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- 1. Yinchuan Development and Planning Committee Document, YDPC Energy [2003] NO. 448 *Project Proposal Approval of the Integrated Hydroelectricity Development of the Nan River Reaches in the Wufeng County of YDPC;***
- 2. Authorziation Statement about Wufeng Nan River Hydroelectricity Development Co., Ltd. to Compile the Project Environmental Impact Report;**
- 3. Approval from the Construction and Environmental Protection Bureau on Execution Standard of Environmental Impact Assessment Program on Qilinguan Hydroelectric power station Project Held by Wufeng Nan River Hydropower Development Co., Ltd.;**
- 4. Program Approval and Evaluation Opinion;**
- 5. Examination and Registration Form of Construction Environmental Protection**



1. General Principles

1.1 Task Origin and Project Background

As the first class tributary of the Wei Shui water system, the Nan River passing the Dongting Lake flows to the Yangtze River. With length of 44 km, the Nan River is one of the largest rivers in Wufeng Tujia Autonomous County. Located in the middle reaches of the Nan River, the Qilinguan Reaches belongs to Renhe Plateau Town, Wufeng Tujia Autonomous County according to China's administrative division. Originated from Beiyamen with elevation of 1260m, the Qilinguan Reaches flows through the Qingshui Bay, the Shenzi Plateau, the Renhe Plateau eastwardly and enters Songzi City in Huangyanlin.

Cascade planning and development report of the Nan River Basin was finished in the year of 2000 by Water Conservancy and Hydropower Survey Studio in Wufeng County. It was planned to build four reservoirs and ten hydro power stations in the original basin. Qingshuiwan hydro power station followed by reservoirs of the Nan river, Yangmudong, Qilinguan, Daquanhe, Longtan, Yushiqiao, Muzhupiao first and second class stations and Meiping hydro power station would be constructed consecutively along the upper reaches to the lower reaches with total installed capacity of 23700kW. The Bureau of Water Conservancy and Hydropower in Yichang replied the above planning achievement in *Approval on Cascade planning and development report of the Nan River Basin*. (Yichang Water Resource [2001] No.180) It is said “cascade planning and development in the Nan River basin, and general arrangement of the project (total installed capacity: 27000kW) is approved. Work in next stage should be focused on improving power quality, enhancing management friendliness, deducing power stations with water head centralizaion, and making further feasibility analysis of dam construction and storage adjustment...”

During implementation, the Investigation and Designing Institute of Water

Conservancy and Hydropower in Yichang recommended through pressure tunnel instead of taking water from the planned Qilinguan diversion power station. Power generation of the second class station is from tail water of the first one the interval water. In July 2003, the Commission of Development and Planning in Yichang approved integrated hydropower development of the Nan River basin in Wufeng, reservoir construction and stage development of Qilinguan in document of Yichang Energy [2003] No. 448.

The first class station of the planned Qilinguan hydropower development project will enjoy 13.8 m³/s water regulation and diversion. It is a medium sized regulating reservoir with installed capacity of the first class station 2×3200 kw, firm output 1755 kW, annual utilization hour 3744h, average power generation 23.96 million kW·h, total reservoir capacity 12.7012 million m³ and regulation capacity 8.8744 million m³. 95% of the second class Qilinguan hydroelectric power station is produced from tailrace of its first class station with selected installation 2×5500 kW, average power generation 42.19 million kW·h and annual utilization hour 3835h. It is an uncompleted annual adjusting medium-size reservoir.

In February 2004, the Investigation and Designing Institute of Water Conservancy and Hydropower in Yichang completed *Feasibility Analysis on Qilinguan hydroelectric power station in Wufeng Tujia Autonomous County in Hubei*. According to related national regulations about environmental protection and local requirements in this regard, entrusted Environmental Protection Research Institute in Yichang to assess project impact on environment. After site exploration, investigation and data collection, Environmental Protection Research Institute in Yichang compiled *Environmental Impact Assessment Program on Qilinguan Hydroelectric power station Project Held by the Wufeng Nan River Hydropower Development Co., Ltd.* (Abbreviated as *Environment Impact Assessment Program*) in line with the *Environmental Impact Assessment Law* of the PRC, *Environmental Protection Management Regulation of Construction Project* (the State Council, Decree. 253), and

Technical Specifications of Environmental Impact Assessment, the Chinese industry standard of environment protection.

1.2 Assessment Purpose

Through site investigation, survey of current environment and public participation in areas under influence of Qilinguan hydroelectric power station project and their surrounding areas, we investigated natural and social environment of the area of Qilinguan hydroelectric power station in Wufeng Tujia Autonomous County, Hubei, analyzed major existing environmental issues so as to assess both positive and negative impact on natural, social and ecological environment delivered by construction, reservoir flooding and project operation; practical environmental protection measures have been proposed to reduce side effects of the project with making its benefit into full play in order to safeguard that the project can promote social and economical development of the area as well as protect and improve local ecological environment.

Environmental impact assessment can perfect project documentation through providing evidences for feasibility argumentation of the project to facilitate successful project launch; and offer scientific proof to environment management, superintendence and monitoring of the project.

1.3 Compilation Reference

1.3.1 Law and Regulation

- (1) *Environmental Protection Law of the PRC* (1986.12);
- (2) *Environmental Impact Assessment Law of the PRC* (2003.9);
- (3) *Water Law of the PRC* (revised in 2002.8);

- (4) *Land Management Law of the PRC* (revised in 1998);
- (5) *Communicable Disease Prevention and Control Act of the PRC* (1989.2);
- (6) *Water and Soil Conservation Law of the PRC* (1991.6);
- (7) *Forest Law of the PRC* (revised in 1998);
- (8) *Wild Animal Protection Law of the PRC* (1988.11);
- (9) *Fisheries Law of the PRC* (2000.10);
- (10) *Water Pollution Prevention and Control Act of the PRC* (2002.11);
- (11) *Air Pollution Prevention and Control Act of the PRC* (revised in 2000.4);
- (12) *Environmental Noise Pollution Prevention and Control Act of the PRC* (1997.3);
- (13) *Environmental Protection Management Regulation of Construction Project* (1998.11);
- (14) *Water and Soil Conservation Management Method of Development and Construction Project* (1994.11);
- (15) *Public Places Health Management Ordinance* (1987.4);
- (16) *Communicable Disease Prevention and Control Approach of the PRC* (1991.12);
- (17) *Classification Management List of Construction Project Environmental Protection* (1998 the State Council Decree. 253);
- (18) *Notification of Improving Public Participation of Environmental Impact Assessment on Construction Project* (Hubei Environment Protection Office Decree

[2003]) as well as other national and local laws and regulations.

