

The Research Institute of Environmental Protection of Xiangfan City

March 2006

1. General

1.1 Origin of the task

Yaozhan Brook Catchment, located in the south of Changyang Tujia Autonomous County, geographically crossing the east longitude $110^{\circ}30' \sim 110^{\circ}54'$ and north latitude $30^{\circ}15' \sim 30^{\circ}24'$, belongs to the primary branch of Qingjiang River, it originates from north and south thoroughfares of Gaofeng Village of Bailuzhuang Township of Wufeng with 2152.7m altitude, its headwater (at the foot of Shizinao Mountain) insinuates (underground) into Koujian Underground River for 4.8km from Zhongzhu Bay, the length of submerged flow is 2.2km; after appearing at Sifang Cave, it passes Diaoshuiyan, Chengwuhe, Shuangmatou, Huilongguan, Xiangshi, Jigongzui, Xiangshuidong, Shibanpo, Wangjiacao (Yuquandong) and Xujiaping, and then flows into Geheyuan Reservoir Area of Qingjiang River at Shuanghekou (elevation 200.00m). The east of Yaozhan Brook Catchment is adjacent to Longtan River Catchment, connects Wufengjieling in the south and borders on Zhongxi River and Quxi in the west, it closes to Geheyuan Reservoir Area in the north, the catchment covers 128.6km^2 , length of the drainage line is 20.6km, total head is 1952.7m, weighted average gradient of drainage line is 17.3%, long-term average rainfall is 1445.7mm, long-term average flow is $3.2\text{m}^3/\text{s}$ and long-term average runoff volume is 101 million m^3 . Theoretical water storage capacity of Yaozhan Brook is 15.5 thousand kW and corresponding annual water energy is 136 million kWh. There are two main branches, i.e. Zhongxi Brook and Chongxi Brook.

Erchakou hydropower station is located in the upper reaches of Chongxi Brook-the branch of Yaozhan Brook, it is the first stage of cascade development of water energy of Chongxi Brook, the water is taken from Neixi Brook, Liujia Brook and Daxigou, it is 58km from Zhuangxi Brook, 135km from Changyang Tujia Autonomous County and 195km from Yichang City; the power house is located in the upper reaches of the

mouth of Daxigou, 48km from Zhuangxi Brook, 125km from Changyang Tujia Autonomous County and 185km from Yichang City. Design intake flow of Neixi Brook intake dam is 0.5m³/s, that of Liujia Brook intake dam is 0.3m³/s and of Daxigou intake dam is 0.3m³/s. In accordance with *Water Power Development Planning of Yaozhan Brook of Changyang Tujia Autonomous County of Hubei Province*, three-station development program will be applied for Chongxi Brook, i.e. taking water from Daxigou, Liujia Brook and Neixi Brook, and then introducing water to Chongxi Brook to construct Erchakou Hydropower Station. Yichang Water Conservancy and Hydropower Bureau issued YS [2005] No. 112 Document *An Official and Written Reply to Water Energy Development Planning Report of Hubei Changyang Yaozhan Brook* and gave an official to the above program on June 2005.

Environmental protection a basic state policy of China, in accordance with *Environmental Impact Assessment Law of the People's Republic of China*, *Regulations on the Administration of Construction Project Environmental Protection* Decree No. 253 of the State Council of the People's Republic of China and *Administration of Construction Project Environmental Protection by Means of Classification Catalogue* Decree No. 14 of the State Environmental Protection Administration, Erchakou Hydropower Station belongs to the first category construction project, i.e. environmental impact report must be prepared in feasibility study period for construction projects that may cause great impact on the environment and submitted to administrative authority of environmental protection for approval. Hubei Changyang Funeng Hydropower Development Co., Ltd officially entrusted Research Institute of Environmental Protection of Xiangfan City of Hubei Province to contract environmental impact assessment of Changyang Erchakou Hydropower Station. Because that environment assessment of the Project was pressing, our Institute reported to Hubei Environmental Protection Bureau about the content, profundity, emphases, scope and standard of the assessment in work, the report could be directly prepared without the general outline and approval of environmental protection assessment as agreed by Hubei Environmental Protection Bureau. After

accepting the entrustment, the assessment unit organized related technical personnel to collect data on the site, monitor existing water quality, survey the ecological status and collect suggestions of the public. During the process, Environment Monitor Station of Yichang Changyang Tujia Autonomous County was entrusted to monitor the environment status and compiled *Environmental Impact Report of Erchakou Hydropower Station of Changyang County of Hubei Province* (Submittal) in December 2005 according to *Technical Guidelines for Environmental Impact Assessment* (HJ/T2.1~2.3-93, HJ/T2.4-95, HJ/T19-1997), *Technical Guidelines for Environmental Impact Assessment---Non-Polluted Ecological Impact* and *Technical Guidelines for Environmental Impact Assessment--- Water Conservancy and Hydropower Engineering*(HJ/T88-2003). Hubei Provincial Environmental Protection Bureau presided technical examination meeting of *Environmental Impact Report of Erchakou Hydropower Station of Changyang Tujia Autonomous County of Hubei Province* in March 2006, assessment units corrected and perfected the Report according to review suggestions of experts group after the meeting, and then *Environmental Impact Report of Erchakou Hydropower Station of Changyang Tujia Autonomous County of Hubei Province* (For Approval) was prepared. The Report will be delivered to the Owner and submitted to Hubei Provincial Environmental Protection Bureau for approval.

We had been sincerely directed and assisted by Hubei Provincial Environmental Protection Bureau, Yichang Environmental Protection Bureau and Environmental Protection Bureau of Changyang Tujia Autonomous County in this assessment, in addition, we closely cooperated and had been vigorously supported by Environment Monitor Station of Changyang Tujia Autonomous County and the construction unit, we herein express our sincere acknowledgement to all of them.

1.2 Assessment purpose and principles

1.2.1 Purpose

Environmental impact assessment of Erchakou Hydropower Station of Changyang Tujia Autonomous County is to analyze status quo of the environment and actual situation of the Project on the basis of applicable laws, rules and technical standards, and then assess favorable and adverse impacts of construction of the hydropower station project on the environment in a complete, systematical and correct way, so as to demonstrate the environmental feasibility of project construction in the aspect of environment, promote feasible environmental protection measures according to adverse impacts on the environment arising from construction of the project, try to minimize the adverse impact and provide scientific references for management departments on decision making and construction unit on environment management.

1.3 Preparation basis

1.3.1 Laws, regulations and legal documents

(1) *Environmental Protection Law of the People's Republic of China* (1989);

(2) *Law of the People's Republic of China on Environmental Impact Assessment* (2002);

(3) *Law of the People's Republic of China on Prevention and Control of Water Pollution* (revised in 1996);

(4) *Law of the People's Republic of China on Prevention and Control of Atmospheric Pollution* (revised in 2000);

(5) *Law of the People's Republic of China on Prevention and Control of Noise and Pollution* (1996);

- (6) *Law of the People's Republic of China on Prevention and Control of Environmental Pollution by Solid Wastes* (revised in 2004);
- (7) *Water Law of the People's Republic of China* (revised in 2001);
- (8) *Law of the People's Republic of China on Water and Soil Conservation* (1991);
- (9) *Land Administration Law of the People's Republic of China* (revised in 1998);
- (10) *Law of the People's Republic of China on the Prevention and Treatment of Infections Diseases*(1989);
- (11) *Law of the People's Republic of China on the Protection of Wild Life*(1988);
- (12) *Forest Law of the People's Republic of China* (revised in 1998);
- (13) *Regulations of the People's Republic of China for the Implementation of Wild Aquatic Animal Protection*(1993);
- (14) *Regulations on the Administration of Construction Project Environmental Protection-Decree* [1998] No. 253 of the State Council of the People's Republic of China;
- (15) *Administration Catalog of Construction Project Environmental Protection-Decree* No. 14 of the State Environmental Protection Administration;
- (16) *State Key Protected Wildlife List*;
- (17) *State Key Protected Wild Plants List (the first group)*;
- (18) *Notification on Strengthening Environmental Protection of Hydropower Construction of State Environmental Protection Administration and National Development and Reform Commission* HF [2005] No. 13;

(19) State Environmental Protection Administration HF [2004] No. 24 *Suggestions on Strengthening Supervision of Ecological Environmental Protection of Resource Development*;

(20) Environmental Engineering Assessment Center of State Environmental Protection Administration HPH [2006] No. 4 on printing and issuing *Technical Instructions of Environmental Impact Assessment of Watercourse Ecological Water, Low Temperature Water and Fish Facilities of Hydropower and Water Conservancy Construction Project (Trial)*;

(21) *Notification on Surface Water Environmental Function Category of Hubei Province* (EZF [2000] No. 10) of the Provincial Environmental Protection Bureau forwarded by Hubei Province People's Government Office Department;

(22) Hubei Provincial Environmental Protection Bureau EHB [2003] No. 27 *Notification of Further Doing Well Public Participation Work in Environmental Impact Assessment of Construction Projects*.

1.3.2 Technical guidelines and specifications

(1) *Technical Guidelines for Environmental Impact Assessment - General Principles, Atmospheric Environment, Surface Water Environment* (HJ/T2.1-2.3-1993);

(2) *Technical Guidance for Environmental Impact Assessment--- Acoustic Environment* (HJ/T2.4-1995);

(3) *Technical Guidelines for Environmental Impact Assessment---Non-Polluted Ecological Impact*(HJ/T19-1997);

(4) *Technical Guidelines for Environmental Impact Assessment - Water Conservancy and Hydropower Project* (HJ/T88-2003);

(5) *Technical Regulation on Water and Soil Conservation Plan of Development and Construction Projects* (SL204-1998);

(6) *Notification on Water Conservation and Comprehensive Treatment and Planning* (GB/T15772-1995);

(7) *Technical Regulation on Comprehensive Treatment of Water and Soil Conservation* (GB/T16453.1~16453.6-1996);

(8) *Technical Specifications for Monitoring of Surface Water and Waste Water* (HJ/T 91-2002).

1.3.3 Approval and entrustment documents of the Project

(1) Water Conservancy and Hydropower Bureau of Yichang City YS [2005] No. 112 *An Official and Written Reply to Water Energy Development Planning Report of Hubei Changyang Yaozhan Brook*;

(2) Water Conservancy and Hydropower Bureau of Changyang Tujia Autonomous County CS [2005] No. 82 *An Official and Written Reply to Preliminary Design Report of Erchakou Hydropower Station* ;

(3) Water Conservancy and Hydropower Bureau of Changyang Tujia Autonomous County CS [2005] No. 86 *Examination Suggestions on Water Resource Demonstration Report of Erchakou Hydropower Station*;

(4) Soil Conservancy Bureau of Changyang Tujia Autonomous County CSBF [2006] No. 1 *An Official and Written Reply to the Report of Water and Soil Conservation Plan of Erchakou Hydropower Station*;

(5) Environmental impact assessment proxy of Changyang Funeng Hydropower Development Co., Ltd.

1.3.4 Technical data

(1) *Environmental Function Division of Changyang Tujia Autonomous County*;

(2) *Social and Economic Development Plan of Changyang Tujia Autonomous County*;

(3) *The Eleventh-Five-Year-Plan Environmental Protection and Long-Term Planning of Changyang Tujia Autonomous County*;

(4) *Report of Water Energy Development Plan of Hubei Changyang Yaozhan Brook* prepared by Yichang Qingjiang Water Conservancy and Hydropower Survey and Design Institute;

(5) *Preliminary Design Report of Hubei Changyang Erchakou Hydropower Station* prepared by Yichang Qingjiang Water Conservancy and Hydropower Survey and Design Institute;

(6) *Report of Water and Soil Conservation Plan of Hubei Changyang Erchakou Hydropower Station* prepared by Yichang Qingjiang Water Conservancy and Hydropower Survey and Design Institute;

(7) *Water Resource Demonstration Report of Hubei Changyang Erchakou Hydropower Station* prepared by Wuhan University;

(8) Other related documents.

1.4 Assessment standard

According to environment category of the project site, geological location of the project and environmental characteristics of the project area, assessment standards have been approved by Environmental Protection Bureau of Changyang Tujia Autonomous County and the environment standards to be executed are shown as follows:

1.4.1 Environment quality standard

(1) Ambient air quality standard

Implement Category II standard of *Ambient Air Quality Quality Standard* (GB3095-1996) of the State, see Table 1-1 for details.

(2) Environmental Quality Standard for Surface Water

Implement Category II standard values of *Environmental Quality Standard for Surface Water* (GB3838-2002) of the State for 3.3km watercourse of Neixi Brook, 2.9km watercourse of Neixi Brook, 7.65km watercourse of Daxigou and 2km watercourse under the hydropower station plant, and the standard values are shown in Table 1-2:

Table 1-2 Environmental Quality Standard for Surface Water (Category II)

Unit: mg/L

No.	Standard value Parameter	Category II	Remarks
1	PH PH	6-8.5	
2	Total nitrogen (counted by p) ≤	0.1	
3	Potassium permanganate index ≤	4	
4	Biochemical oxygen demand (BOD ₅) ≤	3	
5	Ammonia nitrogen ≤	0.5	

(3) Acoustic environment standard

Implement Category I standard of *Standard of Environmental Noise of Urban Area* (GB3096-93) of the State; see Table 1-3 for details.

Table 1-3 Standard Value of Environmental Noise

Unit: LeqdB (A)

Applicable area	Daytime	Night	Remarks
□	55	45	Assessment period: Construction period Assessment object: Assessment area

(4) Standard for classification and gradation of soil erosion

Implement *Standard for Classification and Gradation of Soil Erosion* (GBSL190-96).

1.4.2 Discharge standard

(1) Noise limits for construction site

Implement *Noise Limits for Construction Site* (GB12523-90). See Table 1-4 for details.

Table 1-4 Noise Limits for Different Construction Phases

Unit: Leq[dB(A)]

Construction phase	Main noise source	Noise limit		Remarks
		Daytime	Night	
Earthwork	Bulldozer, excavator and loader	75	55	Assessment period: Construction period
Piling	All kinds of pile drivers	85	Forbid construction	
Structure	Concrete mixer, immersion vibrator, electric saw	70	55	Assessment object: Construction site
Decoration	Crane, lifter	65	55	

(2) Integrated wastewater discharge standard

Implement Level I standard of *Integrated Waste Water Discharge Standard* (GB8978-1996). See Table 1-5 for details.

Table 1-5 Integrated Wastewater Discharge Standard (Level I)

Unit: mg/L

No.	Standard value Parameter	Category II	Remarks
1	PH	6-9	Assessment period: Construction period Assessment object: Production wastewater, sewage.
2	SS	70	
3	Ammonia nitrogen≤	15	
4	(COD)≤ Chemical oxygen demand (COD)	100	
5	(BOD ₅)≤ Biochemical oxygen demand (BOD ₅)	20	

(3) Integrated emission standard of air pollutants

Implement *Integrated Emission Standard of Air Pollutants* (GB12523-90). See Table 1-6 for details.

Table 1-6 Integrated Emission Standard of Air Pollutants

Unit: mg/Nm³

Pollutants	TSP	NO _x
Max. allowable emission concentration	120	240
Remarks	Assessment period: Construction period	Assessment object: Assessment area

(4) Allowable noise limits for motor vehicle

Implement “the standard for products manufactured after January 1, 1985” of *Allowable Noise Limits for Motor Vehicle* (GB1495-79).

Table 1-7 Allowable Noise Limits for Motor Vehicle

Unit: Leq[dB (A)]

Vehicle type		Noise standard
Truck	8t≤truck <15t	89
	3.5t≤truck<8t	86
	Truck<3.5t	84
wheel tractor (below 60 HP)		86

See related sections for corresponding standard values of the above standards, predict and analyze according to the following different situations for environment factors without assessment standards: assess with threshold for related subjects with recognized threshold; conduct impact analysis in relation to present situation for impact factors with neither threshold nor reference standard.

1.5 Assessment class

According to *Administration Catalogue of Construction Project Environmental Protection- Decree* (No. 14 of the State Environmental Protection Administration), Changyang Erchakou Hydropower Station is a water power generation project, so an environmental protection impact report shall be compiled for completely assessing the pollution and environmental impact arising from the project.

According to *Technical Guidelines for Environmental Impact Assessment - Water Conservancy and Hydropower Project* (HJ/T88-2003) and classification rules of assessment specified in *Technical Guidelines for Environmental Impact Assessment-Non-Polluted Ecological Impact* (HJ/T19-1997), *Technical Guidelines for Environmental Impact Assessment-Surface Water Environment* (HJ/T2.3-93), *Technical Guidelines for Environmental Impact Assessment-Atmospheric*

Environmental Impact Assessment-Acoustic Environment (HJ/T2.4-1995), together with comprehensively considering threshold of major ecological environment factors and their variation intensity, project impact scope, sensitivity of ecological environment of the assessment area and whether the ecological impact exceeds ecological load or environmental capacity of the project site, the assessment class of environment impact of the project is determined thereof.

(1) Assessment class of ecological environment impact

As a hydropower project, it is clean energy, there will be no pollutants discharged in operation of the project, so its impact towards the environment belongs to non-polluted impact. Adverse impacts of hydropower project towards the environment are mainly presented by ecological impacts in construction period and operation period.

Construction of the hydropower station project will impact the environment in a certain degree, however, no environmental and ecological sensitive areas such as cultural relics and historic site, nature reserves, famous scenery areas, forest parks and areas rich in species will be involved in it, so it will cause no severe danger towards local ecological function protection areas as well as environmental and ecosystems of the catchment.

Through preliminary analysis, the following variations of ecological factors may be caused after the project is completed:

Impact area: <20km².

Bio-community: reduction of biomass<50%

Reduction of heterogeneity: mere species variation, so reduction of heterogeneity is not great.

Reduction of species diversity<50%

Extinction of rare and endangered species: Non

Regional environment: reduction of green area<50%, uneven distribution and poor connectivity.

Desertification: Non.

Changes of physicochemical property: physicochemical property of water body will be changed in a certain degree and that of soil may be changed in a certain degree because of changes of production capacity.

Sensitive area: Non

According to determination rules for assessment class specified in *Technical Guidelines for Environmental Impact Assessment-NON-POLLUTED ECOLOGICAL IMPACT* (HJ/T19-1997), assessment class of ecological environment of the construction project is determined as Class III.

(2) Assessment class of environmental impact of surface water

Long-term average flow at the dam of Erchakou power station is $0.51\text{m}^3/\text{s}$, it is a small river, environmental function of the present water body of Neixi Brook, Liujia Brook and Daxigou is Category II. After completion of the Project, no wastewater will be discharged in operation instead of construction wastewater and little sewage, assessment class of environmental impact of surface water is determined as Class III according to division rules and determination method of assessment class of surface water specified in HJ/T2.3-93.

(3) Assessment class of atmospheric environmental impact

No atmospheric pollutant is discharged, but little waste gas will be discharged by construction machineries and transportation vehicles together with little fume and SO₂ will be discharged by cooking range of construction personnel, pollutant discharge is greatly less than 2.5×10⁷m³/h. Assessment class of atmospheric environmental impact is brief appraisal according to related classification basis specified in HJ/T2.2-93.

Assessment scope of atmospheric environmental impact mainly is the construction site and spreading to the surrounding for 300 ~ 500m.

(4) Assessment class of acoustic environment impact

No noise will be generated in operation of the project, however, mountain blasting, concrete mix and vehicle transportation in construction period will be noisy, but most of them are intermittent and temporary. Construction site is located in non-sensitive area and only some villagers are living around. Acoustic environment of the construction site belongs to Category I according to present situation and assessment class of acoustic environment impact is brief appraisal based on related classification basis specified in HJ/T2.4-1995.

The assessment scope of acoustic impact mainly is the construction site and spreading to the surrounding for 50-500m.

Assessment class and results of environmental impact are shown in Table 1-8.

Table 1-8 Determination of Assessment Class of Environmental Impact of the Project

Environmental element	Determination basis	Assessment class	Sources of standards
Ecological environment	Project impact scope <20km ² , no sensitive object; reduction of biomass <50%, reduction of species diversity <50%	Class 3	HJ/T19-1997

Water environment	Ⅱ Project impact scope <20km ² , physicochemical property changes; waste water discharge is less than 1000m ³ /d, complexity degree of wastewater quality is simple, surface water is of smaller scale, surface water quality shall be Category II.	Class 3	HJ/T19-1997 HJ/T2.3-93
Acoustic environment	It is in mountain area and the surface is complicate, discharge of pollutant is very little and only limited to construction period	Brief appraisal	HJ/T2.2-93
Noise	Increase of noise level before and after completion of the project is very small (increase of noise level is within 3dB (A)), mere variation in impacted population, and it is only limited to construction period	Level 3	HJ/T2.4-1995

1.6 Key points of assessment

According to characteristics of the project, environmental characteristic and environmental protection requirement of the location, ecological environmental impacts in construction and operation periods of the project will be considered as key points of environmental impact assessment.

The assessment mainly includes: project analysis, survey of general situation of the surrounding and present situation of environmental quality, environmental impact assessment of surface water, ecological environmental impacts assessment, other environmental impact analysis (including environmental noise, solid wastes etc), prevention and treatment of pollution as well as measures for relieving ecological impact. In addition, atmospheric environmental impact assessment, public participation, environment management and monitor, environmental and economic loss and profit analysis are described in the Report.

1.7 Assessment scope and period

According to the scale and characteristics of the project and combined with local environmental characteristics, the assessment scope is determined as follows: 500m in the upper reaches of three intake dams including Neixi Brook Dam, Liujia Brook Dam and Daxigou Dam to the head pond of the station, the head pond to the plant area of the station, the plant area of the station to 1000m in the lower reaches of tail water outlet of the station. Detail scope of each area is shown below:

(1) Ecological environmental impact scope:

As known from engineering design, the project to be constructed covers four kinds of lands including river beach, brushland, barren hill and few hillside cultivated land, the project covers 0.87hm² including 0.50hm² temporary land and 0.37hm² permanent land. In temporary land occupation, waste disposal area takes up 0.20hm², access road takes up 0.07hm² and temporary construction land takes up 0.23hm². After it commences for construction, the original land feature of most area in construction site will be destroyed by excavation disturbance, rolling and occupation in different degrees, the original functions for water and soil conservation will be reduced. Because that the project construction changes the present situation of land use in the area and connectivity among blocks of landscape ecosystem, ecological assessment scope is from 500m watercourse above Neixi Brook Dam, Liujia Brook Dam to 500m watercourse in the lower reaches of tail water of the power station, and spreading to the first ridge line along both sides of the river. It will be assessed in construction period and operation period.

(2) Surface water environment: assessment scope is from 500m in the upper reaches of three intake water dam including Neixi Brook Dam, Liujia Brook Dam and Daxigou Dam to 1km river section in the lower reaches of tail water of the power station; it will be assessed in construction period and operation period.

(3) Ambient air: assessment scope includes three dam construction areas, water tunnel construction area, plant construction area, borrow pit and spoil ground, new access

road inside and outside the area as well as office and living area of construction personnel, it covers about 0.8km² taking the above area as a center spreading along the watercourse for 3.7km and 200m perpendicular to the watercourse. It will be assessed mainly in construction period.

(4) Acoustic environment: assessment scope includes 1m out of the three dam sites construction area, water tunnel construction area, office and living area of construction personnel, construction area of water tunnel opening and 200m out of the construction area of the plant. The area of assessment area is about 0.5km². It will be assessed in construction period and operation period.

1.8 Target year of assessment

Target year for environment assessment in present situation of the project is 2005, target year of construction period prediction is construction peak year 2010 and target year of prediction and assessment of operation period is 2011.

1.9 Identification of environmental impact factors and selection of assessment factors

1.9.1 Identification of environmental impact factors

According to *Technical Guidelines for Environmental Impact Assessment-Water Conservancy and Hydropower Engineering* (HJ/T88-2003), *Technical Guidelines for Environmental Impact Assessment-Non- Polluted Ecological Impact* (HJ/T19-1997) and combined with functions, characteristics of the project as well as environmental characteristics of the impact area, environmental factors will be

identified in two aspects including natural environment and social environment (see Table 1-9).

Table 1-9 Identification of Environmental Impact Factors

Environmental factors	Selection results of assessment factors
Surface water	PH, dissolved oxygen, BOD ₅ , permanganate index, total phosphorus, total nitrogen
Ecological environment	Terrestrial plant, terrestrial animal, aquatic, zooplankton, bottom fauna, fishes, conservation of soil and water, soil erosion, land use, physical and chemical properties of soil
Conservation of soil and water	Soil erosion, land use, soil and water conservation facilities
Acoustic environment	Construction noise and traffic noise
Atmospheric circulation	Total suspended particulate matters, waste gas of fuel
Social economy	Energy utilization, resource utilization, local economy, public facilities, landscape cultural relic
Environmental geology	Stability and leakage of reservoir bank
Human health	Waterborne infection, natural focal disease, arthropod borne infectious diseases, endemic disease
Environmental risk	Construction arrangement, tunnel construction, oil pollution

1.9.2 Selection of assessment factors

The project has certain impact on the nature, biology and social environment, which are mainly presented by: the hydropower station applies the intake dam to cut off water, and then excavate diversion canal to the plant, so hydrological regime of Chongxi Brook will be changed partly, and it must influence the ecological factors in the upper and lower reaches of the intake dam, such as the flow from the lower reaches of cut river and intake dam to the power house is reduced. In construction, excavation, spoil and waste slag will influence the surrounding environment.

Through impact identification and combined with actual situation of the project, it determined that key points of environmental impact assessment are environmental impacts to water environment, ecological environment, water and soil conservation, construction and operation of the power station; local climate, environmental geology, mud and sand, land use, human health and social economy are general assessment factors.

Matrix of identification and selection of environmental impact assessment factors of Changyang Erchakou Hydropower Station is shown in Table 1-10.

Table 1-10 Identification and Selection of Environmental Impact Assessment Factors

Environment category	Environment factors	Construction period					Operation period		
		Earthwork excavation, filling and waste slag	Construction wastewater, dust and noise	Road reconstruction Noise	Stationing of construction personnel	Construction of hydraulic structure	Permanent and temporary land occupation of the project	Water reduction of watercourse under the dam	Generation of the power station
Geologic environment	Landform	√		√		√	√		
	Soil						√		
Climate	Local climate								
Water environment	Surface water							√	
Acoustic environment			√	√		√			
Ambient air	Waste gas and dust	√	√	√					
Ecological environment	Vegetation	√		√					
	Wild species	√		√					
	Aquatic							√	
	Soil erosion	√		√		√	√		
	Landscape ecosystem	√		√			√	√	
Social environment	Population density				√				

	Employment opportunities	√		√		√			
	Land occupation	√		√		√	√		
	Tax	√		√	√				√
	Electric quantity								√
	Human health				√				

Note: the items with “√” will be influenced.

1.10 Objective of environmental protection

Erchakou Hydropower Station will generate certain social efficiency and also will bring about adverse impacts to the environment; according to site survey results, construction of the project will directly influence State key-protected animals in the area, but sensitive objectives under ecological environmental protection that may be indirectly influenced by the project are also distributed around.

According to construction characteristics of the project, environmental protection objects and main objectives are determined as the following aspects:

(1) Surface water: according to *Surface Water Ambient Quality Standard* (GB3838-2002), the functions of water body of Neixi Brook, Liujia Brook and Daxigou shall be kept as original or excel than division objective of water environment functions, and the environment function of surface water will not be destroyed because of construction of the project. After the station is completed, it shall ensure that drinking water of three households in the lower reaches of Neixi Brook and irrigation of 35mu farmland will not be influenced; Liujia Brook Dam is located in the lower reaches of intake water of water supply project of Machi Town and no resident is living there; Daxigou only holds water in rainy season, residents

nearby Daxigou Intake Dam use surrounding spring for living, so water drinking of residents in the lower reaches and irrigation of farmland will not be influenced after completion of the station.

Table 1-11 Main Protection Objectives of Water Environment of the Project to be constructed

Project name	Protection objectives	Protection requirements
Surface water	0.5km river section above Neixi Brook, Liujia Brook and Daxigou dam site	<i>Surface Water Ambient Quality Standard</i> (GB3838-2002) Category II
	About 7.7km river section from the dam site to tail water outlet of the plant	<i>Surface Water Ambient Quality Standard</i> (GB3838-2002) Category II
	Water drinking of three households and irrigation of 35 mu farmland under Neixi Brook Intake Dam	Construction of the station has no influence on water drinking and irrigation of farmland

(2) Ambient air: ambient air quality in the assessment area; the project is located in suburban area and belongs to Category II of ambient air quality function area, so as to ensure ambient air quality in construction area and nearby traffic road inside and outside the site; avoid dust pollution on roads and make the air quality in construction area comply with the secondary standard of *Ambient Air Quality Standard* (GB3095-96).

(3) Acoustic environment: assess sensitive points of acoustic environment in residential area to make them comply with *Standard of Environmental Noise of Urban Area* (GB3096-93) Category I.

(4) Ecological resources: main protection objects are all animals and plants of the assessment area in *State Key Protected Wildlife List*. and *Name List of the Rare and Endangered Protection Plants in China* Keep the completeness and duration development of ecosystem of the project impact area and its impact area, so as to

minimize the influence arising from construction of the station towards biodiversity of the area

There are no state-level and provincial-level protection plants, old and famous trees in the assessment area of Erchakou Hydropower Station; there are ten kinds of state and provincial key-protected animals in the project area: *arctonyx collaris*, Chinese ferret-badger, *lepus capensis*, *trogopterus xanthipes*, red-rumped swallow, barn swallow, large-billed crow, spotted-necked dove, *zaocys dhumnades* and *R.nigromaculata*; there are no State protection fishes.

(5) Land resource: the project will permanently or temporarily requisite the land, so the land shall be used in a reasonable way and the cultivated land shall be protected according to related land use rules and local land use planning. Harness new soil erosion and control loss of original oil to make water and soil in the project area and impact area after treatment be up to or be kept as the level before construction.

(6) Human health: protect residents involved in the project and comply with prevention and control indexes of related diseases (including pandemic, endemic disease, epidemic) and public health indexes specified by health department of the State.

2. General situation of the Project

2.1 General situation of regional planning

Erchakou Hydropower Station planned to be constructed is located in Changyang Duzhenwan Town, it is a branch of Yaozhan Brook- one of cascade development projects of water energy of Chongxi Brook. Dam site of the project is 58km from Neixi Brook, Liujia Brook and Daxigou in the upper reaches of Zhongxi Brook, 58km from Zhuangxi Brook, 135km from Changyang Tujia Autonomous County and 195km from Yichang City; the power house is located in the upper reaches of Daxigou mouth, 48km from Zhuangxi Brook, 125km from Changyang Tujia Autonomous County and 185km from Yichang City, the traffic is not so convenient.

Yaozhan Brook catchment is located in the south of Changyang Tujia Autonomous County and is a main branch of Qingjiang River. Yaozhan Brook covers 128.6km², long-term average flow is 3.2m³/s, and long-term average runoff volume is 101 million m³. Theoretical reserves of water power of Yaozhan Brook is 15500kW, annual water power is 136 million kWh correspondingly. One reservoir and eight stations development plan will be applied for water power development of the trunk stream, i.e. Sifangdong Hydropower Station (constructed, 2×2500kW), Houziyan Hydropower Station (constructed, 2×40kW), Taizi Hydropower Station (2×125kW), Chengwuhe Hydropower Station (constructed, 2×75kW), Huilongguan Hydropower Station (constructed, 2×500kW), Xujia Reservoir (normal water level 437m, total reservoir capacity 2.1698 million m³) and reservoir power station (2×4000kW), Wangjiacao Hydropower Station (2×160kW), Erhekou Hydropower Station (2×175kW), installed gross capacity 15050kW. Level I development program will be applied for water power development of the branch Zhongxi Brook, i.e. Zhongxi Brook Hydropower Station (2×160kW), tail water enters the reservoir area of Xujiaping Hydropower Pivot Project. Three-station development program will be applied for water power development of the branch Chongxi Brook. That is to say,

Erchakou Hydropower Station (2×800kW), Xujiaping Hydropower Pivot Project (capacity increasing 800kW) and Chongxi Brook Hydropower Station (constructed, 2×125kW). Construct Xiangshuidong Hydropower Station by using Bazhangyan spring and flow of adjacent brooks (constructed, 500+250kW). Yichang Water Conservancy and Hydropower Bureau gave an official to the above planning in June 2005 by right of YSS [2005] No. 112 Document.

According to “the eleventh-five year” plan, power load of the whole county in 2012 will be up to 120MW, while the existing installed capacity in Changyang is only 76.3MW, the conflict in power shortage is outstanding increasingly. According to the socioeconomic development and present situation of power system, constructing several key power stations with adjustment function is necessary and pressing. Therefore, the People’s Government of Changyang Tujia Autonomous County decided to invite investment for constructing Erchakou Hydropower Station.

See Fig. 2 Planning Map for Development of Yaozhan Brook for its location.

2.2 Project name, geographical location and characteristics

Project name: Erchakou Hydropower Station of Changyang Tujia Autonomous County

Construction characteristics: new

Geographical location: Erchakou Hydropower Station, located in Duzhenwan Town of Changyang Tujia Autonomous County, is the first stage of hydropower cascade development of Chongxi Brook, the dam is located at Neixi Brook, Liujia Brook and Daxigou in the upper reaches of Chongxi Brook, 58km from Zhuangxi Brook, 135km from Changyang County and 195km from Yichang City; the power house is located

in the upper reaches of the mouth of Daxigou, 48km from Zhuangxi Brook, 125km from Changyang County and 185km from Yichang City. See Attached Fig. 1 for its location (Geographical Location of Hubei Changyang Erchakou Hydropower Station).

Total investment: total static investment of Erchakou Hydropower Station is RMB 14.1432 million, interest in construction period is RMB 621400, total estimate investment is RMB 14.7646 million and static investment per kilowatt is RMB 8840. The fund is composed of 30% capital and 70% bank loan.

2.3 Project task, scale and operation mode

2.3.1 Project development task

The construction of Erchakou Hydropower Station will improve the power supply quality of Duzhenwan Town greatly, assure power supply and promote socioeconomic development of Duzhenwan Town, according to the planning of national economy and social development, constructing Erchakou Hydropower Station is necessary and pressing. The construction of Erchakou Hydropower Station will greatly perfect the quality of power supply of Changyang power grid, assure power supply, adjust the electric quantity in season-of-use and promote socioeconomic development of Changyang. The Station is non-adjustment station, so the project mainly focuses on power generation.

2.3.2 Project scale

(1) Flood control

Intake dam of Erchakou Hydropower Station is only used for stopping water from flowing into the channel instead of flood control, so the flow of flood discharge in flooded area will not be limited. Design flood level and maximum flood level will be determined according to the operation of overflow dam. The intake dam is designed for flooding once per ten years, design peak discharge of Neixi Brook Dam is $64 \text{ m}^3/\text{s}$, design peak discharge of Liujia Brook Dam is $57 \text{ m}^3/\text{s}$ and design peak discharge of Daxigou Dam is $45 \text{ m}^3/\text{s}$; as designed for flood checkup once per 20 years, checkup peak discharge of Neixi Brook is $76 \text{ m}^3/\text{s}$, that of Liujia Brook Dam is $68 \text{ m}^3/\text{s}$ and Daxigou Dam is $54 \text{ m}^3/\text{s}$. The plant is designed for flooding once per 30 years, the peak flow is $195 \text{ m}^3/\text{s}$; as designed for flood checkup once per 50 years, the peak flow is $216 \text{ m}^3/\text{s}$.

(2) Normal water level and tail water level

Normal water level of the head pond of Erchakou Hydropower Station is the normal water level at the end of access tunnel, i.e. 728m; the level of tailwater is limited by the level of flood control of the plant, the normal tailwater level is 437m, according to project arrangement, installation elevation of the plant unit is 438.55m and the center elevation of the nozzle is 438m.

(3) Selection of installed capacity

Erchakou Hydropower Station is a run-of-river hydropower station acting as the base load in the system. After the station is putting into production, the requirements for industrial, agricultural production and living of the Town will be satisfied, surplus power will be connected to the grid in high water period; according to ***PRELIMINARY DESIGN REPORT OF ERCHAKOU HYDROPOWER STATION*** prepared by Yichang Qingjiang Water Conservancy and Hydropower Survey and Design Institute, installed capacity of Erchakou Hydropower Station had been economically evaluated. It is determined through comprehensive consideration that,

installed capacity of Erchakou Hydropower Station is 2×800kw, long-term average annual power output is 6.0449 million kWh, utilization hours in a year are 3778.

Warranted output is 205kW (P = 85%).

(4) Main quantities

See Table 2-1 for Quantities of Permanent Structures of Erchakou Hydropower Station in details.

Table 2-1 Quantities of Permanent Structures

No.	Location	Earthwork excavation (m ³)	Earthwork tunnel excavation (m ³)	Concrete (m ³)	Grouted rubble (m ³)	Face work (m ²)	Fabrication and installation of reinforced bar (t)	Building area (m ²)
I	Intake dam (3)	40		17.5	76	159	2	
1	Neixi Brook	12		4.5	20	40	0.5	
2	Liujia Brook	15		7	30	64	0.8	
3	Daxigou	13		6	26	55	0.7	
II	Diversion structure	4630	5088	464	930	5879	18.2	
1	Intake open channel	2168			930	3045		
2	Non-pressure tunnel	756	5036	280		2834	13.5	
3	Forebay		52	36			1.7	
4	Pressure pipeline	1706		148			3	
IV	Power house	528	120	110	155		4	115
V	Booster station	170		11				
Total		5368	5208	602.5	1161	6038	24.2	115

2.3.3 Operation mode

In general, operation mode of hydropower station actually is a water accumulation-generation-water abandoning process. It only utilizes the water power but not consume water; run-of-river power station nearly change the original spatiotemporal distribution of water resource, the tail water will be discharged into rivers after the flow drives hydraulic turbine for generation.

① Operation mode of non-adjustment hydropower station

It is a run-of-river power station; power discharge (Q_g) in different frequencies is 0.06-1.04m³/s after 5% water is lost according to water power calculation method for non-adjustment hydropower station as recommended in *Hydroenergy Design Code for Small Hydropower Projets* (SL76-94).

② Flood control and safety of flood prevention

Flood prevention is not necessary in the lower reaches of Erchakou Hydropower Station, in addition, intake dam of the station is only used for stopping water from flowing into channels instead of flood control and discharge flow in flood period is not limited, so there is no flood adjustment function. Therefore, the task for flood prevention of Erchakou Hydropower Station mainly is to ensure the safety of flood prevention of the Project and normal operation of the power station.

Erchakou Hydropower Station is a run-of-river station with 1600kW installed capacity; it is Class V project as defined according to Article 6.1.1 of *Flood Control Standard* (GB50201-94) of the People's Republic of China, corresponding hydraulic structure is Level 5 (including intake pivot, intake construction, power house and booster station). According to engineering level, related flood standard is shown as

follows: the intake dam is designed for flooding once per 10 years, design peak discharge of Neixi Brook Dam is $64 \text{ m}^3/\text{s}$, design peak discharge of Liujia Brook Dam is $57 \text{ m}^3/\text{s}$ and design peak discharge of Daxigou Dam is $45 \text{ m}^3/\text{s}$, as designed for flood checkup once per 20 years, checkup peak discharge of Neixi Brook is $76 \text{ m}^3/\text{s}$, that of Liujia Brook Dam is $68 \text{ m}^3/\text{s}$ and Daxigou Dam is $54 \text{ m}^3/\text{s}$, the plant is designed for flooding once per 30 years, the peak flow is $195 \text{ m}^3/\text{s}$; as designed for flood checkup once per 50 years, the peak flow is $216 \text{ m}^3/\text{s}$.

2.4 General layout and main structures of the Project

2.4.1 General layout

Erchakou Hydropower Station is a run-of-river station with 800kW installed capacity, its engineering level is V and the level of corresponding hydraulic structure is 5. Erchakou Hydropower Station is composed of intake dam, tunnel, head pond, pressure pipeline, power house and booster station. See Attached Fig.4 for General Layout of Erchakou Hydropower Station Project in details.

(1) Layout of intake project

Design intake flow of Neixi intake dam is $0.5 \text{ m}^3/\text{s}$. Bottom trash rack dam is applied, the riverbed at dam site is steeper, bedrock is exposed and elevation of the dam site is 730m. Elevation of trash rack dam is 731.56m and its length is 5m. Elevation of overflow dam top is 731.96m and the length of dam section is 10m.

Design intake flow of Liujia Brook intake dam is $0.3 \text{ m}^3/\text{s}$. Bottom trash rack dam is applied, the riverbed at dam site is steeper, bedrock is exposed and elevation of the dam site is 728m. Elevation of trash rack dam is 729.06m and its length is 5m. Elevation of overflow dam top is 729.46m and the length of dam section is 6m.

Design intake flow of Daxigou intake dam is $0.3\text{m}^3/\text{s}$. Bottom trash rack dam is applied, the riverbed at dam site is steeper, bedrock is exposed and elevation of the dam site is 731m. Elevation of trash rack dam is 732.56m and its length is 3m. Elevation of overflow dam top is 732.96m and the length of dam section is 6m.

See Attached Fig. 5 for Plan Layout of Dam Site of Erchakou Hydropower Station in details.

(2) Layout of diversion project

Diversion structures of Erchakou Hydropower Station are non-pressure tunnel, pressure head pond and pressure pipeline. General layout is shown as follows: introduce three water resources from the east and west to the pressure head pond, divide the canal system into east channel and west channel. The east channel intakes the water of Daxigou and the west channel intakes the water of Neixi Brook Dam and Liujia Brook Dam, and then flow together into the pressure head pond at Niejia Dam, the pressure pipeline is connected to the power house from top to bottom of the mountain.

(3) Layout of plant area

The plant area of Erchakou Hydropower Station is mainly composed of the power house, booster station and access road. There are rock tangential slope or obsequent slope in the plant area, integrated stability of slope is better, however, escarps are distributed in the area with quartz sandstone and limestone exposed because of different rock lithology of the slope, vertical relief joints are grown on the rock body because of weathering and gravity, so it may collapse.

The plant area is located on the right bank of Chongxi Brook with ground power house. According to GB50201-94, the power house is Level V building, flood standard of which is designed once per 30 years and checked once per 50 years.

See Attached Fig. 6 Plan Layout of Power House of Erchakou Hydropower Station in details.

2.4.2 Main structures

Erchakou Hydropower Station is a run-of-river station with 1600KW installed capacity, it is Class V project as defined according to Article 6.1.1 of **FLOOD CONTROL STANDARD** (GB50201-94) of the People's Republic of China, corresponding hydraulic structure is Level 5 (including intake pivot, intake construction, power house and booster station). According to engineering level, related flood standard is shown as follows: the intake dam is designed for flooding once per 10 years, as for flood checkup once per 20 years, the power house and booster station are designed for flooding once per 30 years and flood checkup once per 50 years. .

(1) Intake pivot

The intake pivot is mainly composed of three structures: bottom trash rack dam, sand conveying channel and sand basin.

Bottom trash rack dam:

① The length of the bottom trash rack dam of Neixi Brook is 15m, in which the length of overflow dam section at the right bank takes up 10m, elevation at the dam top is 731.96m, the length of trash rack dam section at the left bank is 5m, elevation at the dam top is 731.56m. The height of overflow dam is 2.63m and broken-line practical weir of grouted rubble structure is applied. $D=0.2\text{m}$ pipelines are buried in the overflow dam to ventilate the passage, the pipeline entrance is arranged at the left bank, elevation of the orifice is 734.40m, which is 0.27m higher than the maximum flood level of the dam.

② The length of the bottom trash rack dam of Liujia Brook is 6m, in which the length of overflow dam section at the right bank takes up 1m, elevation at the dam top is 729.46m, the length of trash rack dam section at the left bank is 5m, elevation at the dam top is 729.06m. The height of overflow dam is 3.09m and broken-line practical weir of grouted rubble structure is applied. $D=0.2\text{m}$ pipelines are buried in the overflow dam to ventilate the passage, the pipeline entrance is arranged at the left bank, elevation of the orifice is 732.20m, which is 0.27m higher than the maximum flood level of the dam.

③ The length of intake dam of the bottom trash rack dam of Daxi Brook is 9m, in which the length of overflow dam section at the right bank takes up 6m, elevation at the dam top is 732.96m; the length of trash rack dam section at the left bank is 3m, elevation at the dam top is 732.56m. The height of overflow dam is 3.32m and broken-line practical weir of grouted rubble structure is applied. $D=0.2\text{m}$ pipelines are buried in the overflow dam to ventilate the passage, the pipeline entrance is arranged at the left bank, elevation of the orifice is 735.60m, which is 0.22m higher than the maximum flood level of the dam.

Sand conveying channel: it is 10m connecting the bottom trash rack dam at the top and the sand basin at the bottom. Angle of the channel head is 90° , radius of curvature is 3.0m, width of the channel is 1m, design longitudinal grade is $1/5$, so it can be used for sand conveying and water diversion.

Sand basin: because that the power station is of smaller scale, sand flushing by stopping the machine has less influence on the power grid, so a basin for intermittent sand flushing is applied for the Project, the mode that discharging sand in positive direction and intaking at the side is applied, 5m overflow weir with check gate is set at the end of sand basin. Type of sluice gate is PGZ0.8 \times 0.8 and type of head stock gear is LQ-3. Width, depth and length of the sand flushing channel are 0.8m, 0.8m and 6m respectively, longitudinal grade at the bottom $i=1/50$.

(2) Diversion structure

Diversion structure is composed of open channel, tunnel, pressure head pond and pressure pipeline.

Open channel applies rectangular water-carrying section, the open channel applies grouted rubble coating structure, and comprehensive roughness coefficient is 0.015. The smallest construction section of tunnel is applied for water-carrying section with 1.6m width, 1.8m height and 0.46m arrow height.

Pressure head pond: a diffuser is set in the front chamber with 10.75m length and 1.5m width, elevation at the head end is 726.90m and at the bottom is 724.75m, bottom slope 1:5. A sand basin is set at the end with 4.0m length and 1.5m width, the elevation of base plate is 0.5m lower than the access base plate, $\Phi 300$ sand flushing pipe is arranged at the bottom controlled by $\Phi 300$ gate valve. Width of the side wall top is 0.6m, bottom width is 2.5m, which is lined by M7.5 grouted rubble. The base plate is casted with 0.2m thick C20 (2) concrete. The pressure wall is at the end of inlet chamber with trash rack, gate, hoist and air holes. Height of the pressure wall top is 729.36m, bottom height is 723m, top width is 1.5m, bottom width is 3.0m, which is lined with M7.5 grouted rubble and C20 concrete; the pipe is concreted for 0.2m outside. The inlet of pressure pipeline is made as a horn with 0.5m length and 0.8×0.65 m section, the top and both sides are arcual $R=0.87$ m. A vent duct is set behind the horn mouth, $\Phi=125$ mm. A transition section is set behind the vent duct with 0.5m length, which transiting a rectangle (0.5×0.5) into a circle ($\Phi 0.5$ m). The transition section connects elbow of the pressure pipeline at the end. The end of elbow is connected with the straight section of reinforced concrete pressure pipeline, and the minimum burial depth of the straight section in the pressure wall is not less than 0.5m. A trash rack is set in the inlet chamber, which is made of 50×10 mm bar steel with 4.4m length, spacing of bars is 14mm, the trash rack has 7 beams, angle of inclination is 70° , flow crossing the rack is 0.7m/s, which is

convenient for decontamination artificially. A PGZ1×0.8m gate is set at the inlet of pressure pipeline and the type of hoist is LQ-5.

Pressure steel pipe: it is 497.29m, inner diameter of the main pipe is 500mm, according to *Design Specification for Pressure Steel Pipe of Hydropower Stations* (SL281-2003), so the wall thickness shall be 8&10&12mm after taking account of 2mm rust allowance.

(3) Power house and switch station

The plant area is mainly composed of main and secondary power houses, booster station and flood wall.

The power house is intake-type ground house and the installed capacity of the station is 2×800KW. Two sets of 800KW impulse-type horizontal-shaft units are installed in the plant, type of the water turbine is CJA237-W-90/1×8.5 and type of the generator is SFW800-8/1180; type of speed regulator is YWT-600; size of the gate valve isΦ400 and type is Z941H-4.0-Φ400, they are low-pressure units, so no secondary power house is set. Size of the power house is 18.2m×10m.

Two 1000KVA transformer is installed in the booster station, the size of which is 13m×11m.

(4) Auxiliary project

① Hydraulic machinery and electricity

Installed gross capacity of Erchakou Hydropower Station is 1600KW, two sets of Type CJA237-W-90/1×8.5 turbines shall be installed with 800KW unit capacity, long-term average annual power output is 6.0449 million kWh and annual utilization hours are 3778. Warranted output is 205kW. Block connection is applied for two

generators of the station to transfer 10kV voltage class to farming network after upgrading from 0.4kV. Two sets of SFW800-8/1180 generators are applied with only one output loop. Two set of S₉-1000/10 transformer is applied. In order to prevent outdoor power equipment from lightning strike, one 25m individual lightning arrester is set in the west of booster station.

② Metal structure

Bottom trash rack dam is applied for Erchakou Hydropower Station, ladder type structure is applied for bottom rack, spacing of rack is 1cm, total weight of the three racks is 4.96t, the rack is fabricated in factory and installed on the site. A sand basin is set behind the bottom trash rack dam, one Type PGZ0.8×0.8m sluice gate is set at the three racks respectively equipped with Type LQ-3 screw hoist.

One trash rack and one emergency gate are set in the inlet chamber of pressure head pond. The trash rack is made of 50x8mm flat steel and 56x56x8mm angle steel and made into three 1700mmx800mm grid plates, total weight of which is 1.0t. The emergency gate is PGZ1.0×0.8m cast iron gate equipped with LQ-5 hoist.