1.3.2 Technical Specifications

(1) *Environmental Impact Assessment Technical Guideline, Non-polluting ecological impact* (HJ/T19-1997) ;

(2) *Environmental Impact Assessment Guideline* (HJ/T2.1~2.3-93) ;

(3) *Environmental Impact Assessment Technical Guideline --- Acoustic Environment* (HJ / T2.4-1995) ;

(4) *Technical Specifications of Environmental Impact Assessment of Water Conservancy and Hydropower Project* (SDJ88-2003) ;

(5) *Environmental Impact Assessment Technical Guideline --- Water Conservancy and Hydropower Project* (HJ/T88-2003) ;

(6) *Technical Specifications of Environmental Impact Assessment from the medical view of Water Conservancy and Hydropower Project* (GB/T16124-1995) ;

(7) *Technical Specifications of Water and Soil Conservation Management Method of Development and Construction Project* (SL204-98) ;

(8) *General Planning of Comprehensive Management of Water and Soil Conservation* (GB/T15772-1995) ;

(9) *Technical Specifications of Comprehensive Management of Water and Soil*

Conservation (GB/T16543-1996) ;

(10) *Directory of National Key Protected Wild Plants (the first batch)* (1999.8) ;

(11) *Directory of National Key Protected Wild Animals* (1989.1) ;

(12) *Directory of Hubei Provincial and Municipal Key Protected Terrestrial Wildlife*
(1994.6) ;

(13) *Directory of Hubei Key Protected Aquatic Animals* (1994.12) ;

(14) Technical Specifications of Disinfection (presented by the Ministry of Health in 1992);

(15) *Monitoring Technical Specifications of Surface Water and Wastewater*
(HJ/T91-2002) ;

(16) Technical specifications such as *Health Norm on Drinking Water Quality*
(2001.6) .

(17) *Environmental Assessment Regulations of Hydroelectric power stations in Rural Areas.*

(18) *Soil Erosion Classification and Grading Standards* (SL190-96) .

1.3.3 Relevant Documentation

(1) Yichang Planning Commission Energy [2003] Decree. 448 *Approval on Hydropower Comprehensive Development in the Nan River basin in Wufeng from*

Yichang Planning Commission, Yichang Development and Planning Commission, July 29th 2003. Refer to Attachment I.

(2) Authorization Letter from the Wufeng Nan River Hydropower Development Co., Ltd. about compiling report on environment impact of Qilinguan Hydroelectric power station, September 10th 2004. Refer to Attachment II.

(3) Environmental Impact Assessment Program on Qilinguan Hydroelectric power station Project Held by the Wufeng Nan River Hydropower Development Co., Ltd. Yichang Environmental Protection Research Institute, August 2004.

(4) *Approval on implementation standard of Environmental Impact Assessment Program on Qilinguan Hydroelectric power station Project Held by the Wufeng Nan River Hydropower Development Company Ltd.* Construction and Environmental Protection Bureau, Wufeng Tujia Autonomous County, October 18th 2004. Refer to Attachment III.

(5) *Review Comments on Environmental Impact Assessment Program on Qilinguan Hydroelectric power station Project Held by the Wufeng Nan River Hydropower Development Company Ltd.* Yichang Environmental Protection Bureau, 22nd October 2004. Refer to Attachment IV.

(6) Review Comments of the Expert Group and Its Name List for Environmental Impact Assessment Program on Qilinguan Hydroelectric power station Project Held by the Wufeng Nan River Hydropower Development Co., Ltd. 20th October 2004. Refer to Attachment V.

1.3.4 Documentation of Project Designing

(1) *Feasibility Analysis on Qilinguan hydroelectric power station in Wufeng Tujia Autonomous County in Hubei,* Yichang Investigation and Designing Institute of Water Conservancy and Hydropower, February 2004.

(2) *Report on Water and Soil Conservation of Qilinguan Hydroelectric power station in Hubei Wufeng Tujia Autonomous County in the Initial Designing Stage*, Yichang Investigation and Designing Institute of Water Conservancy and Hydropower, March 2004.

(3) *Report on Water and Soil Conservation of Qilinguan Hydroelectric power station in Hubei Wufeng Tujia Autonomous County in the Initial Designing Stage*, Yichang Investigation and Designing Institute of Water Conservancy and Hydropower, March 2004.

(4) *Geological Survey of Qilinguan Hydroelectric power station Project in the Initial Designing Stage in Hubei Wufeng Tujia Autonomous County*, Wuhan Fengda Geo-engineering Co., Ltd. of China University of Geosciences, February 2004.

(5) *Geological Survey of Qilinguan the Second Class Hydroelectric power station Project in Hubei Wufeng Tujia Autonomous County*, Yichang Investigation and Designing Institute of Water Conservancy and Hydropower, February 2004.

1.4 Goals of Damage Control and Protection of Ecological Environment

(1) Water Quality: we will prevent excessive emission of pollutants and protect water quality of the reservoir. Consistency of wastewater during construction period shall be controlled within the first-class standard of GB8978-1996 *Integrated Discharge Standard of Wastewater* with reservoir water quality in operation period in accordance with II Standard of *Environmental Quality Standard of Surface Water*.

(2) Environment Air Quality and Acoustic Environment

Construction should not degrade air quality and quality of acoustic environment in the area and on the contrary it should reach the second standard of *Ambient Air Quality*

Standards (GB3095-1996)with acoustic environment quality satisfying I standard of *Urban Regional Environment Noise Standards* (GB3096-93) .

(3) Water loss and soil erosion: As for land of which water and soil conservation ability has been weakened or deprived of due to excavation, filling and press in construction, this ability should be redeemed or improved with the help of plants and certain constructions. Over 95% of lost water and soil should be within control and further prevent such phenomenon; over 70% of disturbed land should be restored with over 95% waste slag produced by construction properly disposed.

(4)Vegetation: we should minimize vegetation damage caused by construction and restore it on bare soil in construction area when project done. Vegetation coverage rate should exceed 90% with forestry and grass coverage in areas of responsibility over 20%; malign influences on aquatic living creatures delivered by hydrological changes should be reduced.

(5) Land resource: we should best handle waste slag disposal and conditionally rehabilitate the land so as to avoid land resource reduction brought by construction.

(6) Social economy: we should take care of people’s well-being during construction period. We must prevent epidemic diseases in all forms, and builders as well as local residents near from suffering from air and noise pollution.

Figure1-1 A Sheet for the Environmental Protection Goals of Qilinguan Reservoir Hydroelectric Power Station Project

Protection Object	Distance	Direction	Scale	Protection Level
Nan River	-	-	2km away from the upstream of the dam position until the lower reaches of the river	quality of the surface water: category II

reservoir area, downstream subsidiary dam and the second class power plant construction area	construction activity and its influential area	surrounding area	extending 1km away from the construction border	ambient air: the second grade ; noise: the first grade ; Water and soil erosion has been reduced and controlled, vegetation recovered.
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1.5 Assessment Grading and Scope

1.5.1 Water Environment

Without discharging waste water in operation, Qilinguan hydroelectric power station will affect water environment in its construction and beginning period of reservoir filling.

Grading factors of water environment: ①discharge amount of sewage and waste water: according to feasibility research report, sewage and waste water in construction period mainly come from waste water for rinsing sandrock equipment, regular drainage of concrete production system and foundation ditch with domestic sewage mainly from builders. Discharge amount of sewage and waste water in the busiest time during construction will reaches 2550m³/d ; ②water quality complexity of sewage: SS is the main pollutant of construction waste water, while the domestic one goes to BOD₅, COD and NH₃-N. Sewage water quality of this project is of medium complexity; ③surface water scale: the Nan River reaches in the dam site has flow rate of 4.99m³/s, thus its surface water scale is ranked as rivulet; ④requirement of surface water quality: because protection requirement of water quality in the affected area falls to II standard of *Environment Quality Standard of Surface Water* (GB3838-2002) . Therefore in accordance with assessment and grading principle of

Environmental Impact Assessment Technical Guideline --- Surface Water Quality, water environment quality in this area is in the third class.

1.5.2 Ecological Environment

Since hydroelectric power is one of a kind of clean energy, few pollutants will be discharged in operation period of the station, and environmental impact of project construction belongs to non-polluting ecological impact. According to preliminary investigation, quality and diversity of living creatures in this area caused by the project will be decreased far less than 50% and none of species faces extinction danger. Despite of aggravation of land connectivity degree, it will be controlled within 1/2 and in most cases physicochemical properties of water, soil and land won't be aggravated. No sensitive area is found in this region. Influence scope of the project construction covers about 0.496km² which is less than 20km². According to *Environmental Impact Assessment Technical Guideline --- Non-polluting Ecological Impact* (HJ/T19-1997) , ecological impact of this project ranks the third class.

1.5.3 Atmospheric Environment and Acoustic Environment

Owing to construction of main works and lesser roads, atmospheric environment and acoustic environment will be affected along roads in the construction area and its neighborhood. Because within 2km from dam site and power station there is free from residents and their activities; there are no sensitive receptors such as population centers and schools. Thus only brief assessment of atmospheric and acoustic environment impact is listed here. Main assessing area is the construction site and 1km extensional area from its boundary.

1.6 Assessment Standards

1.6.1 Environment Quality Standards

- (1) II standard of *Environment Quality Standard of Surface Water* (GB3838-2002);
- (2) the second standard of *Ambient Air Quality Standards* (GB3095-1996) ;
- (3) I standard of *Urban Regional Environment Noise Standards* (GB3096-93) .

1.6.2 Pollutant Discharge Standard

- (1) The first-class standard of GB8978-1996 *Integrated Discharge Standard of Wastewater*;
- (2) *Noise Limit in Construction Site* GB12523-90;
- (3) The second-class standard of GB16297-96 *Integrated Discharge Standard of Air Pollutant*.

1.7 Assessment Term

Environmental impact assessment terms for the project are divided into terms of construction and operation. 2004 is the year for status quo assessment, while 2010 is for prediction assessment.

1.8 Assessment Emphasis

After recognition and screening according to project nature, scale and influential scope, and referring to environmental impact assessment of the similar water conservancy and hydroelectric power project, water environment, ecological environment and environment in construction site are regarded as cores of this assessment with local climate, hydrology, sediment, geology and public health assessed in a general manner.

2. Project Introduction

2.1 Basin Introduction

As the first class tributary of the Weishui water system, the Nan River passing the Dongting Lake flows to the Yangtze River. With length of 44 km in Wufeng Tujia Autonomous County, the Nan River is one of the largest rivers there. Located in the middle reaches of the Nan River, the Qilinguan Reaches belongs to Renhe Plateau Town, Wufeng Tujia Autonomous County according to China's administrative division, stretching from east longitude 110°04'09" to 110 °08'53", north latitude 30°03'46"to 30°04'52". Originated from Beiyamen with elevation of 1260m, the Qilinguan Reaches flows through Qingshuiwan, Shengziping, and Renhe Plateau eastwardly and enters Songzi City in Huangyanlin. Elevation of the river bed at the exit of Songzi City is 147m. Watershed area of the Nan River in Wufeng Tujia Autonomous County is 310km² with average stream gradient 15.23‰.

In the basin, mountains rise straight up with deep-cutting gorges crowded, and most of watershed boasts elevation of over 1200m. The Yuzhanhua Mountain in the west has a height of 1380m with the Lilinkou Mountain in the south 1430m, the Huangjiatang Mountain in the north 1350m. As for terrain, it is high in the west and low in the east with 1100m altitude difference. With the length of 245m, Qilinguan Reaches occupies 58% of watershed area of the Nan River, and with its concentrated falls, it is the ideal site for regulating reservoir. Qilinguan Reaches is known as hydropower base on the Nan River basin.

In the basin, there is sound vegetation with forest coverage over 73%. From valleys to mountain peaks, shrubs, trees, deciduous and non-deciduous plants thrive whole year long, which efficiently prevent water loss and soil erosion. Width of river bed in the basin varies from 30 to 60m. And most of valleys have the shape of "U" with the rest "V" shape. Complete rocks stick out on the two banks of the river bed. All the above

are good natural conditions for construction of hydroelectric power station.