Length of the pressure steel pipe from the inlet chamber of head pond to the center of bifurcated pipe is 497.29m and pipe diameter is 500mm; the length from the center of bifurcated pipe to 1# machine is 12.2m, to 2# machine is 8.3m, pipe diameter is 400 mm. One Y-type crescent-rib bifurcated pipe and four expansion joints are equipped, total weight of which is 68t.

③ Fire control

Fire rating of plant buildings is Category D Class II, two exits are set as required by fire break and safe evacuation. Width of the main passage: width of stairs shall be more than 1.2m, net width of evacuation gate shall be more than 0.9m, the gate shall

be opened in evacuation direction. Dry chemical fire extinguishers shall be applied for excitation transformer and power plant transformer. One hydrant shall be set in the main house and outdoor booster station respectively, eight portable type foam extinguisher and dry powder fire extinguishers shall be equipped. Oil storage pit shall be set for transformer of the booster station.

2.5 Construction arrangement and progress

2.5.1 Construction conditions

(1) Traffic out of the site

Erchakou Hydropower Station is located in Duzhenwan Town of Changyang, the project area is 135km from the County, the power house is 2km from the country road, intake dam and tunnel opening are within 1km from the country road, so the traffic is not so convenient.

(2) Traffic on the site

The traffic mainly depends on highway, the project area is 135km from Changyang Tujia Autonomous County and the power house is nearby the country road. But the intake dam and tunnel opening are far away from the country road, so 2km access road shall be constructed.

(3) Water and power supply for construction

Because that the project is of smaller scale and hydraulic structures are disperse, Erchakou Hydropower Station is mainly constructed by machineries assisted by manual work.

Water for intake dam construction is taken from brooks and other structures are

supplied by water pumps.

Power load for construction is the greatest in foundation backfill period of the power house because concrete mix, mortar mix and water pumping are going hand in hand, so the maximum load is 200kVA, voltage is 220/380V, the power supply is provided by the local power grid in the countryside.

(4) Conditions for project arrangement

The project covers a larger area and buildings are relatively dispersed, so construction enterprises shall be arranged dispersedly according to actual landform. Construction camps shall be arranged on the construction site based on local conditions, sandstone aggregate system, concrete mix system and AC station shall be arranged as near as possible, standard products of sheet steel forms and steel structures for the Project shall be provided and processed by designated manufacturers, only repair and maintenance places are planned on the site.

Construction period of the project is short, so villagers' houses will be rented and temporary construction camps will be erected nearby instead of constructing new living houses for construction teams, so as to reduce land requisition and temporary construction cost.

(5) Construction material

① Cement: about 960t cement is required for the project in total, which will be purchased in Yuyanguan Cement Plant, the product quality and quantity are available for the project.

② Steel products: fewer steel products will be used in construction, so they can be supplied by material department of the County or purchased by the Owner.

③ Timber: forest resource at the site is rich, so timbers can be purchased and processed on the site.

④ Supply of explosives, oil material and power: blasting agent, detonator and igniter fuse for the project are supplied by chemical construction company of the County or local public security institute; related rules shall be obeyed for storage and delivery of explosives.

Little petroleum is required for construction; diesel oil is mainly used by construction machineries, so oil material can be purchased by the construction unit for storage.

Power supply: 10kV farming network line is in the construction area, which can satisfy the requirement of power use for construction. Intake dam of Neixi Brook is equipped with one 50kVA transformer, intake dam of Liujia Brook is equipped with one 50kVA transformer, and the power house is equipped with one 100kVA transformer.

2.5.2 Natural construction material

There are natural sandy pebbles in Yaozhan Brook, the quality of sandstone can meet the requirements for construction. Sandstone crushed by excavate materials in tunnel can be used for liner construction of head pond and tunnel, so as to save transportation cost.

Few block stones are used in construction, so it is proper to exploit as near as possible. Type 100 downhole drill is applied for pore creating, bench squeeze blasting is applied, big stones are drilled by portable pneumatic drill after blasting, and then transported to the site for laying by loader after shallow hole blasting.

2.5.3 Construction diversion

(1) Diversion standard

In accordance with *CODE FOR CONSTRUCTION DESIGN OF WATER CONSERVANCY AND HYDROPOWER PROJECT* (SL303-2004), it is Class V project, and diversion structure is Level 5 correspondingly. As designed that diversion structure encounters flood once per 5 years, in November of the first year of dry season to next March, flood flow of Neixi Brook dam is $8.3\text{m}^3/\text{s}$, of Liujia Brook is $7.7\text{m}^3/\text{s}$ and of Daxigou is $6.3\text{m}^3/\text{s}$.

Quantities of the dam body are less and the project can be completed within dry season, so flood handling during construction is not taken into account.

(2) Diversion mode

The intake dams take water at low dam and they are of grouted rubble structure, so pipe culvert diversion is applied.

(3) Water drainage in construction

Bedrock at intake dam is exposed and the low dam is directly constructed on it, so drainage of foundation pit is not necessary.

Level of the power house and tailwater are higher than the low water, so there is no need to drain water.

2.5.4 Construction of main works

(1) Intake project

Intake project covers bottom trash rack, inlet regulating sluice. Regular method and technology are applied for construction.

As for construction of dam body, air pick is applied for clearing the foundation, grouted rubbles are laid manually, 40L mobile mixer is applied for mixing concrete on the site and insert-type vibrating rod is applied for vibration. Racks are fabricated and installed on the site by factory.

(2) Diversion canal system

There are 4 diversion tunnels, 3[#] tunnel is the longest and the construction is the most difficult, tunneling for 550m in one side is essential for the project.

Tunnel excavation: air-leg pneumatic drill is applied for pore creating, the tunnel is driven in the whole section and smooth blasting is applied, hole defect rate is more than 80%, slag is loaded manually and transported by tricycle; there is no turnout lane in the tunnel to save excavation investment. Reversible axial flow fan is applied for ventilation of the tunnel, which is placed at 20m of tunnel face to ensure sufficient air of the work face, so as to ensure safety, the power for construction is supplied by transformer at each construction point, safety management of power use in construction shall be strengthened.

Concrete works of tunnel: it mainly covers lock concrete of each opening and liner of unfavorable geologic section, regular construction method is applied, concrete is mixed by mobile mixer set at the opening, transported manually, and then vibrated by vibrating rod, 100×1500×55mm steel forms are selected and assembled on the site, grout pipe is pre-embedded when placing concrete in convenience for backfill grouting. Concrete at the tunnel bottom is 0.1m thick, vibrated outside the tunnel, transported by tricycle, laid artificially, compacted by plate vibrator and then smoothed manually.

Motor spraying: concrete sprayer is applied according to design average spraying thickness 50mm.

Face work: artificially.

(3) Construction of head pond

Excavation of head pond: excavation is done inside and outside the tunnel, the outside first, the inside later; tunnel construction method is applied for excavation inside the tunnel, portable pneumatic drill is applied for pore creating in excavation outside the tunnel; regular blasting and deslag are done artificially assisted by tricycle for transportation.

Concrete works: 0.8m³ forced mixer is applied for concrete mixing, the concrete is conveyed and pumped into the hopper, and then vibrated with vibrating rod; 1500×150×55mm steel forms are selected and assembled on the site, reinforced bars are fabricated and installed artificially.

(4) Pressure pipeline

The pressure pipeline, because of less excavation, so portable pneumatic drill is properly used for pore creating by hand; regular blasting is applied, stone slag is conveyed to the power house and then transported to waste disposal area by vehicles.

Concrete construction: it is the same to that of the head pond, 1500×100×55mm steel forms are used for assembly, reinforced bars are fabricated and installed artificially.

(5) Power house, booster station

80 downhole drill is used for pore creating in excavation of booster station in the power house, pre-splitting blasting is applied to obtain a smooth slope; hoe excavator

or loader is applied for loading and vehicles are employed for transporting to the waste disposal area.

2.5.5 General arrangement of construction

The project covers a larger area and buildings are relatively dispersed, so construction enterprises shall be arranged dispersedly according to actual landform. Construction camps shall be arranged on the construction site based on local conditions; sandstone aggregate system, concrete mix system and AC station shall be arranged as near as possible, standard products of sheet steel forms and steel structures for the Project shall be provided and processed by designated manufacturers, only repair and maintenance places are planned on the site.

Construction period of the project is short, so villagers' houses will be rented and temporary construction camps will be erected nearby instead of constructing new living houses for construction teams, so as to reduce land requisition and temporary construction cost. See Attached Fig.

(1) Reinforced concrete system

The project is of small scale and construction is dispersed, so it is not proper to collectively arrange construction plants; according to construction arrangement, reinforced bar processing plant of intake pivot is placed at the temporary camp of the dam area. Reinforced bar processing of tunnel, head pond and plants are placed in construction camps in the plant area, so as to satisfy construction requirements and reduce difficulty in finished products transportation.

(2) Waste disposal area

Waste soil, stone and slag are mainly originated from foundation excavation of main

works and surplus soil and stones in slope cutting which cannot be used. Earthwork excavation of the project is 4800 m³, rock excavation is 9900 m³. In the light of “trying to use in a reasonable way if possible”, concrete aggregate is artificial aggregate, 1800m³ can be used for the project, total natural volume of waste soil is 12900m³, converted loose volume is 18700m³, converted solid volume is 14700m³ (volume density 29000 t).

A lot of waste slag will be generated in construction, which may destroy the surface plants, cause soil erosion, influence and even destroy natural landscape if they are not treated reasonably. Therefore, four waste disposal areas are set along the construction line according to general arrangement of the project and actual landform of the project area, 1[#] waste disposal area, located at 50m in the lower reaches of intake dam of Neixi Brook, is used for piling waste slag from excavation of Neixi Brook intake dam and operation face of 1[#] non-pressure tunnel entrance; 2[#] waste disposal area, located about 40m under 1[#] tunnel exit and 2[#] tunnel entrance, is mainly used for piling waste slag from excavation of Liujia Brook intake dam, operation faces of 1[#] non-pressure tunnel exit and 2[#] non-pressure tunnel entrance; 3[#] waste disposal area, located on the right of the power house, is mainly used for piling waste slag from excavation of operation face of 2[#] non-pressure tunnel exit, pressure head pond, pressure pipeline and plant area; 4[#] waste disposal area, located at 30m in the lower reaches of Daxigou intake dam, is mainly used for piling waste slag from excavation of Daxigou intake dam and 1[#] open channel.

Volume of waste slag and retain measures in each waste disposal area are shown in the following Table 2-2.

Table 2-2 Quantities of Waste Slag distributed in Waste Disposal Area

Designation	Origin	Location	Capacity of waste disposal area (m ³)	Actual capacity (m ³)	Area (hm ²)

1 [#] Waste disposal area	Excavation of Neixi Brook intake dam and operation face of 1 [#] non-pressure tunnel entrance	Located at the slope 500m in the lower reaches of Neixi Brook intake dam	3500	3100	0.04
2 [#] Waste disposal area	Excavation of Liujia Brook intake dam, operation faces of 1 [#] non-pressure tunnel exit and 2 [#] non-pressure tunnel entrance	40m About 40m under 1 [#] tunnel exit and 2 [#] tunnel entrance	5500	5000	0.03
3 [#] Waste disposal area	Excavation of operation face of 2 [#] non-pressure tunnel exit, pressure head pond, pressure pipeline and plant area.	On the right of power house	8000	7300	0.08
4 [#] Waste disposal area	Excavation of Daxigou intake dam and 1 [#] open channel	At the slope 300m in the lower reaches of Daxigou intake dam	4000	3300	0.03
Total			19700	18700	0.19

2.5.6 Construction progress

Erchakou Hydropower Station was commenced for construction in April 2009 and completed in March 2011; the construction period was two years.

Construction period of Erchakou Hydropower Station is divided into organization period, preparation period and construction period of main works. At completion of each individual project, construction machineries would be taken away, the site would be cleaned and the environment would be protected, no completion period was planned.

October 2008-March 2009 is organization period of the project, which is mainly for

completing engineering, land expropriation and compensation, selecting construction units, concluding construction contract, lend-lease contract for construction house and promoting application report.

April 2009 is preparation period of the project, which is mainly for completing communication facilities on the site, erecting power line for construction, installing transmitting line, transformer and water facilities to tunnels, so as to ensure official commencement in May 2009.

May 2009-February 2011 is construction period of main works, which is for completing intake dam, inlet channel, head pond, pressure pipeline, power house, booster station and transmitting line, so as to put it into production and operation in March 2011.

2.6 Flooding, land occupation and immigration problem

2.6.1 Flooding and immigration

Erchakou Hydropower Station is a diversion station, the intake dam is a bottom trash rack dam, elevation of the dam top is flush with the riverbed and no reservoir is flooded. Diversion area and power house both occupy wasteland, river beach, hillside woods and grassland, so no immigration is involved. Therefore, flooding and immigration problems will not be described in the Report.

Land occupation of the project mainly is temporary occupation for construction and permanent occupation of structures, totaling 2.32hm² surface area is disturbed, in which permanent structures take up 0.67hm² and temporary structures take up 1.65hm²; we surveyed that the occupied land mainly is river beach and few cultivated

land, which are not basic farmland.

Land occupation of the project mainly is temporary occupation and permanent occupation of structures. See Table 2-3 for details.

Table 2-3 Statistics of Land Occupation of Main Structures

No	Item	Temporary land occupation (hm ²)				Permanent land occupation (hm ²)				Remarks
		River beach	Firewood forest	Barren hill	Cultivated land	River beach	Firewood forest	Barren hill	Cultivated land	
	Total	0.05	0.10	0.24	0.03	0.02	0.14	0.25	0.03	
1	Intake dam (3 places)	0.02		0.02		0.02		0.02		
2	Diversion open channel		0.03		0.03		0.07		0.03	
3	Tunnel			0.02				0.02		
4	Head pond pipeline		0.07				0.07			
5	Power house and booster station			0.03				0.07		
6	Access road							0.07		
7	Waste disposal area	0.03		0.17						
8	Employees' dorm							0.07		

2.7 Engineering management

Erchakou Hydropower Station is the first stage of cascade development of Chongxi Brook, which is composed of intake dam, diversion channel system, pressure pipeline, power house and booster station, project level is V.

In convenience for development and construction of Erchakou Hydropower Station, Project Manager Department of Erchakou Hydropower Station will be established as planned. Manager responsibility system is implemented for the Department taking charge of design examination in the first stage, construction financing, bidding and procurement and operation management. It sets up an office, planning & financial department and engineering department with 4 establishment strength including one project manager, one person of the planning & financial department and two persons of the engineering department.

Personnel quota standard of Erchakou Hydropower Station refers to related rules combined with actual situation of the project, in the light of principles that unmanned on duty, high intelligence and high efficiency as well as satisfying the requirements for operation and engineering management of the station, five management personnel will be appointed including one station master and four operation personnel during operation period of the project, no accountant will be appointed and the account will be managed by the Company.

2.8 Project characteristics, investment and economic index

Main structures, amount of works, main technical and economic indexes of Erchakou

Hydropower Station are shown in Table 2-4.

Table 2-4 Characteristics of Erchakou Hydropower Station Project

No. and designation	Unit	Qty.	Remarks
I. Hydrology			
1. Catchment area			
Whole catchment	km ²	128.60	
Above the dam site	km ²	20.3	
2. Service life of using hydro-sequence (index station)			
	Year	43	
3. Long-term average runoff volume of the catchment			
	m ³ One hundred million m ³	1.01	
Long-term average flow of the catchment	m ³ /s	3.2	
Long-term average flow at the dam site	m ³ /s	0.51	
Long-term average runoff at the dam site	One hundred million m ³	0.16	
Design flood discharge (P=3.3%)	m ³ /s	195	Plant site
Check flood discharge (P=2%)	m ³ /s	216	Plant site
4. Long-term average sediment concentration			
	kg/ m ³	0.22	
II. Power benefit index			
Installed capacity	Kw	1600	
Warranted output (P=85%)	Kw	205	
Long-term average annual power output	Ten thousand kwh	604.49	
Utilization hours in a year	h	3778	
III. Permanent land occupation			
Overflow land	h m ²	0.02	
Firewood forest	h m ²	0.13	

Barren hill	h m ²	0.25	
Cultivated land	h m ²	0.03	
IV. Main structures and equipment			
1. Water retaining structure			
Type		Bottom trash rack dam	
Seismic basic intensity/ seismic fortification intensity	Degree	VI / VI	
Elevation of Neixi Brook dam top	m	731.96	
Length of Neixi Brook	m	15	
Elevation of Liujia Brook dam top	m	729.46	
Length of Liujia Brook	m	11	
Elevation of Daxigou dam top		732.96	
Length of Daxigou dam	m	9	
Full length of sand basin	m	10	
Type of sluice gate	Set	3	PGZ0.8×0.8
Type of hoist	Set	3	LQ-3
2. Diversion structure			
Design diversion flow	m ³ /s	0.8	
Open channel	m	2430	
tunnel	m	2795.85	
Mode of pressure pipeline		Joint water supply	
Length of main pipe	m	497.29	
Inner diameter of main pipe	m	0.5	
Mode of bifurcated pipe		Y-type pipe	
3. Power house			
Mode		Ground-type power house	
Size of main power house (LxWxH)	m	18.2×10×12.32	
Installation elevation of turbine	m	438.55	
4. Booster station			
Mode		Ground-type	

Area	m ²	13×11	
5. Main electromechanical devices			
A. Type of turbine		CJA237-W-90 / 1×8.5	
Qty.	Set	2	
Rated output	KW	860	
Rated speed	r / min	750	
Rated flow	m ³	0.73	
Rated head	m	284.65	
Runaway speed	r / min	1312	
B. Type of generator		SFW800-8/1180	
Qty.	Set	2	
Rated power	kw	800	
Rated voltage	v	400	
Rated power factor	cosΦ	0.8	
Rated current	A	1443.4	
C. Transformer	Set	2	
Type		S9-1000 / 10.5	
Rated capacity	KVA	1000	
Voltage ratio	KV	10.5±2×2.5% / 0.4KV	
D. Type of intake valve		Z941H-4.0-400	
Diameter	m	0.4	
6. Transmitting line			
Voltage	KV	10	
Loop	Loop	1	
Power transmission distance	km	1	

V. Construction			
1. Main quantities			
Earth excavation	m ³	3180	3180
Rock excavation	m ³	16940	16940
Grouted rubble	m ³	1393	1393
Concrete	m ³	2232	2232
Plastering	m ²	618	618
Fabrication and installation of reinforced bar	t	40	40
Metal structure	t	80	80
2. Main construction materials			
Cement	t	960	
Reinforced bar	t	40	
Blasting agent	t	80	
Detonator	发 Each	15000	
Igniter fuse	m	30000	
Gasoline	t	1	
Diesel oil	t	9	
Block stone	m ³	876	
Crushed stone	m ³	1950	
Sand	m ³	1650	
3. Labor	Ten thousand workday	3.33	
4. Outgoing highway distance	Km	135	To the County
5. Construction period	Month	12	
VI. Economic index			
1. Total static investment	Ten thousand yuan	1414.32	
2. Total investment	Ten thousand yuan	1476.46	
Constructional engineering	Ten thousand yuan	726.92	
Electromechanical devices and installation	Ten thousand yuan	190.06	
Metal structure equipment	Ten thousand	91.50	

and installation	yuan		
Temporary works	Ten thousand yuan	55.57	
Other cost	Ten thousand yuan	215.21	
Investment to soil and water conservation	Ten thousand yuan	30.00	
Investment to environmental protection	Ten thousand yuan	25.00	
3. Main economic index			
Investment per kW	Yuan/kW	8840	
Investment per kWh	Yuan/kWh	2.34	
Generation cost	Yuan/kWh	0.05	
Economic internal rate of return (EIRR)	%	8.71>8	
Economic net present value (ENPV)	RMB ten thousand	75>0	
Economic benefit cost ratio (EBCR)		1.05>1	
Financial internal rate of return (FIRR)	%	8.93>7	
Financial net present value (FNPV)	RMB ten thousand	220.84>0	
Backward reasoning price	Yuan/kwh	9.53<10	RMB/kwh
Loan repayment period	a	11.3	

3. Engineering analysis

3.1 Coordination analysis of project and related plans

3.1.1 Conformance analysis of industrial policy

As a clean energy utilization project, the Project is one of the industries encouraged for development, allowed for investment and promotion by the State instead of that must be restricted for development, forbidden for investment and rejected for construction. Erchakou Hydropower Station can provide cheap, clean and regenerable energy for Changyang Tujia Autonomous County, which is of obvious economic and environmental benefits. In construction of the Project, technical starting point will be improved, different effective measures will be applied, natural resources will be used reasonably, environmental pollution and ecological damage will be prevented to comply with environmental protection policies of the State.

3.1.2 Conformance analysis of planning

1. Conformance analysis of catchment planning

Erchakou Hydropower Station to be constructed, located in the upper reaches of Chongxi River, is the first stage of cascade development of water energy of Chongxi Brook, the water will be taken from Neixi Brook, Liujia Brook and Daxigou, and the power house will be constructed at the mouth of Daxigou.

The first stage development planning of water power of Yaozhan Brook catchment is shown as follows:

(1) One reservoir eight stations development program will be applied for water power development of the trunk stream, i.e. Sifangdong Hydropower Station (constructed, 2×2500kW), Houziyan Hydropower Station (constructed, 2×40kW), Taizi Hydropower

Station (2×125kW), Chengwuhe Hydropower Station (constructed, 2×75kW), Huilongguan Hydropower Station (constructed, 2×500kW), Xujiaping Reservoir (normal water level 437m, total reservoir capacity 2.1698 million m³) and reservoir power station (2×4000kW), Wangjiacao Hydropower Station (2×160kW), Erhekou Hydropower Station (2×125kW), installed gross capacity 15050kW.

(2) Level I development program will be applied for water power development of the branch Zhongxi Brook, i.e. Zhongxi Brook Hydropower Station will be constructed. Tail water and intermediate inflow of Sifangdong Hydropower Station will be used, installed capacity is 2×160kW, the tail water enters the reservoir area of Xujiaping Hydropower Pivot Project.

(3) Three-station development program will be applied for water power development of the branch Chongxi Brook. That is to say, water will be taken from Daxigou, Liujia Brook and Neixi Brook, and then diverted to Erchakou for constructing the hydropower station with installed capacity 2×800kW. Tail water and intermediate inflow of Erchakou Hydropower Station will be diverted to pressure adjustment room of Xujiaping hydropower pivot project to increase the capacity to 1600KW. The water will be taken at Sujiazui dam, and then diverted to Xujiaping for constructing Chongxi Brook Hydropower Station (constructed) with installed capacity 2×125kW.

(4) Construct Xiangshuidong Hydropower Station (constructed) by using Bazhangyan spring and the water flow of adjacent brooks with installed capacity 500+250kW.

Yichang Water Conservancy and Hydropower Bureau gave an official to the above planning in June 2005 by right of YSS [2005] No. 112 Document. Therefore, construction of the Project complies with water resource planning of the catchment.

2. “The tenth-five year” plan of national economy development

Changyang enjoys towering and upright mountains, pretty landscape, moderate

climate and rich rain, so it is rich in resources of water, forest, tourist and minerals. In order to quickly transfer resources superiority into economic superiority, Changyang Tujia Autonomous County Committee and the People's Government promoted the "four-county" strategic objective, i.e. "great hydropower county", "powerful forestry county", "famous tea county" and "outstanding tourist county". According to "the eleventh-five year" planning, power utilization load of the whole county in 2012 will be up to 120MW, while the existing installed capacity of Changyang is only 76.3MW, power shortage conflict is obvious day by day. On the basis of social, economic development and present situation of power system, constructing several key power stations with adjustment functions is essential and pressing. Therefore, the energy structure must be adjusted to vigorously develop the rich water resource of the County. Erchakou Hydropower Station satisfies the planning requirements.

3. Power development planning of Changyang Tujia Autonomous County

With the gradually realization of "the tenth-five year plan", power utilization load of the whole county in 2005 will be 97.4 MW, while the existing installed capacity of Changyang is only 76.3 MW, the power shortage conflict is obvious day by day and the season-of-use conflict is obvious. With the development of industry and agriculture especially the high-speed development of industry and development of living level of the people, the demand of power use and power supply quality will be greater, power utilization load of the whole county in 2012 will be up to 120 MW, power shortage conflict becomes more obvious. On the basis of social economic development and present situation of power system, constructing several key power stations with adjustment functions is essential and pressing. The construction of Erchakou Hydropower Station will greatly improve the power supply quality of Changyang Power Grid, improve the assurance of power supply, adjust season-of-use electric quantity and promote the development of social economy of Changyang, Erchakou Hydropower Station Project satisfies the planning requirement.

4. The tenth-five year plan for environmental protection of Changyang Tujia Autonomous County

In accordance with *The Tenth-Five Year Plan for Environmental Protection and 2015 Long-Term Planning of Changyang Tujia Autonomous County*, the whole county will further develop resources in mountains, perfect ecological environment of countryside, so as to realize sustainable development, improve the proportion of clean energy, reduce cutting of forest resource and stop air pollution.

Changyang Tujia Autonomous County possesses plentiful water resources, Erchakou Hydropower Station can sufficiently use the resource to provide cheap, clean and regenerable energy, which is of sustainable availability and will not discharge pollutants in production. In addition, it also can substitute thermal power generation and will not damage forest resources; the station can solve the problem on power supply of Gaoqiao Township, reduce coal use and air pollution arising from it after being put into production. Therefore, the construction of Erchakou Hydropower Station satisfies environmental protection planning of Changyang Tujia Autonomous County.

However, in the light of “the party who develops shall protect and the party who destroys shall recover” policies for resource development, ecological impact demonstration and environmental impact assessment shall be done for hydropower development and project construction, earth backing for farming and foresting shall be implemented to prevent soil erosion.

3.2 Engineering analysis in construction period

3.2.1 Brief introduction to project construction

Erchakou Hydropower Station is a run-of-river plant taking water from three rivers, the dam sites are located at Neixi Brook, Liujia Brook and Daxigou, the plant area is

at the right bank of Chongxi Brook, it is a ground-type plant. It is a Class V small (II) type project. Main and secondary structures are Level 5, permanent structures mainly include river dam, intake tunnel, pressure pipeline, ground-type power house and switch station. Construction area of the project is 1.03hm², mechanical construction and artificial operation will be combined for construction, construction machineries mainly are pneumatic drill, excavator, vibratory roller and dump truck.

Land occupation of temporary structures of the project includes temporary land occupation and waste disposal area taking up 0.43hm² in total, in which the waste disposal area takes up 0.20hm² and temporary land occupation for construction takes up 0.23hm². Construction of the Project will last for 24 months, the number of construction personnel at the peak hour is 85 and average daily labor number is 56.

According to construction of the main works, total volume of earth and rock excavation is 14700m³, in which: open excavation of earthwork 4700m³, rock excavation 9900m³; use 1800m³ and dispose 12900m³, which takes up about 87.76% of the excavation, so the disposal is of great amount. According to construction disposal characteristics of the Project, waste slag will be piled up in four disposal areas.

In construction, 20 sets of different mechanical equipment will be employed, water consumption in production will be 36m³/d; the number of construction personnel in peak hours is 85, water consumption will be 10.2m³/d as calculated by 120L/d per person.

3.2.2 Analysis of environmental impact factors of project construction

Main environmental factors in construction period are project occupation and construction, the impact source is mainly from excavation of foundation pit, excavation and disposal of open diversion channel and discharge of waste mud, land

occupation of engineering structures and construction site; wastewater of construction vehicles and mechanical equipment, sewage discharge of construction personnel; aquatic environment, acoustic environment, atmospheric environment, ecological environment (land resource and soil erosion) and environmental sensitive objectives in the construction area and the surrounding will mainly be influenced in construction period. Different impact analysis is shown as follows:

(1) Impact analysis of aquatic environment in construction period

① Analysis of water consumption in construction period

Water consumption in construction period is mainly for construction and living of construction personnel. Structures of the project are located at the river beach, so construction water can be directly pumped from the river, and the water quality and quantity are satisfying. Living water for construction personnel will be taken from the spring accumulated on the mountain.

According to the project scale and related data compared with other projects of the same kind, it predicts that water consumption in construction peak hour is about $70\text{m}^3/\text{d}$, water discharge in peak hour is $56\text{m}^3/\text{d}$, average daily water consumption in construction period is $58\text{m}^3/\text{d}$, daily discharge is $46\text{m}^3/\text{d}$ and total wastewater discharge in construction is 12542m^3

In addition, a lot of wastewater will be generated from foundation pit during construction, the reason of which is shown as follows: foundation pit is formed from excavation of main structures; drainage of foundation pit is one of the key ways to generate wastewater in construction, which is divided into preliminary drainage and frequent drainage. Preliminary drainage indicates clearing water of foundation pit in the weir, i.e. original river water in addition to water seepage and precipitation, suspended solid (SS) in water may increase because of excavation of earthwork weir and the bank. Frequent drainage is from precipitation, seepage and construction

(concrete maintenance and rinsing) accumulated in foundation pit in structure excavation and concrete placing. Excavation of foundation pit, concrete placing, rinsing, maintenance and cement grouting can increase the content of suspended solid and pH value, pH value of concrete maintenance water can be up to 9~10, if it is directly discharged, the water quality of rivers must be impacted. Therefore, catch pit will be set in foundation pit, wastewater will be pumped for drainage after statically settled for more than two hours and the concentration of suspended solid is less than 300mg/L, so as to reduce impact on ground aquatic environment.

① Construction wastewater: total volume of wastewater discharge in construction is 10462m³. Construction wastewater mainly comes from concrete placing and maintenance, rinsing of sandstone processing system, construction machineries and vehicles.

Wastewater from concrete placing and maintenance: it generates from concrete placing, maintenance and cement grouting, about 602.5m³ concrete is needed for construction, production wastewater in construction also include alkali concrete maintenance wastewater; if 0.25m³ maintenance wastewater will be generated by maintaining 1m³ concrete, 151m³ maintenance wastewater will be generated during the whole construction period, concentration of suspended solid in wastewater is higher, pH value can be up to 11~12. The construction area and water environment in the lower reaches will be greatly impacted if it is not treated.

Rinsing water of sandstone processing system: in general, producing 1t concrete aggregates may consume about 2.7m³ water, sediment content in sandstone takes up 8% in average, the concentration of suspended solid of rinsing water of sandstone is about 2.5×10⁴mg/L according to material balance theory. In sandstone processing, besides water loss arising from surface water of material, evaporation and seepage takes up 20% of the water consumption, other 80% wastewater is arising from production. Total wastewater discharged by processing system of sandstone in

construction is 8486m³.

Wastewater from rinsing construction machineries and vehicles: according to construction design, there are 20 sets of construction machineries and vehicles in the construction area which are parked in one place, about 0.6m³ wastewater will be generated by rinsing one vehicle for one time, about 1825m³ oil-bearing wastewater will be generated per day if accounted by 50%.

② Sewage: it mainly comes from construction personnel. The number of daily workers in peak hour of construction is about 85 at maximum and the number of average daily workers is 56. According to regular living water of construction personnel of hydropower engineering, daily water consumption is about 120L per person, in which 80% will become sewage and be discharged, the discharge index is 96L/d, the maximum daily discharge of sewage is up to 10.2m³, daily sewage discharge is 5.38m³ in average, total sewage discharge in construction is 2080m³, main pollutants are BOD₅, COD and SS. Discharge of sewage and main pollutants are shown in Table 3-1.

Table 3-1 Discharge of Sewage and Main Pollutants in Construction Pperiod

Item		Water consumption (t)	Water discharge (t)	Discharge concentration of main pollutants (mg/L)		
				COD	BOD ₅	SS
Construction area	Before treatment	2600	2080	300	200	250
	After treatment	2600	2080	150	100	75

As analyzed according to the above situation: the project is of smaller scale, structures are dispersed, wastewater discharge is less, polluted water body is Category II and no wastewater can be discharged, so ecological drought toilet will be used for sewage instead of discharge to the outside.

(2) Mechanical equipment and noise

Construction noise is mainly from operation of construction machineries, vehicle transportation, processing and repair of machinery in the process of excavation, drilling, blasting, grinding of sandstone and concrete placing. Noise generated in construction can be divided into fixed continuous drilling noise, noise of mechanical equipment, flow-type traffic noise, short-term blasting in general. The first one comes from earthwork excavation, sandstone processing system and concrete mix system, which is of strong sound source, great sound level and continuity, so it will greatly impact construction personnel. The later is mainly from foundation excavation of main works and exploitation of sandstone, which is periodic, instant and greatly controllable. Sound level of blasting is great, so blasting mode, quantity and time shall be controlled and prepared, so as to control the impact degree and scope. Traffic noise is mainly from engine and horn of vehicles in transportation, which is of greater source intensity and mobility, the noise intensity is shown in Table 3-2.

Table 3-2 Main Noise Source

Category	Equipment name and specification	Unit	Qty.
Loading	Power shovel, oil-driven 1.0m ³	Set	1
	Loader 1.0m ³	Set	1
	Bulldozer 59kW-74kW	Set	1
Rock drilling	Portable pneumatic drill	Set	10
	Air-leg pneumatic drill	Set	18
	Type 100 downhole drill	Set	1
	Jack mill	Set	6
Processing	Jaw crusher 600×900mm		
	Heavy-duty vibrating screen	Set	1
	1500×3000	Set	1
	Disc-type feeder DB-1600	Set	1
Concrete construction	Concrete mixer outlet 0.8m ³	Set	1
	Concrete pump 30m ³ /h	Set	1
	Mortar injector	Set	1
	Air consumption of air (sand) pressure water gun 2-6m ³ /min	Set	1
	Immersion vibrator HZ6X-70	Set	5

Transportation	5t -truck gasoline type Tractor 59kW or farm truck	台	2
		Set	
		台	6
		Set	
Other machinery	Centrifugal pump 14kW Submersible pump 37kW Reversible axial blower 37kW Welder		2
		Set	
		Set	4
		Set	
		Set	4
			2

Construction site is in the mountainous area and the noise is separated by mountains, so some places around the construction site will mainly be impacted; therefore, construction plan layout and operation time shall be reasonably adjusted trying to avoid using noisy equipment and blasting in construction in resting time.

(3) Analysis on earthwork balance, construction waste slag and domestic waste

① Excavation and waste slag:

Total excavation volume of main works is $1.47 \times 10^4 \text{m}^3$, waste soil, stone and slag are mainly redundant earthwork from foundation excavation and slope cutting that cannot be used. Total slag volume is $1.29 \times 10^4 \text{m}^3$. See Table 3-3 for earthwork balance.

Table3-3 Earthwork Balance

Unit: $\times 10^4 \text{m}^3$

Item	Earthwork (10^4m^3)			Stonework (10^4m^3)			Total waste (10^4m^3)			volum e weight (10^4t)
	Excavati on	Us e	Wast e	Excavati on	Us e	Wast e	Natur al	Loos e	Soli d	

Intake pivot	0.05		0.05	0.07	0.02	0.05	0.10	0.14	0.11	0.22
Diversion open channel	0.14		0.14	0.12	0.06	0.06	0.20	0.28	0.20	0.40
Diversion tunnel			0.00	0.65	0.06	0.59	0.59	0.90	0.77	1.48
Pressure head pond	0.02		0.02	0.02	0.01	0.01	0.03	0.04	0.03	0.06
Pressure pipeline	0.14		0.14	0.13	0.03	0.10	0.24	0.34	0.25	0.50
Power house	0.06		0.06				0.06	0.08	0.05	0.11
Booster station	0.07		0.07				0.07	0.09	0.06	0.13
Total	0.48		0.48	0.99	0.99	0.18	1.29	1.87	1.47	2.90

According to the above table, a lot of waste slag will be generated in construction, which may destroy the surface plants, cause soil erosion, influence and even destroy natural landscape if they are not treated reasonably. Therefore, the waste slag will be transported to specified disposal area according to general arrangement of the project and actual landform of the project area.

② Domestic waste

About 85 workers will be on duty in peak hour of construction of Erchakou Hydropower Station, if accounted according to 1.0kg domestic waste one person per day, maximum daily amount of waste is about 0.085t, the construction will last for 12 month, the number of workers per day is about 58 in average, total waste in construction period will be about 21.7t, if the waste is not treated well and piled up freely, it will destroy environmental landscape, bring out breeding of mosquitoes and flies as well as secondary pollution.

Therefore, domestic waste shall be classified and piled in specified place, and then land filled on site after recovery.

③ Production waste

Production waste mainly is construction rubbish and production waste.

The construction area takes up 1.65hm² in total, a lot of construction rubbish and different sundries will be stocked in the construction area at completion of the Project, the removal of temporary structures and construction camps, and then the site will become disorderly; if the waste cannot be treated effectively, it will impact local visual landscape and will not be convenient for recovery of the site in the later stage.

Production waste generated in construction mainly includes fragments, scrap iron, waste bar, oil residue, oil paper and cotton yarn. Scrap iron and bar can be recovered as expected, but waste oil residue, oil paper and cotton yarn will impact the environment of construction area if they are dropped at free will.

(4) Pollution source of waste gas in construction period

The project will impact atmospheric environment of the construction area mainly in the following aspects: dirt and dust arising from earthwork excavation of the foundation of main works and earthwork backfill; dust arising from concrete batching of mix system; dust arising from crushing of artificial sandstone system; dust and waste gas from fuel machinery and vehicles; waste gas from coal and blasting; main pollutants are total suspended particle (TSP), SO₂ and CO.

① Main sources of dirt and dust pollution

A lot of dirt and dust will generated during earthwork excavation and backfill of the main works; dirt and dust from tunnel excavation and blasting; transportation, loading and unloading of cement, fly ash and sediment; exploitation and crushing of aggregate and artificial sandstone as well as dust generated by operating vehicles; dust generated in concrete production at mix station.

According to field data of Gezhou Dam Key Water Control Project in construction period, the concentration of TSP discharged at operation points can be up to 150mg/m³, concentration of floating dust is 0.45~0.6mg/m³ and of dust fall is 32t/km², which exceed the limit of Level I standard of *Integrated Emission Standard of Air Pollutants* (GB16279-96). The construction points are dispersed and far away from residential area, they only have certain influence on the staff in construction area and on the site, so effective prevention measures shall be taken to reduce the hazard.

② Pollution from fuel consumption

Fuel used in construction period is mainly used for power drive of different mechanical equipment. According to engineering data and comparison with similar projects, estimated fuel consumption such as diesel oil(light diesel oil, first level) for construction machineries in construction period is 24.96t (31200L), estimated types and quantity of pollutants generated by fuel are shown in Table 3-4.

Table 3-4 Pollutants Discharge of Fuel in Construction Period

Item	Type of pollutants			
	SO ₂	NO ₂	CO	Hydrocarbon
Fuel pollutant amount per unit (g/L)	4.4	21.4	14.2	4.2
Total discharge (kg)	137.28	667.68	443.04	131.04

In this way, mechanical waste gas generated by construction will have adverse impact on local ambient air in the construction area.

③ Pollutants and impacts of coal for living

Daily coal consumption in construction period is closely related to the number of construction personnel, which is 85 in the peak hour, so estimated coal consumption is about 300t in total. Coverage of influence is mainly nearby the living area. But

diffusibility in gorges is poorer, ventilation and sanitation shall be done well in living area.

Impact on atmosphere is only limited to construction period, which will disappear at completion of the project.

3.2.3 Possible impact of land occupation on environment

The construction of Erchakou Hydropower Station will change land use structure and type in the occupation scope, the original characteristics will be changed by permanent occupation, as for temporary land occupation, the original function can be recovered or developed reasonably according to actual situation at completion of the Project.

(1) Temporary land occupation

Land occupation of the Project includes temporary construction road, stock yard, waste disposal area, temporary processing plant, AC station, parking lot, warehouse of construction equipment, cement storage, oil storage, offices and dorm, which is mainly river beach and little barren land covering 0.59hm² in total.

(2) Permanent land occupation

Permanent land occupation is for the project and engineering management. Land occupation of Erchakou Hydropower Station mainly includes river weir, diversion structure, power house and booster station, which mainly is river beach and barren

land covering 0.44hm² in total.

Details for land occupation of Erchakou Hydropower Station are shown in Table 3-5.

Table 3-5 Statistics of Land Type and Area of Erchakou Hydropower Station Project

No.	Area	Land type and area (hm ²)				Subtotal
		Hillside cultivated	Woodland	Barren land	Overflow land	
1	Main construction area	0.04	0.16	0.22	0.02	0.44
2	Waste disposal area			0.20	0.04	0.24
3	Temporary occupation area for construction	0.04	0.12	0.09	0.02	0.27
4	Access road area for construction			0.08		0.08
Total		0.08	0.28	0.59	0.08	1.03

Land occupation for construction especially permanent land occupation must change the structure and distribution of original vegetation or even impact its quantity and type, so that existing habit of animals and plants in the scope will be damaged, animals will be forced to immigrate, and then the type and quantity may be reduced.

Therefore, permanent structures such as dam area and power house shall be planned and arranged in a reasonable and scientific way, so as to minimize the impact on ecological environment.

The site shall be cleaned timely, vegetation or other original land use structure shall be recovered after the land is used temporarily to prevent soil erosion and other ecological problems.

3.2.4 Possible impact of construction on ecological environment

In construction period, entry of construction machinery and personnel, arrangement of processing yard of stones and soil as well as other construction site in each process will destroy the living environment of wildlife, and it will have certain influence on amphibian and reptile; birds and animals in temporary requisition area will be frightened and leave the site; therefore, the quantity of animals in construction period will be reduced year by year. But construction activity will have no obvious influence on animal population structure in this area.

Permanent highway and temporary construction road constructed cut off the passage of terrestrial animals in a certain degree, separation by road will have certain adverse influence on terrestrial animal. But at the completion of construction, the vegetation on construction access will recover naturally and the separation of animals will disappear gradually.

In construction period, discharge of wastewater, waste slag and sewage will have certain influence on aquatic. If measures are taken for treatment, there will be mere influence on surface water environment.

Influencing factors of aquatic environment in operation include wastewater in living area of the staff, oil and wastewater generated in operation or repair of units, hydro-regime changes and ecological environment. No pollutant will be discharged to the surrounding area in operation and permanent land occupation also will have irreversible influence on the environment. The construction does not cover retaining work, so the operation mainly includes water intake, power generation and water discharge, it is obvious that no wastewater and other pollutant will be discharged in operation period fundamentally; key influence is presented by hydro-regime changes and ecological environment of dehydration section.

3.3.1 Influence on runoff changes

Erchakou Hydropower Station have no field runoff data, while Yuyangguan

hydrologic station is set for the neighboring Yuyang River, so runoff data from 1961 ~ 2003 (43 years in total) is kept, the two catchments are in a same hydrometeor regionalization, their physical geography, climate and hydrology properties are similar to each other, so Yuyanguan hydrologic station can be used as a reference of Erchakou Hydropower Station for runoff design.

Yuyanguan hydrologic station controls 465km² catchment area, long-term average runoff volume is 410 million m³, long-term average flow is 13.0m³/s, long-term average rainfall is 1610.9mm, the dam site of Erchakou Hydropower Station controls 20.3 m³/s catchment area, long-term average rainfall is 1445.7mm. Use hydrologic analogy method and rainfall correction method to ascertain design runoff of Erchakou Hydropower Station, so long-term average flow at the dam site is 0.51m³/s and long-term average runoff volume is 16.04 million m³. As calculated according to frequency ranking, $C_v = 0.28$ and $C_s = 2C_v$. Long-term average flow at the dam site of Neixi Brook is 0.19m³/s, long-term average flow at the dam site of Liujia Brook is 0.17m³/s and long-term average flow at the dam site of Daxigou is 0.15m³/s. See Table 3-6 for design runoff results of Erchakou Hydropower Station.

**Table 3-6 Achievements of Design Runoff of Erchakou Hydropower Station
(P=85%)**

Date	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.
1	0.09	0.09	0.07	0.72	0.27	1.63	0.30	0.13	0.17	0.10	0.14	0.14
2	0.10	0.09	0.07	0.53	0.21	0.72	0.24	0.12	0.16	0.10	0.13	0.14
3	0.09	0.09	0.07	0.39	0.23	0.44	0.19	0.09	0.13	0.10	0.12	0.13
4	0.09	0.09	0.08	0.31	0.34	0.34 7	0.17	0.09	0.14	0.11	0.12	0.13
5	0.09	0.09	0.08	0.25	0.82	0.29	0.16	0.09	0.12	0.10	0.14	0.12

6	0.08	0.08	0.07	0.20	0.69	0.25	0.15	0.10	0.12	0.10	0.14	0.12
7	0.08	0.08	0.07	0.18	0.39	0.22	0.14	0.40	0.17	0.11	0.13	0.12
8	0.08	0.08	0.07	0.17	3.55	0.20	0.13	0.90	0.22	0.12	1.99	0.12
9	0.08	0.09	0.07	0.16	5.60	0.19	0.12	5.01	0.28	0.11	1.98	0.12
10	0.07	0.10	0.07	0.14	2.05	0.17	0.12	5.44	0.28	0.10	1.33	0.12
11	0.07	0.10	0.07	0.13	0.91	0.16	0.12	1.88	0.19	0.09	0.74	0.13
12	0.07	0.09	0.07	0.13	0.45	0.16	0.11	1.01	0.16	0.07	0.44	0.13
13	0.08	0.10	0.07	0.12	0.32	1.65	0.10	0.57	0.14	0.08	0.32	0.12
14	0.10	0.10	0.07	0.12	0.26	2.70	0.10	0.41	0.14	0.08	0.27	0.12
15	0.17	0.09	0.06	0.12	0.21	1.08	0.18	0.34	0.13	0.08	0.31	0.10
16	0.22	0.09	0.07	0.12	0.19	0.49	0.16	0.29	0.12	0.07	0.90	0.10
17	0.17	0.09	0.07	0.12	0.57	0.34	0.16	1.33	0.12	0.07	0.57	0.10
18	0.15	0.09	0.06	0.12	0.58	0.26	0.18	1.03	0.99	0.07	0.36	0.10
19	0.14	0.08	0.07	0.11	0.33	1.20	0.14	0.51	0.58	0.07	0.30	0.10
20	0.13	0.08	1.53	0.50	0.24	1.75	0.13	0.34	0.30	0.07	0.25	0.09
21	0.13	0.09	1.05	0.86	0.20	0.83	0.16	0.26	0.21	0.07	0.23	0.10
22	0.12	0.09	0.46	0.49	0.18	0.46	0.19	0.22	0.19	0.08	0.20	0.09
23	0.12	0.09	0.29	0.34	0.16	0.53	0.27	0.21	0.16	0.10	0.19	0.09
24	0.12	0.08	0.20	0.24	0.15	2.78	0.33	0.19	0.15	0.10	0.18	0.09
25	0.11	0.08	0.18	0.21	0.14	2.40	0.61	0.17	0.14	0.09	0.18	0.09
26	0.11	0.08	0.17	0.19	0.15	3.80	0.54	0.20	0.13	0.23	0.17	0.09
27	0.11	0.08	0.14	1.66	0.32	1.61	0.50	0.17	0.12	0.67	0.17	0.09
28	0.11	0.07	0.13	1.36	0.25	0.80	0.25	0.15	0.12	0.45	0.16	0.10
29	0.11		0.14	0.63	0.66	0.52	0.17	0.40	0.11	0.27	0.15	0.10
30	0.10		0.22	0.37	6.89	0.39	0.15	0.28	0.10	0.19	0.15	0.10
31	0.10		0.50		3.82		0.13	0.20		0.15		0.09
Average	0.11		0.20	0.37	1.00	0.95	0.21	0.73	0.20	0.13	0.42	0.11

As shown in Table 3-6, daily runoff at dam site of Erchakou Hydropower Station changes between 0.09-1.00m³/s, the flow in dry season is small.

At completion of the Project, some river sections will dehydrate in dry season, but Yaozhan Brook is as a gorge, function of the water body mainly is ecological water supply and flood discharge as limited by the topographical condition. Reduction of runoff and water level has small influence on the function of water body.

3.3.2 Influence on slope stability

The plant area is located in the structural environment of relatively stable earth crust, no activity breakage is discovered, frequency and intensity of seismic activity is lower, seismic basic intensity is VI.

Stability in the large of rock mass is better in the section of dam site and diversion line, but part of rock mass is more strongly weathered and the fissure is greater, in addition to the existing of interlayer weak intercalated layer, the stability of part slope, tunnel body and dam foundation will be adversely influenced, but the dam body is low, so the influence on slope stability will not be great at completion of the Project.

3.3.3 Influence on terrestrial animal and aquatic

The station is a run-of-river non-adjustable diversion power station, the heights of intake dams are 2.3m, 3.09m and 3.32m respectively, catchment areas above the dam site are 7.7km², 6.8km² and 5.8km² respectively, catchment area above the plant site is 20.3km². After the Project is completed and put into operation, 1000m under the dam is dehydration section, the length of dehydration section under Neixi Brook is 500m, under Liujia Brook is 300m and under Daxigou is 200m; in addition, no branch

flows into these brooks under dams in dry season. Three households are distributed at the right bank of the dam site of Neixi Brook, the water for living and irrigation is taken from this river section, the Employer has taken measures to ensure drinking water of villagers in construction period, and farmland irrigation will not be influenced (described below), the river section in the lower reaches of dam cannot be used for drinking and irrigation, main function of the water body is ecological water, certain measures shall be taken to ensure ecological base discharge in the lower reaches of the dam.

According to ecological water demand of the river, average flow of the driest month in the recent ten years or average flow of the driest month with ninety percent assurance rate will be applied. Average flow of the driest month with ninety percent assurance rate is applied as ecological water demand, the ecological water demands of Neixi Brook, Liujia Brook and Daxigou are $0.03\text{m}^3/\text{s}$, $0.02\text{m}^3/\text{s}$ and $0.02\text{m}^3/\text{s}$ respectively. No irrigation water or drinking water problem is involved in the dehydration section, which is about 1km after the station is constructed; ecological annual water consumption is 2.2 million m^3 . Detail measure is shown as follows: lay 80mm steel pipe to keep constant water to satisfy the ecological water demand under a dam. Ensuring the above measures, there will be less influence on terrestrial animal and aquatic in operation period.