2.2 Project Geographic Position, Development Task, Scale and Arrangement

2.2.1 Project Location

2.2.1.1 The First Class Power Station of the Reservoir

(1) Dam Site

Qilinguan hydroelectric power station of the Nan River basin is located between the Donggubao Mountain and the Jianshanbao Hill. River channel in this area is quite straight. At the dam site, river bed has a width of 12.0m and elevation of 390.0m. Mountains on the two banks have symmetric shape: on the left, below the height of 450.0m it is cliff with slope gradient about 70°. Above the height the gradient decreases to 36°; on the right, terrain is fairly flatter. It is above elevation of 500.0m with slope angle 45°, which rises to 53° as below the elevation. On two banks of the site, lithology mainly constitutes of medium thin and thin limestone. The rock dip directs to the north with quite sharp dip angle. The fields water injection test indicates that rock body permeability is strong above elevation of 470.0m, low to intermediate between 470.0~450.0m, and below elevation of 450.0m. A relatively impermeable border exists between the two banks. And there is a southward fault (F5) between the Tonggubao Mountain and the Tiger Hill. Caves can be found on the left abutment at its height of 460.0~470.0m.

(2) Station Site

According to planning and field geological investigation, the first class hydroelectric power station will be built near the Daquan River. Before there was a paper making factory on a piece of vacant land on the left bank, which was 25m from the arch

bridge in the lower reaches direction. The land has an elevation of 367.8m, an area of 62×28m² (horizontal river bed × vertical river bed)and bedrock covers only 5 ~ 8m. And it has already accessed to rural highways. As cliff on the right bank, it is not proper for station construction.

2.2.1.2 The Second Class Power Station

(1) Dam Site Location

With consideration of terrain, geological condition and field investigation, dam of the second class power station is planned to be built 600m from the first class power plant in the lower reaches direction.

(2) Diversion Canal Route Selection

Decided by its terrain, route of the second class Qilinguan power station's diversion canal (tunnel, culvert) will be designed along the left bank of the Nan River, and most of part will be constructed in line with the river channel. Plant will be settled on the left bank too.

(3) Plant location

In order to make best use of hydropower resources, plant should be built as near end of the reservoir of Muzhupiao first class power station in the lower reaches as possible after consideration given to forebay arrangement. Due to deep gully in the Qilinguan reaches and precipitous valleys aside, there is limited space for plant construction. After various field investigations and comparisons, the power plant is decided to build on the beach of Shaguandou (a place) on the left bank with the forebay in White Crane Mouth (a place) in the upper part of Shaguandou on the left bank.

Refer to Attached Picture I for geographic position.

2.2.2 Project Task and Scale

2.2.2.1 Project Task

The power station mainly adopts reservoir water regulation and diversion for power generation, and undertakes peak load and modest load in the electrical system. Major task of the project is power generation, which offers needed domestic and industrial electricity to local areas.

Construction of Qilinguan Hydroelectric Power Station will improve electricity consumption for both living and production of the local residential so as to promote development of deep processing industries of forestry, medical products, specialties and mineral products; increase their income; and “replace firewood with electricity as their power resources”. The construction is of positive and practical significance in consolidating achievements of “Closed Forest Project”, and “Conversion of Cropland to Forest.”

2.2.2.2 Project Scale

(1) The First Class Power Station of the Reservoir

According to Article 3.8 of *Hydropower Designing Code for Small Hydroelectrical Power Projects* (SL76-94), the planning guaranteed ration is P=90%, and project scale is as follows: installed capacity of the first class power station is 2×3200kw with firm output 1755kW, annual utilization hour 3744h, average electricity generation amount 23.96 million kW·h, reservoir storage capacity 12.7012 million m³ and regulation capacity 8.8744 million m³. It is an uncompleted annual adjusting medium-size reservoir.

(2) The Second Class Power Station

95% of generating flow of the station is produced from tailrace of the first class power station of Qilinguan. Based on hydropower computation and technological comparison, the second cascade power station of Qilinguan is designed to have installed capacity of $2 \times 5500 \text{kW}$ with average power generation amount 42.19 million $\text{kW}\cdot\text{h}$ and annual utilization hour 3835h.

Total storage capacity of Qilinguan Hydroelectrical Power Station is 12.7012 million m^3 and the total installed capacity is 17400kw. According to *National Flood Control Standard* (GB50201-94) and *Grading System of Water Conservancy and Hydropower Project and Flood Standard* (SL252-2000) , the first class power station project is graded as the III level project; main buildings of reservoir junction dam are designed in accordance with the third level; and diversion and power station projects are planned according to the fourth level. The second class power station project is the IV level project, while main buildings such as the dam, projects of diversion and power station are designed in the fourth level. The rest will be designed in the fifth level.

2.2.3 Project Arrangement

2.2.3.1 Dam Type and Project Arrangement

According to terrain and geological condition of the dam site, RCC double curvature arch dam scheme will be adopted.

Elevation of the foundation plane is 385.0m and that of dam crest is 462.0m. Width of dam crest and dam bottom is 5.0m and 14.96m respectively. Maximum dam height is 77m and minimum thickness-height ratio is 0.194. Arch ring's centerline length of the arch dam crest is 136.1m, with a central angle of 84.48° . Curvature radius of the arch ring's centerline is 92.3m. Length of the bottom arch centerline is 33.4m. Central angle is 62.08° . Curvature radius of the arch ring's centerline is 30.8m

Spillway will be constructed in the middle of the river bed. Flood will be released through and controlled by the crest gate. The weir crest has an elevation of 452.2m and three holes, each of which enjoys the net width of 10m and the height of 9.8m. The exit adopts drop flow type. It will adopt plunge pool of the subsidiary dam for energy dissipation in the lower reaches.

Parabolic arch ring double-curved arch dam in the plane adopt the parabolic variable-thickness double-curved arch linear figure which have variable-curvature and varied radius that its each layer of the arch ring adopt the design of variable-thickness and unsymmetrical arrangement on the left and right bank. Arch ring's centerline length of the arch dam crest is 138.1m, the central angle of top arch on the left is 38.04° on the right 43.27° ; arch abutment on the left of curvature radius of arch ring of the top arch is 143.1m, on the right ones and that of the arch crown is 69.9m and 190.0m respectively. Total length of the bottom arch centerline is 30.6m with its center angle on the left-half of 27.6° , while the right-half of 24.68° ; arch abutment on the left of curvature radius of arch ring of the bottom arch is 40.9m, and that of the arch crown and on the right one is 28.5m and 42.3m respectively. Thickness of arch abutment on the left of arch ring at the top layer of arch dam is 5.85m, the length of chord in the downstream face is 67.05m, the thickness of arch crown is 4.5m; and the thickness of arch abutment on the right is 5.83m, the length of chord in the downstream face is 52.902m; string length of the downstream surface is 52.902m; Thickness of arch abutment on the right of arch ring at the bottom layer of arch dam is 12.39m, the length of chord in the downstream face is 12.024m, string length of the downstream surface is 12.024m, the thickness of arch crown is 12.00m, thickness of arch abutment on the right is 12.34m, The arch crown is as thick as 12.00m. The length of chord in the downstream face is 12.017m, string length of the downstream surface is 12.017m.

2.2.3.2 Main Buildings and General Arrangement of the Project

(1) The First Class Power Station of the Reservoir

Junction Buildings of the Reservoir

Arch dam will be poured with roller compacted concrete and will be designed with parabolic arch ring linetype and thicken hyperbolic linetype. Elevation of the dam foundation plane is 385.0m with calculated elevation 388.0m, dam crest elevation 462.0m, maximum dam height 77.0m and minimum thickness-height ratio 0.162. Arch ring's centerline length of the arch dam crest is 131.81m with central angle of the arch ring 81.31°. Arch ring central angle of the dam bottom is 52.28°. Dam crest width is as follows respectively: 5.85m (the left bank), 4.5m (the crown cantilever), and 5.83m (the right bank). Dam bottom width at the crown cantilever is 12.0m.

Spillway will be constructed in the middle of the river bed. Flood will be released through and controlled by the crest gate. Elevation of the weir crest is 452.2m, and it has three holes for flow discharge, which is controlled by radial steel gate and winding headstock gear with capacity of 2×500KN. Sluice hole has a width of 10m, height of 9.5m and the total width is 30m. The exit adopts drop flow type for energy dissipation. Anti-arc radius is 6.0m and the bucket angel is 6°. In the downstream of the dam, the subsidiary dam will be erected to form cushion pool for energy dissipation. The subsidiary dam will be designed as single curvature arch dam and be constructed of mortar laid stone works. Elevation of the dam crest, dam foundation and the dam is 410.45m, 386.3m and 21.15m respectively. Width of the dam crest and dam bottom is 3.0m and 5.8m. The dam crest will have full face overflow with flow width 65m.

Water inlet of the power station diversion system is to be arranged on the left bank of the dam in the upper reaches, which is 40.0m from the dam axis and central elevation of the exit is 429.0m. Steel pipes will be pre-embedded to be the discharging pipe with diameter $\Phi 800\text{mm}$ in the slope on the dam's right bank. Central elevation of the entry is 420.0m and the exit will be controlled by gate valves.

' **Diversion Tunnel and Power Station**

Diversion route on the left bank is highly recommended due to its flat terrain, and because the average elevation is 460 – 520m, and coverage layer is within 4m in some areas where bedrocks expose. Excavation radius of the tunnel is R1.8m with lining thickness 0.2m and total length 2897.2m. At the exit sluice gate for repairing and work will be set with net hole size 2.8m×2.8m. The diameter of surge-chamber which is set in the downstream is Φ 10.0m. The penstock attached to the back of surge-chamber has a diameter of Φ 2.3m.

According to terrain of the plant area, generating centerline should be arranged in a paralleled way with the river bed. Total length and width of the plant house is 31.62m and 11.0m respectively and its ground elevation is 367.55m.

(2) the Second Class Power Station

' **Diversion Dam**

The dam is constituted of overflow section and non-overflow section. The overflow section is 25m long. The non-overflow section on the left bank is as long as 9m and has arrangement of flushing sluice.

' **Inlet Sluice**

Water inlet sluice is set in front of the sand sluicing gate on the groin head of the left bank of the water in-take dam, with length of the lock chamber 10m. The size of sluice hole is 2.8m×2.8m (width × height) and its designed influent flow 11.5m³/s. The sluice is followed by a diversion tunnel.

' **Diversion Tunnel**

The diversion tunnel is as long as 8793m. 1# tunnel closely follows the inlet sluice and at its entry a settling basin in the tunnel is arranged. 8# tunnel (buried culvert) exit is connected with the forebay entry. Tunnel longitudinal slope in the front of the settling basin is 1/500 with the one in the back of the basin 1/1000. The tunnel section is in the shape of a city gate doorway.

' **Forebay**

The forebay is of open-air style and on its right there is an overflow weir. The forebay has two parts, namely the antechamber and the water inlet chamber. Standard height of the antechamber bottom is 345.00m with its length 28m and width increasing from 3.2m to 6m gradually. Plane dimension of the water inlet chamber is 2.5m×3.0m (length × width) with sidewall height 7.4m, standard bottom height 345.67m, which is 0.67m higher than that of the antechamber. Trash rack will be arranged at the entry of the water inlet room.

' **Penstock**

The penstock adopted joint water supply means featuring in “two machines and one penstock” and it is under the ground. The ferrol between steel pipe and surrounding rock will be built with C15 concrete. Total length of the main penstock is 158.95m with inner diameter 2.0m. It has a 55° angle with the horizontal plane and is arranged near the shape of “Z” in the vertical plane. The bifurcated pipe in the shape of “卜” is connected with a branch pipe of whose diameter is 1.2m. The branch pipe and the turbine butterfly valve are connected with flange.

' **The Plant House and the booster station**

Arranged along the river channel, and with length of 28.02m and width of 12.8m, the main plant house has five floors, which includes floors for collecting well (draft tube),

volute, hydraulic turbine, power generator and erection bay from down to up. Auxiliary powerhouse locates in the back of the main plant house and has four floors.

Refer to attached picture 2 for general layout of the project; picture 3 for general layout of the junction project of the dam. Refer to picture 4 for junction project layout of the first class power station plant; picture 5 for that of the second class power station plant.