3.3.4 Influence on living and irrigation water

According to field inspection, the intake dam of Liujia Brook is located at 10m in the lower reaches of intake dam of Madi Township water engineering, no water supply for cities and towns in the lower reaches of the water catchment of Daxigou dam site and Neixi Brook dam site, only three households are distributed under Neixi Brook Dam, these villagers are living and irrigating through the river section. At completion of the Project, drinking water and irrigation water supply of the three

households will be influenced; therefore, the Employer plans to set one diversion pipe from the dam to introduce water in front of their house and nearby their cultivated land, so as to ensure their living and irrigation water supply.

3.3.5 Operation of generation unit

There is no pollutant discharge in operation of Erchakou Hydropower Station, but lubrication oil will be used in operation of generation unit such as in lubrication and cooling of intake valve operation system, bearing of the unit and speed regulator, escape and leakage is unavoidable, the main pollutant is fossil oil. In addition, insulation oil of transformer will escape and leak, main pollutant is alkane organics. Moreover, the station is equipped with machine repair equipment such as lathe, milling machine and drill machine, which shall be cooled and lubricated in operation, so there will be a little leakage, the pollutant mainly is lipid. These oil pollutants will influence water quality of these rivers without any treatment.

3.3.6 Maintenance management of the station in operation period

Management of Erchakou Hydropower Station Project concerns power generation and structure maintenance; on basis of the principle “computer controllable management and unmanned on duty”, maintenance of the Station will be charged by Engineering Management Department of Erchakou Hydropower Station composed by five persons; domestic waste of management personnel per day will be 0.0025t and annual total amount is 0.92t if one person causes 0.5kg waste per day; these wastes will influence the environment if not being treated. If daily water consumption for living is 0.20m³ and discharge coefficient takes 0.8, so daily discharge will be about 0.8m³/d,

concentration of BOD₅ in sewage is 200mg/L, COD concentration is 300mg/L and concentration of suspended solid is 250mg/L, then daily discharge intensities of pollutants are BOD₅ 0.16kg/d, COD 0.24kg/d and suspended solid 0.2kg/d.

3.4 Conclusion

As known from engineering analysis: wastewater, waste gas, waste slag and noise have certain influence on the environment, corresponding measures shall be taken to reduce adverse influence arising from construction. Temporary and permanent land occupation will cause loss of land resource, terrestrial life, social economy resources. At completion, nearly no pollutant will be discharged in operation of the station and it has obvious economic and social efficiencies in energy supply.

Influence on the environment at completion of Erchakou Hydropower Station is shown in Table 3-7 Summary of engineering analysis.

Table 3-7 Summary of Engineering Analysis

Period	Impact source and intensity		Pollutant and discharge	Process and effect	Discharge location or function object	
Construction period	Aquatic environment	Wastewater from sandstone processing	16m ³ /d	SS:2.5×10 ⁴ mg/L	Preliminary sedimentation, SS removal rate is 90%	Recover or discharge to woodland
		Wastewater from concrete placing and maintenance	2 m ³ /d	SS:5000mg/L PH:11-12		
		Wastewater from rinsing of construction machinery and vehicle	6 m ³ /d	Fossil oil:30-50mg/L SS:30mg/L	Oil separation and preliminary sedimentation, fossil oil and SS removal rates are 40% and 50%	

					respectively	
	Sewage	5.7 m ³ /d	COD : 250-300mg/L	Removal rates of COD, BOD and SS of cesspool are 50%, 40% and 60% respectively		
			BOD ₅ : 150-200mg/L			
			SS : 200-250mg/L			
Noise	Operation of construction machinery in excavation, drilling, blasting, grinding of sandstone and concrete placing as well as vehicle transportation and mechanical processing		Above 90dB(A)	Apply advanced blasting technology for some construction faces to reduce noise, construction strength at night, but it does not reach standard in construction area	Local area nearby the construction area	
Solid waste	Construction slag		1.29×10 ⁴ m ³	Prevent and protect in levels	designated waste disposal area	
	Domestic waste		21.7t/a	Collect, clean and transport regularly	Except the waste disposal area	
Waste gas	TSP		150mg/m ³	Apply buffer blasting and wet blasting for a few excavation faces to reduce dust	Atmospheric environment around the construction area	
	Fuel oil		SO ₂ : 137.28kg			
			NO ₂ : 667.68kg			
			CO : 443.04kg			
		Hydrocarbon : 131.04kg				

	Ecological impact	Construction land occupation: permanent 0.867hm ² , temporary 0.834hm ² ; excavation: earthwork 14700 m ³ , backfill and use 1800 m ³		1.03hm ² Occupation and disturb surface area 1.03hm ²	Removal of temporary construction facilities, smoothing of some cutover land; recovery of temporary land occupation; greening of the plant area; transportation and storage of waste slag to designated temporary area	Temporary and permanent land occupation
	environmental impact	Entry of construction vehicles, the number of construction personnel is 85 in peak hour		May cause traffic jam; may bring about disease from the outside		
	Ecological impact	Run-of-river non-adjustment diversion plant, height of diversion dam is 2.3(3.09, 0.32)m			Satisfy ecological flow	Backwater area of check dam
		Water reduced river reach		1000m		Under dam
	Aquatic environment	Sewage	0.8m ³ /d Water discharge 0.8m ³ /d	COD : 250-300mg/L	Removal rates of COD, BOD and SS of cesspool are 50%, 40% and 60% respectively	No discharge
				BOD ₅ : 150-200mg/L		
				SS : 200-250mg/L		
Solid waste	Domestic waste		0.92t/a	collectively treated		
Acoustic pollution resource	Operation of electromechanical devices		80 dB(A)	Close the power house and implement few-person management to obtain a better effect		

4 . Brief introduction to the environment of project site

4.1 Natural environment

4.1.1 Geographic location

Changyang Tujia Autonomous County is located in Wuling mountainous area in the southwest of Hubei Province in the middle and upper reaches of Changjiang River crossing the east longitude $110^{\circ}21' \sim 111^{\circ}20'$ and the north latitude $30^{\circ}12' \sim 30^{\circ}46'$. Length from the east to the west is 94.5km, width from the south to the north is 63.0km, total land area is 3418.82km^2 , 148km section of Qingjiang River-the second branch in the middle and upper reaches of Changjiang River crosses the whole county from the west to the east. The County borders on Yidu City in the east, connects Wufeng Tujia Autonomous County in the south, interfaces with Badong County in the west and is adjacent to Zigui County and Dianjun District in the north.

Erchakou Hydropower Station is located in Duzhenwan Town of Changyang Tujia Autonomous County and in Chongxi Brook catchment-the branch of Yaozhan Brook. Yaozhan Brook catchment is located in the south of Changyang Tujia Autonomous County geographically crossing the east longitude $110^{\circ}30' \sim 54'$ and the north latitude $30^{\circ}15' \sim 24'$, it is Level I branch of Qingjiang River. Yaozhan Brook originates from the north and south thoroughfares of Gaofeng Village of Bailuzhuang Township of Wufeng at 2152.7m altitude, and flows into Geheyuan Reservoir Area of Qingjiang River at Shuanghekou (elevation 200.00m). Yaozhan Brook catchment has two main branches, i.e. Zhongxi Brook and Chongxi Brook.

Dam site of the project is at Neixi Brook, Liujia Brook and Daxigou in the upper reaches of Chongxi Brook, 58km from Zhuangxi Brook, 135km from Changyang

Tujia Autonomous County and 195km from Yichang City; the power house is located in the upper reaches of Daxigou mouth, 48km from Zhuangxi Brook, 125km from Changyang Tujia Autonomous County and 185km from Yichang City, the water from Chongxi Brook will be used for power generation.

See Attached Fig. 1 (Geographic Location of Erchakou Hydropower Station of Changyang Tujia Autonomous County) for details.

4.1.2 Topography, landform and geology

(1) Topography and landform

The whole county is in the east end of Yungui Plateau, extensions of Wuyishan Mountain and Wushan Mountain. It is divided into Wuyi Mountain in the south and Wushan Mountain in the north by Qingwang, general topography is high in the west and low in the east. Branches of the two extensions are complicated, mountains are overlapping to each other, meandering and fluctuant, gorges are deep and serene with ravine in length and breadth. Bengjianzi Mountain in Yinfengzui Village with 2259.1m altitude is the highest and Xiangjia Brook mouth with 48.7m altitude is the lowest in the whole county, height different is 2210.4m. As divided according to the topography, high mountains (altitude above 1200m) cover 71589.50hm², medium mountains (altitude 800-1200m) cover 103563.80hm², low mountains (altitude 500-800m) cover 66570.10hm², massif and valley (altitude below 500m) cover 100158.40 hm². Few hills in the east, the higher is in the north, west and south, the top is as peak plain; plane dams, irrigated field and basin are spreading in the medium mountain.

The site is located in folded mountains in the southwest of Hubei Province and belongs to tectonic denudation erosion medium mountainous area. The west is

higher than the east, the mountain is steep, the valley is deep with greater fall. The south-central mainly is carbonate rocky area, which almost is cuesta, the north and southwest is mound landform composed by clastic rock. The formation lithology exposes from Luoreping formation of lower Silurian System to Daye formation of lower Triassic and Quaternary System.

(2) Engineering geology

① Geologic conditions of the power station

The power station is located in the overlap area (umbo in the west of Hubei Province) of east-west structural belt in the middle and lower reaches of Changjiang River and north-northeast structural belt of the neocathaysian. The former one is represented by Shizidun composite syncline controlled by the basal structure in the west and east, which is formed in Indosinian and the advanced stage of yanshan movement. The area in the same period of folds breaks and mainly grows in the short limb side of folds, which axially changing with folds in the east and west, north-north east and northwest direction. In the west and east structural belt, there mainly are folds with few breaks.

Since Tertiary, the earth's crust in the area is intermittently rising at a low speed as a whole, the topography is mainly characterized by multistage planation surface, multistage river terrace and locally-grown cave. Planation surface, terrace nearby the site and water system on the site have no distortion, deflection or twist leap, activity of fault in neotectonic period is not obvious, which shows that the site is in a relatively stable structural environment.

② Geologic condition and comparison analysis of dam site

Intake dam of Neixi Brook: bed elevation of the dam site of Neixi Brook is 662m, the river bed slightly inclines to the left bank and depth of the river is about 0.5m,

bedrock of the river bed is exposed, the stratum is thin to medium thick Xiejingsi formation argillaceous limestone mixed with mudstone, attitude of rock formation is $352^{\circ}\angle 41^{\circ}$. Bedrock of slopes at both banks of river is exposed fundamentally, the exposed stratum is thin to medium thick Xiejingsi formation argillaceous limestone with mudstone; about 0.5~1.0m thick residual soil aggregate is distributed in the exposed area of mudstone, and the soil body is loose. Argillaceous limestone in the dam site mainly grows two groups of joints; one inclines 130° with 65° dip angle, the other inclines 255° with 50° dip angle, the joint face is almost tightly closed with shorter extension and poorer connectivity. Joint face of rocks and intersecting line of rock face incline inwards of slope, and there is no free face in the dip direction, so rock joints and rock faces are of stable structure.

Intake dam of Liujia Brook: bed elevation of the dam site of Liujia Brook is 660m, the river is smoother and straighter, and depth of the river is about 0.8m. The thickness of coverage including pebble and boulder is 0.5 ~ 1.0m, underlying bedrock is Qixia Formation limestone. Bedrock on slope of both banks is exposed; the stratum is Qixia Formation limestone. There is argillaceous limestone at the dam site mainly growing with two groups of joints, one inclines 210° with 55° dip angle and the other inclines 120° with 75° dip angle, the joint face is almost tightly closed with poorer connectivity. Joint face and intersecting line of rock face incline inwards of slope, and the structure of rock mass is stable.

Intake dam of Daxigou: bed elevation of the dam site of Daxigou is 663m, the dam site protrudes slightly in the south and the depth of river is about 0.8m. The thickness of coverage including pebble and boulder is 0.5~1.5m, underlying bedrock is Qixia Formation limestone, about 0.8~1.5m thick soil aggregate is distributed on the slope at the left bank of loose structure, bedrock on the slope of the right bank is exposed and the stratum is Qixia Formation limestone. There is argillaceous limestone at the dam site mainly growing with two groups of joints, one inclines 60° with 58° dip angle and the other inclines 295° with 73° dip angle, the joint face is

almost tightly closed of shorter extension and poorer connectivity; the rock formation is heavy layer limestone with rare rock face, the rock mass is of complete structure and the integrated stability of slope is better.

③ Geologic condition of diversion open channel

The diversion open channel is nearly in the east-west direction, this area is a rock slope inclining to the north. Bedrock along the open channel is exposed fundamentally; the stratum is Xiejingsi formation argillaceous limestone mixed with mudstone, Huanglong formation limestone, Qixia formation coal section and limestone section. The bedrock of sandstone and limestone is exposed, which is medium~ slightly weathered with less growth of cleft, weathering thickness is 0.5~1.0m in general; claystone, mudstone, carbon mudstone and coal bed are soft rock with higher weathering degree, which is of strong~ medium degree in general, weathering thickness is more than 5.0m in general. The rock mass is broken, the lower part is slightly weathered~ new rock, the rock mass is more integral. Rock top of local sections is distributed with 0.5~1.0m thick loose soil aggregate of residual soil, integral stability of the open channel is better.

④ Geologic condition of diversion tunnel

Total length of the diversion tunnel is about 2540m almost crossing sandstone and shale of the stratum, the water abundance and water permeability are poorer, these sections have no large-scale underground water, but karst and vertical karst fissure grow along the line when the tunnel crosses carbonate rocks, so the tunnel is more possible to encounter strong karst zone, local section is of rich and more underground water. When constructing the tunnel, strengthen prediction and prepare materials for discharge and support.

4.1.3 Weather

Changyang Tujia Autonomous County is located in subtropical warm and humid monsoon climate zone of the Northern Hemisphere with obvious winter and summer climate changes, so the four seasons are of their own characteristics, sunlight is sufficient, rainfall is rich; the weather is changeable in the warm Spring, rainfall is plentiful in the early Summer, it is dry in fall and cold in winter. In addition, the catchment is in gorges of high mountains, so the weather is of characteristics of mountain climate. The landform is changing, so hydrometeor elements are vertically distributed.

According to statistics of weather station of Changyang Tujia Autonomous County, long-term average temperature is 16.4°C, average monthly temperature is up to the highest 27.6°C in July and the lowest 4.6°C in January. Extreme maximum temperature was 42.1°C happened on August 6, 1966; the extreme minimum temperature was -12.0°C happened on January 31, 1977. Annual average sunshine duration is 1553h; long-term average relative humidity is 80% and absolute humidity is 16.3mb. Long-term average wind speed is 1.5m/s and leaning east wind is prevailing. Maximum wind speed in past years was 16m/s appeared on June 22, 1975 and the wind direction was SE. The frost period almost presents during November to the next March, annual average frost-free period is 282d and long-term average rainfall is 1347.2mm.

4.1.4 Hydrogeology

West part of the planned site of Erchakou Hydropower Station is higher than the east part, the surface divide is high, steep, wide and thick, underground divide is generally the same with the surface divide, but the site center is carbonate rock zone, uneven pipe water-bearing formation and alternative water-bearing formation of small pipe-fissure-hole control the distribution of underground water.

The underground water is divided into three types including clastic rock fissure water, carbonate rock karstic water and loose pore water according to the lithology and breaking through of water of the planned site.

Common generation and movement rules of underground water on the site are shown as follows: the surface aquifer is supplied by atmospheric precipitation, which is transferred as fissure water or pore water firstly, part of fissure water can infiltrate to supply the bedrock fissure water, there is also part of bedrock fissure water supplying the pore water in special landform and structures. Underground water gradient of carbonate rock karst zone on the site is more complicated, gradient of underground water level is 0.04 ~ 0.12, which is smoother; while hydraulic gradient of the water body far away from brooks and rivers is steeper, which is around 0.3.

4.1.5 Soil

Geological structure in the County is composed of a series of multiple fold or superfold and its fissure, stratum emergence of each period is complete except Upper Silurian and Lower Devonian from Sinian System to the lower Triassic System, which almost is marine deposit. The stratum is old, mountains are broken, steep and dangerous, so karst geomorphy is formed all the way, which quickens the permeation and weathering of rocks.

Complex landform, geologic conditions and changeable climate form several kinds of soil with obvious zonality, the whole County mainly has three kinds of soil including yellow earth, yellow-brown soil and brown soil, two kinds of rock soil including limestone soil and purple soil as well as two artificially vegetable soil including fluvo-aquic soil and paddy soil. Regular vertical zonality distributed geographically: yellow soil is mainly distributed under 800m altitude including low-mountain valleys covering Dayan, Duzhenwan, Ziqiu, Yuxiakou and Langping, low-mountain hilly region covering Cituya of Gaojiayan, Longzhouping and the east of Moshifeng

Mountain; limestone soil is mainly distributed in low mountains and medium mountains with 500 ~ 1200m altitude as well as the limestone top above 1500m altitude covering Hejiaping, Langping, Gaojiayan, Longzhoping, Dayan and Duzhenwan; brown soil is mainly distributed in high mountains above 1800m altitude covering Huoshaoping, Yuntaihuang, Zitai Mountain and Bengzijian.

According to *Soil Annals of Changyang*, the county has different kinds of soil; the original soil mainly is limestone, weathering residue of marlite, shale, quartz sandstone, Quaternary clay residue and recent river alluvium. Different originals form various kinds of soil as impacted by complicate topography, hydrology, climate, vegetation, natural factors and artificial factors, which are divided into 7 types, 12 subtypes, 26 soil genus and 38 soil local types, the area of yellow-brown soil is the greatest covering 110300hm² in total, which takes up 43.5% of the total area; limestone soil (limestone) is the next with 88500hm² area taking up 34.9%; and then the yellow soil, paddy soil, purple soil, brown soil and fluvo-aquic soil, which take up 17.2%, 8.75%, 3.70%, 2.5% and 0.26% of the total area respectively. As influenced by water potential and climate, physicochemical property and nutrient content of soil change with the rising of altitude regularly, soil layer is thickening, pH value is reducing gradually, organic matter decomposition becomes slowly, potential nutrient of soil is rising and available nutrient is reducing gradually.

4.1.6 Minerals

Mineral resources in Changyang Tujia Autonomous County is plentiful and there are mainly 14 kinds of minerals taking up 26.9% of the whole province, which including ferrous metal such as iron, manganese and paramontroseite (aluminium ore), non-ferrous metal such as lead, zinc and mercury ore together with nonmetal limestone, phosphate ore, barite and coal. Iron ore reserves is up to 374 million tons, coal reserves is up to 38 million tons; only coal, barite and pyrite are developed or under development.

4.1.7 Seism

Related geologic data from the State Seismology Bureau and Hubei Province as well as trend analysis on seismic activity of Shiyan Seismology Bureau for the east of Three Gorges in the recent years, 57 times of seism ($MS \geq 4.7$) happened within 200km area of the site till now as recorded, these seismic activities were of low intensity, low frequency and shallow seismic source.

Historically, impact intensity of seism within 365km nearby the site does not exceed Level 6, so the destructiveness is weak. Changmaosi in north-northeast of the site west breaks and it had moved for several times, but its activity is not obvious since tertiary. No blatt is discovered in the area, only structure joint is growing, all exposed blatt is of small scale and shallow cutting depth, which is not helpful for accumulation of strain energy.

According to historical data, no destructive seism above Level 6 has ever happened in Yichang District; according to *SEISMIC GROUND MOTION PARAMETER ZONATION MAP OF CHINA Seismic Ground Motion Parameter Zonation Map of China* (GB18306-2001), acceleration of peak value of seismic ground motion of Hubei Changyang Tujia Autonomous County is 0.05g, characteristic periods of response spectra of seismic ground motion is 0.35s and corresponding seismic basic intensity is Degree VI.

4.2 Brief introduction to Ecological environment

4.2.1 Situations of animals and plants

The natural conditions including mountain, water, light, heat, soil and forest of Changyang Tujia Autonomous County provide a proper environment for all kinds of

animals and plants. Biological resources in the area are relatively plentiful including rare fungus, famous and special fruits, medicinal materials, wild birds and animals, which is one of the great economic advantages of the County.

Plant resources in the area are plentiful and distributed spatially because of overlapping mountains and crossing ravines. Subtropical evergreen broad-leaved forest, subtropical evergreen mixed deciduous broad-leaved forest are distributed. It can be divided into four vegetation areas, i.e. economic, firewood forest and cultivated plant area in hill valleys in the east; timber forest and economic forest in low mountains in southeast, northeast and both banks of Qingjiang River; timber forest including pine, *cunninghamia lanceolata* and cypress in the west and central south; timber forest, economic forest and special forest in high mountains in the north and south. Mountains in the County are fluctuant, mountain ridges are overlapping with each other, mountain peaks are bristly, a solid structure of hills, low mountains, medium mountains and high mountains is formed because of the height different; hills and valleys with less than 500m altitude mainly distribute deciduous broad-leaved forest including oaks such as orientalwhite oak, cork oak, Chinese ash and bastard acacia together with evergreen coniferous forest such as *pinus massoniana*; low mountains at 500~800m altitude distribute evergreen broad-leaved forest; medium mountains at 800~1000m altitude distribute evergreen broad-leaved forest, deciduous broad-leaved forest and warm needle-leaved forest; deciduous broad-leaved forest and warm needle-leaved forest are distributed in the area with altitude more than 1200m.

There are totaling 320 kinds of arbors, 229 kinds of bushes and 12 kinds of liane in the County, amount of growing stock in forests is 1.8 million m³ as estimated. In addition, forest medicinal materials such as eucommia, magnolia bark, pawpaw, woody food including walnut, chestnut, woody oil including tung tree, Chinese sapium and paml as well as other economic forest products such as varnish tree are special products of Changyang County.

There are 5 classes, 13 families and 17 categories of animals in the area, in which

field voles of rodentia cricetidae take the most part. There are 11 classes, 32 families and 95 categories of terrigenous birds, in which sparrows of passeriform birds take the most part and ciconiiformes ardeidae is peculiar. There are 3 classes, 3 families and 5 categories of water birds, in which ruddy shelduck of anseriformes anatidae are common and mandarin ducks are rare. There are totaling 2 classes, 5 families and 10 categories of reptiles, in which Gekko japonicus of Squamata Geckos is rare, cyclophiops major and zaocys dhumnadess are of the greatest quantity. There is one class, two families and four categories of amphibian, in which green pond-frog of anura ranidae and big toad of bufonidae are the most, big toads distribute in the whole county as well as wrinkled frog of ranidae anura.

4.2.2 Present situation of soil erosion

According to survey analysis of satellite remote sensing data for soil erosion in the whole province in 1999, soil erosion area in the County is 1685km² taking up 49.21% of land area of the County. As divided according to erosion level, slight erosion area is 541km² taking up 32.11%, medium erosion area is 1000km² taking up 59.35%, severe erosion area is 124km² taking up 7.36% and extreme erosion area is 20km² taking up 1.18%. Annual soil erosion is about 8.2716 million tons, average soil erosion modulus of the whole county is 2420t/km².a and severe soil erosion is up to 6800 ~ 11235.11t/km².a. Soil erosion mainly by water power and gravity is common in the County. Sandshale area at the beach of Qingjiang River, Danshui and Zhaolai River in low mountains is severely damaged because of frequent destroy of vegetation, parent material, bedrock explosion, falling, sliding and earth debris flow. Fissure and cave are growing in limestone area of semi-high mountains, the surface soil is taken away by surface runoff, and then it becomes “smooth rocks”, so it is difficult to recover. With the construction of Geheyuan and Gaobazhou hydropower stations in great scale one after the other, most immigrants in the reservoir area are moving backward, forest and cultivated land are destroyed, the soil is excavated and forests are cut freely, capital construction project including road construction, mining and

plant construction are developed, waste soil and stones are dropped freely, all these aggravate soil erosion and the erosion area is enlarging endless.

A lot of hillside cultivated in the County is one of the key factors that cause soil erosion. Erosion area of hillside cultivated of the whole county is 320.3km³ taking up 17.8%; while annual erosion amount of cultivated land is 2.1836 million tons in total taking up 26.4% of the total erosion amount, annual erosion modulus is up to 6800 t/km².a. Gravity erosion is caused by wastes such as waste soil, stone and slag for capital construction as well as mine tailings and slag of mine industry. As known from the headquarters of highway construction of the reservoir area, 248km highway is reconstructed in Geheyan Reservoir Area excavating 9.92 million m³ earthwork, dropping 6.944 million m³ waste stones and soil, destroying 12.4km² vegetation and farmland. As known from the seism office of the County, there are 247 landslides in all scales in the County and the total landslide mass is 545.7784 million m³, including 124 earth slides, 24 rockslides, 85 locations of poor stability and 34 of poorer stability. According to fuel and environmental protection department, the County has 141 mining sites producing 2.2 million m³ final tailings and stone ballast per year.

4.3 Local economy and society

4.3.1 Social and economic background

Changyang Tujia Autonomous County is a poor county only gathering the old, children, mountains and reservoirs; it governs 11 villages and towns, 154 small businesses, 992 villager groups and 127483 households. Total population is 410793 including 355133 agricultural population with 197303 labor force, natural population increase is -0.71%, land area is 3430km² including 32787 cultivated area. Total grain output of Changyang is 151800 t, gross value of agricultural output is RMB 871 million, net income per capita is RMB 1809. Gross domestic product of Changyang

is up to RMB 2.619 billion, annual average increase rate is 5%. In the recent years, national economy of Changyang Tujia Autonomous County has increased fast, so the demand on power supply is increasing day by day. While the structure of power grid there is not reasonable, the existing transmission capacity cannot keep up with the fast development of load and development of power supply construction. Therefore, the conflict between supply and demand of power and electric quantity of Changyang Tujia Autonomous County stands out.

The land of Changyang Duzhenwan Town administrative area covers 52500hm², has 4495hm² cultivated area, crop sown area is 9228hm², grain sown area is 6619hm², villages and towns now have 15643 households in total (370 household in urban area) including 55523 total population (2254 population in urban area), number of the employed of villages and towns is 28450; there are 848 township enterprises with 2018 employers, total economic income is RMB 123.79 million, net income per capita of peasants is RMB 1544; there are now 28 school of all kinds with 5833 students, 8 hospitals and health centers together with one library.

4.3.2 Present situation of land use

Total land area of the whole county is 341881.74hm² taking up 1.83% of that of the whole province. Land structure: agricultural use land covers 53951.73hm² taking up 15.78%; forestry covers 244667hm² taking up 72.57%; grass land covers 2830.12hm² taking up 0.83%, water land covers 10877.71hm² taking up 3.18%; barren hill and slope cover 8958.19hm² taking up 2.62%; non-production land covers 8861.03hm² taking up 2.59%; land difficult to use covers 11726.03hm² taking up 3.43%.

Land resource in the County mainly is mountain land, land holding per capita is 0.82hm², land resource is more plentiful, so it has the potential for all-round development. At present, the land resource is mainly used for agriculture and forestry, cultivated land is overused but forestry is underutilized; cultivated land in the whole county mainly is dry land covering 51064.73hm² taking up 94.65%; household

land area is only 11625.52hm², the share of one person is not more than 0.03hm²; hillside cultivated more than 25 degree covers 8455.86hm² taking up 13.76%; there is also 12933.33hm² low yield land together with 7333.33hm² cultivated land spreading on high mountains, they have bad soil environment and many obstacles. Only 244677hm² is used for forestry, forest cover rate is only 47.9%, there are a lot of woodland and bush grass as well as 8958.19hm² barren hills and slopes.

There is no greater resident point, no industrial, military, cultural, mechanical and health facilities and no cultural relic in the area.

4.3.3 Cultural education and health of people

In the recent years, with the stable development of education, Changyang Tujia Autonomous County has achieved a lot in popularization of compulsory nine-year education, education level here has been developed, there are two middle schools, five primary schools and two lower primary schools; the culture also has been developed, the cultural network such as village cable TV and township cultural station has been constructed.

Local medical institution is complete, villages and towns have medical and public health departments such as town central hospital and village health centers with sufficient medical care personnel, medical and public health departments in the project area is complete and able to prevent and treat different diseases such as epidemic dysentery, typhoid and malaria, no large scale communicable disease and no typical local disease have happened in several years.

4.4 Assessment of existing environment and main environment problems

4.4.1 Assessment of existing environment

(1) Assessment method and content of existing ecological environment

Collecting existing data on biodiversity of the assessment area and neighboring area and on the basis of comprehensive analysis of existing data, the existing biological environment of the assessment area is assessed together with field survey; the field survey focus on route investigation and key area (such as dam area, power house area and waste disposal area) investigation combined with civilian visit and market survey, on the bases of which mechanism biological analysis method is applied for qualitative or quantitative assessment of ecological environment quality such as characteristics of population structure, distribution of animals and plants as well as bio-community heterogeneity. In addition, on the bases of collecting related data and field survey, spatial information technology such as GPS, RS and GIS is applied for digitization determination of the ground type, completing digital vegetation map and land use type map for qualitative and quantitative assessment of the quality of landscape and ecological environment.

(2) Plant flora structure

Vegetation in the project area is of plentiful type, evergreen plants are widely distributed, vegetation type is numerous and complicate, plant community structure is complex and interlayer plants are plentiful. Vegetation zone is different with the rising of altitude. In hilly terrain with altitude less than 500m, it mainly is deciduous broad-leaved forest including oaks such as orientalwhite oak, cork oak, Chinese ash and bastard acacia together with evergreen coniferous forest such as pinus massoniana and cunninghamia lanceolata; evergreen mixed deciduous forest and needle-leaved forest mainly including cypress, cunninghamia sinensis, pinus massoniana, cork oak, betula luminifera and Chinese aspen are distributed at 500~1300m altitude. Category of evergreen broad-leaved forest is orient white oak, lithocarpus

cleistocarpus, cyclobalanopsis multinervis, Badong oak and Yichang cedar. At the altitude above 1300m, they are mixed broadleaved deciduous forest and warm needle-leaved forest evergreen trees including evergreen species, main constructive species are pinus henryi mast, armand's pine, quercus accuerionalis, fagus lucida, brood tree, hornbeam, castanea henryi, cork oak, betula luminifera, fragrant birch, gray birch, aspen and populus lasiocarpa oliv; evergreen broadleaved tree species are quercus spinosa, holly, Indian azalea, lithocarpus cleistocarpus and Badong oak. The project site is located in mountains at 400-800m altitude, vegetation mainly covers broad-leaved forest, theropencedrymion trees, needle-leaved forest and mountain shrub, details of which are shown as follows:

Assessment area of Erchakou hydropower project is located in Duzhenwan Town of Changyang Tujia Autonomous County enjoying subtropical monsoon climate, vegetation resource in the assessment area is more plentiful. Through field survey to vegetation resource of assessment area, four vertical sample belts and one horizontal sample belt are investigated in the area. According to analysis through remote sensing satellite, forest cover rate in the assessment area of Erchakou Hydropower Station is about 45.8%.

①mixed forest

In assessment area, the natural community is mainly composed of Pinus massoniana and Cunninghamia lanceolata. Other species are associated. Constructive species of Pinus massoniana forest and cunninghamia lanceolata forest are mixed with each other sometimes or mixed in bamboo forest and evergreen deciduous broad-leaved forest.

☆Form.Pinus massoniana

Form.Pinus massoniana is a community most widely distributed in the east of subtropical zone with the richest resources. The project area is located at the hillside

with altitude below 1200m, *Pinus massoniana* is the dominant species, this kind of forest almost is secondary forest growing after the original forest community is cut. Some are planted in the air and maintained later, these forests are under semi-natural growing status.

Physiognomy of Form. *Pinus massoniana* is emerald, leaf canopy is loose with clear layers. The canopy densities are of greater difference because of the intensity of human activities, which is between 0.4~0.7 in general, forest canopy density of some sections is higher because of the intrusion of broadleaf species. In general, the height of *Pinus massoniana* is 10~16m. Community structure is simpler, which is pure forest generally; sometimes it mixes with a few *Betula luminifera*, *Liquidambar formosana* and *Castanea sequinii*, *Cunninghamia lanceolata*. The bush layer is developed with about 50% coverage, it mainly includes *Eurya loquiana*, *Smilax* spp and *Glochidion puberum*. The field layer mainly includes *Dicranopteris dichotoma* and *Hicriopteris laecissima* with greater coverage.

☆ **Form *Cunninghamia lanceolata***

Form *Cunninghamia lanceolata* is widely distributed in the east of subtropical zone, especially growing well in Wuyi mountainous area and Nanling mountainous area at the boundaries of Fujian, Zhejiang, Jiangxi and Guangdong, as well as the mountainous areas at the boundaries of Hunan, Guizhou and Guangxi, which are production center of Form *Cunninghamia lanceolata*. Form *Cunninghamia lanceolata* is located northward or semi-southward with deeper soil in the project area.

The form *Cunninghamia lanceolata* almost is artificial forest, tree stratum is a monodominant community composed of *Cunninghamia lanceolata*, the crown likes a tower, and physiognomy is dark green and orderly. Total coverage of tree stratum is 50%, the *Cunninghamia lanceolata* grows well with 10-15m average height; canopy density of the bush layer is greater, so renewal of seedling is slower. Coverage of the bush layer is above 70%, main species are *Mallotus japonicus* var. *floccosus*, *Rhus*

chinensis and eurya sp. Coverage of the field layer is lower, common species are woodwardia japonica, anemone hupehensis, arthraxon hispidus and Arachniodes rhomboidea. The interlayer plants mainly are diploclisia chinensis and smilax sp.

② Broadleaved forest

Broad leaved forest is a community taking broadleaf species as the main part. The project is located in medium sub-tropical area with rich hydrothermal conditions, the landform is complicated, relative height is greater, plant species are numerous and the flora elements are complex, so different broad-leaved forests are developed. Broad-leaved forests in protection area show their vertical distribution rules with the changes of altitude gradient; evergreen mixed deciduous broad-leaved forest appears in zonality evergreen broad-leaved forest in medium subtropical zone of low-altitude area and certain altitude section in mountains, while deciduous broad-leaved forest grows in the upper part of mountains.

Constructive species of broad-leaved forest in the area is more complicated, constructive plants composing evergreen broad-leaved forest mainly are fagaceae, lauraceae and Theaceae. Constructive plants composing deciduous broad-leaved forest mainly are fagaceae quercus, fagus, betulaceae, juglandaceae and salicaceae.

Evergreen broad-leaved forest is a zonality vegetation form in subtropical zone of China, which is of greatly plentiful category. Constructive species mainly are fagaceae arbor species (part of casianea, liihocarpus, cyclobalanopsis and quercus) and lauraceae arbor species (cinnamomum, phoebe and machilus).

☆ Form.Cyclobalanopsis ciliaris

The community is of stronger cold resistance, soil barren resistance and annidation, so it is widely distributed in the area. Form.Cyclobalanopsis ciliaris is the dominant species of the community; in addition, tree stratum also includes cyclobalanopsis,

sorbus folgeri and fagus lucida with above 80% coverage.

Coverage of bush layer is 60%, which mainly grows fargesia spathacea with about 3m height together with some rhododendron hypoflaucum and R. mariesii.

Evergreen mixed deciduous broad-leaved forest is a transition of evergreen broad-leaved forest and deciduous broad-leaved forest widely distributed in the middle mountains in subtropical zone, it is a common vegetation in the area; thermophilic evergreen species are limited with the rising of altitude and reduction of temperature, cold-tolerant evergreen broad-leaved species and deciduous broadleaf species increase and develop as a mixed forest. Therefore, it is often located in evergreen broad-leaved forest belt and is a kind of transition vegetation in succession, but it has certain stability. Main species composed of this category are nyssaceae, cyclobalanopsis, carpinus fargesiana and form. cyclobalanopsis ciliaris. In the aspect of flora elements, China has plentiful ancient and special plants such as liriodendron Chinese, pterocarya stenoptera, tetracentron sinense, pterostyrax psilophylla and aesculus wilsonii, some of which grows as dominant species and others grows as companions.

Deciduous broad-leaved forest is a community composed of a kind of broad-leaved species falling leaves in the season not suitable for their growth (such as cold winter or dry season with no rainfall). There are two categories of deciduous broad-leaved forest in medium subtropical zone, one is deciduous broad-leaved forest growing in medium mountains in subtropical zone shows in the upper part with higher altitude, its development is mainly impacted by special climate of mountains, and constructive species of the community endure the cold winter in mountains by leaf falling. Another one is in the area with lower altitude, which is developed because of intrusion of deciduous species when the environment becomes degenerated and the land becomes exhausted gradually after evergreen broad-leaved forest, warm evergreen needle-leaved forest and evergreen mixed deciduous broad-leaved forest are destroyed.

③ **Shrub and bush grass**

Shrub in subtropical zone is secondary in general and it is not a kind of zonal vegetation. It develops in the recovery period of forest after being severely destroyed and on rock face, because the environment is bad which limits the development of plants, only shrub which can endure the crucial environment can grow here; and also it can grow at mountain top because of gale and barren soil. Hassock and grass slope in subtropical zone except some dry and hot river valleys almost develops after the original vegetation is destroyed such as burning, waste land after cultivation, especially the former one that can grow a larger area of grass slope, but substitution of the grass slope is fast.

☆ **Form. *Coriaria sinica***

It is a kind of shrub after *Pinus massoniana* and cork oak are cut. *Form. Coriaria sinica* almost distributes semi-southward and semi-southward with 30~50° grade, it grows well on moist land with companion *pyracantha fortuneana* growing in cluster, sumac often mixes in it, common herbs are cogongrass and divaricate *strophanthus* seed.

☆ **Form. *Cotinus coggygia Scop. var. pubescens Engl***

It grows in the soil on mountains at 250 ~ 1500m altitude, is a pioneering community to prevent soil erosion for the area with poor habitat conditions and widely distributed in the assessment area.

☆ **Form. *Imperata cylindrica***

It distributes in semi-high and high mountains, a few of which can be seen in the assessment area. The community mainly covers cogongrass together with *arthroxon hispidus*, bermuda grass, annual bluegrass, *arundinella anomala steud*, awn and

goosefoot.

④ Agricultural vegetation

The assessment area is located in the mountains in northwest of Changyang, a few cultivated lands which distributed in valleys, are mainly divided into the following categories:

Grain crops: wheat, Indian corn, paddy, corn and soybean;

Oil crops: rape, peanut and sesame;

Economic crops: cotton, tea, China grass and watermelon;

Vegetables: mustard, spinage, green vegetable, radish, lettuce and yam.

⑤ Rare plants

Erchakou Hydropower Station is a run-of-river plant and the reservoir will not be flooded. The height of the topmost overflow dam is only 2.63m (3.09m and 3.32m), land occupation of the Project mainly is permanent occupation covering only 0.37hm² because the Project is of small scale; through investigation, no state and province protected rare plants, old and famous trees are discovered in construction area.

⑥ Conclusion of assessment of existing plant resource

★ According to investigation to flora in the assessment area and processing of flora data system accumulated for years, the mountain where Erchakou Hydropower Station locates is artificially planted with pinus massoniana, cunninghamia lanceolata and cypress as well as barren hillside field and bushes.

★ Vertical distribution of forest in the assessment area is different, trench and valleys

are found in low mountains below 500m altitude, the grade is great and vegetation is few, so cypress forest and bush grass grow there. Vegetation distributed at the hillside in construction area mainly is shrub. Main vegetation in waste disposal area is bush grass.

★ No rare endangered protection plants, old and famous trees in the assessment area.

(3) Assessment of existing animal resource

Category, quantity and distribution of animal resource; assess the situation of all communities through field survey, visit and document reference.

① Animals

There are six classes, 10 families and 13 categories of animals in the assessment area, directory of their species is shown in Table 4-1.

Table 4-1 Directory of Animals in Assessment Area

Chinese name and Latin name	Flora	Protection level	Habitat	Distribution of assessment area
I. INSECTIVORA				
(I) Erinaceidae				
1. Erinaceus europaeus	Species of Palaearctic region	Non	Various habits such as root, fallen tree, rock gap and shrub.	√
(II) Soricidae				
2. Nurosorex squamipes	Oriental species	Non	Habit in forest, grassland, field and village.	√
II. CHIROPTERA				
(III) Hipposiderid				
3. Vespertilio superans	Oriental species	Non	Inhabit in grassland or river valley in mountains, live at the upper frame and sunshade	√

			of structures	
III. LAGOMORPHA				
(IV) Leporidae				
4. Lepus capensis	Oriental species	Non	Mainly inhabit in shrub and grass on both sides of farmland or channels nearby farmland as well as shrub and edge at hillside.	√
IV. RODENTIA				
(V) Sciuridea				
5. Dremomys rufigenis	Oriental species	Non	Habit on trees and land. Move on the ground and live in tree cave and rock gap	√
(VI) Hystricidae				
6. Hystris hodgsoni	Oriental species	Provincial level	Inhabit in grass, shrub and trees in mountains.	√
(VII) Muridae				
7. R.fulvescens	Oriental species	Non	Live in trees, shrub, farmland and rock gap in mountains and hills.	√
8. R.niviventer	Oriental species	Non	Live in trees, shrub, crop area, rock gap and grass beside brooks.	√
(VIII) Cricetidae				
9. Cricetulus.barabensis	Oriental species	Non	Live in forest edge and shrub of different habitats.	√
10. C.trtro	Oriental species	Non	Live in grassland, farmland and forest edge in mountains.	√
V. CARNIVORA				
(IX) Mustelidae				
11. Arctonyx collaris	Oriental species	Provincial level	Live in caves of rock gap, tree cave and soil caves, also occupy others holes.	√
12. Mustela sibirica	Widespread species	Non	Inhabit area is wide commonly seen in forest edge, shrub, marsh, valley, hill and plain.	√
VI. ARTIODACTYLA				
(X) Suidae				
13. Sus scrofa	Widespread species	Non	All forests, shrub and grassland.	√

Large and medium size animals are mainly distributed in hillside grass and shrub at

medium altitude in non-flooding area, which are active at nighttime, early morning and late at night. They can go to the riverside to look for food and water in fall and winter, there are also other small animals and small rats in the assessment area.

Arctonyx collaris is a medium and small carnivore of musteline family living in caves, they often dig holes on barren hill or live in rock gap or occupy others hole; badger loves to dig holes beside rivers and brooks as well as on dike dam and reservoir bank; ferret badger lives in rock cave and gap, they are good at tunneling.

Rodent is of the most categories and quantities in the area (6 in total taking up 46% of the total genera) and also an important companion animal of human beings. Habitat for living and movement of some of them are greatly overlapping with the economic activity area of human beings, some of them are of domesticated and wild living habits. In different seasons, they change their living areas between the field and houses of human beings. Some of them have great influence on agriculture and forestry, such as muridae, which including *N. fulvescens*, *niviventer confucianus* and porcupine, can steal a lot of crops including paddy, wheat, rice and sweet potato as well as valuable medicinal materials; some of them even store a lot of potatoes and valuable medicinal materials in their caves for winter, some species of muridae are the spreading source of some natural focal diseases.

② Birds

There are 8 classes, 14 families and 17 categories of birds in the assessment area, directory of which is shown in Table 4-2.

Distribution characteristics of birds: most species populations distribute southward in forest shrub, brook bank, channel side at forest edge and forest canopy, few of them live in farmland, water birds are mainly living in valleys along rivers. 10 categories

of passeriformes taking up 58.8% are living in the assessment area; there are no state-protected animals but 5 kinds of province-protected animals: phasianus colchicus, caprimulgus indicus, barn swallow, large-billed crow and thrush. There are 7 oriental species taking up 41.18%; there are 4 species of palaeartic region taking up 23.53%; there are 6 widespread species taking up 35.29%. There are 10 residents taking up 58.8%; 4 kinds of summer migrant taking up 23.53%, one kind of passing migrants taking up 5.88% and one kind of winter migrant taking up 5.88%.

Table 4-2 Directory of Birds in Assessment Area

Chinese name	Latin name	Residence type	Flora	Population status	Habitat	Distribution in assessment area	Protection level
I. CICONIDFORMES	CICONIDFORMES						
(I) Ardeidae	Ardeidae						
1. Ardeola bacchus	Ardeola bacchus	Summering	Oriental species	+	Live in paddy field, pond and water reservoir, sometimes in bamboo or trees.		Provincial level
II. FALCONIFORMES	FALCONIFORMES						
(II) Aceipitridae	Aceipitridae						
2. Black-eared kite	Black-eared kite	Resident	widespread		Kites often live on rock	Yes	State Level II

					surface and trees in valleys, they can be seen everywhere mostly. They like flying a circle in the air, their sight is sharp, so they will rush to the ground if any quarry is found.		
III. GALLIFORMES	GALLIFORMES						
(III) Phasianidae	Phasianidae						
3. Phasianus colchicus	Phasianus colchicus	Resident	Widespread	+	Live in shrub, bamboo cluster, grass, meadow in valleys and forest edge, cultivated land and reed pond nearby mountains	Yes	Provincial level
IV. COLUMBIFORMES	COLUMBIFORMES						
(IV) Columbidae	Columbidae						
4. Streptopelia	Streptopelia			++	Live in		

orientalis	orientalis	Resident	Widespread		plain and mountains trees, farmland in winter. Take berry and seed as food.	Yes	Non
V. CUCULIFORMES	CUCULIFORMES						
(V) Cuculidae	Cuculidae						
5. Eudynamys Scolopacea	Eudynamys Scolopacea	Summersinging	Oriental		Live in trees nearby redisent point on plain and trees in mountains		Non
VI. CAPRIMULGIFORMES	CAPRIMULGIFORMES						
(VI) Caprimulgidae	Caprimulgidae						
6. Caprimulgus indicus	Caprimulgus indicus	Summersinging	Oriental	+	Live in forest, especially love living in felling forest and forest edge.	Yes	Provincial level
VII. CORACIIFORMES	CORACIIFORMES						
(VII) Alcedinidea	Alcedinidea						
7. Alcedo atthis	Alcedo atthis	Resident	Widespread	++	Live in plain, hills and	Yes	Non

					mountain s. Often stand on stone or cable wires, branches besides water and paddy field.		
VIII. PASSERIFORME S	PASSERIFORMES						
(VIII) Hirundinidae	Hirundinidae						
8. Hirundo rustica	Hirundo rustica	Summerin g	Palaearcti c	++	Often fly in farmland, especially love flying in groups above the plowed land to pry on insects. Build nest under house wall and eaves.	Yes	Provinci al level
(IX) Motacillidae	Motacillidae						
9. M.cinerea	M.cinerea	Traveling	Widespre ad	+	Live in different habitats and build nest on both sides of rivers.	Yes	Non
10. M.alba	M.alba	Resident	Widespre ad	+	Live around water	Yes	Non

					instead of forest.		
(XI) Corvidae	Corvidae						
11. Corvus.macro-rhynchus	Corvus.macro-rhynchus	Resident	Palearctic	+	Live in plain, hill and mountains; often gather at the side of farmland, village and beach.	Yes	Provincial level
(XII) Timaliidae	Timaliidae						
12. G.arrulax canorus	G.arrulax canorus	Resident	Oriental	+++	Live in bushy trees and shrub in hills and mountains or bamboos and gardens nearby villages.	Yes	Provincial level
13. G.sannio	G.sannio	Resident	Oriental	+	Live in bushy trees and shrub of plains and mountains.	Yes	Non
14. Paradoxornis webbianus	Paradoxornis webbianus	Resident	Oriental	+	Live in shrub and bamboo. Build nest in shrub.	Yes	Non
(XIII) Ploceidae	Ploceidae						
15. Passer montanus	Passer montanus	Resident	Palearctic	+++	Live around	Yes	Non

			c		villages and farmland with wide activity area. Take crops as food and eat insects when breeding.		
16. P.rutilans	P.rutilans	Resident	Oriental	+++	Live in mountains nearby villages, valleys, river side, farmland and shrub.	Yes	Non
(XV) Fringillidae	Fringillidae						
17. E.rustica	E.rustica	Wintering	Palearctic	+	Live in field, forest edge, shrub and reed pond. Breed in Siberia	Yes	Non

③ Amphibians and reptiles

There are two classes, two families and three categories of amphibian animals, one class, three families and four categories of reptiles in the assessment area, directory of four species is shown in Table 4-3.

Table 4-3 Directory of amphibians and reptiles animals in assessment area

No.	Chinese name	Latin name	Habitat and protection level
	REPTILA	REPTILA	
	I. Caudata	Caudata	
	(I) Salamandridae	Salamandridae	
1	Cynops orientalis	Cynops orientalis	Live in dead water or beside slow brook in mountains; oriental species; no protection level.
	II. SQUAMATA	SQUAMATA	
	(II) Gekkonidae	Gekkonidae	
2	Gekko japonicus	Gekko japonicus	Live in buildings of plains and neighboring area; oriental; no protection level.
	(III) Lacertidae	Lacertidae	
3	Takydromus sexlinealus	Takydromus sexlinealus	Live in grass or trees; move fast; oriental; no protection level
	(IV) Colubridae	Colubridae	
4	Cyclophiops major	Cyclophiops major	Live in trees, grass or around farmland in mountains; oriental; no protection level.
5	Zaocys dhumnades	Zaocys dhumnades	Live in trees, grass or nearby farmland and surrounding houses in mountains; oriental; provincial level.
6	Elaphe rufodorsata	Elaphe rufodorsata	Live nearby houses and move in grass, garden and hills; palaeartic; no protection level.
	(V) Crotalidae	Crotalidae	
7	Agkistrodon breviaudus	Agkistrodon breviaudus	Live in riprap, weed slope, shrub, farmland and village; widespread; no protection level.
	AMPHIBIA	AMPHIBIA	
	I. ANURA	ANURA	
	(I) Ranidae	Ranidae	
8	Rana limnocharis	Rana limnocharis	Live in dead water of plain, hill, field, trees or around houses; oriental; no protection level.
9	R.nigromaculata	R.nigromaculata	Live in pool, channel, paddy field, reservoir, small river and marsh; widespread; provincial-protected animals.
10	P.plancyi	P.plancyi	Live in pond or paddy field with water grass and lotus leaf.
11	Amolops ricketti	Amolops ricketti	Live in rapid stream of small and big brooks at 400-1500m altitude or water culvert under waterfall; oriental; no protection level.
	(II) Hylidae	Hylidae	
12	H.arborea immaculate	H.arborea immaculate	Live in water land, pond, rivers in low mountains or hills and plain, on shrub and crop plants nearby marsh; palaeartic; no protection level.

	II. LACERTIFORMES	LACERTIFORMES	
	(III) Scincidae	Scincidae	
13	Eumeces chinensis	Eumeces chinensis	Live in plain, hill as well as grass and riprap grass on road side in mountains; oriental; no protection level.
14	E.elegans	E.elegans	Live in trees and rock gaps; oriental; no protection level.

Distribution characteristics of amphibians and reptiles: amphibians widely distributed in the assessment area, frogs are mainly living in bayou, water land, pond and marsh. Megapodiidae distributes in low mountains, semi-high mountains and high mountains of greater amount.

There are two classes, five families and seven categories of amphibian in assessment area and there are no State key protected animals; there is one kind of provincial key protected animals, i.e. *zaocys dhumnades*. Flora elements are: five oriental species taking up 71.4%; one widespread species taking up 14.3% and one palaeartic species taking up 14.3%.

There are two classes, three families and seven categories of reptiles and there are no state key-protected animals in the assessment area. There is one provincial level protection animal, i.e. *rana niromaculata*; the flora elements are: four oriental species taking up 57.2%, one widespread species taking up 14.4% and one palaeartic species taking up 14.4%.

④ Distribution characteristics

★ Horizontal distribution

➤ Animal group distributed around water land and its surroundings

a. All amphibian caudate animals distributed in the area almost live in water, they always live in water although they will not die when leaving water for a short time.

b. Breeding of amphibian caudate animals i.e. frogs in the area must be in water; they cannot keep away from the water because of imperfect body structure to live on land although they prey on land, so they must go back to the water uninterruptedly and absorb water through the skin to compensate that evaporated on land.

c. Ciconiiformes, ciconiiformes and thalasseus bergii are wading birds. They walk in shallow water or water land to look for aquatic like small fish and shrimp. Wading birds are less through field survey, it may because of the smaller water area.

d. Groups looking for food in water. They stand on branches beside banks and prey on small fish and shrimp in water when flying; in addition, a few song birds of passeriforme also do the same thing.

➤ Animal group in forest land

Animals in forest in the area mainly include birds, animals and some reptiles with nests in forest. They are of many categories and great amount as well as the main body of animal groups in the area. They mainly move and look for food in forest, trees, shrub at the forest edge and grass, so a complicated food chain is constructed by them together with other animals and plants.

Species diversity of forest animals is an important factor to keep natural ecological balance. In addition, forest animals and the living of human beings are closely related, they can provide several economic approaches; forest birds together with lacertilian and serpents of reptiles are key natural enemy of pests and bandicoots in farmland and forest.

➤ Animal group closely related with economic activity area of human being

Rodentia animals are of the most categories and quantity, and also an important companion of human beings. Living habitat of some muridae and circetidae are

greatly overlapping with the economic activity area of human beings, some of them are of domesticated and wild living habits. In different seasons, they change their living areas between the field and houses of human beings. Some are greatly endangering agricultural and forestry industries, some rodents are the spreading source of natural focal diseases; in addition, some passeriformes are also important companion animals of human beings, they look for food in residential area and prey on pests so as to purify our environment.

★ Vertical distribution

➤ Vertical distribution of poikilotherm

Amphibian and reptile are poikilotherm animals, they adjust the body temperature through ambient temperature, so most of them love living in warmer area with lower altitude. In reptiles of the area, *R.nigromaculata* and *Rana limnocharis* are widespread species mainly distributed in water land of hills with medium altitude.

Most reptiles distribute in hills with medium altitude, but *cyclophiops major* and *zaocys dhumnades* are widespread species which distribute at all altitudes.

➤ Vertical distribution of homeotherm

Birds and animals are homeotherm animals, they have perfect thermoregulation mechanism, so geographical and vertical distributions of them are wide. Most of them are forest animals living in the area with better forest vegetation, because the forest community has a good food chain, and it is easy to get food, hide and inhabit; these animals migrate vertically because of vertical changes of food in different seasons. For example, they migrate to low altitude when the food is lack at high altitude in winter, while they move to high altitude when the food is plentiful in spring and summer.

⑤ Existing category and quantity of rare endangered animals

Because of several artificial factors such as demand and development of wild life in many years, no state key-protected wildlife and rare animal species of China are discovered in the assessment area through survey. Because Erchakou Hydropower Station Project is of small scale and area, it shows through field survey that there are only provincial protection animals such as *hystrix hodgsoni*, *arctonyx collaris*, *phasianus colchicus*, *caprimulgus indicus*, barn swallow, large-billed crow, thrush, *zaocys dhumna* and *rana niromaculata*.

⑥ Conclusion of assessment of existing terrestrial animal resources

★ Assessment conclusion of animals

There are totaling four classes, five families and ten categories of animals involving no state key-protected animals in the assessment area; there are four kinds of provincial key-protected animals: *arctonyx collaris*, Chinese ferret-badger, *lepus capensis*, *trogopterus xanthipes*. Large and medium size animals mainly distribute in hillside grass and shrub at medium altitude of non-flooding area, rodent is of the most categories and quantities in the area mainly distributing in mountains and hills, they are the important companion animals of human beings and some of them are the spreading resource of natural focal diseases.

★ Assessment conclusion of existing birds

There are five classes, ten families and nineteen categories of birds in the assessment involving no state protection animals but four kinds of provincial key-protected animals: red-rumped swallow, barn swallow, large-billed crow and spotted-necked dove.

★ Assessment conclusion of existing amphibians and reptiles

There are two classes, five families and seven categories of amphibian animals, two

classes, three families and seven categories of reptiles; there is no state key-protected animals and one kind of provincial key-protected animal.

(5) Aquatic resources

Naturally, the sections is torrent invigorated river habitat of fast speed, great changes of flow and water level as well as greater changes of flow in flood and dry period; the substrate mainly is rock, pebble and sand, which is not good for development of primary productivity in aquatic environment. Aquatic resources in the river are limited.

① Phytoplankton

Through survey to the project area (dam site to tailwater of the station), there are five categories totaling 26 kinds of algae in the assessment area, in which there are 15 kinds of bacillariophyta taking up 57.7% of the total algae; five kinds of chlorophyta taking up 18.5%; four kinds of cyanophyta taking up 15.4%; one kind of cryptophyta taking up 3.8%; one kind of pyrophyta taking up 3.8%; category of phytoplankton is shown in Table 4-4.

Table 4-4 Directory of Slgae in Assessment Area

Species Latin name	Habit	Economic use
I. Cyanophyta		
1. Hammatoidea sinensis	Love living in the water of more plentiful organic matters	
2. Phormidium corium	Floating on the water	Feed stuff
3. Chamaesiphon confervicola	Live in fresh water	
4. Oscillatoria Formosa	Live in fresh water	
II. Chlopta		
5. Scenedesmus quadricauda	Float in small water body with static freshwater	Feed stuff
6. Gonatozygon monotaenium	Float or fix	
7. Ankistrodesmus acicularis	Live in shallow water	Feed stuff

8. Oedogonium sp.	Widely spread	
9. Coelastrum sphaericum	Flotation in lakes and ponds	
III. Bacillariophyta	Live in cleaner water	
10. Pinnularia gracillima	Live in fresh water	Feed stuff
11. Navicula exigua	Live in fresh water	
12. Fragilaria brevistriata	Common species	
13. Navicula simplex	Often live in fresh water	
14. Cocconeis placentula	Common species	
15. Cymbella ventricosa	Common species in freshwater and distribute in mountains	Feed stuff
16. Frustulia vulgaris	Common species	Feed stuff
17. Pinnularia brevicostata	Common species in brooks	
18. Cymbella delicatula	Common species in mountains	
19. Pinnularia undulate	Common species in fresh water especially in water body of mountains	
20. Cymbella cistula	Common species in fresh water distributing in mountains	
21. Cymbella gracilis	Common species in mountains	Feed stuff
22. Gomphonema acuminatum	Common species in fresh water	
23. Synedra acus	Common species	
24. Fragilaria virescens	Common species in mountains	
IV. Cryptophyta		
25. Cryptomonas.sp	Common species in fresh water	
V. Pyrophyta		
26. Cerdtium hirundinella	Common species in fresh water	

Chongxi Brook where Erchakou Station located is a typical flashy stream with faster flow speed, riverbed almost is rocky or sandy, the water is clear with little organic; algae float mainly is bacillariophyta accounted from category and quantity, which shows that the water is poor of nutrition, water quality is good and there is little organic pollution. Diatom, as one of the most plentiful groups in companion biological group, has adaptability to low temperature, so it grows as the dominant algae because there grows little higher plant; specific composition of each sample site is similar in similar ecological environment. Prosperous specific composition and quantity of planktonic algae present the characteristics of mountains and rivers.

② Zooplankton

According to survey results, there are four categories totaling 20 kinds of zooplanktons in the assessment area, in which there are three kinds of protozoans, seven kinds of rotifers, six kinds of cladocerans and four kinds of copepodas. Most zooplanktons live in cleaner water, the catchment is a flowing water body, so it is not suitable for growth and breeding of zooplankton, most of which are taken by surface runoff and they are often seen in Changjiang River; there is no special species of the catchment and the specific composition is simpler; the category and quantity are less than that of algae. Category of zooplankton in Yaozhan Brook Catchment is shown in Table 4-5.

Table 4-5 Directory of zooplankton in the assessment area

Species Latin Name	Assessment area
I. PROTOZOA	
1. Strombidium sp.	√
2. Arcella sp.	
3. Vorticella sp.	√
II. ROTIFERA	
4. Schizocerca diversicornis	√
5. Lecane	
6. Philodina erythropalma	√
7. Kweatella cochlearis	√
8. Kweatella valga	
9. Monostyla lunaris	√
10. Mytilina ventralis	
III. CLADOCERA	
11. Daphnia hyaline	√
12. Sida crystalline	
13. Bosminopsis deitersi	√
14. Alona costata	
15. Chydorus sphaericus	

16. Alona rectangular	√
IV. COPEPODA	
17. Cylop vicinus	√
18. Phyllodiaptomus tunguidus	√
19. Eodiaptomus sinensis	√
20. Mesocyclops leuckart	

As known from the above table, specific composition of aquatic zooplankton in construction area of Erchakou Hydropower Station is simple and the quantity is less, which is identical with the characteristics that the water is clear, the water flows fast, it is lack of detention environment and multiply opportunity.

③ Benthos

According to survey results and related data, there are four kinds of benthos in Yaozhan Brook, the dominant species is limnodrilus; in addition, category and quantity of benthos is less. The benthos mainly is aquatic insects, most of which love living in the place with rapid flow, clear water, plentiful oxygen and cobble or sandy gravel substrate. The directory is determined through viewing related data as shown in Table 4-6.

Table 4-6 Directory of benthos in assessment area

Species Latin name	Plant site	Dam site
1. Tubifex	√	
2. Limnodrilus	√	√
3. Rhyacodrilus		√
4. Erpobdella	√	

Through the above survey results, the water in assessment area is clean and lack of nutrients, which cause its less category and quantity. At completion of the project, the reduction of water will cause the reduction of original ephemera-suitable for living in rapid flow in the habitat, and finally substitution by other species, therefore, the composition, biodiversity and biological completeness of species are damaged. If the riverbed is dry in construction, it must cause the changes of composition of

zoobenthos, if the dry period lasts for a long time, it will cause long-time dry of the riverbed and also cause the disappearance of zoobenthos.

However, the zoobenthos also distributes in other areas under similar environment, they are not the special species in the area, so construction of the Project will not cause death of the species as seen from the aspect of species conservation.

④ Fishes

According to related data and survey of present situation, there are three classes, four families and 13 categories of fishes in the assessment area; see Table 4-7 for details.

Table 7-4 Directory of Fishes in Assessment Area

Species	Living environment and habit	Resource type	Distribute in assessment area
I. CYPRINIMOPFIS			
(I) Cyprinidae			
1. <i>Ochetobius elongates</i>	Live in rapid flow take small fishes, shrimps and aquatic insects as food	More important economic fishes	√
2. <i>Parabramis pekinensis</i>	Live in the medium and lower layer of brooks	More important economic fishes	
3. <i>Rhodeus ocellatus</i>	Live in shallow water at smooth river bend and take algae as food	Less economic value	
4. <i>Retoris luxiensis</i>	Live in the middle and upper reaches of rivers		
5. <i>Abbottina rivularis</i>	Live in the medium and lower layers of water	Less economic value	√

6. <i>Carassius auratus</i>	Live in the lower layer of flow water or dead water, omnivory	Important economic fishes	√
(II) Cobitidac			
7. <i>Misgurnus anguillicaudatus</i>	Dermarsal in dead water	With certain economic value	
8. <i>Botia superciliaris</i>		Less economic value	
9. <i>Triplophysagrahami</i>	Live in rock gap or water grass in river and take benthic insects as food	Less economic value	√
(III) Homalopteridae			
10. <i>Lepturichthysfimbriata</i>	Live in stone beach of rivers and mountain brooks, take periphyton on stones as food	Less economic value	√
11. <i>Metahomnloptersomeiensis</i>		Less economic value	
II. SILURIFORMES			
(IV) Bagridae			
13. <i>Pelteobagrusfulvidraco</i>	Live at the bottom and take small fishes, shrimps and aquatic insects as food	Fishing takes up a great proportion	√

Yaozhan Brook Catchment is the first level branch of Qingjiang River and is flashy stream with great fluctuation in stage, frequent changes, great gradient, rapid flow and extremely unstable water surface, so it is not suitable for breeding. Growth of adult fishes in the river mainly depends on small torrent rough fishes; the time and geographic distribution of breeding of adult fishes are not collective. There are no state protection fishes and Hubei Provincial key-protected fishes in the assessment area.

(6) Assessment conclusion of existing biological environment

① Productivity analysis of natural system in the assessment area

Vegetation is the most important and sensitive natural elements of ecological environment, which determines the changes and stability of ecosystem; net productivity of vegetation indicates the quantity of organics accumulated in unit area

and unit time by green plants, is the rest part after autotrophic breath is deducted from the total amount of organics generated through photosynthesis, it directly reflects the production capacity of plant community in natural environment, and also an important parameter for assessing the quality of existing ecological situation. The data for assessment of natural system productivity in ecological assessment area of Yangshukou Hydropower Station are mainly obtained from field survey and collected materials, research findings of natural ecosystem productivity and vegetation biomass of the State are applied for analysis.

Vegetation investigation of ecological assessment area is completed through comprehensive analysis of field survey, satellite interpretation, indoor analysis combined with collected data. The process of satellite information extraction is shown as follows: apply remote sensing image processing software ERDAS to interpret the selected TM data, conduct data fusion through geometry fine adjustment and image enhancement, and then comprehensively analyze according to information data in different environment and related image processing software, then obtains related data and ecological map required for ecological environment research in the assessment area.

According to satellite image interpretation combined with existing surface coverage and situation of vegetation occurrence in the ecological assessment area, the vegetation can be divided into the following categories:

☆ Broadleaved forest: it almost covers 2600847.64m^2 taking up 40.87% of the total area, which mainly includes paulownia, Chinese ash, *carpinus fargesii* franch and form *cyclobalanopsis ciliaris*; average net productivity is $1021.5\text{g}/(\text{m}^2\cdot\text{a})$.

☆ Needle-leaved forest: it almost covers 2443648.43m^2 taking up 43.50% of the total area, which mainly includes *Pinus massoniana* and then *cunninghamia lanceolata*. Average net productivity is $1031.92\text{ g}/(\text{m}^2\cdot\text{a})$.

☆ Open forest land: it covers about 416810.320m² taking up 6.97% of the total area, most of which is artificial pure forest or natural regeneration pure forest; average net productivity is 600 g/(m²·a).

☆ Shrub: it covers about 440094.06m² taking up 7.36% of the assessment area, representative plants are salix daliensis and rhododendron hypoglaucom Hems. The vegetation mainly distributes on hillside, roadside and both sides of farmland without high forest as well as at the edge of high forest. They are important for farmland protection and the conservation of soil and water, grass land and shrub alternately distribute in the assessment area; therefore, grass land and shrub are considered as one vegetation type, the average net productivity of which is 821.39 g/(m²·a).

☆ Cultivated land: it covers about 77529.59m² taking up 1.30% of the assessment area, crops in the area mainly is paddy together with wheat, corn, millet, sorghum, potato, bean and all kinds of vegetable, average net productivity is 840.72 g/(m²·a).

Vegetation type in the assessment area of Erchakou Hydropower Station is shown in the Attached Fig. 7.

Average net productivity of the assessment area of Erchakou Hydropower Station is 978.83g/(m²·a) as calculated, average net productivity of the global continent ecosystem is 720g/(m²·a), the former one is 258.83g/(m²·a) higher than the later one, which indicates that vegetation in the area grows higher, theropencedrymion and shrub in the assessment area are the main vegetation and the aquatic shrub mainly grows on flood land; forest and grass land are important for the stability and changes of ecosystem. Natural vegetation in the assessment area grows flourishing, which is important for the stability and changes of ecosystem.

② Existing land use and assessment

Assessment of the existing land resource is comprehensively analyzed through

determination and interpretation of ETM+ satellite remote sensing data with 30m ground resolution combined with 1:5x10000 topographic map as well as the map for existing land use of Changyang and Yichang City.

According to wave length ETM1-7 wave band and ground scene information of each wave band, as well as participation of *Key Technology of Making 1:5 x 10000 Tm Image*, the program of 4, 5 and 3 wave bands integrating R (red), G (green) and B (blue) is applied for visual interpretation of the land resource, synoptic map of water land, cultivated land, structural house sites and unused land are indicated with different colors; in addition, different land use types are interpreted combined with microcomputer remote sensing image processing system (RS), the application of supervision classification (establishing training area) approach and compared with the map of existing land use; the assessment results are shown in Table 4-8 and Attached Fig. 8 Existing land use of the assessment area.

According to assessment results shown in Table 4-8, land area in the assessment area is 776.62hm² and the open forest land covers 64.95%. The land is mainly shared by forest land, and then shrub, others only take up little proportion.

Table 4-8 Schedule for Existing Land Use in Assessment Area

Land use type	Blocks (Qty.)	Area (m ²)	Percentage of the assessment area (m ²)
Cultivated land	40	1787269.09	23.01
Forest land	12	5044496.02	64.95
Open forest land	8	416810.32	5.37
Shrub	11	440094.06	5.67
Land use for construction of residents	27	77529.59	1.00

③ Assessment of landscape space structure

Space structure analysis is fundamental for heterogeneity analysis of landscape,

changes of landscape structure includes interaction of natural environment, different organisms and human beings, which almost is assumed by human beings; while in the view that landscape ecology structure and functions are greatly suitable for each other, whether the structure is reasonable determines the landscape functions and how we obey the natural rules.

In the three components of landscape, mould land is the background and of landscape and an important landscape element, which determines the characteristics and the dynamics of landscape.

There are three standards to determine mould land, i.e. whether the relative area is large, connectivity degree is high and it has dynamic control function or not.

Quantitative method to determine landscape mould land is not sophisticated; the method of the traditional ecology to calculate the important value of vegetation to determine the advantage of one block type is often applied, which is called as dominance degree, the dominance degree is calculated through three parameters, i.e. Density (R_d), frequency (R_f) and landscape proportion (L_p), the three parameters can better reflect the first two standards for mould land determination and not definite express the third standard; however, we can consider according to the determination procedure of mould land in landscape that, the relative area is great and the connectivity degree is high when the determination of the first two standards is clearer, that is the mould land we are looking for.

Formula for calculating the dominance degree is shown as follows:

Density $R_d = \text{Qty. of block } i / \text{total qty. of blocks} \times 100\%$

Frequency $R_f = \text{Quadrat of block } i / \text{total quadrat} \times 100\%$

Landscape proportion $L_p = \text{Area of block } i / \text{total area of quadrat} \times 100\%$

Dominance degree $D_o = \text{Error!} \times 100\%$

In which:

D_o ——dominance degree;

R_d ——density of blocks;

R_f ——frequency;

L_p ——landscape proportion.

Calculation results are shown in Table 4-9

Table 4-9 Dominance Degree of Different Blocks of the Project and Surrounding Area

Unit: %

Block type	Density (R_d)	Frequency (R_f)	Landscape proportion (L_p)	Dominance degree (D_o)
Cultivated land	40.82	24.85	23.01	27.92
Forest land	12.24	70.15	64.95	53.07
Open forest land	8.16	5.80	5.37	6.18
Shrub	11.22	6.12	5.67	7.17
Land use for construction of residents	27.55	1.08	1.00	7.66

As shown in the above table, in dominance degree of each block in the assessment area, each index of forest land such as dominance degree (53.07%), density (12.24%), frequency (70.15%) and landscape proportion (64.95%), is higher than that of others. In addition, each index of cultivated land such as dominance degree (27.921%), density (40.82%), frequency (24.85%) and landscape proportion (23.01%) is next to that of the forest land, it indicates that the forest land and cultivated land are the mould lands of assessment area and the ecosystem essential to landscape in the area. Therefore, the assessment area is of better ecological environment, greater

productivity, anti-interference capacity and strong system adjustment capacity.

4.4.2 Quality of existing ambient air and assessment

(1) Arrangement of monitor point

In order to know the quality of ambient air in the construction area, Environment Monitor Station of Changyang Tujia Autonomous County monitored the ambient air of the area during December 2-6, 2005 for successive five days.

According to meteorology characteristics, distribution of sensitive points and valley trend, four monitor points are set at dam site and power house, detail location of which shown in Attached Fig. 1 (geologic location and distribution of monitor point of ambient air).

(2) Monitor items and methods

Ambient air monitor factor is total suspended particles. Sampling and analysis are done in the method specified by the State Environmental Protection Administration. Setting of sampling point and height shall comply with *Technical Criteria for Environmental Monitoring-Atmosphere Part*, the method for sampling and analysis are shown in Table 4-10.

Table 4-10 Sampling and Analysis Method of Ambient Air Pollutants

Pollutants	Daily monitor time	Sampling method	Sampling instrument	Analysis method	Analysis instrument	Reference
TSP	≥12h	Filtration membrane concentration method	Type TH-1000C large-capacity intelligent sampler of	Weighting method	TG328A analytical balance	GB3095-1996 GB/T15432-95

			total suspended particles			
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(3) Assessment standard

The secondary standard of *Ambient Air Quality Standard* (GB3095-1996) shall be obeyed for assessing TSP; standard value is shown in Table 4-11.

Table 4-11 Standard Value of Ambient Air Quality Assessment

No.	Pollutants	Standard value (mg/m ³)		Standard
		Hourly value	Daily average	
1	TSP	/	0.30	The secondary standard of <i>Ambient Air Quality Standard</i> (GB3095-1996)

(4) Monitor results of existing ambient air

Statistics of monitor results of ambient air quality in the assessment area is shown in Table 4-12.

Table 4-12 Statistics of Monitor Results of Ambient Air Quality

Monitor point	Item	Daily average value		
		(mg/m ³) Concentration (mg/m ³)	Over limit rate (%)	Maximum out-of-standard times
1# dam site	TSP	0.049-0.058	0	0
2# power house	TSP	0.047-0.062	0	0

(5) Assessment results of existing ambient air quality

As known from Table 4-12, TSP daily average value in assessment area is 0.047-0.062mg/m³, which obeys the secondary standard of *Ambient Air Quality Standard* (GB3095-1996), so the quality of ambient air in the area is good.

The assessment area is located in out-of-the-way mountains, air pollution source in the mainly area nonpoint source and line source, nonpoint source indicates the pollutants discharged from burning of sulfur coal, char and firewood in daily life of local residents; line source indicates exhaust gas and dust discharged by vehicles.

The area is thinly inhabited and the traffic is undeveloped, so pollutant discharge from both nonpoint source and line source is extremely low, so it has little impact on ambient air, air quality is up to or higher than the secondary standard of *Ambient Air Quality Standard* (GB3095-1996).

4.4.3 Assessment of existing surface water quality

(1) Sectional layout of water quality monitor

Erchakou Hydropower Station is a power generation project located at Yaozhan Brook Catchment. According to environment, incoming flow and project characteristics around the project area, there are totaling four monitor sections set in the area, designation and location of water quality monitor are shown in Table 4-13.

Table 4-13 Schedule of Monitor Sections of Water Quality

Section No.	Location	Remarks
1	Dam site of Neixi Brook	Control section
2	Dam site of Liujia Brook	Control section
3	Dam site of Daxigou	Control section
4	Power house	Control section

(2) Monitor items

Monitor items: PH, SS, total phosphorus, Permanganate index.

(3) Sampling and analysis method

Sampling and analysis method shall comply with *Monitoring Method of Water and Waste Water* (the fourth version) issued by the State Environmental Protection Administration; analysis method is shown in Table 4-4.

Table 4-14 Analysis Method of Water Quality

No.	Monitor item	Analysis method	Standard and rules
1	PH	Glass electrode method	GB6920-86
2	SS	Weighting method	GB11901-89
3	Permanganate index	Permanganate method	GB11892-89
4	total phosphorus	Ammonium molybdate spectrophotometric method	GB11892-89

(4) Monitor time and frequency

Conduct one phase of water quality monitor in dry season lasting for three days.

(5) Assessment method and standard

Assessment method: According to *Technical Guidelines for Environmental Impact Assessment- Surface Water Environment* (HJ/T2.3-93), single-factor index method is applied for assessment.

Assessment standard: environmental quality of surface water shall be assessed according to Category II standard of GB3838-2002 as shown in Table 4-15.

Table 4-15 Standard Value of Environmental Assessment of Surface Water

Item	PH	Total phosphorus	SS	Permanganate index
Standard value	6-9	≤0.1	-	≤4

(6) Monitor results and assessment

Statistics of quality monitor data of aquatic environment

Table 4-16 Statistics of Quality Monitor Data of Aquatic Environment

Unit: mg/L

No. and location of monitor section	Monitor item	(mg/L) Average value (mg/L)	Assessment standard value (mg/L)	Standard index	Out-of-standard rate (%)
1# dam site of Neixi Brook	PH	7.87	6-9	0.445	/
	SS	2.5	/	/	
	Permanganate index	0.85	≤4	0.2125	/
	Total phosphorus	0.01	≤0.1	0.1	/
2# dam site of Neixi Brook Dam	PH	7.90	6-9	0.445	/
	SS	2.5	/	/	
	Permanganate index	0.76	≤4	0.19	/
	Total phosphorus	0.01	≤0.1	0.1	/
2# dam site of Neixi Brook Dam	PH	7.86	6-9	0.43	/
	SS	2.5	/	/	
	Permanganate index	0.84	≤4	0.21	/
	Total phosphorus	0.01	≤0.1	0.1	/
4# dam site of Neixi Brook Dam	PH	7.89	6-9	0.445	/
	SS	2.5	/	/	
	Permanganate index	0.84	≤4	0.67	/

	Total phosphorus	0.01	≤0.1	0.1	/
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(7) Assessment conclusion

As shown in Table 5-17: according to monitor data of present situation and applying the above assessment method, monitor index of sectional water quality complies with Category II standard of *Environmental Quality Standards for Surface Water* (GB3838-2002), it indicates that water quality of the catchment is good.

4.4.4 Survey and assessment of existing acoustic environment

(1) Monitor points

According to the function and plan layout of the assessment area, four noise monitor points are set, which are noise monitor points of the plant boundary. Location of noise monitor points is shown in Table 4-17.

Table 4-17 Ambient Noise Monitor

Monitor point	Designation	Remarks
1	Construction area at dam site of Neixi Brook Dam	Construction area
2	Construction area of dam site of Liujia Brook Dam	Construction area
3	Construction area of dam site of Daxigou Dam	Construction area
4	Construction area of power house	Construction area

(2) Monitor time and frequency

The monitor lasts for three days and each monitor point shall be monitored once at

daytime (6:00-22:00) and night (22:00-6:00).

(3) Monitor method

According to *Method of Measuring Noise at Boundary of Industrial Enterprises* (GB12349-90) and *Measuring Method of Environmental Noise of Urban Area* (GB14623-90), conduct noise monitor and data processing of sensitive points and the plant site to be constructed.

(4) Monitor results and standard

Standard of existing ambient noise is shown in Table 4-18.

Table 4-18 Noise Assessment Sstandard Unit: dB (A)

Item	Daytime	Night	Remarks
Standard value	55	45	GB3096-93 Category I

The monitor results of existing ambient noise are shown in Table 4-19.

Table 4-19 Monitor Results of Existing Ambient Nnoise Unit: dB (A)

Point No.	Monitor location	Daytime		Night	
		Monitor value	Out-of-standard dB	Monitor value	Out-of-standard dB
1	Construction area at dam site of Neixi Brook (nearby river)	67	12	66	11
2	Construction area at dam site of Liujia Brook (50m from river)	44	0	42	0
3	Construction area at dam site of Daxigou (above 100m from river)	39	0	38	0
4	Construction area of power house	42	0	38	0

(5) Assessment conclusion

According to analysis of monitor results of the plant boundary, 2#, 3# and 4# monitor points comply with Category 1 of *Standard for Environmental Noise of Urban Area* (GB3096-93); noise of 1# monitor point is 12dB(A) out of standard at daytime and 12dB(A) out of standard at night, the main reason is water flow because 1# monitor point is nearby the river. So the existing noise environment in the area is good.

4.5 Main environmental problems

4.5.1 Soil erosion

Soil erosion in the project area mainly is caused by water erosion and leaching erosion, main forms of which are surface erosion and gully erosion. The soil erosion mainly happens in hillside cultivated, barren hill and slope as well as young open forest land, the loss type of which changes with the lithology. As seen from loss strength distribution, there are mainly slight and light soil erosion, and lithology of the section mainly is limestone, leaching erosion is discovered in field inspection, which causes rock emergence, strong cutting and difficult treatment.

4.5.2 Flood

Yaozhan Brook Catchment where Erchakou Hydropower Station locates is a typical flashy stream, the catchment is in northern hemisphere sub-tropical warm and humid monsoon climate. Flood is mainly arising from rainstorm of the cyclonic rain and frontal rain system as well as Typhoon rain system; therefore, the flood is greater than nearby catchment in magnitude. The gradient on both sides of Yaozhan Brook Catchment is greater and the collection time is short, so the river rises and drops suddenly and sharply, the flooding process almost is single peak belonging to sharp and thin peak; even if the flooding process is double peak, the acme and amount of secondary peak are extremely small, which only lasts for a short time. Duration of

the whole flooding process is 1~3 days in general.

Flood of Yaozhan Brook happens in April~October and gathers in July~August, rainstorm is collective and lasting for a short time, so flood with greater peak often happens. It is a typical flashy stream, the river rises and drops suddenly and sharply, disparity in high water period and dry period is great.

4.5.3 Undeveloped economy

It is located in the mountain, economy of the impact area mainly is agriculture of lower production level; infrastructure such as power supply, water supply and traffic is worse, which severely impact economy development of the area.

4.5.4 Others

There are no industrial enterprises in the area and catchment, the population density is low and the area of cultivated land is less, vegetation is of good situation; employment level of pesticide and chemical fertilizer is low. Therefore, the impact of different environment pollution is lower. Main existing environmental problem in the area is that, the road level is low, so the traffic is limited, low-level village or mountain road is the main traffic way for construction of dam site and power house, the undeveloped traffic severely restricts economic development of the area, and also has influence on the project construction.

5. Prediction and assessment of environmental impact

5.1 Analysis of ecological environment impact

5.1.1 Analysis of ecosystem integrity impact

(1) Changes of hydroregime

Yaozhan Brook Catchment is mainly covered by high mountains and the water in rivers is clear. Sediment accumulation of riverbed is caused by soil erosion, so the whole riverbed almost is laid by mud and cobble, the water flows more rapid and is muddy in flood period, the water level rises, a lot of mud and stones are in the river; the river is clear and shallow in dry season.

At completion of the power station, the river runoff from the lower reaches of dam to the power house will reduce obviously because of diversion of channels, it will change the space distribution of river runoff, intermittent discontinuous flow and dewatering even happen in dry season, so as to generate influence on aquatic environment and ecological environment under the dam.

Hydraulic project can greatly promote the development of economy and society. In addition, the construction of hydraulic project also endangers ecosystem of rivers, such as homogenization and discontinuity of river configuration, which reduces the diversity of river configuration in a certain degree; the change of habitat diversity causes the reduction of diversity of bio-community in water area, so as to influence the health and stability of ecosystem in a certain degree.

As for this hydropower station, surface runoffs will change in the space because of diversion of channel system, and cause abrupt reduction of surface runoff of some rivers; in addition, although no big artificial reservoir lake is formed because of the

construction of intake dam, an artificial barrier is still formed, which causes discontinuity of water flow, so that the diversity level of bio-community is reduced thereof.

① Impact on terrestrial animals and plants

As impacted by construction activities, the surface vegetation will be impacted in a short period for 12 months; temporary land occupation of construction is 1.65hm², native vegetation disappears on the land temporarily occupied, vegetation almost is bush grass mixed with a few theropencedrymion; forest vegetation in the area with gentler slope almost has been substituted by farmland vegetation because of the interference of human activities, forest lands are sprinkling in it, forest vegetation is high tree-shrub-grass, farmland vegetation is paddy-rape-corn. There is no flaky forest vegetation in construction site, soil and stone stock, the plants are common; there is no state key-protected plant and ancient tree, no die out of species arising from local flooding. With fund investment in construction and perfecting of traffic conditions, favorable conditions for regeneration of vegetation around the station will be provided, which is good for vegetation growth and consequent succession.

According to site survey, there is no resident in 300m around the construction site of Erchakou Hydropower Station, vegetation on both sides is of better condition, which provides a better living environment for wildlife. With the access of construction personnel, machinery and equipment, human activities and mechanical noise will directly impact the habitat quality of surrounding terrestrial animals, which will force animals and birds to immigrate to a new environment, the reduction of habitat area is adverse, but it is short and of smaller impact scope. According to site survey results, as for species diversity of animals, rodent species in the area has the absolute advantage, most of them live in the field and also in farmhouse in different seasons, they almost live in farmhouses in winter and under individuals of farmland in summer and autumn; moreover, most of them are pests, but their reduction will cause the

changes of snake and mustelid in quantities, which take them as food. However, their capacity in immigration is strong, so construction of the Project has no obvious impact on them.

There is no rare endangered wildlife in the construction area and impact scope, but there are some ordinary small rodents distributing widely in the area; therefore, the impact on land natural community is minute and there is no obvious impact on breeding and survival of species.

② Impact on aquatic and fish

Plankton: a dam will be constructed in the river at completion of the Project, sediment will accumulate in front of the dam, so the water will become clear, which is favorable for growth of plankton. In the aspect of flora structure, there will be more species especially those loving to live in slow and dead flows. Phytoplankton mainly covers chlorophyta and cyanophyta loving to live in dead water, the original diatomeae living in flow water will reduce; while the individuals number of copepoda and nauplius larva may be dominant in zooplankton.

Zoobenthos: existing substrate in the river almost is pebble, there is little organism sediment, the flora of zoobenthos is poorer, only a few of them are anti-cleaning, such as snails and mussel. Based on the above reasons, the species and individual density of zoobenthos in the river above dam will not obviously change, while the density of those between the dam bottom and the power house may reduce in dry season because of the reduction of surface runoff.

Fish: fishes taking algae and zoobenthos as food and loving to live in dead water or lagging water are living in the river section of Yaozhan Brook Catchment Project.

5.1.2 Impact on biodiversity

(1) Impact on terrestrial animals and plants

Direct impact on vegetation of Changyang Erchakou Hydropower Station is from construction activities, indirect impact on vegetation is from local climate changes.

When constructing, excavation, blasting and slag piling will destroy the surface vegetation on both side of the dam site, nearby the power house and along the construction road, 1.03hm² vegetation will be changed as estimated (see the section for soil erosion). Vegetation destroyed in construction mainly is secondary shrub. With the implementation of soil conservancy plan, the above vegetation almost can be recovered.

Therefore, project construction has less impact on forest ecosystem and vegetation flora in the area.

According to our survey, there is no rare endangered wildlife in the impact area, but there are some ordinary small rodents distributing widely in the area, the quantity of which may be reduced and they may immigrate to other places because of noise and activities of construction personnel in construction period; however, the disturbance will disappear with the reduction of noise and human activities at completion of the project, the species will recover soon, so it has less impact on species diversity.

(2) Impact on aquatic

Phytoplankton such as cyanophyta and chlorophyta loving living in dead water will increase because of construction of the dam, diatomeae loving flow water will reduce. However, it is a small intake dam and no large scale artificial reservoir will be constructed, so the impact on species diversity of aquatic is smaller.

The stoppage of river by the intake dam and changes of hydroregime will have some impact on aquatic. At present, no rare fishes and aquatic are found in Yaozhan Brook.

5.1.3 Analysis of ecological base flow of rivers

At completion of the power station, the river runoff from the lower reaches of dam to the power house will reduce obviously because of diversion of channels, it will change the space distribution of river runoff, intermittent discontinuous flow and dewatering even happen in dry season, so as to generate influence on aquatic environment and ecological environment under the dam.

In order to avoid damage on ecosystem of the river in the lower reaches arising from discontinuous flow and dewatering, ensure certain ecological base flow of river in the lower reaches after the dam is constructed (also called as environmental flow or ecological water demand). Ecological base flow is to protect ecological resources under the dam which become rundown increasingly because of the development of water resources. At present, the method applied almost aims at protecting indicator species of aquatic, which changes the problem of ecological water demand into the relation problem between inner flow of rivers and organism habitat. In consideration that there is no indicator species of aquatic to be specially protected, and there is no definite standard and rules for reference in China now, calculation method for the minimum ecological water demand of environmental impact assessment practices of hydraulic projects in China is applied, average flow in the driest month of ten years or 90% warranted rate of average flow in the driest month is often considered as ecological water demand.

According to *DEMONSTRATION REPORT OF WATER RESOURCE*, ecological water in the area is supplied by Neixi Brook, Liujia Brook and Daxigou (calculated according to long-term average flow at dam site), discharge ecological flow of Neixi Brook is $0.03\text{m}^3/\text{s}$, that of Liujia Brook is $0.02\text{m}^3/\text{s}$ and of Daxigou is $0.02\text{m}^3/\text{s}$, total discharge ecological flow of Erchakou Hydropower Station is $0.05\text{m}^3/\text{s}$ in total. The concrete measure is that, lay 80mm steel pipe at the lowest place of the dam bottom to

keep constant water to satisfy ecological water use under the dam and the lowest requirements on ecological flow of the river in the lower reaches.

5.1.4 Comprehensive assessment

(1) Plants damaged in construction mainly are secondary shrub, there is no impact on rare plants; the above disturbed vegetation can be recovered with the implementation of soil erosion program.

(2) There is no rare endangered wildlife in the impact area, but there are some ordinary small rodents distributing widely in the area, their inhabitation scope may be impacted in construction, but it can be recovered at the completion.

(3) Because of non-adjustment operation of the Project, intermittent discontinuous flow of the river below dam may happen in dry season, which will damage the ecosystem of rivers in the lower reaches; $0.051\text{m}^3/\text{s}$ ecological base flow shall be assured for rivers in the lower reaches after the dam is constructed.

To sum up, the impact on ecological system is advantageous but also disadvantageous, remedial measures can be taken to reduce adverse impacts to an acceptable degree.

5.2 Prediction of aquatic environment impact

Erchakou Hydropower Station of Changyang Tujia Autonomous County is a small hydraulic project aiming at power generation; the construction of dam for water intake by cutting the river will change the distribution of the original river runoff in some spaces, so that aquatic and ecological environment of the river under dam will be impacted.

5.2.1 Impact on hydroregime

(1) Existing hydroregime

The catchment above the dam site covers 20.3km², long-term average flow at dam site is 0.51m³/s, long-term annual average runoff is 16.04 m³, the flood is influenced by the intensity of rainstorm and landform; if the rainstorm intensity is great, slope of river bed is steep, flood collection time is short, so it will cause suddenly rise and drop of flood. In addition, the rainstorm only happens in one period, so it causes uneven distribution of rainstorm in the year, precipitation in flood season takes up about 83.1% and in dry season only takes up 16.9%.

(2) Analysis of hydroregime changes after construction of the dam

After the dam is constructed, river flow will change greatly. Runoff in the river reach about 1km from the power house under the dam is greatly reduced because of the diversion channel; water of the river reach may reduce or cut in dry season because most water is discharged through channels; the impact in flood period is not obvious, the above changes will have certain impact on aquatic.

(3) Sediment

It is a small diversion station and vegetation in the project area is under good situation; erosion degree of geological structure along Chongxi Brook is low, the short-term flood arising from gully in the upper reaches of the dam area carries a little sediment, which can be discharged freely through the dam top.

5.2.2 Impact of construction on water quality

Possible impact of project construction on surface water environment mainly is wastewater of construction and production, domestic waste of construction personnel in living area, dropped sand and stone in construction; according to engineering analysis, construction period of the Project is one year, total discharge of wastewater

is 12542m³. Construction wastewater mainly comes from rinsing of sandstone processing system, placing and maintenance of concrete together with rinsing of construction machinery and vehicles, mainly pollutants are suspended solid and fossil oil with greater pH. Domestic wastewater is mainly discharged by construction and production personnel in daily time, BOD₅ and COD in wastewater are out of standard.

(1) Analysis of construction wastewater impact

Total discharge of construction wastewater is 10462m³, which mainly covers wastewater of concrete placing and maintenance wastewater, sandstone processing system as well as construction machinery and vehicles.

① Wastewater from sandstone processing system

Construction technology of sandstone processing covers sieving and grading, water shall be added for dustfall in sieving technology, most added water will be discharged as wastewater except the part used in production. When rinsing aggregate in sandstone processing system, slurry in coarse aggregate and fine sand less than 0.15mm will be carried by water, SS concentration in rinsing wastewater is extremely high, sediment content in sandstone on stock yard is about 2.26-13.6% in general. The content of sandstone and sediment takes 8% for calculation; SS concentration in sandstone rinsing wastewater is 25000mg/L according to material balance theory.

SS concentration of wastewater of sandstone aggregate processing plant greatly exceeds 70mg/L Level I standard of the maximum allowable discharge concentration of the secondary pollutants specified in *Integrated Waster Water Discharge Standard* (GB8978-96); if the wastewater is directly discharged without any treatment, the concentration of suspended solid in river will greatly increase as compared that under natural conditions, so it will severely pollute the river; therefore, it shall be reused or discharged into forest after treatment.

② Wastewater of concrete placing and maintenance

According to comparison survey, pH value of the wastewater is about 11~12, concentration of suspended solid in wastewater is about 5000mg/L, which is 70mg/L higher than the allowable discharge concentration; the wastewater must be reused after being treated to standard because of the following characteristics: high concentration of suspended solid, smaller water quantity and intermittent collective discharge.

③ Oil-bearing wastewater

Oil-bearing wastewater of the Project is from machine shop and vehicle washing, main pollutants are fossil oil and suspended solid. The oil film will disturb the reaeration of water body after being discharged into the water body if not treated, and then it will adversely impact the water quality, so it has to be treated.

According to engineering analysis: discharge of production and domestic wastewater in peak hour of construction is 12542m³, construction wastewater and sandstone rinsing wastewater take up above 60% of the total amount, the main pollutant is suspended solid and the concentration is extremely high (concentration of untreated sandstone rinsing wastewater is above 25000mg/L). It will destroy water quality of rivers if it is directly discharged into river before treatment. However, discharge of suspended solid in wastewater will reduce (SS removal rate above 90%), impact scope and degree will be greatly reduced as compared with direct discharge. The supernatant will flow into solution tank for production after sandstone processing wastewater is settled through sedimentation tank, the wastewater will not be discharged to the outside. Other production wastewater will be discharged into the nearby shrub and forest to naturally absorb by the forest after being treated by facilities, production wastewater will not be directly discharged into water body.

(4) Domestic wastewater

The number of construction personnel in peak hour of construction is about 85, domestic wastewater is from living water and excrement discharge of construction personnel. Construction, living and office facilities are mainly in local residents' houses, so domestic wastewater can be directly discharged into farmland for irrigation after simple treatment. Therefore, there is no wastewater discharge to the outside in construction period, so domestic wastewater will have no obvious impact on the water quality of river.

5.2.3 Analysis and assessment of water quality in the lower reaches of the dam

It is a diversion station and there is no reservoir at the bottom dam, water quality under the dam is slightly influenced with the changes of river flow; when the flow becomes small, total amount of pollutants entering the water body does not change, while pollutant concentration increases, this is more obvious in dry season; while the river flow is great in flood period, the flow shared by diversion channels takes smaller part of the total flow, so the pollutant concentration in water is not obvious; vice versa, the impact is obvious when the river flow is smaller in dry season.

In general, impact scope of the Project is smaller, vegetation coverage rate in the area is higher and there is no industrial wastewater and domestic wastewater along the river, so construction of the Project has no obvious impact on water quality in the river reach.

5.2.4 Impact on drinking and irrigation water source in operation

According to field survey, Liujia Brook Intake Dam is located 10m from the lower reaches of the intake dam of water supply project of Machi Township, there is no water supply for cities and towns in the lower reaches of water catchment at the dam

sites of Daxigou and Neixi Brook, only three households distribute at the right bank about 100m from the lower reaches of Neixi Brook dam site, the water for living and irrigation is taken from the river reach. During construction of the Project, water supply for living and irrigation of the three households will be influenced if no measure is taken. Therefore, the Employer shall connect diversion pipes to houses and nearby the cultivated land from the upper reaches, so as not to influence their living and irrigation. In operation, water supply for living and irrigation of the three households shall be ensured as well.

5.2.5 Comprehensive assessment

The source of water pollution in construction period mainly is production wastewater, total volume of the wastewater is small, but pollutant concentration is higher; the water shall be reused or discharged into shrub and forest after being treated, and the wastewater will disappear at completion of the Project.

5.3 Prediction and assessment of ambient air impact

There is no industrial enterprise of great energy consumption or consuming fuel coal in the assessment area, only a few residents live 500m away from construction area of the power house, so the quality of ambient air is good at present.

Dust and dirt produced in foundation excavation, earthwork backfill, aggregate processing and sieving, material loading and unloading for the main works in construction period; dirt caused by operation of construction machineries, transportation in and out of the site as well as vehicle tail gas; waste gas caused by operation of excavating machinery and powder blasting as well as waste gas of coal in living area, are intermittent and temporary non-organization and non-source discharge;

main pollutants in waste gas TSP, SO₂, NO_x, CO, hydrocarbon and lead compounds will influence the surrounding ambient air and the health of operation personnel in the area; however, only a few machineries are employed and operated in stages, so the influence on ambient air around the area is not great.

The amount of blasting agent is 60.7t and the blasting agent mainly produces noxious gas such as CO, NO_x and C₂H₂ as well as TSP. The pollutant is discharged intermittently and the amount of use is less, so it will cause a little pollution to the air.

Concentration of TSP discharged in earthwork excavation, blasting, sandstone grinding and earthwork transportation will be up to 150mg/m³, and that in local construction area will be out of the secondary standard of *Ambient Air Quality Standard* (GB3095-1996). The operation points for foundation excavation, blasting, earthwork backfill, aggregate processing and sieving, cement loading and unloading as well as concrete mixing are numerous and distributed widely, so the pollutants will mainly be non-organically discharged from non-point source, construction personnel will be impacted.

Exhaust gas of construction machineries also will cause pollution, predicted diesel oil consumption of construction machineries is 24.96t, exhaust gas discharged by the machineries taking diesel oil as main fuel contains harmful substance such as SO₂, CO, NO₂, C₂H₆ and lead compounds. Estimation of annual average pollutants discharged in construction period is shown as follows: SO₂ is about 137.2kg/a, NO₂ is about 667.68 kg/a, CO is about 443.04kg/a and alkylate is 131.04kg/a. As compared with monitor results of other projects, exhaust gas discharged by construction machineries and vehicles in transportation inside and outside the area mainly has impact on the surrounding of operation point and within 50m on both sides of the transportation route. The transportation routes are in lower valleys, meteorological divergence condition is close, a lot of exhaust gas is discharged at point source of the construction area (such as foundation pit) with collective large and medium machineries and line source of vehicle transportation between aggregate yard and dam

site, so the concentration of pollutants such as NO₂ and CO is relatively higher, and exceeding related discharge standard at local construction points. There is no sensitive point within 30m of the area, the pollutant generated by fuel oil in construction is of small amount and dispersed, so it has little impact on the surrounding ambient air.

There are no people living in the construction area. Residents will not be influenced in construction. In addition, air pollution arising from blasting, concrete mixing and system work face may have adverse impact on the health of construction personnel, so labor protection of them shall be strengthened. Construction will have no great impact on ecological environment in a short time.

5.4 Prediction and assessment of acoustic environment impact

5.4.1 Analysis of main pollution sources

The construction area of Erchakou Hydropower Station is in valleys of deep mountains, there is no noise interference around; according to monitor data of existing noise, average of equivalent noise level at daytime in the local place is about 42dB (A); according to type-selection of construction machinery and equipment as well as related comparison resources, source intensity of main construction noise is shown in Table 5-1.