2.3 Reservoir Inundation and Permanent Land Occupation of the Project

2.3.1 Treatment Scope of Reservoir Inundation and Object Indexes

(1) The First Class Power Station of the Reservoir

Qilinguan Reservoir area is in the middle reaches of the Nan River, which is 20km from Yuyanguan Town, Wufeng County and 150km from Yichang City. It is in Renhe Plateau Town, Wufeng County according to the administrative division. In normal reservoir storage, 462.00m, the correspondent reservoir capacity is 12.2435 million m³ with water area 0.453 km² and backwater length of the river channel 6.04km; at the highest water level, 466.33m, the correspondent reservoir capacity is 15.32 million m³ with water area 0.496 km² and backwater length of the river channel 7.85km. Elevation of the dam crest, riverbed at the dam site and dam foundation is 462.0m, 390.00m and 385.00m respectively. Due to the steep and precipitous mountains in the reservoir area, cultivated land is rare and barren mountains dominate this area. Most cultivated land is dry land and all distributed above the elevation of 520m.

In accordance with agricultural economy of the construction area, measuring and investigation result of the reservoir area, and material provided by local government,

submerged object index of the reservoir area includes economic forest and barren hills. In maximum reservoir level, 462.0m, citrus orchard, which is 2km from the dam, will be inundated. It has an area of 80 mu (6800 citrus tree in total). Cultivated land will be free from inundation.

No resettlement work needed in the reservoir area.

(2) The Second Class Power Station

The second class power station of Qilinguan Reservoir is in the middle reaches of the Nan River, which is 38km from Yuyangguan Town, Wufeng County and 159km from Yichang City. It is in Renhe Plateau Town, Wufeng County according to the administrative division. Water in-take dam of the power station is 600m away from the first class power station plant of the Qilinguan Reservoir and in the downstream direction. The maximum dam height is 15.1m with design flood level 364.09m, backwater length of the river channel 400m; in the highest water level, 365.11m, backwater length of the river channel is about 600m.

From the dam to plant house of the first Qilinguan Hydroelectric Power Station, there is nothing but precipitous cliff along the river channel. Below 368.87 elevation, no cultivated land and material object exist. Even on the gentle slope above cliff on the two banks, barren hills play the major role with less cultivated land all distributing above 400m elevation. Thus no resettlement is needed and no cultivated land will be inundated in the reservoir area.

2.3.2 Permanent Land Occupation of the Project

(1) The First Class Power Station of the Reservoir

According to arrangement of the junction project, permanent buildings such as the dam, water inlet and outlet will occupy 3.0 mu with power station plant 2.5 mu. The total occupation area will reach to 5.5 mu.

(2) The First Class Power Station

According to project arrangement, permanent buildings like the dam and water inlet will occupy 1.0 mu with power station plant 2.5 mu. The total size of occupied land is 3.5 mu.

2.4 Project Construction

2.4.1 Construction Condition

(1) Access Road and Transportation

Location in the remote area brings Renhe Plateau Town slightly backward transportation. It is accessible only with highways at present. Yichang City is connected with Yuyanguan Town by a provincial highway of 130km. And from Yuyanguan Town, there is a 10km third-class rural highway to Shengzi Plateau Village, Renhe Plateau Town. Another 10km mudstone highway of rural level is needed from Shengzi Plateau Village to the Qilinguan Dam, which is also linked with the power station by a section of mudstone highway. In the construction area of the second class power station, along the tunnel line of the power station diversion tunnel there is a section of 15km village road. Distance between each branch tunnel portal and the village road is within 1km: The highway to Shaguandou where the power house locates is under construction, which forks from the highway from Renhe Plateau Town to Muzhupiao the first class power station at the 4km point, and 2km away from the second class power house. The existing highway from Yichang to Renhe Plateau County can satisfy transportation requirement of this project. Partial section of the highway from the dam to the power station needs repairing to meet requirement of transporting large-scale equipment.

(2) Characteristics of Project Arrangement

The junction project of Qilinguan Reservoir Power Station is made up of Qilinguan

Reservoir, diversion tunnel and the power station. The dam of the reservoir situates at Tonggubao (a place), Qilinguan. It is normal concrete arch dam with maximum dam height 81.5m and elevation of dam crest 462.0m. The water intake, diversion tunnel of the power station as well as the spillway will be arranged on the left bank. Located 3000m from the dam on the left bank, the power station's tail water will enter water intake of the second class Qilinguan Power Station after passing a 500m river channel. Surge tank and plant area of the first class power station is built on Guniu Cliff in the opposite of the right bank of Daquanhe Power Station. Plant house of the second class power station situates in Shaguandou with total length of diversion system 8793m.

(3) Main Conditions for Construction Site

Main construction site of the first class power station project of the Qilinguan Reservoir features in "Two Points, One Line". Two points refer to construction areas of the dam junction and the power station; one line means construction area of the diversion tunnel of the power station. In the "Two Points" construction areas, the deep and narrow valley is flanked with steep slopes with width of valley bottom 12-18m. The area is not suitable for construction. But at the height of 540.0m on the left bank, there is a piece of low relief area, which can be used for arrangement of storage houses, construction camps and machine repairing. Tunnel portals of both the first and second class diversion tunnel (including branch tunnels) locate on cliffs. Construction camps, storage houses and pressure stations can be constructed in the adjacent area. Construction site can be settled near the plant area of the first class power station, while the deep valley with bottom width only 12-16m renders river bed in the plant area of the second class power station unsuitable for being the construction site. Therefore aggregate processing factory, concrete mixer station, storage house, construction camp, machine repairing field and so on are going to be built at the 300-320 elevation on the left bank of Shaguandou along the highway leading to the factory.

(4) Hydrology and Climate Conditions

The reservoir's basin locates in the subtropical monsoon climate area. It is warm, humid and rainy with annual average rainfall 1701.4mm. Rainy season usually starts from May to October, which contributes 90% of rainfall of the whole year. Rainstorms concentrate during June to September especially in July. It is measured that the maximum storm intensity in the month of the most rainfall is 279.5mm. Annual average temperature is 13.5°C. Monthly highest temperature occurs in July as 27.9°C with the lowest in January as 4.6°C. And monthly highest and lowest temperatures are 33.1°C and 1.3°C respectively.