Table 5-1 Source Intensity of Main Construction Noise

Type of noise source	Designation of equipment and system	Sound level value [dB(A)]
Fixed point source	Ball mill, crusher, sieve and mixer	95-100

Mobile line source	Truck and bulldozer	85-95
Blasting noise	Explosive of blasting agent	130

According to construction layout, nearby villagers (about 150m) and construction personnel will mainly be impacted by construction noise, in which construction personnel will be greatly influenced, but the influence is temporary. Impact of each noise source on the environment is shown as follows:

5.4.2 Prediction mode of noise attenuation

(1) Prediction mode of attenuation of fixed source

In accordance with *Technical Guidance for Environmental Impact Assessment-Acoustic Environment* (HJ/T2.4-1995), the following formula will be applied prediction and the maximum source intensity of each equipment will be selected for calculation.

$$L_A(r) = L_{WA} - 20 \lg r - 8$$

In which:

$L_A(r)$ ——sound level A from source r;

L_{WA} ——A sound power level of sound source;

r——the distance from prediction point to one source, m.

Noise overlapping mode:

$$L_A = 10 \lg \left(\sum_{i=1}^n 10^{0.1 L_i} \right)$$

In which:

L_A ——Total A sound level from the source r (m);

n——number of sources (n);

L_i ——sound level of source i.

(2) Attenuation prediction mode of mobile source

Noise generated by traffic of trucks and bulldozer can be considered as mobile source, the noise level is related with flow, vehicle type, speed and traffic flow. Main transportation vehicles in construction are heavy-duty trucks, the maximum noise intensity can be up to 90dB (A), noise generated by traffic of trucks and bulldozer can be considered as mobile source, the noise level is related with flow, vehicle type, speed and traffic flow, prediction mode of mobile source will be applied for calculating its attenuation.

$$L_m = 101g(N/r) + 301g(v/50) + 64$$

In which:

L_m ——sound pressure level from the source r (m), dB;

N——flow, vehicle/h (10 vehicles/h);

v——vehicle speed, km/h (15km/h);

r——distance between measurement point and noise source, m (the nearest residential area is 150m).

5.4.3 Noise prediction results

According to noise source and intensity listed in Table 5-1 and general construction

layout of Erchakou Hydropower Station, noise sources of construction are restricted by the landform, which are dispersedly distributed; there is no sensitive point of environmental noise in the qualified area of point source noise. Calculation results of fixed and continuous point source noise on the site are shown in Table 5-2.

Table 5-2 Noise Prediction Value of the Fixed and Continuous Point Source

Noise source	Source intensity (A)	Noise prediction value from the sources at different distances [dB(A)]								Qualified distance (m)
		20m	50m	100 m	150 m	200 m	250 m	300 m	500 m	
Sandstone processing	110	79.9	68.4	60.6	56.0	52.7	50.1	47.9	41.6	164
Foundation pit	112	81.9	70.4	62.6	58.0	54.7	52.1	49.9	43.6	195
Ball mill	100	69.9	58.4	50.6	46.0	42.7	40.1	37.9	31.6	67
Mixer	95	64.9	53.4	45.6	41.0	37.7	35.1	32.9	26.6	50
Blasting	130	99.9	78.4	80.6	76.9	72.7	70.1	67.9	61.6	250

* Noise limit within qualified distance is 55 dB (A) at night, in which blasting noise is considered as instantaneous noise; noise limit within qualified distance is 70 dB (A)

According to situation of road in the area and comparison data, flow on main road is 30vehicle/h at daytime and speed is 40km/h; flow at night is 20vehicle/h and speed is 25km/h. Prediction results of mobile noise sources on the main road are shown in Table 5-3.

Table 5-3 Prediction Value of Noise from Mobile Source

Distance to the noise source (m)	Flowrate (vehicle/h)	Speed (km/h)	Noise prediction value from the sources at different distances [dB(A)]								Qualified distance (m)
			10	20	30	40	50	100	150	200	
Daytime	30	40	65.9	62.8	61.1	59.8	58.9	55.9	54.1	52.9	5

Night	20	25	58.0	55.0	52.2	52.0	51.0	48.0	46.2	45.0	20
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Referring to noise limit in earthwork construction period specified in *NOISE LIMITS FOR CONSTRUCTION SITE Noise Limits for Construction Site* (GB12523-90): daytime 75 dB (A) and night 55 dB (A); environmental noise on both sides of main road shall be controlled according to four categories specified in *Standard for Environmental Noise of Urban Area* (GB3096-93): daytime 70 dB (A) and night 55 dB (A). As known from the attenuations of different noise sources listed in Table 5-1, the area with 20m of the site is greatly influenced by noise of construction machineries, which may be out of standard. So impact scope of construction noise is within 200m of the construction site, the adverse impact on nearby construction personnel mainly comes from foundation excavation of main works, which is periodic and instantaneous, instantaneous noise can be up to 130 dB (A); the peak value of instantaneous noise within 250m of the blasting point will exceed 70 dB (A) when blasting, construction personnel and residents will be influenced and animals will be frightened. As analyzed from Table 5-3, main road on the site is of greater flow, which is out of standard within 5m of the main road in daytime and within 20m at night.

5.5 Environmental impact analysis of blasting vibration

Ammonal is applied for chiseling and blasting, several holes will be chiseled at one time and the use of blasting agent shall be about 30kg at most for one time. Blast wave in blasting will cause vibration of the ground, according to Sadaovsk vibration attenuation formula:

$$V=K\cdot[Q^{1/3}/R]^a$$

In which:

V——Vibration speed, cm/s;

K——Geological coefficient at blasting point;

Q——Use of blasting agent, kg;

R——Distance between prediction point and blasting center, m;

a——Vibration attenuation coefficient.

According to field survey and combined with geological examination data, geology of the project site is bedrock, geological coefficient of blasting point K is 220, vibration attenuation coefficient a is 1.67, the residential area impacted by blasting is above 500m from the blasting center. As calculated, the vibration speed of residential area 150m from the blasting center is 0.034cm/s, residents buildings nearby mainly are non-brick construction, vibration speed of non-brick construction in blasting shall be less than 1cm/s according to *Safety Regulations for Blasting* (GB6722-86), so there is no obvious impact of coal mine blasting on surrounding houses. In addition, blasting is not frequent, the vibration arising from blast wave is temporary, which will disappear after blasting; no people lives there, so the impact of vibration arising from blasting is slight. In order for safety, the use of blasting agent shall be cared, so as to avoid unnecessary engineering geologic hazard.

5.6 Analysis of solid waste impact

5.6.1 Environmental impact analysis of solid waste in construction

Pollution source of main solid waste in construction include: waste slag, construction

waste such as cement, lime and sandstone as well as domestic waste of construction personnel. If the solid waste in construction is not treated well, it will not only impact water quality and human health, and also impact the natural landscape.

(1) Waste slag

Total slag quantity is $1.47 \times 10^4 \text{m}^3$ about $2.9 \times 10^4 \text{t}$, which is stocked in four waste disposal areas. If no protection measure is taken for the waste slag area, waste slag will be rinsed into Chongxi Brook and then cause new soil erosion. Construction slag not treated perfectly once is rinsed into the river, it will not only increase construction difficulty and impact construction progress, and moreover, it will destroy the surrounding vegetation and cause soil erosion, and then impact local ecological balance. In addition, waste slag will destroy the landscape along the bank if disposed freely, cause soil erosion and influence water quality of the river if not treated properly; excavated earthwork may influence the surface water before recycle in gale and rainstorm; fragments of weathered waste rocks and flying dirt will pollute the ambient air and endanger human health in drought.

(2) Domestic waste

The construction lasts for 12 months, the number of construction personnel in peak hour is up to 85, average number of daily construction personnel is 58, waste produced per day will be 85kg if one person produces 1.0kg waste per day, so totaling 42.34t waste will be produced in construction.

Domestic waste will not only pollute the air and destroy the landscape, but also cause breeding of mosquito, fly and rats if stocked freely, increase the spreading possibility of diseases, cause outbreak of disease in construction area with dense population and influence health of construction personnel.

Organic pollutant and germ of domestic waste will flow into the river with runoff or

others, and then pollute the river and increase the concentration of pollutant in water body.

(3) Production waste

Production waste is mainly from builders rubbish and processing scrap.

The construction area takes up 1.65hm² in total, a lot of construction rubbish and different sundries will be stocked in the construction area at completion of the Project, the removal of temporary structures and construction camps, and then the site will become disorderly; the removed part of structure can be kept if it can be recovered, the part that cannot be reused will be filled and burned according to their uses; it will not impact local visual landscape and recovery of the site in the later stage if the waste can be treated effectively.

Production waste generated in construction mainly includes fragments, scrap iron, waste bar, oil residue, oil paper and cotton yarn. Scrap iron and bar can be recovered; waste oil residue, oil paper and cotton yarn will not impact the environment of construction area if they are treated collectively.

5.6.2 Environmental impact analysis of solid waste in operation

Soil waste produced in production mainly is domestic waste of management personnel responsible for its operation totaling five persons. 4kg domestic waste will be produced per day if one person produces 0.5kg per day and annual waste discharge will be 1.36t; there will be adverse impact on the environment if these domestic wastes are not treated well.

5.7 Impact on social economy

5.7.1 Impact on social economy in operation

With the rapid development of industry and agriculture, power demand will increase endlessly, the existing power supply is insufficient for production and living, which has become the “bottle neck” that restricting economy development of Changyang. With the development of industry and agriculture especially the high speed development of industry and the improvement of living level of the people, the demand of power use will be increased and the requirement on power supply quality will become higher; power load of the whole county will be up to 120MW till 2012, while the existing installed capacity of Changyang is only 76.3MW, the conflict between supply and demand on electric power and quantity is incisive, so sufficiently using local water resource advantages to develop hydropower and construct new power supply point is pressing.

After the station is completed, long-term average power generation will be up to 604.49kW.h, it can provide sufficient energy for Duzhenwan Town, which will bring about the revival of power industry and development of township enterprises, so that power supply quality of Changyang Grid will be improved greatly, power supply can be ensured, electric quantity in high-water period and dry period can be adjusted, and socioeconomic development of Changyang will be promoted. After that, the number of power supply villages and households as well as electric furnace households will be greatly increased, forest harvesting will be reduced if electricity substitutes firewood, i.e. the beneficial cycle of “protecting the forest with power, accumulating water by forest and generate by water” can be ensured. Local energy structure by burning firewood and coal will be changed into the structure focusing on clean energy, so as to bring about new opportunity for sustainable development of local economy.

Construction of the Project is a comprehensive utilization project mainly aiming at power generation; it not only brings fiscal levy for Changyang, and also can perfect local energy and traffic conditions. The station is located in mountain, the mountain

is high and water is low, cultivated lands are dispersed, agricultural irrigation and drinking of animals and residents are difficult, the production of crops is often reduced because of drought; at completion of the Project, water for three households and 35mu farmland in the lower reaches of Neixi Brook Intake Dam can be directed introduced from channels, so that the existing way for water drinking and agricultural irrigation is changed, which gives more convenient for local farmers in production and living. The station perfects the way of irrigation of farmland and water drinking of residents, the loss of agricultural production arising from irrigation shortage can be reduced, and water drinking conditions of human and animals in the mountain is greatly perfectly.

5.7.2 Impact on social economy in construction

With development of the Project and stationing of construction personnel, the production and sales of local subsidiary foodstuff such as meat and vegetable will be promoted; about RMB 8000 sales amount will be increased in peak hour of construction if one person costs RMB 200 per month. Construction personnel also will promote the prosperity and development of the third industry such as local service industry and cultural recreation; construction of different temporary facilities will provide employment opportunity for local residents, it is not only helpful for developing local village economy, increase economic income of the public and improve living quality of the local people, but also have deep influence on local social economy.

5.8 Impact on human health

5.8.1 Impact on human health in construction

There are not many foreign construction personnel and other personnel in

construction, the number of construction personnel in peak hour is more than 250 and they are live with local villagers, so local population density will not be changed obviously. The probability of communicable disease is extremely low. Therefore, if health protection is not done well in construction, it may bring about communicable disease or even cross infection and spreading, which may cause adverse impact on human health, so it shall be paid enough attention. We only have to strengthen health management, actively advertise general knowledge of hygiene and disease control, pay attention to strengthen management of food hygiene and prevent the occurrence of group food poisoning. There are also accidental injury risks in construction, effective safety measures shall be taken in construction, communication and reconstruction of transmission facilities to prevent and avoid the occurrence of industrial accident.


5.8.2 Impact of human health in operation

At completion of the Project, local ecological environment as well as population density (5 management persons at most, totaling two shifts) will not be obviously changed; therefore, operation of the Project will not cause adverse impact on local human health.

5.9 Analysis of environmental geology impact

Stability of dam site depends on lithology, combination, breakage development, valley structure, neotectonic movement and human activity. The surrounding of dam side almost is bedrock slope with gentle slope, the lithology is arenaceous limestone mixing with mudstone, rock mass structure is complete with good integral stability. The stratum at dam site of Neixi Intake Dam is arenaceous limestone mixing with mudstone; rock mass structure grows tightly and the integrity of rock mass is worse. Limestone at stratum interface is eroded; the deep part may have

covered karst, which will influence the construction and seepage prevention of the dam foundation. The stratum of the dam site of Daxigou intake dam is thick containing mud knollenkalk, the rock mass structure is undeveloped, joint face is tight in general with poor connectivity, better integrity of rock mass, higher bearing capacity and shear strength, so the dam foundation is of better stability. There is no large scale fracture zone, weak interbed and other unfavorable geology in the dam area; according to *Seismic Ground Motion Parameter Zonation Map of China* (GB18306-2001), basic intensity at the dam site to be constructed is IV, the whole project area is of better geologic conditions and the river dam can be constructed.



6. Analysis of environmental risks

Water and power are clean energy, water conservancy and hydropower project will not cause pollution accident, but it has other accident potential, which will bring about destroy of ecological environment in different degree once happens. Combined with the environmental situation of Yaozhan Brook Catchment of Erchakou Hydropower Station and on the basis of analyzing and reviewing environmental risks of similar projects, the risks in the combined system of project and environment are identified, estimated and analyzed in the report, and then the strategies and measures to avoid risks under certain standards are promoted.

6.1 Risk identification

Erchakou Hydropower Station is run-of-river plant, the highest intake dam only is 3.32m (dam heights of Neixi Brook Dam, Liuji Brook Dam and Daxigou Dam are 2.63m, 3.09m and 3.32m respectively) and it is overflow dam, so there is no dam failure risk arising from different factor. In addition, according to geological exploration conclusion of the Project, seism is nearly impossible in the production area and the storage capacity is small, so it has no risk of dam failure and the above risk factors will not be assessed and analyzed in risk assessment.

According to development task, scale, engineering arrangement of Erchakou Hydropower Station, design and application of main structures as well as geological environment, climate, landscape vegetation, hydrology sediment, quality of aquatic environment, environment situation of aquatic in the area, combined with prediction and assessment of construction environment impact, environmental risks of the Project mainly are flood and construction accidents happened in diversion tunnel through preliminary risk identification.

6.2 Risk analysis of flood environment

(1) Rainstorm characteristics and flood origin

The flood of Yaozhan Brook Catchment is formed by rainstorm and is mainly arising from rainstorm of the cyconic rain and frontal rain system as well as Typhoon rain system, flood magnitude is greater than nearby catchments. The catchment is located in subtropical warm and humid monsoon climate zone with obvious winter and summer climate changes, so the four seasons are of their own characteristics, sunlight is sufficient, rainfall is rich; the weather is changeable in the warm Spring, rainfall is plentiful in the early Summer, it is dry in fall and cold in winter. Flood of Yaozhan Brook happens in April~October and gathers in July~August, rainstorm is collective and lasting for a short time, so flood with greater peak often happens.

The gradient on both sides of Yaozhan Brook Catchment is greater and the collection time is short, so the river rises and drops suddenly and sharply, the flooding process almost is single peak belonging to sharp and thin peak; even if the flooding process is double peak, the acme and amount of secondary peak are extremely small, which only lasts for a short time. Duration of the whole flooding process is 1~3 days in general. Flood of Yaozhan Brook mainly happens in April~October and gathers in July~August, rainstorm is collective and lasting for a short time, so flood with greater peak often happens. It is a typical flashy stream, the river rises and drops suddenly and sharply, disparity in high water period and dry period is great.

(2) Flood risk analysis

According to the latest power industry standard *Classification & Design Safety Standard of Hydropower Projecys* (DL5180-2003), it is a Class V and small (II) station, main and secondary structures are Level 5.

Damming height of intake dam is less than 15, and the maximum head difference in

the upper reaches and lower reaches is less than 10m, flood design standard shall be determined according to the standard for plain and coastal areas, i.e. regular flood (i.e. design flood) happens once per ten years as shown in Table 6.0.10 of the STANDARD, extreme flood (i.e. checkup flood) happens once per twenty years as determined.

The Power house complies with the flood standard for power house in mountains, it determined according to Table 6.0.9 of the *Standard* that the flood happens once per thirty years and extreme flood happens once per fifty years.

According to 1961-2004 field flood data and historical flood survey data of Yuyanguan hydrologic station, design flood flow is shown in Table 6-1.

Table 6-1 Design Flood at Dam Site and Plant Area of Erchakou Hydropower Station (m³/s)

Sectional location		Catchment area F(km ²)	Peaking duration (h)	rainstorm H ₂₄ (mm)	Q _m (m ³ /s) Peak discharge Q _m (m ³ /s)	Remarks
Neixi Brook Dam	Design P=10%	7.7	1.0	205.3	58	Long catchment in mountains
	Checkup P=5%			252.5	81	
Liuji Brook Dam	Design P=10%	6.8	0.99	198.8	51	Long catchment in mountains
	Checkup P=5%			243.6	69	
Daxigou Dam	Design P=10%	5.8	0.99	203.9	40	Long catchment in mountains
	Checkup P=5%			253.4	56	
Power house	Design P=3.3%	21	0.97	199.8	136	General catchment in mountains
	Checkup P=2%			248.4	187	

There is no requirement on flood control in the lower reaches of the Project, so risk assessment mainly takes the safety of flood control of the Project as principle. Installed gross capacity of Erchakou Hydropower Station is 1600KW, it is less than 10000kW; according to *Flood Control Standard* of the State (GB50201-94), *Standard for Classification and Flood Control of Water Resources and Hydroelectric Project* (SL252-2000), *Design Code for Diversion Channel and Head Pond of Hydropower Station* (DL/T5079-1997), it is Class V small (II) project. Main structures including intake dam, diversion tunnel, head pond, pressure pipeline, power house and booster station are Class 5 constructions.

Intake dam of Erchakou Hydropower Station is only used for stopping water from flowing into the channel instead of flood control, so the flood discharge in flooded area will not be limited. Design flood level and maximum flood level will be determined according to the operation of overflow dam.

Power house of the Station is located at 20m in the upper reaches of complement intake dam of Xujiaping hydropower project, relation curve of water level and flow at the plant site shall be determined according to the operation of complement intake dam of Xujiaping hydropower project.

According to engineering level, corresponding flood control standard is shown as follows: based on *Classification & Design Safety Standard of Hydropower Projects* (DL5180-2003), when the damming height is less than 15m and the maximum head difference in the upper and lower reaches is less than 10m, flood standard shall be determined according to the standards for plain and coastal area; the maximum height of the overflow dam is less than 10m, if the regular application flood (i.e. design flood) standard is determined as once per ten years, design peak discharge of Neixi Brook Dam is $64\text{m}^3/\text{s}$, of Liujia Brook Dam is $57\text{m}^3/\text{s}$ and of Daxigou Dam is $45\text{m}^3/\text{s}$; irregular application flood (i.e. checkup flood) standard is determined as once per twenty years, checkup flood flow of Neixi Brook Dam is $76\text{m}^3/\text{s}$, of Liujia Brook Dam is $68\text{m}^3/\text{s}$ and of Daxigou Dam is $54\text{m}^3/\text{s}$; design flood standard of power house

is determined as once per thirty years, the peak discharge is 195 m³/s; checkup flood standard is determined as once per fifty years, the peak discharge is 216 m³/s,

According to feasibility study report, Erchakou Hydropower Station Project is of small scale, short construction period, structures are almost constructed in dry period, so design flood in high-water period is not necessary to calculate, only the design flood from the current November to the next March in construction period shall be calculated. The impact of flood in construction period is not great.

(3) Risk reduction measures

In order to ensure safety of the check dam, remove the risk and develop water conservancy, sufficiently exert efficiency, try to avoid disaster and risk, all kinds of effective and emergency measures shall be taken in the whole process of survey, design, construction and operation for prevention risks. Suggestions on the assessment are shown as follows:

① Rainstorm and flood in Yaozhan Brook Catchment are frequency, the mountain is high with steep slopes, the speed of flow convergence is fast, the flood rises and drops rapidly, engineering flood control is low and there is no retention capacity; in order to ensure safety of the pivot and sufficiently exert efficiency of the station, information in the upper reaches shall be collected in good time, so as to provide reliable basis for implementing the optimum dispatching program of flood control.

② Strengthen flood monitor and report, especially care the flood exceeding safety design standard, try to obtain more time for preventing the flood. Flood discharge measures shall be prepared in advance for super-rainstorm flood and notify the people in the lower reaches to prepare for flood control and rushing to deal with the emergency.

③ Operation management personnel shall operate strictly according to scientific

dispatching program, closely care local weather forecast and hydrologic forecast of the catchment, and conduct reasonability analysis. Strengthen daily safety maintenance of main structures, timely solve problem and hidden trouble, strictly implement the management system and operation specifications as well as strengthen supervision and management. In addition, prepare different emergency plan and reduce environmental loss.

④ Establishing auto regimen measuring & forecasting system in operation and making accurate and timely flood forecast can effectively improve the accuracy and prolong period of forecast, so as to provide basis for making flood dispatching decision and ensure safety of hydropower project.

⑤ Strengthen comprehensive monitor of natural disasters such as landslide, rockfall, block glacier and karst collapse of local section in construction period especially in rainstorm period and flood period, so as to minimize the environmental risk.

6.3 Sudden accident risk in construction of diversion tunnel

Total length of diversion tunnel is about 2795.85m, the tunnel almost penetrates sandstone and shale, so the water yield property and permeability are poor; no large scale underground water is discovered in the section, but karst grows along the line when it passes through the carbonate rock, vertical karst fissure grows, it is more possible to encounter strong karst zone in the tunnel; underground water in local section is plentiful, water quantity is great, so the water is possible to bleed and burst at the top.

According to *Code for Water Resources and Hydropower Engineering Geological Investigation*, five factors such as rock strength, rock integrity, structural status, status

of underground water and main structural face shall be taken as the basis for overall assessment of the geology of surrounding rock engineering; the surrounding rock is Category II-IV; according to experience of similar projects, tunnel of Category II-IV surrounding rock can not be lined fundamentally, but leakage prevention, reduction of roughness coefficient and strengthening conveying capacity shall be considered to reduce excavation sections of tunnels.

Possible geologic problems of diversion tunnel are shown as follows:

(1) Stability of tunnel entrance and exit

Rocks at the tunnel entrance and exit are generally weathered to medially weathered, fissure and joint are growing, but the opening is locally covered with quaternary colluvial deposit and the surrounding rock at the opening top is thin, so the condition for constructing tunnel is poor and the top is easy to collapse. In order to ensure stability of the opening, it is proper to enter it earlier and get out later for construction to avoid front slope and outrageous sideslope. In addition, support and protection shall be strengthened in construction, and it shall be lined in good time.

(2) Water permeability

If the tunnel penetrates carboniferous huanglong formation carbonate rock, karst fissure grows and there is a little karst fissure water. Karst and water permeability may influence construction, so drainage preparation shall be done well before construction.

Besides poor conditions for tunnel construction caused by rock fissure, joint growth at the entrance and exit, local collapse and slope deposit at opening, as well as instability caused by karst and water permeability, fresh medium soft-medium hard rocks, opening axis aslant crossing with the stratum in general, greater burial depth of tunnel body except the entrance and exit, the diversion tunnel is stable generally.

(3) Suggestions on reinforcement and prevention measures

The diversion route penetrates karst water system is unavoidable, so preparation shall be done for preventing collapse or karst inrush of water, so as to avoid greater hazard of construction. In tunnel construction, pay attention to avoid collapse or karst inrush of water; if inrush of water happens, the construction shall be stopped, construction personnel shall be evacuated in time and the quantity of inrush water shall be observed; construct again after it reinforced concrete is applied for lining, ensure the safety of construction personnel in construction. If a underground river is discovered, stop construction immediately and make a proper construction plan according to the type and scale of it, but it must ensure that the construction of diversion tunnel must not disturb the flow of underground water and cause discontinuous flow of the river in the lower reaches.

General measures include emergency organization, responsibility, emergency facilities, equipment and apparatus emergency communication, emergency safety, safeguard, emergency medical rescue, emergency evacuation measures and emergency exercises. Detail survey, proper precautions and emergency plan shall be made in preliminary design.

6.4 Other environmental risk

6.4.1 Risk analysis in construction period

Environmental risk of Erchakou Hydropower Station in construction mainly is artificial risk, i.e. the risk in construction activities, risk of the Project mainly concerns transportation and storage of blasting agent and various fuels.

Because of the flammability and explosion hazard of oil and blasting agent, certain

environment risk exists in their transportation and storage. Related rules for transporting dangerous goods must be strictly obeyed in transportation, DO NOT put blasting agent and detonator together for transportation. In order for safety, the warehouse of blasting agent shall be in out-of-the-way mountain area in the upper reaches, the distance of which to the construction site must be not less than 300m, so no severe hazard will happen in accidents. The warehouse of blasting agent must be strictly managed, fire and smoking are forbidden there, lightning arrestor shall be set trying to avoid any accident.

6.4.2 Risk analysis in operation period

(1) Analysis of stability of river bank

According to field survey, there are four physical and geological phenomenons in the area such as weathering, karst, collapse and landslide. In small scale collapse will happen if unloading fissures and vertical joints or fissures are discovered at steep slope or cliff in the area. The right bank about 300m from the lower reaches of the power house is a 35 ~ 40° slope, landslide matter is clinosol, thickness of the sliding mass is about 3~5m, which happened in the rainstorm of 1976; the front edge of the slide has been eroded by river water. Only local section will have small scale landslide and collapse, which will not endanger operation safety of the Project.

(2) Risk analysis of oil spill

At completion of the hydropower project, there will be no “three wastes” pollution generally; adverse impact on the environment in operation period is small, but oil spill will have certain adverse impact on the water quality in the lower reaches, so oil spill is one of the environmental risks in operation period.

Oil system of the hydropower station includes turbine oil system and insulating oil system. Turbine oil system mainly supplies thrust bearing of generator, the upper

and lower guide bearing, guide bearing of water turbine, speed control system and oil pressure unit for operation of butterfly valve; insulating oil system mainly supplies transformer and oil switch. According to operation experience of small hydropower station, no treatment and storage facilities are set in the station, so the local power system shall be paid for providing the services. According to the data provided by manufacturer of the machine set, turbine oil consumption of one unit is only 0.2m^3 , only three 200L oil tanks shall be prepared, the local power system also shall be paid for oil treatment. 4t insulating oil for transformers and few switches shall be prepared, the type of which is 40[#].

If type selection and construction strictly obeys the design requirements, no oily substance will spill in regular operation of the Station.

6.4.3 Risk of human health

Environmental sanitation conditions of the site is poor, foreign personnel enter and exit the site frequently, construction personnel is relatively collective, so population density is great and it may bring about some diseases; therefore, the sanitary condition shall be perfected, the drinking water shall be prevented from pollution and be strictly sterilized; management of hygiene and disease control in living area shall be strengthened, domestic wastewater, wastes and excrement shall be treated well trying to reduce or eliminate mosquitoes and flies, so as to avoid epidemic disease.

7. Conservation of soil and water

7.1 Existing soil erosion in the project area

Soil erosion in the project area mainly is caused by water erosion and leaching erosion, main forms of which are surface erosion and gully erosion. The soil erosion mainly happens in hillside cultivated, barren hill and slope as well as young open forest land, the loss type of which changes with the lithology. As seen from loss strength distribution, there are mainly slight and light soil erosion, and lithology of the section mainly is limestone, leaching erosion is discovered in field inspection, which causes rock emergence, strong cutting and difficult treatment.

7.1.1 Origin of soil erosion

(1) Natural factors: landform of the area is complicated with ravine in length and breadth, the mountain is high and the slope is steep, convergence of surface runoff is rapid, so it is easy to cause soil erosion. Rainfall in the whole county is plentiful, precipitation is collective, the frequency of rainstorm is high, Qingshui Bay and Wantan of Yuyangguan are of the greatest rainstorm strength in the whole province, so it is severely eroded, disastering speed is fast and soil erosion is severe.

(2) Artificial factors: because of the fast increasing of population, the people cut trees in forest for cultivation to solve food problem and the vegetation is destroyed. In the recent years, the vegetation is destroyed in road construction and quarrying, but no proper measures are taken, so it also cause a lot of soil erosion.

7.1.2 Hazard of soil erosion

(1) Reduce soil fertility: because the soil is eroded by surface runoff, the stratum becomes thinner, fertility reduces, capacity in drought defying becomes poor, so that the output of crops is instable.

(2) Destroy ground integrity: erosion groove is widening and spreading forward, so the land is eroded, available land reduction and emergence of rocks increases.

(3) Fill up rivers in the lower reaches: water level of reservoir is raised and flood disaster in the lower reaches is increased. The capacity of cutting and accumulating runoff of the surface is reduced, mountain torrents often happen in rainstorm and mud-rock flow will happen in some places, which ruin farmland in lower reaches and cause loss of properties such as houses, human beings and animals.

(4) Clog river in the lower reaches: damage facilities of water conservancy and traffic engineering. Sediment from soil erosion accumulates in rivers in the lower reaches, reservoir and check dam, which reduces service life of the Project; the river bed rises and water level increases because of silting, so the flood will severely endanger traffic and water conservancy facilities.

According to *Declaration on Dividing Key Protection Areas of Soil Erosion of Hubei Provincial People's Government*, the Project is located at the south bank in the middle reaches of Qingjiang River Catchment, one of the key eight protection areas of Hubei Province.

Soil erosion in the project area mainly caused by water and gravity, surface erosion and gully erosion of water power are strong; gravity erosion is intensifying endlessly because of unreasonable social economy activities (such as inordinate deforestation and land reclamation, forest cutting, planting on slopes and house construction, quarrying, mining and infrastructure construction) of human beings, which severely destroys the ecological environment.

As known from *Integrated Treatment Planning for WATER AND Soil Conservancy* of Changyang Tujia Autonomous County: the project covers 10762hm² land in total, the area of soil erosion is up to 6900hm² taking up 64.08% of the catchment area. Slightly erosion area is 1055hm² taking up 15.30% of the total erosion area; medium erosion area is 4490hm² taking up 65.10% of the total erosion area; severely erosion

area is 962hm² taking up 13.90% of the total erosion area; extremely erosion area is 393hm² taking up 5.70% of the total erosion area. Annual soil erosion is up to 309000 tons in total, annual erosion modulus is 2870t/km.a.

According to field survey, soil of the area is eroded mainly in slight and medium degree, minute soil erosion in the project area is 5484590.13m², slightly soil erosion is 416810.32m², medium soil erosion is 1787269.08m² and engineering erosion area is 77529.59m²; background value of soil erosion in the project area is 3218t/km².a.

7.2 Existing conservation of soil and water in the project area

In the recent years, in order to promote ecological beneficial cycle of agriculture, leaders of the government of Yuxiakou Town pay special attention and each department coordinates, the Party Committee and Government bring comprehensive treatment of the conservation of soil and water into agenda. It mainly includes the following items: strengthen forest reservation and returning land for farming to forestry, develop forestry production, use barren mountain and slope to plant soil conservancy forest, collect funds through different channels, adjust measures to local conditions and develop economic forest, promote the use of fire-wood-saving stove and in countryside, solve the conflict between forest reservation and firewood in countryside, strengthen treatment achievements; promote advanced agricultural technology, improve grain output, realize food self support in the treatment area, provide conditions for returning land for farming to forestry and grassland. Land use has been reasonable, soil erosion has been released gradually, living level of farmers has been greatly improved and ecological environment has been greatly improved through a series of soil conservancy measures.

There are still problems in soil conservancy and treatment of soil erosion, the main

one is lack of integrity and continuity, treatment is regarded but management is ignored, there is treatment but no management; what's more severe is that one treats but several destroy.

7.3 Prediction of new oil erosion in construction

7.3.1 Prediction period

According to *Technical Regulation on Water and Soil Conservancy Plan of Development and Construction Projects* (SL204-98), the prediction of soil erosion shall be done in construction period and operation period.

Prediction year includes construction period (capital construction period) and impact period (production and operation period), construction period of the Project is one year; the duration of prediction is determined according to concrete construction periods of main construction area, waste disposal area, temporary construction area and construction access road area; impact period indicates the time that water and soil holding capacities recovers to the original by itself after artificial interference is eliminated, impact period of the prediction assessment is three years, Prediction year of each construction area is shown in Table 7-1.

Table 7-1 Statistics of Prediction Year of Soil Erosion in each Area

Unit: Year

No.	Predication area	Prediction year (year)			Prediction period
		Construction period	Impact period	Subtotal	
I	Main construction area	1	3	4	January 2006-December 2009
II	Waste disposal	1	3	4	January 2006-December 2009

	area				
III	Temporary construction area	1	3	4	January 2006-December 2009
IV	Construction access road area	1	3	4	2 January 2006-December 2009

7.3.2 Prediction content and method

According to characteristics of actual situation of construction, on the basis of analysis and assessment, the prediction content and method determined based on *Technical Regulation on Water and Soil Conservancy Plan of Development and Construction Projects* are shown in Table 7-2.

Table 7-2 Prediction Content and Method

No.	Prediction object	Prediction purpose	Prediction content	Prediction method
1	Disturb the original landform, destroy land and vegetation area	Provide basic data for accurately predicting soil erosion	Predict the area and quantity of disturbed surface, occupied area and destroyed trees, grass and vegetation	Study engineering data and design drawing, conduct field survey and collect related data of each location.
2	Spoil, waste rock and waste slag	Provide important reference for arrangement of engineering measures	Predict earthwork excavation, utilization, origin and quantity of spoil and slag according to construction	Study engineering data and budget, statistic of each area in details.
3	Category and area of destroyed soil conservancy facilities	Provide reference for calculating compensation of soil conservancy facilities	Predict the area and quantity of soil conservancy facilities such as destroyed forest, grass land, terrace field and earth dam.	Field survey, collect and study related statistics, acknowledgement of local administrative department on the area of soil conservancy facilities
4	Possible soil erosion and total erosion	Provide reference for arranging concrete soil conservancy	Master the disturbance of surface vegetation in construction, know the composition of wastes, stocking location and form,	Field survey and analysis

		facilities and calculating soil conservancy efficiency	predict soil erosion	
5	Hazard analysis of soil erosion	Provide reference for project feasibility and taking measures	Impact and degree of soil erosion on the project, land resource and ecological environment	Analyze according to actual situation of the Project

Based on the principle that “the party who develops shall protect, the party who causes soil erosion shall take charge of treatment”, through reviewing technical data of the construction project, using design drawing and combined with field survey, the total responsible scope of soil erosion of Erchakou Hydropower Station is from the intake pivot to the power house. It mainly covers main construction area, material yard, waste disposal area, temporary construction area, living area and traffic road. Main construction area covers the intake dam, intake structure, power house and booster station.

7.3.3 The area of disturbed original landform, destroyed land and vegetation

The area of disturbed surface, occupied land and destroyed forest, grass and vegetation in construction period shall be counted individually according to the main construction area, waste disposal area, temporary construction area and construction road area: the main construction area covers the intake pivot, tunnel entrance and exit, pressure head pond, pipeline, power house and booster station covering 0.37hm², and it becomes 0.44hm² after disturbance impact factor is taken into account; the waste disposal area takes up 0.20hm² and becomes 0.24hm² after disturbance impact factor is taken into account; temporary construction area includes erection of construction camp for temporary living and production as well as temporary stocking of sandstone material in dam area, tunnel pipeline area and plant area, which takes up 0.27hm² after the disturbance impact factor is taken into account; total area of construction access

road is 0.08hm² after the disturbance impact factor is taken into account; total disturbance surface area is 1.03hm². Statistics of disturbance surface area is shown in Table 7-3.

Table 7-3 Statistics of Disturbed Surface Area

Unit: hm²

Unit: hm ² No.	Prediction area					Subtotal
		Hillside cultivated	Forest land	Barren land	Flood land	
I	Main construction area	0.04	0.16	0.22	0.02	0.44
II	Waste disposal area			0.20	0.04	0.24
III	Temporary construction area	0.04	0.12	0.09	0.02	0.27
IV	Construction assess road area			0.08		0.08
Total		0.08	0.28	0.59	0.08	1.03

7.3.4 Prediction of spoil, waste rock and waste slag

Spoil, waste rock and waste slag in construction are essential for soil erosion, but not all waste slag will be lost, only the part flowing into river is lost. The following formula is applied to analyze and predict slag loss:

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

In which:

W_{S2} ——Discharged slag loss (ten thousand ton)

D_{ei} ——Slag in each waste disposal area (ten thousand ton)

W_i ——Loss coefficient of each waste disposal area.

There are many factors influencing waste slag loss coefficient, which mainly concern

landform of its storage, dynamic condition such as rainstorm runoff, composition of waste slag and prevention measures. The gradients of the ground in different construction areas of main works are extremely different, and the rainstorm runoff is different, so different loss coefficients shall be applied according to the location of each waste disposal area, details of which are shown in Table 7-4.

Table 7-4 Calculation of Waste Slag Loss

Item	Capacity (ten thousand t)	Erosion coefficient	Volume
Intake pivot	0.22	0.15	0.03
Diversion open channel	0.4	0.15	0.06
Diversion tunnel	1.48	0.25	0.37
Pressure head pond	0.06	0.15	0.01
Pressure pipeline	0.5	0.25	0.13
Power house	0.11	0.1	0.01
Booster station	0.13	0.1	0.01
Total	2.90		0.62

According to the above table, waste slag of soil and rock generated in construction is 29000t, which may destroy the surface plants, cause soil erosion, influence and even destroy natural landscape if not treated reasonably. Therefore, this waste slag will be transported to specified disposal area for treatment according to general arrangement of the project and actual landform of the project area.

7.3.5 The area of destroyed water and soil conservancy facilities

In construction area, the original landform, surface rock structure and vegetation are destroyed at different degree because of excavation or slag, so original soil conservancy capacity is reduced or lost, the development of soil erosion is quickened. This part of surface area destroyed in construction is the area of destroyed water and soil conservancy facilities. According to *Official and Written Reply of Interpretation of "Water and Soil Conservancy Facilities" Problems of the Provincial Water Resources Department* (ESBF [2001] No. 593), barren hill,

exposed rock, flood land and reservoir flood area are not counted into the area of destroyed water and soil conservancy facilities. Through field survey and statistics of land use of the original landform on the site, the area of destroyed water and soil conservancy facilities caused by construction is 0.23hm², which is shown in Table 7-5 for details.

Table 7-5 Statistics of the Area of Destroyed Water and Soil Conservancy Facilities

Unit: hm²

No.	Prediction section	Intake pivot	Diversion area	Power house	Total
I	Main construction area		0.10		0.10
II	Waste disposal area				
III	Construction temporary occupation area		0.13		0.13
IV	Construction access road area				
Total			0.23		0.23

7.3.6 Prediction of possible soil erosion

(1) Background value of soil erosion

Soil conservancy facilities and accelerated erosion area destroyed by construction of the Project is 0.23hm², the construction period is considered as one year and the impact period is considered as three years.

According to *Technical Regulation on Water and Soil Conservancy* (SL204-98) and *Standards for Classification and Gradation of Soil Erosion* (SL190-96), combined with actual landform in the project area, background value of soil erosion modulus is

shown in Table 7-6.

Table 7-6 Background Value of Soil Erosion Modulus in Project Area

Soil type	Characteristics	Landform type	Erosion intensity	Erosion modulus
Cultivated land	Gradient <5°	Flat	Slight	300
Hillside cultivated	Gradient <15°	Flat	Light	1000
Forest and grass land	Gradient <25°, coverage>30%	Mountain	Medium	2500
Barren land	Gradient <25°, coverage>30%	Mountain	Strong	5000

Combined with actual landform of the project area, existing soil erosion in the land occupation is shown in Table 7-7. Average erosion modulus in the project area is 3218t/km².a.

Table 7-7 Existing Soil Erosion

Subitem		Land occupation (hm ²)					Soil erosion (t)	
		Slightly	Lightly	Medium	Strong	Extremely strong		Subtotal
Main construction area	Intake pivot	0.02			0.02		0.01	1
	Diversion open channel		0.02		0.08		0.1	4
	Pressure head pond				0.02		0.02	1
	Pressure pipeline		0.02		0.05		0.07	3
	Plant area	0.01	0.03		0.1		0.14	5
	Subtotal		0.07	0	0.27	0	0.37	14
Temporary occupation of construction			0.05	0.06	0.07		0.2	6
Waste disposal area			0.06	0.02	0.1		0.23	6
Construction and access road area			0.02	0.02	0.02		0.07	2
Total		0.08	0.2	0.1	0.46	0	0.87	28

Background value of soil erosion in the construction area can be calculated, i.e. annual soil erosion of the original landform is 28t if Erchakou Hydropower Station is not constructed.

(2) Prediction for possible soil erosion area

Soil erosion area covers that caused or induced by production and construction activities as well as that of the original landform not reaching up to allowable loss amount in the land requisition scope. Possible soil erosion area indicates the area with obvious changes in surface soil erosion caused or induced by production and construction activities such as excavation, burial of waste slag and excessive cutting. Possible soil erosion is shown in Table 7-8.

Table 7-8 Calculation of Possible Soil Erosion Area of Project Construction

Unit: hm²

Content Item	Land type and area				Subtotal
	Hillside cultivated	Forest land	Barren land	Overflow land	
1. Main construction area	0.04	0.16	0.22	0.02	0.44
2. Waste disposal area			0.20	0.04	0.24
3. Temporary construction occupation	0.04	0.12	0.09	0.02	0.27
4. Construction access road area			0.08		0.08
Total	0.08	0.28	0.59	0.08	1.03

(3) Prediction of possible erosion

① Soil erosion caused by disturbance of the surface

a. Field survey and erosion class gradation

The strength of soil erosion in different sections shall be divided and determined

according to survey results of land occupation, geological landform, soil vegetation and soil erosion characteristics; according to soil erosion intensity gradation standard and surface erosion gradation index specified in *Standards for Classification and Gradation of Soil Erosion* (SL190-96), the original situation of soil erosion, strength and quantity of the project area is determined; and then the erosion amount can be calculated according to the strength of possible soil erosion in construction of different sections. Difference of the two indicates the new soil erosion of the Project (excluding loss of spoil and waste slag).

b. Empirical formula method (accelerated erosion coefficient method)

According to prediction and analysis, soil loose coefficient is uneven, dense structure changes, cohesion force, viscosity and internal friction angle of slag will be greatly changed because of surface excavation and backfill. Therefore, weatherproof and anti-erosion capacities are obviously reduced; erosion intensity and erosion modulus will increase.

Prediction of soil erosion is calculated according to the following formula:

$$M_s = F \cdot A \cdot P \cdot T$$

$$M = M_s - M_o = F(A-1) \cdot P \cdot T$$

In which:

M_s ——Soil erosion in prediction period (t);

M_o ——Original soil erosion (t);

M ——New soil erosion in construction period (t);

F ——Accelerated erosion area (hm^2);

A ——Accelerated erosion coefficient;

P—Soil erosion modulus of native land ($t/km^2 \cdot a$);

T—Prediction time (a).

Aiming at the characteristics of soil erosion generated by different construction technologies and methods, predict according to the characteristics of the project area.

Through field survey, considering rainfall erosivity, soil erodibility, gradient and length of failure plane as well as residue of destroyed vegetation of each part, firstly determine accelerated erosion coefficient, and then review and adjust the coefficient through field survey and erosion class gradation, it is finally determined as 3~6; prediction period of each project area is determined according to construction arrangement of design report of main works, possible soil erosion in construction is 112t in total and new soil erosion is 84t as predicted. Prediction of soil erosion is shown in Table 7-9.

Table 7-9 Prediction of Soil Erosion in Project Area

Subitem		Accelerated erosion area (hm^2)	Erosion modulus ($t/km^2 \cdot a$)	Prediction period (a)	Original surface erosion (t)	Predicted erosion (t)	New erosion (t)
Main construction area	Intake pivot	0.04	2500	4	1	4	3
	Diversion open channel	0.1	4000	4	4	16	12
	Pressure head pond	0.02	5000	4	1	4	3
	Pressure pipeline	0.07	4286	4	3	12	9
	Plant area	0.14	3571	4	5	20	15
	Subtotal	0.37			14	56	42
Temporary occupation of construction		0.20	3000	4	6	24	18
Waste disposal area		0.23	2609	4	6	24	18
Construction and access		0.07	2857	4	2	8	6

road area						
Total	0.87			28	12	84

② Prediction results of total soil erosion

Construction period of the Project is two years and impact period is two years; if no protection and treatment measure is taken, total new soil erosion will be up to 6280t including 6200t slag loss and 80t surface damaged soil erosion.

Therefore, it is necessary to design, construct and put into production of conservancy engineering and main works at the same time. Through conservation of soil and water, ecological environment that may be aggravating can be recovered and perfected. Key point of soil erosion prevention is the treatment of waste slag, the recovery of trees and grass as well as the treatment of soil erosion.

7.4 Impact analysis of soil erosion

In construction, the surface in requisition area will be damaged in different degrees, local landform will be greatly changed, new soil erosion in the area will be up to 6280t if no water and soil conservancy measure is taken, which will generate different impact on changes of local land capability, regional ecological environment and river channel scouring.

7.4.1 Direct hazard and impact of the Project

(1) Protection responsible scope of the Project is 1.03hm², including 0.87hm² construction area;

(2) Disturbed surface area of the Project is 1.03hm², and the damaged area of soil conservancy facilities is 1.03hm²;

(3) Total earthwork excavation is 1.47 hm², waste slag (loose volume) required to be treated is up to 12900 m³;

(4) Prediction total volume of soil erosion if no conservation measure is applied in construction is 6280t, prediction total volume of soil erosion if a slag guard wall is applied is 80t.

7.4.2 Possible soil erosion hazard

In construction of Erchakou Hydropower Station, the surface in construction area will be damaged in different degrees, local landform will be greatly changed, new soil erosion in the area will be up to 84t if no water and soil conservancy measure is taken, which will generate different impact on local land capability, river channel scouring and regional ecological environment changes.

(1) Damage and impact on land resources.

The stockpiling, burial and excavation of a lot of spoil, rock and slag generated in construction disturb the surface vegetation and also destroy the original landform, soil structure and surface vegetation, adhesion layer of cultivated horizon and vegetable layer which forms through years of cultivation or natural curing is severely damaged or disappearing, which causes “three losses” of farmland, reduction of fertility and influence the development of local agricultural production.

(2) Destroy ecological environment and cause vicious cycle.

Surface vegetation is destroyed by construction of the Project, so the soil exposes, corrosive resistance and impact resistance of soil are reduced, water and soil holding capacity is greatly reduced, soil erosion becomes severe and natural disaster happens frequent, so that it causes a vicious cycle.

(3) Impact on the power station.

Soil erosion will have impact on construction of the Project and operation of the hydropower station. Eroded soil will flow into construction site, impact construction process and safety operation in production and also endanger personal safety if the spoil in construction site cannot be treated timely.

New soil erosion mainly is waste slag generated in construction; therefore, key protection sections are construction site of main works, transfer point of slag yard and waste disposal area. According to strength prediction of soil erosion, engineering measures assisted by plant measures shall be taken to prevent waste slag. Drainage facilities must be equipped at slag yard and temporary stock points to prevent loss of slag charge by rinsing of rain. According to strength of soil erosion and total loss prediction, construction period is the key monitor period; key sections are temporary stock points of slag charge and waste disposal yard.

7.5 Prevention and treatment measures for soil erosion

7.5.1 Requirements on prevention and treatment measures

Protection facilities of most main works are closely related with soil conservancy measures in construction of the Project. New soil erosion mainly happens in construction, so the following requirements shall be satisfied at the aspect of soil conservancy measures in construction period:

- ① Prepare construction plan according to the measures specified in soil conservancy plan, ensure construction quality and prevent new soil erosion.
- ② In excavation of structure foundation and slope, it is extremely easy to cause a lot of new soil erosion, but they also have the function for conservation of soil and water

after each section is completed. So each structure cannot be used for conservation of soil and water in construction, reasonable measures (such as temporary interception and constructing drainage ditch) shall be taken in construction trying to reduce soil erosion.

③ A lot of waste slag generated from excavation is a plentiful loose material source to cause soil erosion, which is extremely easy to be taken into river and form large scale sediment transport, it is adverse to the ecological environment in the lower reaches. Therefore, the selection of waste disposal area and slag protection shall draw highly attention; otherwise, there will be a lot of future troubles.

④ As known from the prediction achievements of soil erosion, the key period for conservation of soil and water is the construction period and main areas that may generate new soil erosion is excavation area of main works, temporary stock yard of surface soil and waste disposal area. These will be the key area for prevention and treatment in preparation of soil conservancy plan.

7.5.2 General layout of soil conservancy measures

Soil erosion prevention and treatment system shall be determined according to prediction results of soil erosion combined with types and characteristics of soil erosion of each area as well as the purpose after construction. Combine key treatment with surface treatment, permanent treatment with temporary project, engineering measures with plant measures as well as treatment measures and reclamation to make a whole plan for different water and soil conservancy measures, and then form an integral prevention and treatment system for soil erosion. In detail arrangement of prevention and treatment measures, sufficiently exert the quickly available and controllability of engineering measures, and also the subsequence and ecological effect of plant measures.

① Main works area: the area is permanent land occupation area, which will be disturbed by excavation. Some requirements on soil erosion prevention and treatment in construction will mainly be promoted.