(5) Main Construction Material

24535t cement is needed in this project. Songmuping Cement Factory in Yidu City and Huaxin Cement Factory near Wufeng County can produce cement of 42.5MPa and 52.5Mpa. The two factories is 50km from Yuyangguan Town, whose production capacity and cement quality can satisfy the project requirement; the used reinforced bar and steel can be procured for Yichang City; fly ash can be purchased in Jingmen Thermal Power Plant and Shimen Thermal Plant in Hunan Province; fire work materials can be provided by Wufeng Chemical Construction Company with firewood for construction and gasoline offered by the petroleum company in Wufeng County. 1000kVA transformation facility will be installed to provide electricity for the construction. The electricity will be offered by grid in the county, which directly accesses from the 10kV transformation station of Dalishu Village.

(6) Excavation of Concrete Aggregate

Natural building materials needed in this project include rubbles, crushed stones and sand aggregate. However natural building material for direct use in the project area is insufficient. Most of demanded materials have to be acquired from stone mining by builders. And stones can be excavated from thick-bedded limestone in the Jialing River Group. Places available for excavation include: the Yangzibao Hill and the

Tonggu Mountain on the left bank, the Dongshanbao Hill on the right bank etc. With principle of making best use of excavated slag materials, all materials for filling (backfilling) of such as river closure and cofferdam filling are planned to use excavated materials. Except concrete aggregate for the dam, all the parent rocks for concrete aggregate will be chosen from qualified excavated materials.

Most ground surface of the quarry is covered with a layer of earth but with thickness within 0.5m. Most of the place is exposed bedrock. The surface layer of the bedrock is weakly weathered layer with thickness of 1-2m, and the slightly-weathered layer follows with thickness of 3-5m, which are easy for excavation. Quality materials in each quarry can satisfy the construction requirement. With abundant reserves and relatively short transportation distance, the quarries are suitable for large-scale excavation. After processing excavated materials can be made into both coarse and fine aggregates, rubbles and stone bars of various kinds to meet construction demand. Open terrain of the selected quarries render the quarries the ideal places for large-scale excavation, processing and storage. And the quarries are near the dam axis.

In the quarries the deep-hole blasting will be adopted. Stone materials will be transported to the level ground at the mountain foot by 1m³ hydraulic excavator, and be further forwarded to stone crushing field by 1m³ loader and 15t dump truck for crushing, selection and washing. Concrete aggregate used in the plant area of the power station will be processed and produced from the excavated spoil in this area. If it is not enough, the needed concrete aggregate will be excavated from the near places after necessary explosion.

(7) Sand-gravel Processing Factory

The sand gravel processing factory has workshops for coarse materials receiving, preliminary crushing, preliminary selection, the second round of crushing, the second selection, sand making and storage of ready materials. Belt conveyor is also installed in the factory.

The excavated materials will be transported to storage house for coarse materials receiving by dump truck. Steel strip on the roof of the storage house can screen out stone whose diameter exceeds 350mm. The rest sand materials will be transported to the preliminary crushing workshop by belt conveyor after passing vibrating feeder. Then crushed by jaw crusher, the materials will be transferred to preliminary selection workshop for selection by belt conveyor. Double layer screen machine in the preliminary selection workshop has screen mesh of 80mm and 40mm size. A far selection materials >80mm will be sent back to storage house for coarse materials receiving for another round of crushing; materials between 40mm~80mm will be divided into two categories by material separation pipe: one will be sent into the storage house for ready materials by belt conveyor with the other to the second crushing workshop. The selected materials < 40mm will be transferred to the second selection workshop; the second crushing workshop is equipped with standard cone crusher whose discharging materials < 40mm. The crushed and the materials <40m from the preliminary selection will be sent into the second selection workshop. Double layer screen machine in the second selection workshop has screen mesh of 20mm and 5mm size. A far selection materials >20mm will be sent to storage house for ready materials by belt conveyor; the rest will be divided into two categories by material separation pipe: one will be sent into the storage house for ready materials by belt conveyor with the other to the sand making workshop; The selected sand < 5mm will be washed by spiral classifiers. The sand making workshop is equipped with short head cone crusher. The crushed and the materials <5m from the second selection will be sent to spiral classifier for washing, and the ready sand will be forwarded into the particular storage house by belt conveyor.

The ready aggregates will be transported to each concrete mixer system by 1m³ loader and 10t dump truck. Rubbles utilization is not much, which is mainly for factory construction and can be gain from excavation in the surrounding areas.

(8) Others

Average flow of the Qilinguan Reaches of the Nan River in moist years is $15.49\text{m}^3/\text{s}$ with $13.04\text{m}^3/\text{s}$ in mid-range years and $9.31\text{m}^3/\text{s}$ in dry years. The water amount can satisfy the construction requirement. With consideration of the project scale and principle that early water storage leads to early power generation and early benefits return, construction period should be controlled within one and a half year. Largest town of Wufeng County, Yuyangguan is only 20km from the construction site, which can provide ordinary machine repairing services to the construction.

2.4.2 Construction Diversion

According to figure 2.2.1 in SDJ339-89 *Construction Organization Specification of Water Conservancy and Hydropower Project*, related diversion buildings of the dam should fall in the V level. In line with regulation about earth rock fill cofferdam in 2.2.2, flood standard of the diversion buildings is five-year frequency in dry periods with corresponding flow $77.4\text{m}^3/\text{s}$. Standard of temporary flood control of the dam is ten-year frequency with flow $650\text{m}^3/\text{s}$. The dam and plant houses of the second class power station will be constructed in dry periods. Flood standard of cofferdams and diversion buildings is five-year frequency in dry periods with flow at the dam site $83.6\text{m}^3/\text{s}$ and in the plant house area $120.0\text{m}^3/\text{s}$.

(1) Diversion and River Closure Method

' The First Class Power Station of the Reservoir

In accordance with the hydrology, terrain, geological conditions and junction arrangement, construction diversion of Qilinguan Reservoir junction project will adopt one time closure by cofferdam and tunnel diversion.

River closure will be completed in the middle of November, and at the end of April next year excavation of the abutment and the dam foundation, and pouring of some parts of the dam will be finished. Concrete pouring of the dam will be held in winter. With consideration that normal concrete arch dam can flow through the dam, only

temporary gap in flood seasons will be constructed rather than diversion bottom outlet of the dam. Based on the project scale and contraction condition, water storage period of the reservoir lower lock is preliminarily settled to be January to March in the third year since the river closure.

‘ The Second Class Power Station

The project diversion is mainly held in the period of water in-take dam construction, which is overflowing dam made of mortar laid stone works. According to terrain at the dam site and the construction, with consideration that mortar laid stone dam can use the dam for flood, temporary gap in flood seasons will be adopted. Thus diversion standard can be lowered with multi-year average flow only $5.60\text{m}^3/\text{s}$ at the dam site. Diversion amount takes overflow ability of the flushing sluice. The diversion method is one time closure by cofferdam, and open diversion channel connected with the flushing sluice and the flushing sluice on the left bank.

(2) Diversion Buildings

‘ The First Power Station of the Reservoir

Due to the terrain condition of the river bed at the dam site and junction arrangement requirement, diversion tunnel will be arranged on the left bank. After comparison between circular gate and city gate doorway, the diversion tunnel section will choose the first shape owing to its smaller construction workload and investment. The entry will locate at 40m point in the upstream of the dam axis with its diameter 4.1m and central elevation 394.233m. The central elevation of the exit is 392.05m. The diversion tunnel is in the shape of circular arch on the plane with line segment length of the entry 44.797m; axis radius of the central arch segment 24.05m, its central angle 60° and length 25.185m. Line segment length of the exit is 38.658m. The total length is 108.64m. A sluice of $4.2\text{m}\times 4.2\text{m}$ will be left at the entry of the diversion tunnel, which will be sealed with water storage in the lower lock by C20 concrete with the help of consolidation and contact grouting after completion of the dam.

In accordance with characteristics of medium and small sized projects, water-retaining cofferdam in the upper and lower reaches will be constructed in earth-rock structure and filled by excavated spoils from the abutment. Cofferdam in the upstream has top elevation of 396.4m, bottom elevation 390.0m and weir elevation 6.4m. Top width of the weir is 2.0m with rock slope in the up and down stream 1:2. Cofferdam in the downstream has top elevation of 393.0m, bottom elevation 390.0m and weir elevation 3.0m. Rock slope in the up and down stream is 1:2. The cofferdam has been coated for seepage control and at its foundation concrete coggling will be installed.

The Second Class Power Station

To meet the terrain at the dam site, and requirement of dam foundation excavation and dam construction, two cofferdams will be erected. The cofferdam in the upstream is on the main river channel, 15m from the dam axis in the upstream direction, while the cofferdam in the downstream is also on the main river channel, 20m from the dam axis in the upstream direction. The open diversion channel passing through the hole of the flushing sluice will be constructed on the left bank along the slope. The cofferdam will be used for one whole dry season, when the dam construction can be done by the end of March next year.

Only with foundation pit and cofferdam, the plant house mainly depends on the main river channel in flood seasons. According to the terrain condition of the plant area, only longitudinal cofferdam outside of the foundation pit is needed. The cofferdam, constructed by mortar laid stone works, will be used for one whole dry season. It is designed that weir top width is 0.6m with slope in upstream face 1:0, in downstream face 1:0.4, weir top elevation 226.30m and bottom elevation 219.50~221.0m.

2.4.3 Construction of Main Body Project

2.4.3.1 I Hydroelectric Station of the Reservoir

(1) Rcc Double Curvature Arch Dam

‘ Excavation of Abutment And Dam Foundation

Construction diversion adopts the way of cofferdam, zero flow, and domestic sewage. Considering the tight schedule of the project, abutment excavation must be completed before river closure. It means abutment excavation and on the either side or bank cleaning at the height of over 395.300m should be conducted first. Then dealing with bank cleaning and foundation engineering construction less than 395.00m after river closure. Excavation takes use of the top-down general procedures. By means of drilling by onion peeling method, bench blasting and side wall presplitting to excavate higher side slope, excavation faces transport slag directly. Slope cutting the lower slope by labor. Introducing the method of level presplitting blasting to protect foundation plane, and excavators equipped with dump trucks tap slag. The total rock excavator of the dam is 42,000 m³. Calculated by 450m³ daily averaged excavation intensity, the construction period of abutment excavation is about 80days.

‘ Foundation Treatment Construction

Curtain grouting, consolidation grouting and contact grouting are adopted for foundation treatment. Curtain grouting is conducted on the basis of consolidation grouting and contact grouting.

The layout of consolidation grouting is quincunx. The distance between two rows is 3.0m; the whole distance is 3.0m. The construction is made up of three steps. It is planned that drilling and pre-burying grouting pipelines first, then grouting construction on the concrete platform of downstream dam body. Adopting the Type 150 geological drill borehole, grouting pressure is defined by field test. The full hole is grouted at a time. Contact grouting is combined with grouting at the same time.

‘ Dam Body Roller Compacted Concrete Construction

The pouring amount of dam body roller compacted concrete is about 51,000 m³. The height of dam crest is 462.0m, the height of dam foundation is 385.0m and the maximum dam height is 77.0m. One HZ75.0A Type mixing plant is installed on the left side of the dam. Concrete is unloaded to 10-ton dump truck from mixing plant, and transported to pouring position by 10-ton dump truck. And intermission is controlled in 3 to 7 days.

The cable crane is simple and radial. The lifting capacity is 20t. It is installed a cable, the span is 143.05m, the height of fulcrum on the left bank is 480m, on the right is 475m, the maximum sag of main cable is 7m. The cable crane is anchored into mountain body directly.

When pouring the dam body concrete over the height of 388.0m, dump trucks are transported to the lifting point of cable crane, concrete is unloaded into tanks and transported to pouring position, the height of unloading should be under 1.5m. 3m×3m cantilever steel mould is used to be template. Concrete is paved by 59kW bulldozer. When it is liquidation, better to pave 3 times, every layer is about 18cm. It also can be two layers, each is 26cm. YZJ-10P(73.6kW , 1500r / min) vibrating rollers, produced in Luoyang, the running speed of rolling should be controlled under 1.5km/h. Rolling should be reversed water flow in the range of 3m around the dam body upstream face.

Before the construction, experiment of mixing and crushing to Roller Compacted Concrete should be done, in order to determine the parameter of roller