② Waste disposal area: select proper waste disposal area and make protections for waste disposal area of the main works. Use grouted stone wall as enclosure, set drainage ditch on slope in the area, set a settling basin at the end; clean and level the surface and then plant trees and grass at completion.

③ Temporary land occupation area of construction: temporary measures for protection must be taken when stocking sandstone material, woven bags carrying soil will be used for enclosing around to prevent loss of sandstone. Other temporary land occupation (such as construction camp erection, temporary arrangement of construction machineries and facilities) will be protected with plants after construction because the land is relatively smooth.

④ Traffic road area: part of the construction road is new, so excavation and backfill in construction shall be balanced, drainage measures shall be taken on both roadsides, the retaining wall shall be constructed at the slope with greater gradient; plant measures shall be taken for permanent road, which mainly include planting grass and trees in impact on both sides for greening.

Key protection areas for soil erosion are waste disposal area, the area with greater earthwork excavation quantities and the area with unstable geological structure. Engineering measures and plant measures will be applied for treating soil erosion, and the systematic diagram for soil erosion prevention of the Project is shown in Fig. 7-1.

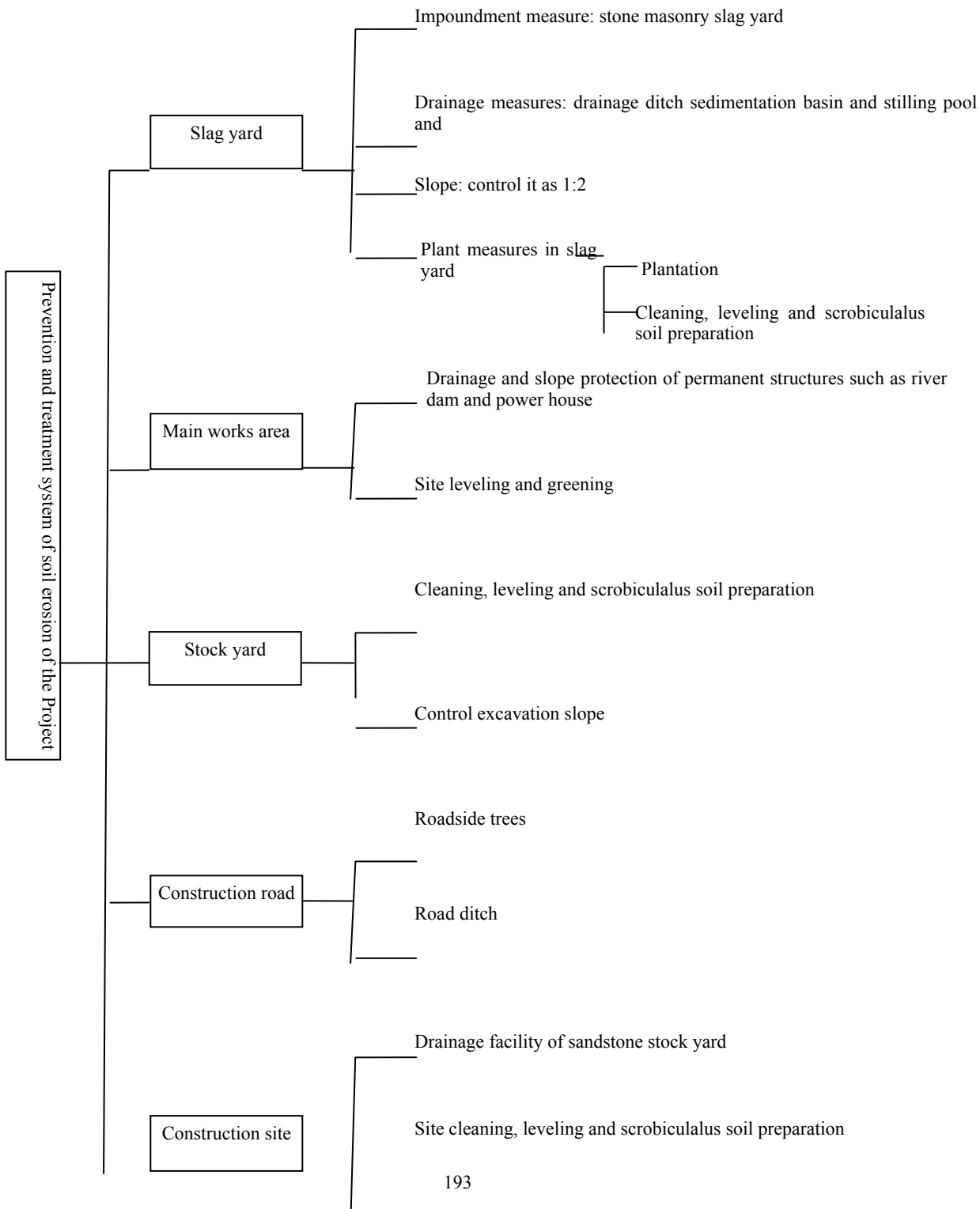


Fig. 7-1 Systematic diagram for soil erosion prevention of the Project

7.5.3.4 Investment to treatment of conservancy engineering

Total investment of soil conservancy plan of Erchakou Hydropower Station is RMB 264500 including capital construction investment RMB 199100, individual cost RMB 54300 and fundamental reserved cost RMB 7600, reserved fund for price differentials will not be counted as specified, reserved fund for price differentials will not be counted as specified, compensation for soil conservancy facilities is RMB 3500; see Table 7-12 for details.

Table 7-12 Estimate of Investment to Soil Conservancy Measures

Unit: RMB ten thousand

Unit: RMB ten thousand No.	Project and cost	Cost for construction and installation	Plant measure cost		Equipment cost	Individual cost	Total
			Plantation cost	Nursery stock, grass and seed cost			
I	Part I Engineering measures	17.27					17.27
II	Part II Biological measures		1.32	0.20			1.52
	Part III	1.11					1.11

III	Construction temporary works						
IV	Part IV Individual cost					5.43	5.43
	Total						25.34
	Fundamental reserved fund (3%)						0.76
	Total static investment						26.10
	Reserved fund for price differentials						
	Financing interest in construction period						
	Compensation for soil conservancy facilities						0.35
	Total investment of the Project						26.45

8. Countermeasures and suggestions of environmental protection

8.1 Ecological protection measures

8.1.1 Protection measures for plant resources

Protect existing vegetation and reasonably adjust the vegetation structure in the assessment area. Select local varieties and specials according to ecological theory, obey succession rules of vegetation, beautify the environment on the basis of greening, increase tree species according to characteristics of natural geography environment, vegetation annidation and succession rules. Select local tree species and grasses for vegetation recovery in project impact area according to characteristics of local landform, relief, climate and vegetation, mainly including temporary land occupation for construction, sandstone stock yard, waste disposal area, both sides of road, office and living area; rescue and transplant species discovered in construction under the state protection to uninfluenced area in good time.

Try to reduce destroy towards forest vegetation in construction; secondary bare area formed in construction shall be filled with soil and planted with trees in good time according to local conditions; sufficiently use climatic resources, recover and improve productivity, develop farm production, expand planted area and increase types of economic plants, focus on developing economic plants, promote local economy construction and improve living quality of local residents.

Strengthen comprehensive treatment of soil erosion. Do well soil conservancy planning, increase fund and labor investment, take effective measures to prevent forest fire combined with tree planting and afforestation, strengthen protection especially in construction period, such as setting warning boards of fire control in construction area, living area and on surrounding mountains; dividing fire scope,

patrol inspection, constructing expansion construction facilities of fire brigade so as to prevent and stop fire.

According to survey of existing ecology and impact prediction assessment, all guidelines, policies, regulations and rules of nature reserve must be strictly implemented, all measures for forest vegetation and wildlife protection shall be carefully fulfilled, so as to promote protection and construction of surrounding ecological environment, promote coordinate and sustainable development of society, economy and environment of the area taking construction of the assessment area as a good opportunity.

Develop ecological monitoring and management. The ecological impact shall be monitored or surveyed in both construction and operation periods. Monitor the changes of habitat, vegetation, wildlife population and quantity as well as integral changes of the ecosystem. Strengthen management of the ecology through monitoring, appoint ecological environment management personnel in the project management organization, setup different management and reporting system, develop environmental education of the impact area, improve environment consciousness of construction personnel and management personnel. Make the ecology develop in a good or favorable way through dynamic monitoring and perfect management.

After construction, develop environmental protection in construction area according to environmental protection design to afforest and beautify construction environment. Plant bank protective forest and soil conservancy forest along the bank of dam in reservoir area, select evergreen species with economic value for plantation to form an innocuous ecosystem.

8.1.2 Protective measures of terrestrial animals

Improve environmental protection consciousness of construction personnel, strengthen promotion of *Law of the People's Republic of China on the Protection of*

Wild Life; construction personnel must strengthen management and not hunt wildlife especially those under protection of the State in and around construction area in construction. Organize construction personnel to study related laws and regulations of the State and study how to identify state protection animals before construction; the forestry public security shall strengthen patrolling and protection in the places gathering animals, enhance punishment towards individuals and organizations hunting wildlife on purpose, so as to ensure the protection of wildlife can be fulfilled sufficiently

Treat the relations between diversity protection and epidemic prevention well. Some poisonous snakes and pestiferous animals of natural focal disease (some rats) will immigrate to the non-flood area and their density will be increased after the Station is completed; in this case, not only the food chain of natural ecological system shall be maintained, but also the treatment and epidemic prevention of people, animals and construction personnel in non-flood area shall be concerned if bitten by poisonous snakes.

Strengthen management to reduce pollution. Mountains, water, forest and birds will form a new landscape with road construction, greening and afforestation, activities of human beings will increase, and these will bring about new hidden troubles for environment pollution. So management must be strengthened to reduce pollution, protect aquatic birds and avoid destroy of the new landscape.

Avoid disturbance of wildlife by blasting noise, arrange construction time and method according to animals' biorhythm. Most wild birds and animals seek for food in the morning, evening or at night, birds are resting at noon. In order to reduce disturbance of blasting noise on wildlife, the plans for blasting method, quantity and time shall be made trying not to blast in the morning, evening and at noon as well as in the breeding season of animals.

8.1.3 Protective measures of aquatic

Aquatic in water area is common species distributed in nearby similar environment, the changes of environment must cause substitution or extinction of some aquatic population in local water area after the Station is constructed, but species resources will not be severely destroyed and also will not influence the survival of species. Protective measures of aquatic are shown in the following Table 8-1.

Table 8-1 Protective Measures of Aquatic

No,	Detail measures	Implementation period	Enforcement body
1	Make remediation in design and station dispatching to prevent fishes from bubble disease.	Construction period	Construction unit
2	<ul style="list-style-type: none"> ◦ In order to protect the environment of aquatic and fishes as well as eliminate the influence of dewatering of water reduced river in dry season, discharge of the Station from November in the dry season to the next May must be not less than the existing average flow of the driest month for ten years, i.e. 0.051m³/s ecological flow, to maintain living environment of aquatic and keep river landscape. 	Operation period	The Employer

After the Station is put into production, in one aspect, the water flow in the lower reaches under Liujia Brook Dam, Neixi Brook Dam and Dagouxi Dam must not have great change before dam construction, especially in dry season, ecological water demand in the lower reaches shall be assured at least; combined with suggestions on ecological flow specified in *Water Resource Demonstration Report of Erchakou Hydropower Station*, the incoming flow in the lower reaches must not be less than 10% of the original after the Station is constructed as suggested in the Report, i.e. keep the discharge of Neixi Brook, Liujia Brook and Daxigou be 0.03m³/s, 0.02 m³/s and 0.02m³/s respectively, so as to ensure the minimum ecological safety flow of; in addition, water supply for living and production of three households under Neixi

Brook Dam shall not be impacted, which shall be controlled by the Employer of the Station.

8.1.4 Ecological recovery measures

(1) Protection area of main works

According to the design of main works, when excavating the entrance and exit of diversion tunnel, earthwork is easy to roll towards the downstream slope, which may influence the plants there; therefore, when excavating the entrance and exit, excavate manually at first, and then fill the earthwork in woven bags, lay these bags at the lower side of opening as a temporary slag wall, so as to prevent earthwork from rolling along the slope. The temporary slag wall has a 80×100cm (width x height) trapezoidal section with 1:1 slope, the length of the temporary slag wall at each opening is designed as 15m, so total length of the wall is 45m and the volume is 0.36m³.

(2) Prevention area of waste disposal area

◆1[#] disposal area

Located on the slope at 50m in the lower reaches of Neixi Brook intake dam, used for stocking waste slag from excavation of Neixi Brook intake dam and operation face of the entrance of 1[#] non-pressure tunnel, the disposal area shall store 3100 m³ loose waste slag as required and it takes up 0.04hm² barren hills.

According to construction design, part of the construction site has been started for arrangement, on the basis of the principle that “retaining first and drop later”, construct layered grouted rubble retaining wall around the disposal area. Excavated waste slag will be transported to the site for leveling and compaction in time in the construction of main works. The functions of retaining wall are shown as follows:

prevent the slide of slag block, keep the slope toe stable, filter water in slag block, rise slope elevation of slag block and increase capacity of the disposal area.

Length of the retaining wall of disposal area is 15m and height is 3.5m, wall slope ratio is 1:0.1, slope ratio of the retaining face is 1:0.4, top width of the retaining wall is 0.8m, while the bottom width is 2.55m. Height of revetment at the top of retaining wall is 1.5m, slope ratio is 1:1.5 and thickness is 0.3m. The retaining wall is equipped with drainage facilities, spacing of drain holes is 2m, section size is 0.2×0.2m. 45m³ earthworks shall be excavated, 93m³ M5 grouted wall and 36m³ M5 grouted rubble for slope protection shall be completed for constructing the waste disposal area.

◆2# disposal area

It is located about 40m under 1# tunnel exit and 2# tunnel entrance. Mainly used for stocking waste slag from excavation of operation faces of 1# non-pressure tunnel exit and 2# non-pressure tunnel entrance, the waste disposal area shall store 5000 m³ loose waste slag and takes up 0.04hm² barren hills. Length of the retaining wall of disposal area is 153m and height is 2.5m, the slope ratio along river channel is 1:0.1, slope ratio of retaining face is 1:0.4, top width of the retaining wall is 1 and bottom width is 2.25m. Height of the top revetment at the top of retaining wall is 1m, slope ratio is 1:1.5, and thickness is 0.3m. The retaining wall is equipped with drainage facilities, spacing of drain holes is 2m, section size is 0.2×0.2m. 37m³ earthworks shall be excavated, 57m³ M5 grouted wall and 34m³ M5 grouted rubble for slope protection shall be completed for constructing the waste disposal area.

◆3# disposal area

It is located about 50m under 2# tunnel exit and 3# tunnel entrance. Mainly used for stocking waste slag from excavation of operation faces of 2# non-pressure tunnel exit

and 3# non-pressure tunnel entrance. The disposal area shall store 0.73m^3 loose waste slag and takes up 0.08hm^2 barren hills; length of retaining wall of the disposal area is 35m, the height is 3.5m, wall slope ratio is 1:0.1, slope ratio of retaining faces 1:0.4, top width of retaining wall is 0.8m and bottom width is 2.55m. The height of revetment at the top of retaining wall is 1.5m, slope ratio is 1:1.5 and thickness is 0.3m. The retaining wall is equipped with drainage facilities, spacing of drain holes is 2m, section size is $0.2\times 0.2\text{m}$. 105m^3 earthworks shall be excavated, 217m^3 M5 grouted wall and 48m^3 M5 grouted rubble for slope protection shall be completed for constructing the waste disposal area.

◆4# disposal area

It is mainly used for stocking waste slag from excavation of Liujia Brook Intake Dam, 3# and 4# tunnels as well as open channel for 3300m^3 , excavation and filling shall be balanced in design of open channel; all waste slag will be used for filling the outer bank of open channel for reducing transportation distance at one hand and stabilizing of channel at the other hand. Area of the diversion open channel has been covered in permanent land occupation of the main works, so only 0.04hm^2 disposal areas will be counted. The total length is 600m, it will be arranged along the external breakwater of open channel, $b\times h=0.7\text{m}\times 1.0\text{m}$. Placed rockfill retaining wall will be applied with 0.3m foundation burial depth. Width and height of the retaining wall are 0.5m and 1.3m respectively. Waste disposal areas along the channel have been covered in permanent land occupation of the Project; therefore, only the waste disposal area at intake dam covering 300m^2 , i.e. 0.03hm^2 will be considered. 90m^3 earthwork excavation and 390m^3 placed rockfill shall be completed for constructing the disposal area.

Uncover 15cm surface mellow soil of each disposal area before use according to construction progress. The uncovered mellow soil will be piled up at the higher corner in the disposal area, and temporary protective measures shall be applied for the

surface soil; based on the principle that “protect firstly and discard later”, construct the retaining wall at slope toe, arrange surrounding drainage facilities, and then discard the slag, grind and level the ground layer by layer at the same time. Recover the surface soil and vegetation after discarding.

According to overall soil conservancy plan and combined with site condition type of the protected disposal area, if the packway at slag block top, slope forest and packway at sideslope of waste disposal area are created, on one hand, the slag block can be held by root system of trees so as to enhance its stability; in another hand, the vegetation can be recovered to increase greening area,

At completion, the waste disposal area will be leveled and covered with soil (from excavated waste) not less than 0.30m thick, holes will be made to plant trees and grass for land preparation. Specification of land preparation: hole diameter×depth=0.60m×0.70m. Select three-year-old tree seedling (height≥0.80m, ground diameter ≥0.20m), plant Manila under trees, which is suitable for growing in the project area.

Plantation specification of locust tree is 2.0m×2.0m; grass will be planted in rows, two rows for one ridge with 0.8m row spacing, 15kg Manila seeds will be sown for one hm².

(3) Protection measures of temporary land occupation

Temporarily occupied land of the Project is 0.22hm² in total, which is mainly used for construction production and erection of construction camp for living as well as temporary storage of materials and mechanical equipment.

① Engineering measures

In temporary land occupation, engineering measures shall be taken only for sandstone stockyard, i.e. set temporary drain ditch around the yard for discharging extraneous

water and preventing sandstone from being rinsed by the mountain water. Sectional size of drain ditch is 0.5m×0.5m, the ditch applies M5 grouted rubble structure and the bottom applies C15 concrete structure. Six temporary sandstone stockyards will be set, i.e. two for intake dam area, two for tunnel project, one for pipework and one for plant area, the total length of drain ditch is 300m as estimated.

At completion of construction, the hardened layer on the site will be removed for 15cm thick as planned; the removed layer will be used for leveling nearby construction road.

② Design of plant measures

Temporary land occupation of the Project will mainly destroy adhesive material on the ground, disturb the surface water and soil. Plant measure is major for soil conservancy, that is to say, remove temporary structures on the ground, clean construction rubbish, and then dig, make holes, plant trees and grass or plow again, recover vegetation and ecological environment of the temporarily occupied land after the Project is completed.

(4) Protection measures of access road area

When designing the main works, existing traffic road has been sufficiently used assisted by transportation over water. Only 0.1km new permanent road shall be constructed to the power house and 1km temporary road shall be constructed at each tunnel opening; road width is 4-6m and mud glued macadam pavement will be applied according to determined road quality classification.

① Engineering measures

★ Fill section

Fill horizontally layer by layer in construction for fill section, the large face of stones shall be downward, which shall be stabilized and compacted, small stones shall be used to fill the gaps to ensure its tightness.

Tampering layer by layer and mechanical rolling shall be applied for reclaiming fill section, so as to ensure tightness of the subgrade, grouted rubbles shall be applied at the toe for slope protection.

★ Excavated section

Different excavated side slope shall be set according to geological conditions for excavated sections. Excavated side slope of temporary construction road mainly is rock side slope and gravel side slope, so as to ensure security and stability of the side slope.

★ Subgrade and roadway drainage

Drainage system shall be set along construction road, the section of side ditch in rocky section is 0.5m×0.5m rectangle, 0.4m×0.4m×0.6m (lower side×height×upper side) trapezoid side ditch will be applied for earthy section, 0.2m grouted rubble will be applied on the internal surface of side ditch for reinforcement, surface transversal slope is 3% in convenience for drainage.

Construction road only has technical requirements on soil conservancy in construction, quantities and cost have been covered in main works, which will not be counted in the Report.

② Design of plant measures

The vegetation is good and there are many trees along the road, so roadside trees will not be planted on both sides in the design, only grass seeds will be sown in impact

area on both sides for plant protection. The impact area is disturbed by excavation, ground soil is exposed, soil erosion is increased and also the natural landscape is destroyed. The exposed surface will be seeded for greening and beautification, seed selection and typical plantation design are the same with that of plant protection measures of the temporarily occupied land.

Quantities of soil conservancy measures of Erchakou Hydropower Station are shown in Table 8-2.

Table 8-2 Quantities of Soil Conservancy Measures

Item		Earthwork excavation (m ³)	M5 grouted rubble (m ³)	Placed rockfill (m ³)	Artificial soil covering (m ³)	locust tree (ten thousand stock)	Grass (hm ²)	Remarks
Waste disposal area	Impoundment works	277	485	390				
	Drainage works	301	189					
	Plant measure				800	0.05	0.20	
	Subtotal	578	674	390	800	0.05	0.20	
Construction site		200	150		880	0.06	0.22	
Total		778	824	390	1680	0.11	0.42	

8.1.5 Ecological management

Management of ecological environment is a kind of administrative management of the competent authorities for effective management of ecological impact of the development and construction project according to related laws, rules, regulations, technical specifications and standards of protection of natural resources and ecological environment,

(1) According to survey of existing ecology and impact prediction assessment, all guidelines, policies, regulations and rules of nature reserve must be strictly

implemented, all measures for forest vegetation and wildlife protection shall be carefully fulfilled, so as to promote protection and construction of surrounding ecological environment, promote coordinate and sustainable development of society, economy and environment of the area taking construction of the assessment area as a good opportunity. Prepare ecological protection rules for construction personnel in construction period and the staff in operation of the Station, which mainly cover the following content: obey all laws and regulations for natural resource protection and ecological protection; forbid any activity that may have adverse impact on habitat in the area such as hunting; protect mountain forest and grass land in the project area; strictly obey related rules for protection of local natural forests.

(2) Develop ecological monitoring and management. The ecological impact shall be monitored or surveyed in both construction and operation periods. Monitor the changes of habitat, vegetation, wildlife population and quantity as well as integral changes of the ecosystem. Strengthen management of the ecology through monitoring, appoint ecological environment management personnel in the project management organization, setup different management and reporting system, develop environmental education of the impact area, improve environment consciousness of construction personnel and management personnel. Make the ecology develop in a good or favorable way through dynamic monitoring and perfect management.

To sum up, the protection and construction of ecological environment of the area shall be strengthened, legal publicity and education shall be enhanced; *Environmental Protection Law, Forest Law, Law of the People's Republic of China on the Protection of Wildlife* and *Water Law* shall be carefully fulfilled in construction and operation of Erchakou Hydropower Station, so as to stop soil erosion, recover and perfect local ecological environment, protect bio-diversity, promote sustainable development of social economy and improve living level of the local residents endlessly.

8.2 Protective measures of surface water environment

Main structures of the Project mainly contain the intake dam, power generation tunnel, power house and booster station, large area and high-intensity earthwork excavation, storage of waste slag, operation of different mechanical equipment, transportation of numerous materials from the outside, stationing of many construction personnel will generate a lot of wastewater, which may impact the water quality of the river reach on the site. In addition, operation of the Station also will bring about a series of changes in hydrology and water quality, so the construction unit must take effective environmental protection measures to minimize the adverse impact on aquatic environment.

8.2.1 Protection measures of aquatic environment in construction period

According to engineering analysis of the Project, total wastewater discharge in construction period is 14710m³, mainly including concrete placing and maintenance wastewater, rinsing water of sandstone processing system, rinsing water of construction machineries and vehicles as well as a lot of wastewater in foundation pit generated in construction, and also include domestic wastewater of construction personnel. River on the site is Category II water body, so the above wastewater must be reused or used for other purpose after being treated instead of directly discharged to rivers.

(1) Concrete placing and maintenance wastewater

A little wastewater of this kind will be discharged intermittently, each machine shift shall rinse once. The concentration of suspended solid in wastewater is 5000mg/L, PH11-12. It is recommended to apply intermittent natural sedimentation method to remove easy-sedimentary grit. Because pH value of the wastewater is higher, a

proper amount of acid can be added in the sedimentation tank to adjust pH value to neutrality and then treat it through sedimentation. Detail design is shown as follows:

① Neutralization sedimentation tank: two separation walls will be constructed in the tank, pH value calcimeter will be equipped at the outlet, industrial sulphuric acid will be used for neutralization to ensure 6-9 pH value of discharge water.

② Sand basin: it is divided into two parts used alternately. Rinsing wastewater at the end of machine shift will be discharged into the basin, and then discharged to the end of the next machine shift after static sedimentation for above 6 hours when concentration of suspended solid in wastewater is $\leq 70\text{mg/L}$.

The supernatant after sedimentation will be used for concrete mixing and maintenance, or made with natural depression assisted by retaining wall, but the capacity of sedimentation tank shall be ensured and the tank shall be cleaned in time.

(2) Rinsing water of sandstone processing system

Total discharge of rinsing water of sand stone processing system in construction is 8486m^3 , main pollutant is SS (concentration is $2.5 \times 10^4\text{mg/L}$). Because the surface water of Chongxi shall comply with Category II standard of *Quality Standards for Surface Water* (GB3838-2002), the requirement on water quality is higher; moreover, topography on both sides of the construction area is abrupt, construction land is short, the sandstone processing wastewater can be treated in sand basin which covers small area according to suspended solid in the wastewater is greater and its sedimentation is fast. Sand basin is of strong adaptability towards impact load and temperature change, easy construction and low cost; after sedimentation, the supernatant will flow into clear water tank completely used for production, the wastewater will not be discharged outside. After treatment, above 98% suspended solid can be removed, the sediment will be transported to the waste disposal area for landfill after natural

drying.

(3) Wastewater from rinsing construction machineries and vehicles

4380m³ wastewater from rinsing machineries and vehicles will be generated in the whole construction period. In order to prevent soil and aquatic environment in the construction area from pollution by the wastewater, catch pits will be set in repair and maintenance yard of machineries and vehicles to collect oil-bearing wastewater. Treatment measures are shown as follows: arrange drain ditch under the rinsing and service rack, arrange catch pit around the parking lot to collect wastewater in drains. Steel plates will be set at the end of catch pit to separate oil, thin weir will be set at the outlet of catch basin, the overflow will gather in water recycle system for construction. Waste oil before the steel plates shall be cleaned regularly, silt at the bottom shall be removed and treated well instead of discharged into water body. Regularly remove waste oil before steel plate and silt at the bottom. Specifications of catch basin are shown in Table 8-3.

Table 8-3 Specifications of Catch Basin

Location	Wastewater in peak hour (m ³ /d)	Detention period (d)	Design capacity (m ³)	Specification (m)
Parking lot	6	1	16	4×2×2

As for construction and transportation machineries, strengthen repair management, reduce discharge of oil-bearing wastewater to avoid mechanical oil leakage accidents.

(4) Wastewater in foundation pit

The Project is of small scale with no cofferdam, so a little wastewater in foundation pit will be generated in construction period. Pollutants in this wastewater mainly are SS, PH and fossil oil splashed by construction machineries. Concentration of

suspended solid is around 2000mg/L, pH value of concrete maintenance water is about 11-12. They are mainly gravels and mortar, which are sedimentary. According to monitoring results of hydropower projects constructed or under construction, the concentration of suspended solid of regular water in foundation pit will be qualified for discharge if statically placed in the foundation pit for about two hours. As for treatment of water in foundation pit, construction personnel can clear the floating oil, and then add proper amount of acid into it to adjust pH value to neutrality (use acid-base indicator to test pH value of wastewater), and the water can be pumped out after being statically settled for two hours, and then discharged if qualified; acid-base indicator can be used for testing wastewater in foundation pit. Strengthen water quality monitoring of wastewater in foundation pit during construction; the healing time shall be prolonged properly if SS and PH in water are abnormal or concentration of pollutants in wastewater are too high; the wastewater also can be used for concrete mixing and maintenance after treatment.

(5) Protective measures of domestic wastewater

In construction, maximum discharge of domestic wastewater is 5.7m³ per day and total discharge is 2080m³. Main pollutants in wastewater are BOD₅, COD, SS and ammonia nitrogen.

Underground treatment facilities, cesspool, micro-power wastewater and biomass pool can be applied for treatment of domestic wastewater.

Although underground non-powered treatment facilities and cesspool have their advantages, the treated wastewater is difficult to reach the standard for discharge. As for biomass pool treatment plan, the capacity of biomass pool is great, so it is difficult to arrange.

The construction area is located in wild mountains far away from residential area and urban area; giving consideration to overall level and regional environment in the

construction area, temporary toilets will be constructed around the construction site, excrement in which will be used as farmyard manure after composting.

Wastewater from canteen in temporary living area can be used for irrigating farmland or forest land, but must not be discharged into surface water. DO NOT discharge food residue and solid wastes into surface water.

8.2.2 Protective measures of aquatic environment in operation period

(1) The plant area shall be equipped with oil-water separator and oil treater, a little oil-bearing wastewater shall be treated through oil-water separator in overhaul of the Station, the waste oil will be reused after being treated by the oil treater; the operation in treatment shall be standard to prevent waste oil from leaking into the water body. In addition, emergency oil tank shall be set around the oil storage devices and transformers to avoid accident oil leakage into the water body.

(2) Main wastewater after the Station is put into operation is domestic wastewater of the staff, discharge is 292t/a. Although the discharge is less, it is also out of standard if not treated, so treatment facilities for domestic wastewater shall be constructed in construction. Ecological dry toilet is recommended in the Report and domestic wastewater cannot be discharged outside.

(3) Strengthen treatment of non-point pollution of the catchment. In order to reduce the impact of non-point pollution on water quality, local water conservancy department, agriculture department and forestry department shall strengthen and quicken the treatment of soil erosion in the upper reaches of the dam site and around; the construction unit shall take greening measures to make forest coverage in impact area be more than 40%. Strengthen the use and management of pesticide and

fertilizer, effectively and scientifically fertilize according to different soil types, crops and seasons, so as to reduce pollution of water quality arising from pesticide and fertilizer.

(4) Regularly monitor and forecast water quality before the dam and provide scientific basis for aquatic environment management in the area.

8.3 Other measures for environmental protection in construction area

8.3.1 Protective measures of acoustic environment

(1) Strengthen the control of noise source in construction. The construction unit must select construction equipment complying with related standard of the State, low-noise production machineries and equipment, and strengthen maintenance of equipment.

(2) Rubber sieve, plastic coated steel sheet and damping material shall be applied for the sandstone sieving system to reduce noise. Shockproof mount can be used for equipment with greater vibration.

(3) Afforest the construction area and main traffic road to reduce noise pollution. The speed shall be reduced, vehicle flow shall be controlled and tweeter shall be forbidden at night when vehicles pass through living area and residential area.

(4) Strengthen labor protection and perfect operation conditions of construction personnel. Operators must not work under high-noise environment for more than 6 hours per day. Appliances for labor protection such as noise protecting ear plugs, ear protectors or anti-noise helmets shall be equipped for them.

8.3.2 Protection of ambient air quality

(1) Reduction and control of excavation and blasting dust

The construction unit must apply construction machineries and vehicles complying with related hygienic standard of the State, discharged waste gas shall comply with related standards of the State. In surface blasting, try to use grass bags to cover the blasting surface to reduce dust. In dam area, stockyard and other construction area with intensive excavation and blasting, spray water for dust fall and reduce pollution scope. Drills shall be equipped with dust collector; according to the experience of Gegou Dam Project concentration of dust is up to $317\text{mg}/\text{m}^3$ in operation of down-hole drill, which can be reduced by 99.4% after the dust collector is installed. Spray water and increase ventilation facilities for underground excavation to improve diffusion conditions of pollutants and reduce the concentration of dust in operation area.

Operation personnel under dusty environment shall be equipped with dustproof supplies such as anti-dust respirator according to related rules for labor protection of the State.

(2) Dust reduction and control of sandstone aggregate and concrete system

Low-dust wet crushing technology is applied for sandstone aggregate processing, which can reduce dust yield. Enclosed type transportation shall be applied for cement and fly ash to reduce dust transmission; spray water around each processing system to reduce dust pollution.

(3) Reduction and control of exhaust gas of fuel oil

Strengthen management of large construction machineries and vehicles, mechanical equipment of the Contractor shall be equipped with facilities for smoke prevention and dust control, vehicles shall be installed with tail gas purifier; top quality fuel of low pollution shall be applied. Regularly inspect and repair to ensure each environmental protection index of construction machineries and vehicles to satisfy the requirement for tail gas discharge.

(4) Reduction and control measures of traffic dust

Try to apply asphalt pavement or concrete pavement when constructing new roads to reduce dust arising from the traffic on earth or gravel road. Regularly maintain and clean the road to keep its normal operation, equip special sprinkler in construction period, spray water 2-3times per day in sunny and windy days to reduce dust.

Dusty materials shall be properly wetted or covered with canvas in loading, the storage tank of vehicles transporting bulk cement shall be sealed well, and must be covered and sealed when transporting bagged cement; the vehicles must be cleaned frequently.

(5) Health protection

Office and living area of construction personnel shall be arranged in the upper drift of prevailing wind direction of dusty operation points and cooking ranges, so as to avoid dust and dirt pollution in construction.

Individual protection measures shall be taken for construction personnel greatly influenced by pollution, such as wearing anti-dust respirator. Combined with soil conservancy, afforest the office and living areas as well as both sides of road for dust control, take measures to limit traffic flow and restrict the speed of vehicles within 15km/h.

8.3.3 Treatment of solid wastes

(1) Domestic wastes

Output of domestic wastes in peak hour of construction is 0.06t/d and total amount of domestic waste is 21.7t. Trash bins shall be set in living area for collecting and clearing wastes to the nearby waste disposal area in time. Certain area shall be preserved in the waste disposal area as stockyard of construction wastes, the foundation of stockyard shall be treated in a proper way. Frequently spray insect killer in the stockyard to prevent breeding of flies, so as to reduce the adverse impact of domestic wastes on aquatic environment and health environment of construction personnel. Seal the site properly after construction, and cover with some surface soil to plant vegetation.

(2) Waste slag

Try to use construction waste slag for backfill and comprehensive utilization, construction rubbish, waste soil and stone as well as sediments in production wastewater treatment that cannot be used shall be transported to the disposal area for a proper treatment. The flood land occupied by waste slag shall be constructed with retaining wall to prevent water pollution by slag flowing into rivers with surface runoff; unused land and flood land occupied in construction area shall be cleaned and leveled at completion of the Project, exposed soil shall be recovered for greening to avoid soil erosion and landscape destroy.

8.4 Prevention measures of construction accidents

Erchakou Hydropower Station is a run-of-river station with no reservoir, so there will be no risk of outburst arising from destroys of reservoir dam. According to the

analysis of environment risks of the Project, referring to safety research achievements at home and abroad, the following prevention and emergency measures will be promoted aiming at the main reasons for possible construction accidents.

8.4.1 Fire prevention measures

(1) Carry out “prevention first and active extinction”, statistic forest fires and set up fire archives. In forest fire prevention seasons, DO NOT use fire in the field of forest area; strictly obey related rules if it has to do so.

(2) Construction period: advertise forest fire prevention knowledge, strengthen management, reasonably arrange living area of construction personnel and forbid construction personnel to use open fire in forest coverage area.

Operation period: strengthen advertisement of forest fire prevention knowledge, standardize management, control tourists to use open fire and strengthen management of firewood consumption of villagers.

(3) Immediately put out the forest fire once discovered and timely report to People’s Government or forest-fire prevention headquarters of the local place. Award those contributing to forest fire prevention and take those disobeying forest fire prevention management in to custody according to *Regulation on the People's Republic of China on Administrative Penalties for Public Security*, which shall be determined by the department of public security; If the circumstances and consequence are serious, whereas the case constitute a crime, judicial organs shall investigate the criminal responsibilities of those who have violated the criminal law.

8.4.2 Prevention of other risks

(1) Strictly comply with *The State Safety Regulations for Blasting* (GB6722-88) and take prevention measures before blasting, so as to avoid all kinds of effects such as vibration, noise, shock wave, dust and flying on surrounding people and organism.

It is suggested to cover the rock to be blasted with coverings such as old blanket after blasting agent is buried well, and then it can be ignited for blasting.

(2) The place such as temporarily used explosive magazine and oil tank for storing inflammables, explosives and toxic materials must be separated because of the risks including leakage oil burning, fire and explosion accidents. 120m safety distance shall be set, personnel shall be appointed for storage and comply with related rules for hazardous material management. Take accident prevention measures and prepare accident emergency plan such as forbidden fire source, control leakage of inflammables, explosives and toxic materials, perfect supervision, repair, warning and safeguard systems, equip scientific and complete fireproofing, explosion-proof equipment, fire alarm device, extinguishing system and oil-leakage warning device, and conduct monitoring management of the system to eliminate accident potentials. In addition, safety marks and facilities must be set in dangerous area and place on the site.

8.5 Land resource and soil environment protection

Land use structure and type in the occupied area for construction will be changed, so the following suggestions are promoted in the Report concerning sufficient use of land resources and soil environment protection:

8.5.1 Protect and sufficiently use existing land resources

Pay attention to save land, strictly control occupation of cultivated land and increase investment to labor, fund and science towards cultivated land in construction trying to improve grain output and increase population bearing capacity of the land.

Fill and level temporarily occupied land for construction with spoil, and then cover

the surface for agricultural and forestry utilization according to concrete conditions. Concave land also can be reconstructed as reservoir and other water surface utilization if possible.

8.5.2 Reconstruction of waste disposal areas

Waste disposal areas of the Project take up 20000m² temporarily, so proper drainage measures, engineering measure and plant measures shall be taken. Construct slag retaining wall at the slope toe of the disposal area and arrange perfect drainage facilities; the top of disposal area shall be leveled in general at completion, which shall be laid with clay firstly, and then compacted to form a barrier layer, finally covered with surface soil for forestation to increase the area of forest land.

8.5.3 Reclamation of temporary land occupation

Temporarily occupied land can be recovered or developed in a reasonable way according to actual situation after construction. At completion of the Project, temporarily occupied land, domestic wastes and construction rubbish shall be cleaned in time or collected for treatment, and the land shall be recovered to the original situation or arranged for other purposes according to regional planning.

8.5.4 Land use after treatment

The soil of flat and gentle slope (below 15°) after treatment is of good quality and provided with certain conditions water conservancy, so it can be used as farmland.

The soil with more than 15° ground slope or of poorer quality after treatment shall be used for forestry and animal husbandry, trees, shrubs and grass shall be reasonably arranged to recover the vegetation for soil conservance as soon as possible.

8.6 Protective measures for human health

8.6.1 Protective measures for human health in construction period

(1) Disinfection of the site

Cleaning and disinfection mainly focus on construction camps, human gathering places, original toilet, cesspit, pens for livestock as well as temporary living area, toilet and waste stockyard. Use carbolic drugs for sterilization with power sprayer according to *Technical Standard for Disinfection* and clean wastes in the same time.

(2) Destroy of vectors

In construction, destroy rat, mosquito and fly in living area in spring and autumn regularly, so as to control the infection source of different communicable diseases and cut off the transmission route. Rat clamp method and poison bait method will be applied for deratization; Insect Killer will be used for killing mosquito and fly; hand out drugs and tools to construction personnel for use under the directions of hygiene and disease control personnel.

(3) Health quarantine

Health quarantine shall be done by local medical institution for construction personnel before entering the site to discover and control carriers and new diseases taken into the construction site, so as to prevent cross infection and popularity in construction personnel and local residents. Take samples for quarantine according to survey results, which mainly include viral hepatitis, hemorrhagic fever and malaria. Quarantine frequency is shown as follows: construction personnel and management personnel must be quarantined before entering the site, the infectious victim shall be

isolated in time for treatment to avoid spreading of communicable diseases; then, random test 20% of the construction personnel twice in construction, and regularly do health survey and set up archives for epidemic situation. Forbid infectious victim to enter the site.

(4) Health examination

After commencement, environmental medicine situations in construction area are changing gradually, labor intensity of construction personnel is greater and the physiques of construction personnel are different, so there may be new infection cases. Observation and health checkup of construction personnel are helpful for mastering health conditions of labors, timely preventing and controlling development and spreading of all diseases, timely treating patients or the injured, so as to ensure normal construction. Health examination shall be determined according to concrete situations, canteen service personnel and construction personnel involved in dust and high noise as well as those engaging in the work type harmful towards human body shall be checked once per year and the results shall be filed.

(5) Prevention immunity

The construction area is of dense population and great operation strength, so planned immunity shall be done for construction personnel to improve their disease resistance and prevent cross infection and spreading of communicable diseases such as typhoid, hemorrhagic fever and malaria in construction. According to characteristics of disease spreading and disease spreading rules of hydraulic project, preventive medication and vaccination will be applied. In addition, medical unit on the site shall store enough tetanus immunity preparation and medicine for detoxicating snake poison in convenience for timely rescuing tetanus infected persons and those bitten by poison snakes.

(6) Advertisement and management of sanitation

The construction unit and the Employer shall define principal of hygiene and disease control to take charge of advertisement and management of human health in the management scope. Establish and perfect reporting network of epidemic situation, timely report to the superior department for any epidemic situation. Regularly supervise and inspect food hygiene in the construction area, check the health certificates of the employed for food and drink in the construction area. Strengthen purification and sterilization of drinking water in construction area, comply with ***SANTTARY STANDARD FOR DRINKING WATER***.

(7) Sanitation facilities

The arrangement of sanitation facilities shall be determined according to general layout of the Project combined with actual situation of the project management and distribution of construction personnel.

Arrangement of temporary WC: it shall be above 30m away from the canteen and shall be convenient. The arrangement of squatting positions shall comply with ***Hygienic Standards for the Design of Industrial Enterprises*** (TJ35-79) issued by the Ministry of Health and the State Labor Bureau. Number of WC and squatting positions shall be determined according to population density.

According to distribution of personnel and living camps in construction area, set trash bins (boxes) in living area; clean domestic wastes in time and transport away in regular, DO NOT pour into rivers or drain ditches to avoid water pollution. First-aid medical station shall be set in construction area provided with medicines and apparatuses for common communicable diseases and injuries.

8.6.2 Protective measures for human health in operation period

Establish health care system in local villages and towns, strengthen emergency capability of health care, hygiene and disease control under possible epidemic

situation, strengthen health advertisement for local residents, apply different ways to advertise knowledge of communicable diseases prevention and planned immunoprophylaxis inoculation knowledge, improve sanitary knowledge level and health protection consciousness of local residents. Do well protection of during water source and management of food hygiene.

According to present popular diseases of the local place, infectious diarrhea, viral hepatitis, bloody flux and tuberculosis must be randomly tested, hemorrhagic fever and leptospira shall be prevented, vaccination or medicine shall be provided for local residents according to results of monitoring and random test of communicable diseases.

After construction, rats and mice shall be killed regularly in local shallow water and drawdown area of river branches. The work shall be done coordinated by local hygiene and disease control department, “Shatazhang” or “Dalong” can be used for killing mice on basis of investigation of mouse and its density, and then the place shall be checked again.

The changes of water level and flow under the reach of tail water when adjusting the Station in operation period also may endanger people’s life. Therefore, warning boards shall be set in the lower reaches of gates, flood land nearby the Station and in the lower reaches of power house to remind and notify residents in good time, so as to avoid accidents. In addition, conduct safety education of the local residents in the first two operation years of the Station to let them know operation characteristics of the Station and draw their attention.

8.7 Technical and economic analysis of countermeasures

Table 8-4 Technical and economic analysis of environmental protection of Erchakou Hydropower Station

Category			Environmental protection measures	Technical and economic analysis
Aquatic environment protection measures	Yaozhan Brook	Management measures	<ul style="list-style-type: none"> ◦ Sufficiently use river resources, reasonably do well soil conservancy along the river and control non-point pollution. 	Realize water resource utilization and water quality protection through forceful management procedures.
	Wastewater treatment in construction area	Sandstone processing wastewater	Apply simple sand basin for sedimentation, reuse the supernatant.	<ul style="list-style-type: none"> ◦ The construction is simple and the cost is low; above 90% suspended solid can be removed in wastewater after treatment, it is feasible technically and economically.
		Oil-bearing wastewater	Set simple wastewater collection system to collect oil-bearing wastewater, mix with deemulsifying agent, separate oil and water through filtering.	It is economic and feasible, the content of fossil oil in the treated wastewater will be reduced below 5mg/L, it can be reused if qualified.

		Alkaline wastewater	Equipment wastewater collection system applies neutralization+sedimentation for treatment	Alkaline wastewater is dispersedly discharged, so it is difficult to use equipment for collective treatment; while the structure is simple, the cost is low and management is convenient, we only have to clean the tank regularly. It is feasible technically and economically.
		Domestic wastewater	Set dry cesspool in construction camp site and use as farmyard manure for nearby farmers.	Using as farmyard manure for nearby farmers is feasible. It can not be discharged when cleaned in time without overflow.
Ecological recovery and protection	Reduction of ecological impact	Protection of terrestrial animal	Reasonably arrange operation mode and period of construction machinery, especially blasting benches shall be applied for quarrying and foundation excavation, so as to reduce the usage of single-bang blasting agent.	It can effectively avoid unreasonably construction method of construction personnel.
	Ecological impact recovery	Ecological recovery and compensation of soil conservancy	◦ Waste disposal area: in construction, firstly construct ridge and a row of drain ditch outside to collect water flow on the slope and introduce the water into nearby channels.	After engineering measures are taken in waste disposal area, soil conservancy effect can be realized and the investment can be reduced.

			Before earthwork excavation, remove 30cm surface soil and pile up aside for 2m height, slope around 1:2, compact the surface and cover the surface with geomembrane for protection. Level the site after construction; construction site: construct drain ditch in sandstone stockyard, clean and level the site as well as recover the vegetation after construction.	It can effectively protect the occupied surface cultivated soil and can effectively recover the vegetation.
	Ecological management	Management regulations	Prepare ecological management regulations of the construction area, ecological protection rules for construction personnel in construction period and the staff in operation period.	Ecological destroy caused by human beings of the construction area can be avoided.
Acoustic environment protection	Noise control	(1) Request the construction unit to select construction machineries complying with noise standard of the State, apply low-noise equipment and technology, and strengthen maintenance of equipment; (2) use vibration reduction stand for large machineries to reduce noise, restrict work hours at night of comprehensive processing plant.		It can effectively reduce construction noise and stop noise transmission; these measures and equipment are of less investment, convenient installation and operation, which is reliable and effective technically.
Ambient air protection	Waste gas control measures	(1) Install dust collector for drill; (2) Hand out dustproof articles for construction personnel; (3) equip dust collector is that of the self-provided concrete mix		These measures not only can control the pollution source, but also can protect the impact objectives, it is reasonable technically, of less investment and convenient operation.

Solid waste treatment	Treatment of domestic waste	Equip simple trash bins in living area, collect and fill the wastes in the disposal area nearby. Spray insect killer on trash bins in construction area to prevent breeding of flies, so as to reduce adverse impact of domestic waste on the environment.		The measures can effectively prevent freely discard of domestic wastes and production waste, it is helpful for keeping the environment clean, preventing diseases and keeping people healthy.
	Construction rubbish and production waste	Production wastes shall be piled in designated place; oily cotton yarn shall be recovered uniformly for collective treatment. At completion of the Project, clean construction wastes and different sundries, do well recovery of destroyed construction site.		
	Traffic waste	Construction materials shall be covered in transportation to avoid dropping of sandstone and soil. Clean the trunk road in regular.		
Health protection of human being	Health protection in construction area	Health cleaning	Kill rat/mosquito and fly in construction area before construction personnel enter in it.	It can reduce source and medium of diseases, prevent construction personnel from infection, and it costs a little.
		Health supervision and management	Sterilization and management of drinking water, regular monitoring and food sanitation.	Water borne infection can be prevented; food poisoning and intestinal tract communicable disease can be prevented.

		health agency and prevention	Clarify responsibilities for hygiene and disease control, conduct sanitary propaganda and education, set medical care points, equip common medicals, develop simple treatment and first aid of industrial accident; develop sanitary and epidemic prevention in construction period. Take preventive medication and immunization measures. conduct physical examination of construction personnel in regular.	Technically, infectious victim cannot involve in construction team, cross-infection and popularity can be avoided in construction personnel; master dynamic changes of different diseases and keep construction personnel healthy.
		Sanitary facilities	Set dry toilet in construction area, appoint personnel for sterilization and cleaning in regular, collect and use as farmyard manure; regularly collect and filled waste in construction area in nearby disposal area.	Setting temporary sanitary facilities is good for environmental sanitation and preventing outbreak of disease.

9. Analysis on environment rationality of land occupation and construction plan

9.1 Environment rationality of permanent land occupation and arrangement of main structures

9.1.1 Environment rationality of permanent land occupation of main works

Main structures of the Project take up 0.37hm². Dam body is bottom trash rack dam (heights are 2.63, 3.09 and 3.32m) with extremely low flood damage. The Project mainly covers flood land and little cultivated land (not basic farmland), there is no cultural relic or valuable mineral resources in permanent occupation scope. The existing nature of cultivated land occupied by the Project will be changed, soil erosion will be aggravated in construction, so as to generate certain adverse impact on ecological environment; however, it is a small hydropower station with smaller permanent land occupation area, the occupation of main works will not cause great social, economic and ecological impacts on local residents; generally, it is reasonable to select flood land and little cultivated land for the main works.

9.1.2 Environment rationality of arrangement of structures of main works

Recommended overall arrangement of the Project is shown as follows: dam site of the Project is located at Neixi Brook, Liujia Brook and Daxigou in the upper reaches of Chongxi Brook, the power house is located at the mouth of Daxigou at the right bank of Chongxi Brook. The diversion tunnel is introduced to the power house from dam site. The tailwater directly flows into Chongxi Brook; intake dam of the Project is bottom trash

rack dam and located at the river, the flood submerged area is small, so no resettlement of affected residents is involved in the whole Project. Pressure head pond is on the ridge at Niejia Dam and in the diversion tunnel, so excavation can be reduced. The power house is at the right bank of Chongxi Brook and the contour line is arranged in a line. According to site survey, diversion tunnel of the Station is on the mountain, no farmland is excavated or occupied, no residents shall be resettled, vegetation destroy is of small scale and the natural landscape is kept. The power house occupies channels of barren hill and flood land growing with a little shrub, the exposed surface is used better and it does not generate great impact on production and living of the local residents. However, the construction of check dam and connection structure interferes the connectivity of riverine wetlands in the upper and lower reaches of the dam site, it may cause dewatering of a short river reach in the lower reaches and influence activities of organism in riverine wetlands.

Generally, the arrangement of main structures is reasonable environmentally.

9.2 Environment rationality of arrangement of waste disposal area and construction access as well as land occupation

According to field survey, vegetation on both banks grows well, but there are a few barren hills, the principle that occupying less forest land and cultivated land shall be obeyed to reduce impact of waste slag transportation on the way according to the landform. Therefore, excavated earthwork shall be used as more as possible in the light of the principle “try to use if possible” in preliminary design of the Project; moreover, excavated earthwork also shall be used for reconstruction of access road, other waste slag that cannot be used will be transported to four waste disposal areas as planned. The waste disposal area, construction access and camps are arranged at the left bank.

In the soil conservancy plan, grouted rubble slag wall shall be constructed outside the waste disposal area for protection; the requirement is also promoted in the environmental impact assessment. Applying this arrangement plan, the stock of waste slag will not influence the water level in the upper and lower reaches; the retaining wall also can avoid new pollution caused by the slag flowing into rivers. The waste disposal area occupies the land, so the Employer must negotiate with local department and give some compensation for the local people; in addition, the waste disposal area must be leveled and reclaimed after construction. On this basis, the arrangement of waste disposal area is reasonable.

9.3 Environment rationality of temporary land occupation for construction

According to arrangement of the Project, assistant enterprise for construction of the main works are mainly distributed in four places: (1) The slope nearby Neixi Brook Dam: take charge of construction of check dam, water catchment, inlet sluice gate and tunnel; mainly arrange with concrete mix system, different warehouses, repair and parking lot of construction machineries; (2) The slope nearby Liujia Brook Dam: take charge of construction of check dam, water catchment, inlet sluice gate and tunnel; mainly arrange with concrete mix system, different warehouses, repair and parking lot of construction machineries; (3) The slope nearby Daxigou Dam: take charge of construction of check dam, water catchment, inlet sluice gate and tunnel; mainly arrange with concrete mix system, different warehouses, repair and parking lot of construction machineries; (4) Power house location: ground elevation of the area is 445.30~446m; take charge of construction of pressure head pond, power house, switch station, channel and channel ends; mainly arrange concrete mix system, reinforced bar processing plant, timber, factory, different warehouses, repair and parking lot of construction machineries. Land occupation of construction is about 0.30hm², which is temporary land occupation (requisition); the Project covers a wide

area, structures are relatively dispersed; construction enterprises are arranged dispersedly according to actual landform; construction camps are arranged nearby construction site, sandstone aggregate system, concrete mix system and AC station are arranged nearby; steel form standard products and steel structures involved in the Project shall be provided and processed by designated manufacturers, only the repair and maintenance site is planned on the site. In temporary land occupation of construction site, flood land, forest land, barren hill and hillside cultivated take up 7.4%, 44.4%, 33.3% and 14.9% of the total site respectively, in which the forest land takes up a large proportion (44.4%), no great impact on local ecological environment will be generated in construction. But it is a temporary occupation, so the temporarily occupied land can be covered with original mellow soil after construction for reclamation, and can be planted with grass and trees to recover the local ecological environment, and also can be planted with crops and recover a part of dry land as cultivated land. Therefore, generally and seen in the long run, temporary land occupation of construction is reasonable environmentally.

9. 4 Environment rationality of arrangement of construction road and land occupation

Erchakou Hydropower Station is located in Duzhenwan Town of Changyang and the township-level road passes through the project area; the project area is 135km from Changyang Tujia Autonomous County and the power house is nearby the country road. However, the intake dam and tunnel opening are far away from the country road, so 2km access road shall be constructed, the traffic is extremely inconvenient. Most part of the Project occupies the existing road, so excessive land occupation can be avoided; grass planted on both road sides can reduce soil erosion, so road arrangement and land occupation are reasonable environmentally.

According to environment rationality of permanent land occupation and main structures as

well as environment rationality of temporary land occupation and arrangement of construction site, generally, land occupation and construction plan are reasonable in the aspect of environment. However, a lot of waste slag will be generated in construction, most of which are from tunnel excavation; therefore, the Employer is suggested to carefully do well the management of waste disposal area and vegetation recovery, so as to reduce soil erosion and protect soil resources.



10. Public participation

10.1 Investigation purpose and basis

Public participation is a kind of two-way communication of construction plan and the public, the purpose of which is to make the Project be sufficiently recognized and supported by the public, so as to improve the environmental, social and economic benefits better; therefore, public participation is essential for decision-making and successful implementation of construction plan.

Public participation is one of the key parts of environmental impact assessment of the planned project, through which impact on the surrounding can be directly reflected. In order to make the public sufficiently know the Project and directly participate in group decision of the environment and development, understand what problems it will bring about earlier, support and assist in construction of the Project, further eliminate or mitigate adverse impact on environment in construction and operation periods, make the planning and design be more reasonable and perfect as well as exert comprehensive efficiency of the Project at maximum, according to LFH [1993] No. 324 Document dispatched by four departments including State Environmental Protection Administration, the public participation work on construction of the Project is developed in the assessment forcefully assisted by the local government in December 2005.

10.2 Participants and methods

10.2.1 Participants

(1) Administration authorities

The People's Government of Changyang Tujia Autonomous County, the People's Government of Duzhenwan Town, Water Conservancy and Hydropower Bureau, Water Resources Protection Bureau, Environmental Protection bureau and Land Resource Bureau of the County.

(2) Residents

Residents live around the construction area.

10.2.2 Participation method

The public participation investigation is done randomly by handing out *Questionnaire of Public Opinion of Erchakou Hydropower Station of Changyang County of Hubei Province* in the impact area through private interview, household interview and group interviews. The questionnaire will be filled by the investigated or recorded by the investigator when listening to their opinions.

Content of the Questionnaire is shown as follows:

Attached List:

*Questionnaire of Public Opinion of Erchakou Hydropower Station of Changyang
Autonomous County*

I. Brief introduction to the Project

Erchakou Hydropower Station, located in Changyang Duzhenwan Town, is a branch of Yaozhan Brook-one of cascade development projects of water energy of Chongxi Brook. It is located in the upper reaches of Chongxi River and is the first stage of cascade development of water energy of Chongxi Brook, the water will be taken from Neixi Brook, Liujia Brook and Daxigou, the power house will be constructed at the mouth of Daxigou. The Project mainly covers the intake dam, diversion tunnel, head pond, pressure pipeline,

power house and booster station. The Station is a run-of-river hydropower station acting as the base load in the system. Design head of the Station is 284.65m, design flowrate is $0.8\text{m}^3/\text{s}$, installed capacity is $2\times 800\text{kW}$, warranted output is 205kW ($P=85\%$), long-term average power generation is 6.0449 million kWh and annual utilization hour is 3778. The requirements for industrial, agricultural production and living of the Town will be satisfied, surplus power will be connected to the grid in high water period

Erchakou Hydropower Station is Class V project; corresponding hydraulic structure is Level 5. According to the engineering level, related flood standard is shown as follows: the intake dam is designed for flooding once per ten years, design peak discharge of Neixi Brook Dam is $64\text{m}^3/\text{s}$, design peak discharge of Liujia Brook Dam is $57\text{m}^3/\text{s}$ and design peak discharge of Dagouxi Dam is $45\text{m}^3/\text{s}$; as designed for flood checkup once per 20 years, checkup peak discharge of Neixi Brook is $76\text{m}^3/\text{s}$, that of Liujia Brook Dam is $68\text{m}^3/\text{s}$ and Daxigou Dam is $54\text{m}^3/\text{s}$. The plant is designed for flooding once per 30 years, the peak flow is $195\text{m}^3/\text{s}$; as designed for flood checkup once per 50 years, the peak flow is $216\text{m}^3/\text{s}$.

Temporary land occupation is 0.373hm^2 and permanent land occupation is 0.413hm^2 .

Construction of Erchakou Hydropower Station will last for one year.

Earthwork excavation of main works is 10576m^3 and concrete 602.5m^3 .

In construction, more than 95 sets of different machineries will be applied, daily water consumption for production will be $25\text{m}^3/\text{h}$.

Construction of the Project, especially in construction, may bring about certain impact on the environment; in order to sufficiently refer to the public opinions in environmental impact assessment, we hereby hand over the *QUESTIONNAIRE*; please make your own choice, thanks a lot.

II. Brief introduction to the investigated

Name _____ Sex _____ Age _____

Ethnicity _____ Occupation _____ Income per head _____ yuan

Address _____

III. Content (please make your choice by drawing “√”)

(1) Education background

① Above college _____ ② Senior high school _____ ③ Junior high school _____

④ Primary school _____ ⑤ Illiterate _____

(2) Do you support the Project?

① Yes _____ ② General _____ ③ No _____

(3) If the station will be constructed, your existing address belongs to:

① Construction area _____ ② Beside construction road _____ ③ Other areas _____

(4) The greatest impact of the Station on you is:

① Noise _____ ② Dust _____ ③ Poor traffic _____ ④ Destroyed landscape _____

⑤ Communicable diseases _____

(5) Whether your living will be improved?

① Yes _____ ② Do not know _____ ③ No _____

(6) Do you know what is environment?

①Yes_____②A little_____③No_____

(7) Do you think the environment will be improved after the Station is constructed?

①Yes_____②A little_____③No_____

(8) Whether the Project will improve the local environment or not?

① Yes _____②A little_____③No_____

(9) Whether the Project will drive local economy after it is completed?

①Yes_____②General_____③No_____

(10) Which one do you care about more, benefit of the Project or the cost paid by environment?

①Environment_____②Environment and benefit_____③Benefit_____

IV. Your rationalization proposal:

10.3 Investigation results

10.3.1 Formation of the investigated

The public in different ages, ethnicities, occupation and education background actively participates in the investigation. We designed 60 samples and obtained 52 samples, recovery rate of samples is 95%; basic situation of public participants is shown in Table 10-1.

Table 10-1 Statistics of General Situation of Public Participation of Erchakou Hydropower Station Project

Item	Category	Number	Proportion (%)
Sex	Male	36	69.2
	Female	16	30.8
Age	Below 20	5	9.6
	20 -35	28	53.8
	36-50	12	23.1
	Above 50	6	11.5
Occupation	Farmer	9	17.3
	Worker	4	7.7
	Cadre	12	23
	Teacher	8	15.4
	Doctor	3	5.8
	Others (students, businessmen and the unemployed)	16	30.8
Ethnicity	Han ethnicity	4	7.7
	Tujia ethnicity	48	92.3

10.3.2 Investigation results of public participation

The public actively participated in the investigation after knowing something about Erchakou Hydropower Station Project, and practically expressed their opinion, thoughts and

suggestions about the Project. The investigation reflected the passion of the public in participating in social activities and the investigation results sufficiently reflected their willingness.

Statistics of public investigation is shown as follows:

Table 10-2 Investigation Results of Public Participation of Erchakou Hydropower Station Project

No.	Content	Choices	Number (person)	Proportion (%)
1	Education background	① Above college	23	44.2
		② Senior high school	18	34.6
		③ Junior high school	11	21.2
		④ Primary school	0	0
		⑤ Illiterate	0	0
2	Do you support the Project?	① Yes	52	100
		② General	0	0
		③ No	0	0
3	If the station will be constructed, your existing address belongs to:	① Construction area	35	67.3
		② Beside construction road	10	19.2
		③ Other areas	7	13.5
4	The greatest impact of the Station on you is:	① Noise	20	38.5
		② Dust	32	61.5

		③Poor traffic	0	0
		④Destroyed landscape	0	0
		⑤ Communicable diseases	0	0
5	Whether your living will be improved?	①Yes	49	94.2
		②Do not know	1	2
		③No	2	3.8
6	Do you know what is environment?	①Yes	49	94.2
		②A little	3	5.8
		③No	0	0
7	Do you think the environment will be improved after the Station is constructed?	①Yes	31	59.6
		A little	21	40.4
		③No	0	0
8	Whether the Project will improve the local environment or not?	① Yes	39	75
		②A little	13	25
		③No	0	0
9	Whether the Project will drive local economy after it is completed?	①Yes	50	96.2
		②General	2	3.8
		③No	0	0
10	Which one do you more care about, benefit of the Project or the cost paid by environment?	①Environment	10	19.2
		② Environment and benefit	40	77

		③Benefit	2	3.8
	Your rationalization proposal:	Most of them want us to speed up the construction progress and complete construction earlier, and protect the ecological environment well.		

10.3.3 Problems the public cared

Through analyzing the feedback information of public participation activities in different forms, we can see that, most people care about the following aspects:

(1) Land compensation. They hope that the government and construction unit can prepare compensation plan and related implementation program. Land requisition compensation shall be determined in a reasonable way according to policies and standards of the State combined with actual situation of the area. Go deep into the project area and understand the thoughts and demands of villagers, solve the problem well to prevent any trouble in the future.

(2) Quality of the project construction. It is a project of vital and lasting importance, they often remind us not to “construct a jerry-built project”.

(3) Development and utilization after the Project is completed, i.e. long term planning of local economy depending on the Project. Some people suggest the government to prepare a construction planning for supporting infrastructure (such as road and communication) and welfare facilities, a planning how to promote development of local economy and improve living level of people as well as collect construction fund.

(4) Timeliness of flood discharge in operation period and flood control capacity. Care about soil erosion. Hope that the government can pay attention to these problems and carefully review technical measures for solving these problems in design and environment assessment.

10.3.4 Investigation results of public participation

(1) In the investigated, 23 persons have education background above college taking up 44.2% the total investigated, 18 have education background of senior high school taking up 34.6% the total investigated and 11 have education background of junior high school taking up 21.2% the total investigated.

(2) 100% of the public support the Project.

(3) If the Station is constructed, the houses of 35 persons are in construction area taking up 67.3% the total investigated, of ten persons are beside construction road taking up 19.2% the total investigated and of seven persons are in other areas taking up 13.5% the total investigated.

(4) 20 persons consider the construction impact is noise taking up 38.5% the total investigated, 32 persons consider the construction impact is dust taking up 61.5% the total investigated, no person considers the impact is poor traffic or landscape destroy both taking up 0% the total investigated.

(5) 49 persons consider that the project will improve their living level taking up 94.2% the total investigated; one person has no idea taking up 2% the total investigated and two persons consider that it will not improve their living level taking up 3.8% the total investigated.

(6) 49 persons know what is the environment taking up 94.2% of the total investigated and 3 persons know a little about the environment taking up 5.8% of the total investigated.

(7) 31 persons consider that the Project will improve surrounding environment taking up 59.6% of the total investigated and 21 persons consider that there will be little changes taking up 40.4% of the total investigated.

(8) 50 persons consider that the Project will improve local environment after it is constructed taking up 96.2% of the total investigated and 13 persons consider that it will have little effect taking up 25% of the total investigated.

(9) 50 persons consider that the Project will drive the development of local economy taking up 96.2% of the total investigated and two persons consider that the function is general taking up 3.8% of the total investigated.

(10) As for benefit and cost paid by the environment, 10 persons pay attention to environment taking up 19.2% of the total investigated, 40 persons pay attention to environment and benefit taking up 3.8% of the total investigated.

Rationalization proposal: Most of them want us to speed up the construction progress and complete construction earlier, and protect the ecological environment well.

10.4 Conclusion of public participation

Main reasons for the public to support the Project are shown as follows:


10.4.1 Erchakou Hydropower Station takes power generation as the main task, it will satisfy the power consumption of Changyang County, improve power supply quality and warranted rate of power supply of Yichang City.

10.4.2 Existing traffic can be improved after the Station is constructed, so as to provide better transportation conditions of production and living of the people in mountains.

10.4.3 Construction of the Project is good for perfecting the poor infrastructure in mountains, water and power energies can perfect living conditions in mountains after it is completed, so as to improve conditions of power and water consumption of villagers in mountains.

The investigation results of public participation indicate that: main problems of the construction of Erchakou Station concerned by the Public are shown as follows: soil erosion, vegetation protection, pollution prevention of catchment, how to minimize construction destroy towards the environment and ensure sustainable development of the area. The

problems concerned by the public are solved through propaganda of the Owner and communication with local people. The Employer ensures to pay sufficient attention to the public opinion and solve their problems in engineering and construction, and ensure to care about ecological environment construction and soil erosion, ensure project quality, fulfill each environmental protection measure promoted in the Report and really minimize impact of the Project on environment.



11. Investment estimate and economic profit & loss analysis of environmental protection

11.1 Investment estimate of environmental protection

According to environmental economics theory, environmental legislation and fundamental principle of “the party who destroys shall take charge of treatment” of ecological environment, prediction and prevention investment estimate of possible ecological impact is essential for minimize environment risk, so as that the Project to be constructed will not cause severe loss of the environment, avoid deterioration of ecology, promote beneficial cycle of economy and ecology as well as realize sustainable development.

11.1.1 Investment principles

(1) The principle that “who pollutes shall bear the responsibility, who develops shall protect”. As for the measures such as environmental protection, supervision and engineering for environmental protection and serving the main works, mitigating or eliminating adverse impact of project construction on environment, the part of investment shall be covered in the environmental protection investment if it is not contained in the main works and its conservancy engineering according to adherence properties of the Project.

In the Report, facilities, equipment and environment management and monitoring for eliminating adverse impacts on Erchakou Hydropower Station on natural and ecological environment will be listed into special investment for environmental protection, which mainly covers construction environmental protection (including conservancy measures), aquatic environment protection, environment management and monitoring. Special investment in other aspects concerning land flood compensation and project protection investment such as reservoir bottom cleaning, land and forest flood compensation, environment geology measures (including engineering protection measures such as reservoir leakage, stability of reservoir bank and induced seism), shall be covered in the cost for

construction and protection engineering instead of special investment of environmental protection of the Project.

(2) The principle “giving prominence to the key points”. Environmental factors that having great impact on the Project, concerned by the Public and of higher protection level, shall be protected first and given priority to funding.

(3) The principle “function recovery”. The compensation measures taken for adverse impact of the Project on environment and the increased investment according to removal and reconstruction standard or scale expansion, shall be borne by the local government or related department and the owner of property rights.

(4) The Principle “lump sum compensation”. Substitution compensation and ecological recovery measures or lump sum compensation in a reasonable way according to related standard can be applied for environmental impact objective that is difficult in recovery and reconstructed as well as ecological and environmental losses caused by the Project.

11.1.2 Estimate reference

Rules For Preparation of Estimate (Budget Estimate) of Environmental Protection Design of Water Conservancy and Hydropower Project.

11.1.3 Division of investment project

According to *Rules of Environmental Protection Design of Construction Project*, devices, equipment, monitoring instruments and engineering facilities for pollution treatment and environmental protection belong to environmental protection facilities, investment estimate of environmental protection facilities shall be listed.

Facilities, equipment and monitoring instruments on the purpose of eliminating adverse impact of the power station on ecological environment are considered as special

environmental protection investment in the Report, which mainly concerns the investment of environmental protection, monitoring and management in construction period.

11.1.4 Investment estimate of environmental protection

(1) Investment target year

Investment estimate of each environmental protection item shall be determined according to the price level of 2005.

(2) Environmental protection investment in construction period

Engineering cost of environmental protection facilities shall be counted according to lump sum investment, transfer cost, environment monitoring cost and other expenses for three years.

(3) Environmental protection investment in operation period

In operation period of Erchakou Hydropower Station, main environmental protection investment is for regular monitoring (including water quality, ecological monitoring) of each environment factors in preliminary operation stage of the Project.

Soil conservancy cost of the Project has been covered in special investment for soil conservancy; special investment of environmental protection includes environmental protection equipment, environment monitoring measures and temporary measures of environmental protection.

According to base price and comprehensive unit price of the implementation of environmental impact and environmental protection measures as well as related measures, total investment to environmental protection of the Project is RMB 775200 (see Table 11-1) including RMB 510700 investment of environmental protection measures of key projects

taking up 9.63% of the total investment and RMB 264500 total investment of soil conservancy taking up 4.98% of the total investment as estimated based on the above principles. The investment is shown in Table 11-1 and 11-2 for details.

Table 11-1 Investment Estimate of Environmental Protection Subitem of Erchakou Hydropower Station Project

Unit: RMB the thousand

Unit: RMB the thousand No.	Cost and designation	Unit	Qty.	Unit price (RMB ten thousand)	Total (RMB ten thousand)	Remarks
Part I					7.25	
Construction period					2.01	
I	Water quality monitoring				1.32	
1	Water quality	Sample	12	0.06	0.72	
2	Pollution source	Sample	10	0.06	0.6	
II	Ambient air				0.24	
	Air monitoring	Point·Time	6	0.04	0.24	
III	Noise monitoring	Point·Time	30	0.015	0.45	
Operation period					5.24	
I	Water quality monitoring				1.44	
1	Water quality	Sample	24	0.06	1.44	
II	Ecological monitoring				3.8	
1	Aquatic monitoring	Point·Time	15	0.2	3.0	
2	Monitoring of animals and plants	Point·Time	10	0.08	0.8	
Part II Instrument, equipment and installation					22	
I	Environmental protection equipment				22	
1	Sandstone wastewater	Set	1	12	12	

	treatment equipment					
2	Alkaline wastewater treatment equipment	Set	1	3	3	
3	Oil-bearing wastewater treatment equipment	Set	1	3	3	
4	Domestic waste treatment equipment	Set	1	4	4	
Part III Temporary measures of environmental protection					9.02	
I	Wastewater treatment in construction area				2.2	
1	Operation cost of sandstone wastewater treatment	Set·Year	1	1	1	
2	Operation cost of alkaline wastewater treatment	Set·Year	1	1	1	
3	Operation cost of oil-bearing wastewater treatment	Set·Year	1	0.2	0.2	
II	Human health protection in construction period				2.82	
1	Sterilization of drinking water	Person·Year	100	0.0012	0.12	
2	Health quarantine	Person	58	0.012	0.7	
3	Mosquito –killing and deratization	Person·Year	100	0.02	2	
III	Ecological environment protection				4	
1	Reserve for transplantation of rare plants				2	
2	Reserve for transplantation of rare animals				2	
Total of environmental protection investment of Part I-III					38.27	

Part IV Individual cost					9.57	
I	Environment management cost				1.3	3% of the total of Item I-III
II	Environment supervision cost	Person ·Year	2	2	4.0	
III	Cost for scientific survey and design				3.5	
	Cost of survey and design for environmental protection				3.5	8% of the total of Item I-III
IV	Project quality supervision cost				0.11	0.25% of the total of Item I-III
V	Propaganda and education				0.66	1.5% of the total of Item I-III
Total investment of environmental protection of Part I-IV					47.84	
Basic budgetary reserves					3.23	6% of the total of Item I-IV
Special investment to environmental protection area					51.07	
Special investment to soil conservancy					26.45	
Total					77.52	

**Table 11-2 Summary of Investment Budgetary Estimate of Soil and Water
Conservation of Erchakou Hydropower Station**

Unit: RMB ten thousand

Unit: RMB ten thous and No.	Project and cost	Cost for construction and installation	Plant measure cost		Equipment cost	Individual cost	合计 Total
			Plantation cost	Forest, grass and seed cost			
I	Part I Engineering measures	17.27					17.27
II	Part II Biological measures		1.32	0.20			1.52
III	Part III Temporary works	1.11					1.11
IV	Part IV Individual cost					5.43	5.43
	Total						25.34
	Reserved fund (3)%						0.76
I	Total static investment						26.10
II	Investment counted into the main works						25
III	Compensation for soil conservancy facilities						0.34
IV	Total investment of the Project						26.45

In bid document of the Project, Environmental protection investment shall be clarified in budgetary estimate of project investment and the special fund for environmental protection shall be ensured for special use in implementation, so as that the environmental protection work can be really fulfilled.

11.2 Economic profit and loss analysis of environmental impact

11.2.1 Analysis purpose and principles

(1) Analysis purpose

The purpose of economic profit and loss analysis of environmental impact is to apply cost-efficiency analysis method to completely analyze environment profit and loss of the Project based on the theories of ecology and environmental economics giving consideration to sustainable, stable and coordinate development of ecological environment and regional social economy, so as to conduct comprehensive economic assessment towards the investment of countermeasures to eliminate adverse impact of the Project on environment and provide scientific reference for competent authorities to make decisions.

(2) Principles

At present, there is no uniform specification for profit and loss analysis of environmental economy of hydraulic project in domestic China, some environmental impacts are difficult to be quantized and monetized accurately. Therefore, environment profit and loss analysis of Erchakou Hydropower Station Project will be done based on existing experience in environment profit and loss analysis of hydraulic project in domestic China combined with environmental impact characteristics of the Project. Main principles for environment profit and loss analysis are shown as follows:

Ultimate impact principle: hydraulic project concerns a large area and the construction period is long, the impacted ecological system is complicated and of large scale, the relations of internal environmental factors of the system are complicated, a series of chain reaction for the impact on ecology and environment will occur, so only the final results of direct impact on ecological environment and economic activities of human beings will be

considered when analyzing environmental economic profit and loss of the Project.

Function recovery principle: when analyzing possible environmental impact of the Project, prevention, protection and rescue shall be focused to keep and recover the original functions of ecological environment; therefore, determination of the cost for protection measures and remedial measures in profit and loss analysis of environmental economy as the standard reflecting impact scale of the Project, as well as specifying the investment scale of these measures, shall only be in the limit of keeping and recovering the ecological environment functions before construction.

Lump sum estimate principle: because environment loss and environment efficiency time of the Project are different, these profits and losses have no comparability. Therefore, environment loss and profit of the Project will be properly converted as the present value of certain years according to related rules in analyzing, so as to make a lump sum estimate in convenience for analysis and calculation.

Only qualitative description instead of quantitative economic analysis will be applied for the priceless environmental impact.

(3) Analysis method

According to the above basic principles and characteristics of main impacted ecological and environmental factors, market value method, protection cost method and recovery cost method will be applied. Shadow project method will be applied for estimating environment profit and loss, and then gain and loss ratio will be assessed. Application of these methods depends on the characteristics of concrete objective or factor. In which:

Market value method is used for assessing the impact of quality changes on market output level of products.

Protection cost method is applied for assessing the economic efficiency of environment

quality impact through the cost of environmental protection measures.

Recovery cost method is applied to assess the economic efficiency of environment quality impact by right of the cost for destroyed natural resources or different properties to recover to the original status.

Shadow project method is a special mode of recovery cost method actually. It is to estimate environment loss or efficiency of environmental protection through the cost of shadow project. Shadow project indicates the supplementary item as substitute of the original environment quality.

11.2.2 Environment economic profit and loss analysis

(1) Economic benefit

According to preliminary design report of Erchakou Hydropower Station Project, the installed capacity is 1600KW and long-term average power generation is 6.0449 million kWh. At present, on-grid price is about 0.2943 Yuan/ kWh, annual power benefit in operation period of the Station is RMB 831900. Total pretax profit per year of the Station is RMB 703600 after deducting production cost RMB 128300, so the power benefit gained in operation period is RMB 21.108 million if the economic operation period is thirty years.

Construction of Erchakou Hydropower Station is meaningful for promoting economy development of minority area along the river as well as casting off poverty and becoming better off; therefore, construction and operation of the Station will obviously promote socioeconomic development, the economic benefit is great.

(2) Social benefit

The construction of Erchakou Station not only has good economic benefit, but also has better social benefit.

Firstly, construction of the Station is helpful for quickening industrial restructuring and promoting local economy development; the Station can be a new leading industry in regional economy, promotes coordinate development of related industries, helpful for promoting industrial restructuring of the whole city and quicken local economy development. Secondary, construction of the Station will promote economy development of minority area along the river as well as cast off poverty and become better off. Erchakou Hydropower Station is located in northwest of Hubei Province, the economic base of which is weak; construction of the Station will bring along the development of other resources, transfer resource advantages into economy advantages, which is meaningful for promoting economy development of minority area along the river as well as casting off poverty and becoming better off.

To sum up, construction of Erchakou Hydropower Station is of good social and economic benefits.

(3) Loss analysis

Loss in project construction covers total static investment, loss of land resource and ecological destroy, ecology recovery cost and environmental protection investment for eliminating adverse impact.

① Total static investment of the Project

Total static investment of the Project is RMB 14.7646 million.

② Investment to environmental protection

In order to treat and prevent environment pollution and control ecological environment damage in construction, necessary environmental protection measures to be applied contain environmental protection, soil-water conservation and ecological protection measures, environment management and monitoring, which will be invested for preventing

environment loss caused by the Project. As known from analysis of the above environmental protection investment estimate, special investment to environmental protection of the Project is RMB 510700 and to soil conservancy is RMB 264500, so the total investment is RMB 775200.

(4) Profit and loss analysis of environmental economy

Main environmental economy benefit of the Project covers the income of power generation, economic efficiency obtained from ecological recovery investment and the ecological efficiency from ecological environment protection in operation period, quantitative analysis of economic profit and loss of environmental impact is shown in Table 11-2.

① Positive benefit

After Erchakou Hydropower Station is finished, what's essential for reducing environmental impact of remote poor area is to prevent soil conservancy as well as protect local vegetation and forest.

Developing power supply and substituting firewood with power are more acceptable for local residents. After the Station is completed, power supply substituting firewood can be assured reliably and it also can provide material basis for protecting existing forest resources, which will bring about deep influence to the local environment. In addition, local economy can be developed after it is put into operation, which is fundamental for casting off poverty and becoming better off of the people in mountains.

After Erchakou Hydropower Station is constructed, the installed capacity is 1600KW and annual average power generation is 6.0449 million kWh, power benefit will be calculated according to shadow price method and shadow price will be applied for national economy, but the price of investment is not adjusted besides shadow price because the price of “three materials” in project investment almost is market price, the construction period is short, so it

will have little impact on assessment if not adjusted; shadow price $S=(K_1 \times K_2 \times K_3) \times$ average shadow price of the area specified by the State Development and Planning Commission), $K_1=1.15$, $K_2=1.15$ and $K_3=1.15$ according to *Economic Evaluation Code for Small Hydropower Projects*, shadow price in central China is 0.2225yuan/kwh, and shadow price $S=0.3384$ Yuan/kWh as calculated; according to operation of similar stations, rate of power consumption by factory takes 0.5%, grid loss rate takes 5% and effective power coefficient takes 1.0.

Power sales =Long-term average power generation×Effective power coefficient×(1- rate of power consumption by factory)×(1-grid loss rate) = 5.7139 million kWh.

Power generation income=power sales×S=RMB 1933600.

② Negative benefit

Erchakou Hydropower Station takes up 0.87hm² in total including 0.37hm² permanent occupation and 0.50hm² temporary occupation. Permanently and temporarily occupied lands are barren hill, flood land, forest land and hillside cultivated, barren hill covers 0.5hm², flood land covers 0.07hm², forest land covers 0.23hm² and hillside cultivated covers 0.07hm² with lump sum compensation RMB 20700 in total, in which RMB 13600 for permanent occupation and RMB 4100 for temporary occupation.

Ecological economy assessment method is applied for estimation if quantitative analysis is available in ecological impact assessment factors. If quantitative analysis is not available for some loss and benefit factors, qualitative analysis can be applied because of its uncertainty. Quantitative and qualitative analysis of profit and loss of environmental impact are shown in Table 11-3.

Table 11-3 Analysis of Profit and Loss of Environmental Economy

Unit: RMB ten thousand

Unit: RMB ten thousand Environment factor	Property of environmental impact	Present value		Profit and loss rate
		Benefit	Loss	
1. Local climate	Slightly improved	+		54.25:1
2. Water quality	A little change			
3. Water temperature	No obvious adverse impact			
4. Environmental geology	Landslide, collapse, leakage and induced seism are possible		+	
5. Sediment	Stop sediment in the upper reaches and improve water quality in the lower reaches	+		
6. Terrestrial animals and plants	No obvious impact on surrounding terrestrial animals and plants; no blockage of the immigration passage of animals; may attract birds to live here and provide favorable conditions for regeneration of surrounding plants.	+		
7. Aquatic	Cause adverse impact on aquatic ecological environment		+	
8. Environmental protection of construction area	“three-waste” treatment, health care of construction personnel, construction destroyed site.		40.00	
9. Soil conservancy	Soil erosion in construction area		26.45	
10. Environment monitoring and management	Environment monitoring, management and project quality supervision in construction and operation periods		10.22	
11. Power generation	Total profit is calculated for 50 years.	4159.5		
12. Flood control	Improve flood detention and routing	+		
Total		4159.5	76.67	

As known from Table 11-3, ecological environment loss of planned area mainly is bad environment quality in construction area, soil erosion, local climate, aquatic, water quality,

terrestrial life, environment monitoring and management; whole the benefit is presented by power generation. As known from profit and loss estimate of environmental economy, the rate of ecological economic benefit and loss is 54.25:1, ecological economic benefit is greater than loss; according to Table 11-3, many favorable impacts that quantitative analysis is difficult are not considered, so the Project is feasible in the aspect of environmental economic benefit according to quantitative and qualitative analysis results of different environmental economic profit and loss.



12. Environment management, monitoring and supervision

12.1 Environment management plan

Environment management is a key part of environmental protection. Environment management basically takes environmental protection as the purpose to strengthen environment management in construction period and operation period.

(1) Target of environmental protection management

Ecological destroy and environment pollution can be effectively prevented and controlled through strict environment management, so as to minimize the adverse impact on environment in construction and operation period and make the “three simultaneities” be obeyed, and try to realize the unification of economic benefit, social benefit and environmental benefit of Erchakou Hydropower Station Project.

(2) Responsibilities of environment management

The construction unit shall set up environmental protection management institution in the project management organization in convenience for supervision and management of environmental protection during constructing and operating. Environment management department shall include environment management and supervision department with one or two full-time workers; responsibilities of environmental protection department at each level are shown as follows:

① Execute national and local environmental protection policies, guideline, related laws and regulations, assist in preparing and implementing environmental protection planning of the reservoir, cooperate related department to examine and fulfill the design of environmental protection facilities and completion acceptance of these facilities.

② Organize and coordinate all tasks promoted in the Report and approval suggestions, fulfill the funds for ecological compensation and pollution prevention; set up and perfect work system of environmental protection; clarify environmental protection responsibility system, awards and punishments.

③ Do well the following work for environment management in construction: organize environment supervision and monitoring in construction, regularly prepare environment quality report in construction area and report to the superior department; do well prevention of ecological destroy and pollution accident, take emergency measures in accidents; in the later stage of construction, organize recovery and improvement of ecological environment of the construction area, such as recovery of construction destroyed site and greening of construction area; do well environment and health management and environmental protection such as treatment of waste slag before the intake pivot stores water.

④ Collect and management related environmental protection rules (especially the protection of ecological environment), environment technical data and monitoring data; set up archives of environmental protection .

(3) Environmental protection plan of the Project

Table 12-2 Environmental Protection Plan of the Project

Environment problems		Mitigation measures	Implementation institution	Responsible party
Construction period	1. Air pollution	<input type="checkbox"/> Timely spray water on construction site and road to reduce air pollution; <input type="checkbox"/> Cover the material storage yard to prevent dust pollution, cover the vehicles transporting materials with canvas; <input type="checkbox"/> Shield the mixing equipment well. <input type="checkbox"/> Reasonably design driving route of vehicles.	The Contractor	The Employer

	2. Water pollution and soil erosion	<input type="checkbox"/> Strengthen management of living area of construction personnel, apply necessary measures to avoid direct discharge of construction wastewater and domestic wastewater to the surface water body and rivers; <input type="checkbox"/> Reasonably prepare project plan, protect the existing natural vegetation and avoid soil erosion; <input type="checkbox"/> Take necessary measures to prevent rivers from clogged by waste slag.	The Contractor	The Employer
	3. Noise	<input type="checkbox"/> Strictly implement noise standard for industrial enterprises; work personnel close to the sound source shall take protection measures and their work time shall be restricted; <input type="checkbox"/> Reasonably design transportation routes for vehicles and keep away from sensitive areas; <input type="checkbox"/> Strengthen management of construction machineries and personnel, reduce noise impact; <input type="checkbox"/> Implement approval system of blasting operation, avoid blasting at night and in afternoon.	The Contractor	The Employer
Construction period	4. Protection of ecological resources	<input type="checkbox"/> DO NOT set waste disposal area (yard) at free will; <input type="checkbox"/> Strengthen protection of existing mountain forest and vegetation, DO NOT destroy and excavate, make plans and take measures when transplanting tree species to be protected; <input type="checkbox"/> Construction personnel shall ensure civil construction, must not cut trees, shrub, grass and natural vegetation as well as kill wildlife at free will; <input type="checkbox"/> DO NOT destroy natural surroundings when disposing waste slag, consult the environmental protection department for disposal area.	The Contractor	The Employer
	5. Protection of cultural relic and landscape	Stop construction if any cultural relic is discovered, report to related department and then continue construction after being approved. Reasonably arrange the construction site, save land use area and protect natural landscape well.	The Contractor	The Employer
	6. Construction camp	Set waste bins and sanitation facilities in construction camp, regularly treat rubbish and waste in the bins. Drinking water must comply with drinking water standard of the State; prevent the environment from pollution by domestic waste and solid waste.	The Contractor	The Employer
Operation period	Ecological environment protection	1. Take effective measures to protect forest land and recover the vegetation around the whole station after construction; <input type="checkbox"/> DO NOT construct any structure in river and on both sides.	The Contractor	The Employer

2. Water pollution	Forbid new water pollution source.	The Contractor	The Employer
3. Noise and solid wastes	<input type="checkbox"/> Set waste bins and collection system of solid wastes <input type="checkbox"/> Appoint persons to regularly treat solid waste at dam site and around the station, DO clear away wastes on the current day.	The Contractor	The Employer
Environment monitoring	Prepare monitoring plan and execute according to rules of the State	The Contractor	The Employer

(4) Environmental protection management institution and responsibilities

According to tasks and responsibilities in environmental protection, responsibilities of management and supervision institution of environment management are shown in Table 12-2.

Table 12-2 Management Institution of Environmental Protection and Responsibilities

Period	Organization institution	Supervision institution	Responsibilities
Preliminary period	Yichang Qingjiang Water Conservancy and Hydropower Survey and Design Institute	Yichang Water Conservancy and Hydropower Bureau, Water Conservancy and Hydropower Bureau and Soil Conservancy Bureau of Changyang Tujia Autonomous County	Demonstration of environmental and economy technology of the Project
	Environmental Protection Institute of Xiangfan City of Hubei Province	Yichang Environmental Protection Bureau, Environmental Protection Bureau of Changyang Tujia Autonomous County	Determine environmental impact, demonstrate environmental feasibility of the Project and promote environmental protection measures

Construction period	Each environmental protection measures and soil conservancy measures	Construction unit	Yichang Environmental Protection Bureau, Environmental Protection Bureau of Changyang Tujia Autonomous County	According to construction of environmental protection facilities, ensure fulfillment of environment protection measures and realization of “three simultaneities”.
	Environment supervision	The Employer, qualified supervision institution	Yichang Environmental Protection Bureau, Environmental Protection Bureau of Changyang Tujia Autonomous County	Monitor each environmental protection measures and fulfillment of ecological protection projects, report fulfillment of each environmental protection measure, existing problems and improvement suggestions
	Environment monitoring	Environment monitoring station of Changyang Tujia Autonomous County	Environmental Protection Bureau of Changyang Tujia Autonomous County	Finish environment monitoring in construction
	Environmental protection acceptance	The Employer, environmental protection acceptance unit	Yichang Environmental Protection Bureau, Environmental Protection Bureau of Changyang Tujia Autonomous County	Inspect the fulfill of all environmental protection measures
Operation period	Daily management of environment protection	The Employer	Yichang Environmental Protection Bureau, Environmental Protection Bureau of Changyang Tujia Autonomous County	Keep normal operation of all environmental protection facilities and make pollutant discharge concentration satisfy local environment requirement
	Environment monitoring	Environment monitoring station of Changyang Tujia Autonomous County	Protection Bureau of Changyang Tujia Autonomous County	Finish monitoring task promoted in environment assessment report

12.2 Environment monitoring plan

Environment monitoring is essential for environmental protection and management, and a complete environment monitoring system can be established as coordinated by environment management institution, sufficiently using existing institution, technology and equipment (environment monitoring station, hydrologic station, sanitary and anti-epidemic station as well as weather station) to bear environment monitoring task together. Contract system management can be applied in the monitoring system to determine rights and obligations of each party through agreement.

12.2 .1 Main responsibilities of monitoring institution

- (1) Regular monitor of water quality, ambient air and noise, monitor and inspect of pollution source, emergency and track monitor of pollution accident of the Station.
- (2) Regular hydrographic observation, hydrologic regime and rainfall regime forecast in the upper reaches of dam area and rivers under dam.
- (3) Forecast temperature, rainfall and wind speed related with local climate of the dam area.
- (4) Monitor soil erosion around the dam area.
- (5) Timely monitor and forecast the occurrence and development of different diseases.

12.2.2 Environment monitoring plan

Construction of water conservancy and hydropower project lasts for a long time and the operation time is even longer; construction and operation of the Project will have widely and deep influence on the natural environment and social environment. Some potential environment risks cannot be identified completely in feasibility study period and preliminary construction period, so the impact area shall be monitored for a long term.

(1) Environment monitoring plan in construction period

① Aquatic environment quality monitoring

A. Monitor of water quality of rivers

Section setting: because the construction area is dispersed, so one monitoring section will be set at 100m in the upper reaches of Neixi Brook Dam, Liujia Brook Dam and Daxigou Dam as well as the power house.

Monitor item: pH, SS, permanganate index and ammonia nitrogen.

Monitor method: monitor according to *Technical Specifications Requirements for Monitoring of Surface Water and Waste Water* (HJ/T91-2002).

Monitor time and frequency: monitor for one year before water quality storage of river; monitor time of the section in construction area is one year. The frequency of which is thrice per year in high water period, dry period and level period respectively.

B. Monitor of discharge outlet

Arrangement of monitor points: set one wastewater monitor point at discharge outlet of different wastewater treatment devices (neutralization sedimentation discharge outlet and oil separating pool), wastewater discharge outlets of foundation pit and domestic wastewater respectively.

Monitor item: construction wastewater, pH, SS; domestic wastewater: SS, COD, ammonia nitrogen.

Monitor frequency: construction period is one year, monitor twice per year synchronistically with water quality monitoring.

Monitor method: monitor according to *Technical Specifications Requirements for*

Monitoring of Surface Water and Waster Water (HJ/T91-2002).

② Monitor of ambient air

Arrangement of monitor points: set one monitor point at construction area of three dams and the power house respectively, master and control existing environment quality at all hours in convenience for take effective measures and reduce pollution of ambient air.

Monitor item: TSP, because a lot of construction machineries shall be applied in construction.

Monitor method: comply with *Ambient Air Quality Standard* (HGB3095-1996) and *Technical Criteria for Environmental Monitoring Atmosphere Part* .

Monitor time and frequency: monitor once per season for five continuous days per time, the monitor period is one year of construction period. Environment monitoring shall be reported quarterly and yearly, the local environmental protection administration shall be reported regularly after the report is prepared, environment monitoring can be finished by local environment monitoring station entrusted by the construction unit.

③ Regional environment noise

Arrangement of monitor points: In order to know the impact of construction noise on the surrounding, set one monitor point in construction area of three dams, sandstone yard, construction site of power house, living area of construction personnel and access road respectively, seven in total.

Monitor time and item: equivalent sound level dB (A) at daytime and night.

Monitor frequency: monitor twice per year in construction period, one is in winter and the other is in summer for 24h per time; monitor period is one year.

Monitor method: comply with *Measuring Method of Environmental Noise of Urban Area* (GB14623-90) and *Measurement Method of Noise from Construction Site* (GB12524).

④ Aquatic monitor

.Monitor fishery production, varieties and quantities of fishes for one year.

⑤ Human health

Monitor content: regular monitor of human health is mainly monitored through three-level rural health network towards the epidemic information in construction area, so as to know the pollution arising from construction activities on human health. Local communicable diseases such as natural focal disease, water-borne infection and arthropod borne infectious diseases will be monitored. In high risk area of communicable diseases, random test and vaccination shall be done for the group liable to infection, so as to ensure healthy of construction personnel.

Monitor scope: Construction personnel on the site.

Monitor time: at construction peak hour and before completion, once per time, monitored by local hygiene and disease control department as required by the Ministry of Health.

⑥ Soil erosion

Monitor factor: rainfall, wind, ground gradient, slope length, ground constructional material, strength, characteristics and hazard of soil erosion in construction, plant growth, vegetation and its coverage, amount of soil erosion, soil nutrient, quantity and quality changes of soil conservancy facilities.

Monitor content: amount and hazard of soil erosion, efficiency of conservancy engineering.

Monitor method: Field survey method and fixed point monitor method.

Arrangement of monitor points: select two typical sections to set monitor section, one section can be arranged with one to two points.

Monitor time and frequency: once in construction period

⑦ Observation of terrestrial animals and plants

Set one observation point in each construction area, four in total; observe and protect terrestrial animals and plants

(2) Environment monitor plan in operation period

Monitor plan in operation period is mainly for the Project.

① Monitor of water quality

Arrangement of sections: key points of quality monitor of aquatic environment in operation period; therefore, one regular section will be set with obvious mark at 200m before Neixi Brook Dam, Liujia Brook Dam and Daxigou as well as 100m in the lower reaches of the discharge outlet of the Station.

Monitor item: pH, permanganate index, ammonia nitrogen and total phosphorus

Monitor frequency: monitor once in level period and dry period per year after the station is put into operation.

Monitor method: arrangement of sampling point shall comply with *Technical Specifications for Monitoring (Surface Water)*, inspection and analysis shall comply with *Environmental Quality Standards for Surface Water* (GB3838-2002).

② Soil erosion

Monitor factor: rainfall, wind, ground gradient, slope length, ground constructional material, strength, characteristics and hazard of soil erosion in construction, plant growth, vegetation and its coverage, amount of soil erosion, soil nutrient, quantity and quality changes of soil conservancy facilities.

Monitor content: amount and hazard of soil erosion, efficiency of conservancy engineering.

Monitor method: Field survey method and fixed point monitor method.

Arrangement of monitor points: select two typical areas to set monitor section for plant road, each section can be arranged with one or two points.

Monitor time and frequency: within three years in operation period of the station, monitor once before flood, after flood and in winter per year.

③ Aquatic

Monitor section: set one monitor section in the end of backwater at the dam site, 25m on the dam.

Monitor content: zooplankton, phytoplankton benthos, aquatic higher plant and fishes.

Monitor time and frequency: monitor in April of the third year after water storage in the dam area.

④ Hydrographic observation

Set hydrographic observation point to observe water level, flow and sediment content according to *Code for Hydrologic Surveying*.

⑤ Observation of human health

Conduct health screening and sampling survey of the people in typical area around the

station.

⑥ Meteorological observation

Set two to three observation station points to forecast and report temperature, wind speed, direction, frequency, rainfall, humidity and fog.

12.3 Environment supervision plan

According to environmental protection design, environment supervision is essential for project supervision and shall penetrate the whole process of project construction. The construction unit shall entrust qualified supervision institution to supervise, inspect, manage, timely treat and solve temporary environment problems in environmental protection of professional environmental protection department and project contractor; completely inspect each construction area such as slag yard and occupied land, recovery as well as the implementation of ecological recovery and protection measures according to environmental protection plan before putting into operation at completion, so as to reduce the adverse impact of construction on the environment.

12.3.1 Environment supervision purpose

In accordance with related rules, regulations, policies of the State and related department in charge, bid document and supervision contract, environment supervision personnel shall fulfill environment supervision obligations based on the scope and content of supervision services, trying to satisfy the environmental protection requirement in design, construction and operation, main work objectives of environment supervision are shown as follows:

(1) Ensure that the work specified in environmental design and related supervision document can be reasonably implemented and the environmental protection requirements in

the Report can be fulfilled, this is the main objective of environment supervision and also the fundamental requirements of environmental protection policies and regulations.

(2) Combined with actual situation of the Project, assist the Employer in environment management, advertise environment protection knowledge and enhance environmental protection consciousness. This is a work objective promoted because environmental protection consciousness in construction project at present is not strong and environmental protection management level is low, so it hopes to further enhancing environmental protection management level of the Employer through active environment supervision.

(3) Supervise the construction unit to take effective measures, so as to control the adverse impact of construction activities on environment to acceptable scope, improve environmental protection level and maintain the rights and interests of construction unit. As entrusted by the Employer, the environment supervisor participate in construction as an individual “third party”, it shall be at a scientific and fair standpoint to coordinate the relationship between the Employer and the construction unit, it shall carefully supervise and strictly manage the construction party, and also shall make allowance for actual difficulty in construction and allow the construction party to implement environmental protection measures in a flexible and effective way.

(4) Prepare plentiful and complete supervision data, actually reflect the work process to provide reference for environmental protection acceptance. Environment supervision is the bridge connecting environment assessment and acceptance in environment management of the Project, rich and detailed environment supervision data will made a solid foundation for successful environment acceptance.

12.3.2 Environment supervision

The tasks for environment supervision in construction preparation, construction and acceptance of the Project are different.

(1) Construction preparation

Organize environment supervision disclosure meeting, draw special attention of the construction unit on environment sensitive factors, related environmental protection requirements and environmental supervision; review the part concerning environmental protection in construction plan of subunit of project (construction bid section) and subproject; inspect the preparation of environment protection of the construction unit.

(2) Construction periods

Inspect the organization and operation of environmental protection institution of the construction unit; inspect the implementation of environmental protection articles in contract and fulfillment of environmental protection measures; preside and hold related meetings concerning environmental protection in project area, collect the suggestions concerning environment, review treatment promoted by the construction unit, coordinate each party in environmental protection, mediate environmental disputes; prepare written data of environment supervision.

(3) Project acceptance period

Supervise and inspect the construction unit on site for treatment of unsolved environment problems; settle environment supervision data for acceptance. Comprehensively assess the situation and results of construction unit in implementing environmental protection articles in the contract and fulfilling environmental protection measures; participate in project acceptance and give environment supervision suggestions

12.3.3 Establishment of environment supervision institution

The Project is of smaller scale, so it is advised to appoint one or two environment supervision engineers, who shall answer for the Employer.



13. Conclusion and suggestion

13.1 Brief introduction to the Project

Yaozhan Brook catchment, located in the south of Changyang Tujia Autonomous County, geographically crossing the east longitude $110^{\circ}30' \sim 110^{\circ}54'$ and north latitude $30^{\circ}15' \sim 30^{\circ}24'$, belongs to the primary branch of Qingjiang River. Dam site of the project is at Neixi Brook, Liujia Brook and Daxigou in the upper reaches of Chongxi Brook, 58km from Zhuangxi Brook, 135km from Changyang County and 195km from Yichang City; the power house is located in the upper reaches of Daxigou mouth, 48km from Zhuangxi Brook, 125km from Changyang County and 185km from Yichang City, the water from Chongxi Brook will be used for power generation.

Erchakou Hydropower Station aims at power generation and its installed capacity is $2 \times 800\text{kW}$; long-term average power generation is 6.0449 million kWh, utilization hours in a year is 3778. $P=85\%$ warranted output is 205kW. Engineering level is V and the level of corresponding hydraulic structure is 5.

Intake dam of Erchakou Hydropower Station is only used for stopping water from flowing into the channel instead of flood control, so the flood discharge in flooded area will not be limited. Design flood level and maximum flood level will be determined according to the operation of overflow dam. The intake dam is designed for flooding once per ten years, design peak discharge of Neixi Brook Dam is $64 \text{ m}^3/\text{s}$, design peak discharge of Liujia Brook Dam is $57 \text{ m}^3/\text{s}$ and design peak discharge of Daxigou Dam is $45 \text{ m}^3/\text{s}$; as designed for flood checkup once per 20 years, checkup peak discharge of Neixi Brook is $76 \text{ m}^3/\text{s}$, that of Liujia Brook Dam is $68 \text{ m}^3/\text{s}$ and Daxigou Dam is $54 \text{ m}^3/\text{s}$. The plant is designed for flooding once per 30 years, the peak flow is $195 \text{ m}^3/\text{s}$; as designed for flood checkup once per 50 years, the peak flow is $216 \text{ m}^3/\text{s}$.

Total investment of the Project is RMB 14.7646 million, in which total investment to

environmental protection is RMB 510.7 thousand taking up 3.5% of the total investment. Planned construction period is 24 months.

13.2 Main impact factors and impact sources of the Project

Main environmental impact factors in construction period is occupation and construction, which mainly originates from excavation of foundation pit, excavation of guide open channel and discharge of waste slag and mud, land occupation by engineering structures and construction area, as well as “three wastes” discharged by construction vehicles and operation of mechanical equipment, discharge of domestic waste of construction personnel. Aquatic environment, acoustic environment, atmospheric circulation, ecological environment (land resource and soil erosion) and environmental sensitive objects in the construction area and surrounding area will be impacted mainly in construction.

Main environmental factors in operation are limited by the dam; main impact is the changes of hydroregime of river flow. The aquatic environment and trunk stream of river will be impacted in operation.

13.3 Conclusion of existing environmental quality

13.3.1 Ecological environment

A lot of rinsing water of sandstone, domestic waste of construction personnel and construction waste slag are deposited in the river, so the turbidity and physicochemical property will change, the original aquatic community (including phytoplankton, zooplankton, benthos, fishes and amphibians) will be destroyed and even disappear.

Erchakou Hydropower Station is located in Duzhenwan Town of Hubei Changyang Tujia Autonomous County, vegetation in the catchment is good and forest coverage is 60%. Vertical distribution of vegetation type can be generally divided into evergreen needle-leaved forest above 750m, evergreen broadleaved forest and shrub less than 750m and agricultural land less than 450m. Pine and cypress grows from the river valley to mountain top mixed with hardwood forest and *cunninghamia lanceolata* Form., shrub forest and high forest as well as deciduous forest and evergreen forest; human activities have little influence on the catchment, it is a transition ecological system between boreal forest and temperate zone broadleaved forest, which is of stronger resistance stability.

There are six classes, ten families and three categories of animals in the assessment area; there are no state key-protected animal and four kinds of provincial key-protected animals including *arctonyx collaris*, ferret-badger, *lepus capensis* and *trogopterus xanthipes*. There are five classes, ten families and nine categories of birds; there are no state protection animals and four kinds of provincial protection animals such as red-rumped swallow, barn swallow, large-billed crow, spotted-necked dove. There are two classes, five families and seven categories of amphibians, there are two classes, three families and seven categories of reptiles, there is no state key-protected animals and one kind of provincial key-protected animal.

There are five classes and 26 categories of phytoplankton, in which bacillariophyta takes the most part; there are four categories and twenty kinds of zooplankton in total; there are four kinds of benthos in total; there are three families, four sorts and thirty kinds of fishes, in which no fish is under state-level protection and key protection of Hubei Province.

Average net productivity in the assessment area of hydropower station is $978.83\text{g}/(\text{m}^2\cdot\text{a})$, needle-leaved forest takes the more part, so that the average productivity is higher, which is $258.83\text{g}/(\text{m}^2\cdot\text{a})$ higher than global land level and indicates that growing ability of vegetation in this area is greater. Theropencedrymion and shrub are the main vegetation in the assessment area, the forest land is sufficient for stability and changes of ecological system.

In dominance value of each block in the assessment area, each index such as dominance value, density, frequency and landscape proportion of forest land is higher than that of others, which indicates that forest land is the mould land of the area and the essential ecological system of landscape; therefore, the quality of ecological environment in the area is good; productivity, anti-interference capacity and system control capacity are greater.

13.3.2 Existing soil erosion

The traffic in Duzhenwan Town of Changyang Tujia Autonomous County where the project locates is inconvenient and thinly inhabited, the vegetation is kept well, sand content in rivers is relatively less, and soil erosion is almost caused by the water power. The vegetation in the catchment is kept well, so the type of soil erosion mainly is surface erosion involving 1.03hm². Gulley erosion and gravity erosion happen accidentally. Average erosion modulus in the project area is 3218t/km².a.

13.3.3 Ambient air quality

TSP daily average value in the assessment area is 0.047-0.062mg/m³, which complies with assessment standard, so ambient air quality in the project area is good.

13.3.4 Surface water environment

According to monitor data of present situation, assess the water quality of each sampling section in the assessment area with the above method; monitor index of water quality of each section complies with Category II standard of *ENVIRONMENTAL QUALITY STANDARDS FOR SURFACE WATER* (GB3838-2002), which indicates that the water quality is good.

13.3.5 Acoustic environment

Noise at each monitor point of the planned area at daytime and night complies with category

I of *Standard for Environmental Noise of Urban Area* (GB3096-93). The noise at environmental sensitive points at daytime and night complies with assessment standard, so the present situation of noise in the assessment area is good.

13.4 Conclusion of environmental impact assessment

13.4.1 Conclusion of environmental impact assessment in construction

(1) Ecological environment

Construction of the power station and reconstruction of traffic routes will destroy vegetation in different levels; discharge of wastewater in construction will have certain impact on aquatics in river. The Project mainly occupies flood land, forest land, barren hill and cultivated land instead of a large area of natural forest and rare plants; therefore, it has no impact on rare plants and natural forest protection area as well as no obvious impact on breeding and living of species. After construction, the site will be leveled, backfilled, greened and planted with trees, so as to recover the vegetation in construction area and promote ecological environment to develop in a good way.

With the entry of construction personnel and mechanical equipment, human activities, mechanical noise and reconstruction of public facilities will directly impact habitat quality of nearby terrestrial animals, force animals and birds to immigrate to a new environment, and the habitat is relatively reduced, the adverse impact is temporary and of a small scale.

At completion of construction, different recovery and protection measures will be fulfilled, vegetation in temporarily occupied land will be recovered, the wide life also can return to their original field; therefore, construction activities will have no obvious impact on the

structure of animal species in the assessment area. Construction wastewater and domestic wastewater will be treated or discharged into forest land if being up to standard through effective treatment, so construction of the Project has little impact on aquatic habitat and will disappear when construction is completed.

(2) Soil erosion

Possible accelerated erosion area in construction period is up to 1.03hm², slag erosion amount is 6200 t, the destroyed surface runoff is 110t including 80t new erosion, so new soil erosion arising from construction will be 6310t in total. The local relief will be greatly changed, new soil erosion in the area will be up to 84t if no water and soil conservancy measure is taken, which will generate different impact on local land capability, channel scouring and deposition as well as regional ecological environment changes.

(3) Solid wastes

Solid wastes mainly are waste slag and domestic waste.

① Construction waste slag: 12900m² waste slag will be generated in construction, if the construction slag not treated perfectly once is rinsed into the river, it will not only increase construction difficulty and impact construction progress, and moreover, it will destroy natural ecological environment and cause soil erosion, so as to impact local ecological balance. According to general layout and actual landform of the Project, four waste disposal areas will be arranged along the line.

② Domestic waste: total domestic waste in construction is 21.7t. If it is not treated perfectly, it must cause mosquito, fly, malignant bacteria and rat, which are important sources of epidemic. In addition, improper stock of domestic waste also will destroy soil structure or be polluted by malignant bacteria, so as to cause secondary pollution and generate adverse impact on the surrounding ecological environment.

(4) Analysis of aquatic environment impact

Sandstone processing wastewater will be settled statically for treatment. Neutralizing treatment and static sedimentation treatment will be applied for alkaline wastewater, excrement wastewater will be discharged into dry toilet and then collected by cleaner regularly to use as farm manure; wastewater in kitchen will be collected to use as the feed of live pig. The wastewater will not bring about great impact on water quality if being discharged into the river after being treated in different ways.

(5) Acoustic environment

Main impact on acoustic environment is in construction period, the noise mainly comes from operation of construction machineries and vehicle transportation in blasting, drilling, concrete placing and excavation. The noise will obviously impact the environmental sensitive points nearby the construction area, so construction management must be strengthened, night construction must be forbidden to avoid disturbance on people.

(6) Atmospheric environment

The impact on surrounding atmospheric environment mainly is construction dust and waste gas of living coal in construction, the impact scope mainly is nearby the construction area and the living area. But diffusibility in gorges is poorer, the height of exhaust mast shall be increased properly, so as to improve diffusibility and improve local air quality.

The impact of construction on surrounding air quality is periodic and limited, which will disappear once the construction is completed.

13.4.2 Conclusion of environmental impact in operation period

(1) Ecological environment

After the station is completed and put into operation, the land use function will be changed correspondingly, natural productivity of landscape system will be reduced, but the reservoir will not be flooded, permanent occupied area of main structures is extremely small, so the impact of construction and operation of power station is within the limit of ecological bearing capacity, which can be borne by the natural system in assessment area.

The original natural swelling process of the river under dam becomes weak, which is adverse for breeding of fishes that have to be activated by swelling, and may cause some fishes to be incapable of spawning or immigrate to other rivers for spawning.

At completion of the Project, if ecological water supply can be ensured, the water is clear and related protection measures are taken in the catchment, the original aquatic resources and habitat environment will not be greatly changed, and all kinds of animals and plants will be recovered through a period of operation.

(2) Surface water environment

The intake dam is only used for stopping water from flowing into channels, normal water level in front of the dam is higher than natural water level, in addition that the river side from the dam site and the upper reaches is uninhabited and few pollutants are discharged, eutrophication will be not easy to happen although water depth is increased and flow is reduced after the dam is constructed.

Erchakou Hydropower Station is a run-of-river station, although an intake dam is constructed, normal water level is slightly higher than natural water level before the dam is constructed, water flow in front of the dam is rapid and mixed, the water temperature will not change horizontally and vertically in one year, water temperature before the dam is even, which is similar to that of natural rivers in the same period.

(3) Runoff adjustment

Erchakou Hydropower Station has little impact on river runoff. In dry season, the intake dam can stop the water of Neixi Brook, Liujia Brook and Daxigou, and then the water is introduced into the station for power generation; in order to ensure ecological water demand of aquatic and bankside plant under the dam, the Employer is requested to set ecological relief holes at three dam sites to adjust ecological water demand in the lower reaches.

(4) Sediment scouring and deposition

As stopped by gravity dam, water level of the dam rises, the flow becomes slow, and sediment is easy to be deposited in front of the dam. However, it is a small intake station, vegetation in the project area is good, geologic structure erosion degree along Chongxi Brook is low and sediment mixed in short-time flood arising from gully in the upper reaches of the dam area is less, so little sediment can be discharged through the dam freely.

(5) Environmental geology

It is a run-of-river station, local geologic structure is stable, so the possibility of seism is extremely low.

13.5 Conclusion of environmental protection measures

13.5.1 Protection measures of aquatic environment: sandstone processing wastewater, concrete placing and maintenance wastewater as well as rinsing water of construction machineries and vehicles will be treated through neutralization sedimentation, concrete sedimentation and oil separating pond respectively; sewage will be treated through cesspool.

13.5.2 Measures of conservancy engineering: treat soil erosion sources such as spoil and waste rock through constructing slope and levee of the waste disposal area; at completion of the Project, timely recover the vegetation, eliminate construction destroyed site and do well greening in construction area.

13.5.3 Biological protection and other ecological protection measures: reasonably design construction land use, method and progress, protect forest vegetation and wildlife at maximum.

13.5.4 Other environmental protection measures: apply wet operation to control air pollution; reasonably adjust the construction plan and operation time, avoid constructing with high-noise equipment and blasting when people are resting; collect, transport and treat domestic waste at timely fixed point.

According to technical and economic analysis, aquatic environmental protection , ecological recovery and protection, acoustic environmental protection, ambient air protection and human health protection as well as environmental protection facilities are feasible technically and convenient for operation and practices as well as more reasonably economically. Total investment for environmental protection is about RMB 775200, in which special investment for environmental protection is RMB 510700, special investment for soil conservancy is RMB 265400, total static investment is RMB 14.7646 million taking up 5.3% of the total investment of environmental protection.

13.6 Conclusion of comprehensive assessment

The construction of Erchakou Hydropower Station Project complies with industrial policies of the Station, overall planning of local economy development, environmental protection planning as well as development and planning of water resources; at completion of the Project, the utilization rate of water resources of Yaozhan Brook can be improved, it can provide good quality power energy for Changyang County and has obvious economic benefit and social benefit; the Project will be important for improving local economy and social development.

13.6.1 Favorable impacts

Main favorable impacts of Erchakou Hydropower Station on the ecology and environment are shown as follows:

It not only can improve assurance rate of power supply of Changyang Tujia Autonomous County, and also provide powerful energy guarantee and scarce opportunity for local economy development and further development of resources.

In operation, because of power dispatching of the Station, the flow of rivers in the lower reaches can be increased in dry season, water quality can be improved, occurrence and popularity of communicable diseases can be prevented, which are beneficial for the development of local social economy and local people in living.

In construction, the investment of construction fund, material and technology will be good for development of local social economy, development and utilization of resources as well as harnessing and construction of ecological environment.

13.6.2 Adverse impacts

The pressure of land loss caused by permanent land occupation on local environmental

capacity and adverse impact of permanent land occupation are permanent and irreversible.

The water at 1km in the lower section will be reduced and flow slowly, self-cleaning capacity of water body will be reduced, so the pollutants in the upper reaches shall be strictly controlled to ensure no depravation trend after the Project is completed.

To sump up, Erchakou Hydropower Station Project will have certain impact on the ecological environment, the adverse impact is permanent land occupation and temporary land occupation, permanent land occupation is irreversible impact, other impacts can be prevented or reduced through taking measures. As analyzed from environmental impact and development of ecological environment of the site, construction scale and site selection of the Project are feasible in the aspect of environment.

13.7 Suggestions

In order to minimize the adverse impact and make full play of social benefit, economic benefit and environmental benefit, the following suggestion for our work is given hereby:

(1) Divide a natural and complete river in Changyang County for sustainable development

The development of small scale hydropower station has severe impact on environment, although corresponding ecological protection measures and the minimum discharge base flow for aquatic in living have been promoted for hydropower development, we suggest reserving a natural and complete branch not for development in Changyang County to protect special species of the area for sustainable development.

(2) Prepare overall plan for integrated development in the area

Systematically combine construction and development planning of the catchment, treatment planning of the soil and environmental planning, prepare an integrated development planning of the area, establish an ecological and economic system of high efficiency, high energy and good beneficial cycle, so as to realize coordinate development of economy and environment as well as the unification of social benefit, economic benefit and environmental benefit.

(3) Prepare local water resource planning

According to project task, existing water quality and function in the area, prepare and implement integrated utilization planning of water resource before completion of the Project, ensure that the minimum flow under dam is not less than $0.05\text{m}^3/\text{s}$, so as to satisfy the minimum ecological water supply of water reduced section and the water supply of aquatic in the lower reaches. In addition, strictly control the new pollution source, insist on regular monitor and forecasting of water quality of the river to exert comprehensive benefit of the station at maximum.

(4) Fulfill all environmental protection investment

Fulfill environmental protection investment, set up related supervision mechanism and ensure special fund for special use; practically fulfill the environmental protection measures specified in the assessment report, so as to ensure “three simultaneities” of each environmental protection measure with the main works.

(5) Reduce soil erosion

Perfect engineering and construction plan: further perfect the balance of earthwork quantity in construction when the Unit designs the main works in the later stage; with the increasing of project investment, reduce waste slag in construction, so as to reduce new soil erosion and ecological destroy because of construction.

Strengthen and normalize construction environment management, try to balance the excavation and backfill in construction; backfill in time when excavating, take measures for slope protection while rolling; try to reduce construction period, reduce emergence of loose soil, reasonably arrange construction time, try to stop waste slag flowing into river, try not to construct in rainy season and flood period; take temporary guard measures well especially when excavating the dam abutment, try to stop waste slag flowing into river and avoid soil erosion in construction.

New soil erosion caused by construction mainly happens in construction period, while the main measures for reducing soil erosion are waste slag guard measure, drainage measure of temporary construction facilities and material yard, temporary protection measure of the lower slope at entrance and exit of tunnel in construction and prevention measure of soil erosion, most part of which cannot be directly inspected when accepting the conservancy engineering, so the Employer must strengthen construction management of the construction unit to fulfill temporary measures and prevention measures in construction, so as to minimize soil erosion during that period.

Document of Yichang Water Conservancy and Hydropower Bureau

Yichang Water Conservancy and Hydropower Bureau 2005/No.112 Document

Signed by: Wang Yuancheng

The Official Reply on *Changyang Yaozhanxi River Basin Hydro-Energy Development Planning Report of Hubei Province*

The Water Conservancy and Hydropower Bureau of Changyang Tujia Autonomous County: The Changyang Yaozhanxi River Basin Hydro-Energy Development Planning Report of Hubei Province sent in Changyang Water Conservancy and Hydropower Bureau 2005/No.35 Document was under careful examination by experts invited by our bureau, and according to the experts appraisal, the official reply is as follows:

Yaozhanxi River Basin is situated on the Southwest of Changyang Tujia Autonomous County , is a first level tributary of the south of the mid-reach of Qingjiang River, it neighbors Longtanhe River in the east, Chaibuxi River and Tianchihe River of Wufeng in the south, Quxi River in the west, and Geheyan Reservoir range in the north. The main tributaries include the upstream left Zhongxi River, downstream right Chongxi River, the basin has a collective area of 128.6 km². The length of the main course is 20.6km. And the main drop is 1952.7m. The theoretic hydropower reserve is 15.5 thousand kW.

The five hydroelectric power stations such as Sifangdong station and Gaoshuitou station, etc. that developed in a sporadic manner in Yaozhanxi River Basin feature the installed capacity of 7230 kW, and part of the built projects are unreasonable in a planning perspective, therefore, for the sake of complete and rational use of water resource, it is necessary to carry out a unified planning on the hydropower development in Xiaoxi River Basin.

1. The hydrological computation and results in the planning report are approved, and it is been established that the annual average rainfall in the river basin is 1445.7mm. The

assessment of the geological structure and the hydrological and geological condition of the area in the planning report in approved.

2. The development plan recommended by the planning report is approved.

That the hydropower development of the main stream of Yaozhanxi River Basin adopts the "one reservoir and nine power station" plan is decided, i.e. water channeling to Sifangdong Hydroelectric Power Station (built) that has a installed capacity of 2*2500kW in the upstream left tributary – Zhongxi River; Houziyan Hydroelectric Power Station (built) of 2*40kW; Taizi Hydroelectric Power Station of 2*125kW; Chengwuhe Hydroelectric Power Station (built) of 2*75kW; Huilongguan Hydroelectric Power Station (built) of 2*500kW; Xujiaping Reservoir (normal impounded level of 437m, total capacity of 2.1698 million m³) built after the water converges with Zhongxi River and diversion type Xujiaping Hydroelectric Power Station of 2*4000kW downstream the reservoir; Xiangshuidong Hydroelectric Power Station (built) that utilizes spring water of 1*500kW plus 1*250kW; Wangjiacao Hydroelectric Power Station of 2*160kW that utilizes the tail water of Xiangshuidong Hydroelectric Power Station and the water from downstream of the Xujiaping Reservoir; Erhekou Hydroelectric Power Station of 2*125kW that connects the tail water of Wangjiacao Hydroelectric Power Station. The total installed capacity is 15800 kW.

In the Zhongxi River of the left tributary the Zhongxi Hydroelectric Power Station will be built downstream the Sifangdong Hydroelectric Power Station, and the tail water will go to Xujiaping Reservoir.

The upstream reach of the right tributary connects with Daxigou Gully, Liujiayi River and Neixi River, and water was channeled to Erchakou, where Erchakou Hydroelectric Power Station will be built, with a installed capacity of 2*320kW; the tail water of Erchakou Hydroelectric Power Station and the upstream water are intercepted and channeled to the surge tank of Xujiaping Hydroelectric Power Station to increase the power production of

Xujiaping Hydroelectric Power Station; the built downstream Chongxi Hydroelectric Power Station (installed capacity of 2*125 kW) will be maintained, so is the layout.

4. The Grid connecting method of the cascaded power station recommended in the report is approved.

5. The report appraisal on the regional environmental status quo and the environmental impact from construction, as well as the proposed environmental protection measures is approved. Regarding to single development project, the project design should be carried out upon the water resource report and the water and soil conservation scheme. In the design and construction of various unit projects, full consideration should be given to other water demand after the impoundment and diversion, human and livestock drinking water and irrigation water demand must be prioritized.

6. It is approved that in the current stage, graded estimation is employed in the computation of project investment, and the estimation compilation method, foundation and standards; and technical and economic indicators are employed in the current stage to embody benefit.

7. The planned sequence of hydropower development in Xiaoxi River Basin is approved.

Hereby the official reply is presented.

Attachment: *The Advices on the Hydropower Development Planning Report for Changyang Yaozhanxi River Basin of Hubei* July 3rd 2005

Keyword: Hydropower, Development, Planning, Examination

The General Office of Yichang Bureau of Water Conservancy and Hydropower Printed on June 28th 2005 15 Copies in Total

Document of the Bureau of Water Conservancy and Hydropower of Changyang Tujia Autonomous County

Bureau of Water Conservancy and Hydropower of Changyang Tujia Autonomous County/2005 No.82

Signed by Tian Guoliang

Official Reply on the Preliminary Design Report for Erchakou Hydropower Station by the
County Bureau of Water Conservancy and Hydropower

Changyang Funeng Hydropower Development Co., Ltd:

Your *Preliminary Design Report for Erchakou Hydropower Station of Changyang, Hubei* has been received. After examination, the official reply is as follows:

1. The Necessity of the Project Construction

With rapid development of local economy and big improvement of locals' lives, the current electric capacity can hardly meet the increasing requirement of electricity load. Erchakou Hydropower Project, one of the main cascaded development projects on Yaozhanxi River, will not only yield desirable economic benefits for the power production company, but also promote the sustainable development of economy and society of Changyang when completed by optimizing water resources, alleviating power deficiency and improving valley ecological environment. Therefore, it is necessary to build this project as soon as possible.

2. Hydrology and Hydropower

2.1 It is permitted to use Haiyangguan Hydrometric Station, with analogy method and consider the rainfall to modify and deduce dam site runoff, and the result is basically reasonable. The average flow rate of the dam site over the years is $0.51\text{m}^3 / \text{s}$.

2.2 It is agreed to calculate flood design with the instantaneous unit hydrograph method, and its result is basically reasonably.

2.3 The method and result of flood design by stages are permitted.

2.4 The result of sediment design is permitted.

2.5 The result of dam site water level-flow relation is agreed.

2.6 It is permitted to have an installed capacity of $2 \times 400\text{KW}$ and an annual average energy output of 3.3029 million kWh since the top priority of this project is to generate power.

3. Project Geology

3.1. The assessment of regional geological structure and seismic activity is agreed. According to *Seismic Ground Motion Parameter Zonation Map of China (GB18306-2001)*, the acceleration of seismic peak in the project area is less than 0.05g, and the characteristic period of ground motion response spectrum is 0.35S with correspondent seismic basic intensity of six degree.

3.2. The slope bodies of the dam site, fore bay, penstock and powerhouse section are all rock tangential slope or reverse slope with a good overall stability and no geological sign of collapse. The dam site rock mass structure is relatively complete with intake dam site mainly being shale which features a good anti-seepage effect. The stratum along penstock, however, varies in lithology, hardness, and weathering depth. The anchor block foundation of penstocks should be placed on moderately weathered bedrock.

3.3. The diversion tunnel goes through strata mainly of limestone and shale. The limestone tunnel has an uneven pipe leakage which requires measures taken for anti-seepage and drainage. The shale tunnel is of water-weakening nature, which demands careful lining.

3.4. The neighborhood of this hydroelectric power station has abundant stone materials and is quite accessible for mining and transportation. It is suggested to carry out investigations and experiments to the selected material ground during construction.

4. Water Conservancy Project

4.1 Erchakou Hydroelectric Power Station has a installed capacity of $2 \times 400 \text{kW}$, is a Grade V Minor 2 Project, and the Class of buildings are 5. It is approved that the bottom trash rack dam will be designed for flood of "10 years return period", and checked for flood of "20 years return period", the powerhouse designed for flood of "30 years return period", checked for flood of "50 years return period".

4.2 The project general layout is approved.

4.3 The foundation of the penstock anchor block should be placed on weak weathering stratum.

4.4 The project design should emphasize the treatment plan of the powerhouse foundation and the rear side slope.

5. Hydrological Machinery

1. Agreed to use TYPE CJA237-W-80 / 1×8 Hydro-turbine, with supporting TYPE SFW400-8 / 850 Generators.

2. Approval is granted on the selection of inlet valve and speed governor.

3. Approval is granted on the computing result of regulation guarantee.

4. Approval is granted on the design plan of Oil-air-water system.
5. Approval is granted on the project setup of the hydrological monitoring system.
6. It is approved that the main powerhouse should adopt natural ventilation method, and the central control room employs air conditioning method.
7. Approval is granted on the layout style of electromechanical devices in the powerhouse establishment.

6. Electric Arrangement

6.1 The operational liability of the rural power grid the station connects to is relatively poor, so it is suggested the station to use 35kV voltage, and connects to the system through Xujiaping Hydroelectric Junction Project.

6.2 Basic approval on the two generators and one transformer extended main connection plan.

6.3 Approval on the second design in the report that proposed according to the requirement of non-attendance and few on duty, but the computer monitoring equipments and installments should be simplified.

6.4 Grounding for lightning should be designed and computed, to specify the dimension of the earth mat and the lightning protection area, determine the grounding method of the lightning rod and its earth mat dimension, and resistance reducing method should be proposed.

6.5 It is suggested to optimize the layout design of the service room and the booster station.

7. Metallic Structure

7.1 Approval is granted on the selection of the graduating valve, sand sluice, bulkhead gate for the fore bay, and hoisting device.

7.2 Approval is granted on the type selection of steel penstock.

8. Construction

8.1 It is approved that the temporary division structure is graded as 5. It is agreed that intake dam construction employs the pipe diversion style.

8.2 The project construction method of the main works is approved.

8.3 It is approved that the whole construction period will be controlled within one year.

9. Construction Cost

9.1. The quota, fare-setting standard, and various adjustment coefficients employed by the budget estimate making are approved. The basic unit price, main materials and unit equipment price, construction project and equipment installment unit price employed by the budget estimate making are approved.

9.2 Upon checking, the estimated project total investment is 5.41million, total fixed investment is 5.3million.

10. Economic Assessment

Basic approval on the economic assessment method and conclusion, and the project is regarded as economically feasible.

Dec 31st 2005

Keyword: Hydroelectric Power Station, Initial Design, Report, Official Reply

CC: Municipal Water Conservancy and Hydropower Bureau, the General Office of County People's Government, County Development and Reform Commission, County Bureau of Land and Resources, County Construction Bureau, County Water and Soil Conservation Bureau, County Flood Control Office.

The General Office of the Water Conservancy and Hydropower Bureau of Changyang Tujia Autonomous County

Printed on Dec 31st 2005

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**Document of Bureau of Water Conservancy and Hydroelectric Power of
Changyang Tujia Autonomous County**

**Bureau of Water Conservancy and Gydroelectric Power of Changyang Tujia
Autonomous County /2005 No.86**

Signed by: Tian Guo-liang

**Suggestion on the demonstration report for the Water Resource of Erchakou
Hydropower Station by the County Bureau of Water Conservancy and
Hydropower**

Changjianag Funeng Hydropower Development Co., Ltd:

Your company's submitted *The Report on the Erchakou Hydropower Station Water Resources (refer to as the report hereafter)* has received the experts' assessment with the official reply as follows:

1. *The report* targets on the requirement of the water volume and water quality by Erchakou Hydropower Station demonstrated and analyzed the development and utilization condition, water inlet and outlet and environmental impact of the construction site. With detailed and accurate information, broad and well-organized content and basically meets the compilation requirement of the water resource demonstration report.
2. The intake dam site of Erchakou Hydropower Station is located at Neixi River, Liujiaxi River and Daxigou Gully, with installed capacity 2×400KW, it is reasonable for the water resource demonstration and analysis to establish its range as Yaozhanxi River Basin.

3. The annual average flow of the construction site is $0.51 \text{ m}^3 / \text{s}$, the runoff $16,000,000 \text{ m}^3$, the objective of the project is power generation, and the average water consumption is $8,000,000 \text{ m}^3$.
4. The upstream of the dam site boasts good water quality and meets the Class II water quality standard of *Surface Water Environmental Quality Standard (GB3838-2002)*. According to analysis and demonstration, the water intake and consumption is reasonable, the water volume and quality can meet the project's demand.
5. The intake and consumption of the project will not create major adverse effect towards the water resource condition, water environment and other uses of water.
6. *The report* is proved feasible in terms of the water resource conservation measures during the construction and operation period.
7. The water quality should be ensured that it is above the Class II standard during the construction and operation period.
8. We agreed to take *the report* and the experts' observation of examination as technical basis for the water intake permission. We hope your company should submit the official reply, *the report* and other relevant documents and go to the water resource administration for water intake license according to law and procedure.

December 31, 2005

Key words: Hydropower Station, water resource demonstration, review, comments

CC: Municipal bureau of water conservancy and hydroelectric power, general office of the county people's government, reform and development commission of the county, bureau of land and resources of the county, bureau of construction of the county, bureau of water and soil conservation of the county, flood control office of the county

Office of Bureau of Water Conservancy and Hydroelectric Power of Changyang Tujia Autonomous County Printed December 31, 2005

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**Bureau of Water and Soil Conservancy of Changyang Tujia Autonomous
County**

Changyang Water and Soil Conservancy Bureau 2006/No.1 Official Reply

**Official Reply on Water and Soil Conservation Planning Report of Erchakou
Hydropower Station**

Erchakou Hydropower Station:

Your submitted *the report on the Erchakou Hydropower Station water resources (refer to as the report thereafter)* has been received, and after expert assessment, the official reply is as follows:

1. Erchakou Hydropower Station Project is graded the fifth and is composed of intake dam, water diversion open channel, non-pressure tunnel, pressure fore bay, pressure pipeline, powerhouse, booster station and other buildings, with the installed capacity of 2×400KW and total investment of 5.4 million yuan.

The water conservancy plan compiled by the construction unit for the station serves in line with the relevant legal requirement and shows great significance to the potential water and soil erosion caused by the construction.

2. The planning report features firm foundation, comprehensive content, specific responsibility area and prevention goal for water and soil erosion. The total layout of the area is reasonable, the various prevention and conservation measure feasible, meets the regulations of relevant technical standards and stipulations and can serve as the basis for the next phase of the works.

3. Basically agree the predictions on water and soil erosion, and the facility-damaging area of 0.23hm².

4. Agree the responsibility range on water and soil conservation, 1.03 hm².

5. Agree in principle the diversion and divisional measures on water and soil conservation.

6. Agree in principle the arrangement of the implementation progress on the water and soil conservation plan.

7. Agree in principle the content and method on the water and soil conservation monitoring.

8. Agree in principle on the evaluated investment on water and soil conservation, with the newly added investment 199,100 yuan, among which the water and soil conservation facility compensation fee 3,500 yuan.

9. The construction unit should arrange and allot fund, implement supervision and other guarantee measures according to the progress of plan implementation, and strictly observe the "three-simultaneous" system for water and soil conservation facility and main works.

January 20, 2006

Keywords: water and soil conservation, plan, official reply

CC: Bureau of Water Conservancy and Hydropower of Changyang Tujia Autonomous
County, Survey and Design Society on Water Conservancy and Hydroelectric of
Qingjiang, Yichang

General Office of Bureau of Water Conservancy and Hydropower of Changyang Tujia
Autonomous County Printed on January 20, 2006

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Yichang Municipal Bureau of Environmental Protection

Yichang Municipal Bureau of Environmental Protection's Letter on the EIA Implementation Standard of Erchakou Hydropower Station Project

Changjianag Funeng Hydropower Development Co., Ltd:

According to your company's application and the preliminary examination opinion from bureau of water conservancy and hydropower of Changyang Tujia Autonomous County, we currently confirm the EIA implementation standard of Erchakou Hydropower Station Project is as follows:

1. Environmental Quality Standard

- (1) The quality of the surface water environment serves the second class standard of *GB3838-2002 Surface Water Environmental Quality Standard*.
- (2) The ambient air quality within EIA of the project observes the second class standard of *GB3095-1996 Ambient air quality standard*.
- (3) The sound environment within EIA of the project observes the first class standard of *GB3096-93 Standard of Environmental Noise of Urban Area*.
- (4) *GBSL190-96 Classification and Grading Standard of Soil Erosion*.

2. Pollutant Emission Standard

- (1) The wastewater discharge during construction period observes the first class standard on table 4 of *GB8978-1996 Comprehensive Emission Standard of Wastewater*.

(2) The wastewater discharge during construction period observes the first class standard of ***GB16297-96 Comprehensive emission standard of air pollutants.***

(3) The noise emission during construction period observes ***GB12523-90 Noise limits for Construction Site***; the noise emission from powerhouse during construction period observes the second class standard of ***GB12348-90 Standard of Noise at Boundary of Industrial Enterprises.***

December 20, 2005

Letter of Commission

Xiangfan Institute of Environmental Protection Science:

According to the Environmental Impact Assessment Law of People's Republic of China, our unit is obligated to carry out environment impact assessment for Erchakou Hydropower Project, we hereby commission your institute to implement the EIA works for the project.

Stamp by Client

December 20, 2005

Technical Evaluation Comment on *Hubei Changyang Tujia Autonomous County Erchakou Hydroelectric Power Station Environmental Impact Report*

Environmental Protection Bureau of Hubei Province convened an examinational conference in Wuhan on *Hubei Changyang Tujia Autonomous County Erchakou Hydroelectric Power Station Environmental Impact Report*, with an expert group of 12 presents on March 3, 2006, which is consisted of three specially invited experts and delegates from Environmental Protection Bureau of Hubei Province, Environmental Protection Bureau of Yichang and Environmental Protection Bureau of Changyang Tujia Autonomous County, Environmental Protection Research Institute of Xiangfan City, Changyang Funeng Water and Electricity Development Co., Ltd, etc. After earnest evaluation and examination, the experts' comments are as follows:

I. Project Overview and Analysis

Erchakou Hydroelectric Power Station is located in Changyang Duzhenwan Town and is one of the Chongxi River - the sub-tributary of Yaozhanxi River – Cascaded Development Project. Project dam site is at Neixi River, Liujiaxi River and Daxigou Gully upstream of Chongxi River while the powerhouse site is in the upstream reach of Daxigou Gully. Project total fixed investment is 5,302,900yuan with installed capacity of 2×400KW. Its multi-year average generated electricity reaches 3,302,900kWh and annual utilized hours accumulate 4129h. Erchakou power station is a runoff diversion type power station with project ranks at fifth class and corresponding hydraulic structure level at fifth grade, which is consist of intake dam, tunnel, fore bay, pressure pipe, powerhouse, booster station and so on. The bottom trash rack dam height of Neixi is 2.63m, Liujiaxi 3.09m, Daxigou 3.32m. S-shaped practical weir type is adopted for all with stone blocks with cement mortar structure. Open channel is 600m in length and diversion tunnel 2420m.

Permanent occupied area of project structure is 0.67km² while temporary structure takes 0.43km² including temporary occupied land for construction 0.23km², waste disposal site 0.20km² and so on. Earth-rock excavation totals 14,700 m³: earth open excavation 4,700 m³,

rock excavation 9,900 m³, utilized earth and rock 1,800 m³, and total waste amount 12,900 m³, which will be stocked into four waste disposal site. Total construction is proposed to last one year.

Evaluation: introduction of engineering overview is basically clear; project analysis and pollution source concentration calculation are basically reasonable.

II. Environmental Impact

1. Water environment

The project may have impacts on surface water environment mainly in the producing of waste water in construction, domestic sewage of construction workers in living quarters, and dropped mud and sand during construction. Waste water drainage of engineering totals 12,300m³. With major pollutants being suspended solid, petroleum and alkaline production waste water, construction waste water is mainly from rinsing waste water produced by aggregate processing system, waste water of concrete pouring and curing as well as rinsing waste water of construction machinery vehicles. Domestic waste water drainage of construction unit as well as construction personnel contribute a major part to domestic sewage which contains standard-exceeding BOD₅ and COD. Being dealt with measures like sediment tank, construction waste water will be discharged into water body but domestic sewage will not, after being dealt with septic tank and then filtrated through forest land. Thus, domestic sewage will not have obvious affect surface water quality.

Evaluating Suggestion:

1. According to project practice, verify output and emission of production sewage in construction period.
2. Construction waste water can take the advantage of self purification of forest land and should not be discharged into second class functional water body.
3. Further verify the length of dehydration, water reduced river reach and

corresponding ecological water demand.

2. Ecological Environment

Construction Period: The activities during construction period will cause various degrees of damages on vegetation; the sewage discharge during this period will affect the aquatic organism in the river. After this period, along with different kinds of recovery and protection measures, the vegetation of the temporary expropriated area will be recovered, the wild animals' territory will be greatly improved, they can still come back to their former homes. Therefore the construction activities will not obviously affect the animal species group structure in evaluated area. Project construction will not put any effect on the habitat of aquatic organisms, and the impact will disappear along with the complement of the construction.

Operation Period: After the operation of hydropower station, land function will be changed; the original production capability of landscape system will be descended. However for there is no reservoir drowning problem, the permanently occupied area of the main buildings is small, so the regional production capability influence caused by the running of the station is below the ecological bearing, it's also can be accepted by the natural system in the valued area. After the project, if there is guarantee of ecological water use quantity in the basin, the water is clear, and also there is protection measure, the original aquatic organism resource and its habitat will not be changed a lot. And after a long time of running, all kinds of fauna and flora will be restored to a new balanced condition.

Evaluation Suggestions:

① To supplement the material resource of ecological status quo assessment, and check the relevant species directory and its protection level.

② To further modify the content of ecological impact assessment, and re-demonstrate the ecological base flow rate downstream of the dam.

3. Water and Soil Conservation

The waste of the construction is 12.9 thousand m³, if there is no proper treatment, and once rushed into the watercourse, the construction difficulty will be added and also the progress delayed, in addition, natural ecological environment will be destroyed and soil and water loss will be caused, so that to influence the regional ecological balance. This project locates four waste disposal areas along the construction route.

Evaluation Suggestions:

① Supplement and demonstrate the rationality of the waste disposal area locations, and according to the principle of “first prevent then abandon”, rising strict measures of soil and water loss control.

② Ecological recovery measures will be taken after the completion in construction roads and construction site of other project-involved areas.

4. Other Environmental Impacts:

Atmospheric Environmental Impact: The project construction will cause certain pollution to the area during construction period, however the impact is limited, upon the completion, the environmental air quality will turn back to its former condition.

Sound Environment: The impact of this project is mainly in construction period, the main noises comes from blasting, drilling, concrete casting, digging and other mechanical running and vehicle transportation. However because the noises are limited in

transportation route and construction area, the affected range is fairly small, which will cause unfavorable effects in part of the area, and they will disappear after the completion.

The report section on the sound environment, ambient air and other environmental impact assessment content is approved.

III. Environmental Protection Measures

Aiming at the specific characteristics of the Erchakou Hydropower Station Project, direct and operable ecological environmental protection measures will be selected.

IV. Assessment Conclusion

The compilation of the report is formal, comprehensive, and the evaluation method is correct, and the raised environmental protection measures are basically feasible, the environmental impact assessment conclusion is generally credible, so the report is ready for submission after revision.

V. Suggestion

Due to the significant impact on ecological environment of the river basin caused by the small hydroelectric power plant development, we suggest that Changyang County remains a natural and complete tributary without any water conservancy and hydroelectric power development.

Expert Panel Leader: Fang Fang

March 23rd, 2006

Expert Panel Name List of the Examination Committee for Environmental Impact Report
of Erchakou Hydropower Station of Changyang Tujia Autonomous County of Hubei

March 23rd 2006

Name	Organization	Professional Title	Signature
Wang Jiayi	Environmental Science Research Institute of China	Researcher	王家骥
Zou Jiayang	Yangtze River Water Resource Protection Bureau	Professor level <i>senior engineer</i>	邹家祥
Fang Fang	Hubei Environmental Science Institute	Senior Engineer / director	方芳

Questionnaire of Public Opinions on Hubei Changyang Erchakou Hydroelectric Power Station Project

1. Brief introduction of the Project

Erchakou Hydropower Station, located in Changyang Duzhenwan Town, is a branch of Yaozhanxi River-one of cascaded development projects of water energy of Chongxi River. It is located in the upper reaches of Chongxi River and is the first stage of cascaded development of water energy of Chongxi Brook, the water will be taken from Neixi River, Liujiaxi River and Daxigou Gully, the powerhouse will be constructed at the mouth of Daxigou Gully. The Project mainly includes the intake dam, diversion tunnel, fore bay, pressure pipeline, powerhouse and booster station. The Station is a runoff-diversion hydropower station acting as the base load in the system. Design head of the Station is 199.56m, design flow rate is 0.54 m³/s, installed capacity is 2×400kW, firm capacity is 150kW (P=80%), long-term average power generation is 3.3029 million kWh and annual utilization hour is 4129. The demand for industrial, agricultural production and living of the Town will be fulfilled, surplus power will be connected to the grid in high water period

Erchakou Hydropower Station is Class V project; corresponding hydraulic structure is Level 5. According to the project level, corresponding flood standard is shown as follows: the intake dam is designed for flood of “10 years return period”, design peak discharge of Neixi Dam is 64 m³/s, design peak discharge of Liujiaxi Dam is 57 m³/s and design peak discharge of Dagouxigou Dam is 45 m³/s, checked for flood of “20 years return period”, checking peak discharge of Neixi Dam is 76 m³/s, that of Liujiaxi Dam is 68 m³/s and Daxigou Dam is 54 m³/s. The powerhouse is designed for flood of “30 years return period”, the peak flow is 195m³/s; checked for flood of “10 years return period”, the peak flow is 216m³/s.

Temporary land occupation is 0.373hm² and permanent land occupation is 0.413hm².

Construction of Erchakou Hydropower Station will last for one year.

Earthwork excavation of main works is 10576m³ and concrete 602.5 m³.

In construction, more than 95 sets of different machinery will be used, daily water consumption for production will be 25m³/h.

Construction of the Project, especially in construction process, may bring about certain impact on the environment; in order to sufficiently refer to the public opinions in environmental impact assessment, we hereby hand over the *QUESTIONNAIRE*; please make your own choice, thank you.

2. Brief introduction to the Surveyed

姓名 李小军 性别 男 年龄 41

Name Li Xiaojun Gender Male Age 41

民族 土家 职业 干 家庭人均收入 6200 元

Ethnicity Tujia Occupation 干 Income per capita 6,200 yuan

住址 都镇湾镇人民政府

Address People's Government of Duzhenwan Town

3.Content (please make your choice by drawing “√”)

(1) Education background

- ① Above junior college _____ ② Senior high school ③ Junior high school _____
④ Primary school _____ ⑤ Uneducated _____

(2) Do you support immediate launch of the Project?

- ① Yes ② Normal _____ ③ No _____

(3) If the station is constructed, your current dwelling belongs to:

- ① Area of reservoir inundation _____ ② Construction area _____ ③ Beside construction road
④ Other areas

(4) The greatest impact of the Station on you is:

- ① Noise ② Dust _____ ③ Traffic inconvenience _____ ④ Landscape damage _____ ⑤
Communicable diseases _____

(5) Will your life be improved by the project?

- ① Yes _____ ② Do not know _____ ③ No

(6) Do you know what is environment?

- ① Yes ② A little _____ ③ No _____

(7) Do you think the environment will be improved after the Station is constructed?

- ① Yes _____ ② A little ③ No _____

(8) Whether the Project will improve the local environment or not?

① Yes ② A little ③ No

(9) Will the Project mobilize local economy after it is completed?

① Yes ② General ③ No

(10) Which one do you more care about, benefit by the Project or the cost on environment?

① Environment ② Environment and benefit ③ Benefit

4. Your rationalized proposal:

Questionnaire of Public Opinions on Hubei Changyang Erchakou Hydroelectric Power Station Project

1. Brief introduction of the Project

Erchakou Hydropower Station, located in Changyang Duzhenwan Town, is a branch of Yaozhanxi River-one of cascaded development projects of water energy of Chongxi River. It is located in the upper reaches of Chongxi River and is the first stage of cascaded development of water energy of Chongxi Brook, the water will be taken from Neixi River, Liujiaxi River and Daxigou Gully, the powerhouse will be constructed at the mouth of Daxigou Gully. The Project mainly includes the intake dam, diversion tunnel, fore bay, pressure pipeline, powerhouse and booster station. The Station is a runoff-diversion hydropower station acting as the base load in the system. Design head of the Station is 199.56m, design flow rate is 0.54 m³/s, installed capacity is 2×400kW, firm capacity is 150kW (P=80%), long-term average power generation is 3.3029 million kWh and annual utilization hour is 4129. The demand for industrial, agricultural production and living of the Town will be fulfilled, surplus power will be connected to the grid in high water period

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Temporary land occupation is 0.373hm² and permanent land occupation is 0.413hm².

Construction of Erchakou Hydropower Station will last for one year.

Earthwork excavation of main works is 10576m³ and concrete 602.5 m³.

In construction, more than 95 sets of different machinery will be used, daily water consumption for production will be 25m³/h.

Construction of the Project, especially in construction process, may bring about certain impact on the environment; in order to sufficiently refer to the public opinions in environmental impact assessment, we hereby hand over the *QUESTIONNAIRE*; please make your own choice, thank you.

2. Brief introduction to the Surveyed

Name Tan Yuhong Gender Male Age 36

Ethnicity Tujia Occupation _____ Income per capita 6,200 yuan

Address People's Government of Duzhenwan Town

3. Content (please make your choice by drawing “√”)

(1) Education background

① Above junior college _____ ② Senior high school √ ③ Junior high school _____

④ Primary school _____ ⑤ Uneducated _____

(2) Do you support immediate launch of the Project?

①Yes ②Normal _____ ③No _____

(3) If the station is constructed, your current dwelling belongs to:

①Area of reservoir inundation _____ ②Construction area _____ ③Beside construction road
 ④Other areas _____

(4) The greatest impact of the Station on you is:

①Noise ②Dust _____ ③Traffic inconvenience _____ ④Landscape damage _____ ⑤
Communicable diseases _____

(5) Will your life be improved by the project?

①Yes ②Do not know _____ ③No _____

(6) Do you know what is environment?

①Yes ②A little _____ ③No _____

(7) Do you think the environment will be improved after the Station is constructed?

①Yes _____ ②A little ③No _____

(8) Whether the Project will improve the local environment or not?

① Yes _____ ②A little ③No _____

(9) Will the Project mobilize local economy after it is completed?

①Yes ②General _____ ③No _____

(10) Which one do you more care about, benefit by the Project or the cost on environment?

①Environment _____ ②Environment and benefit √ ③Benefit _____

4. Your rationalized proposal:
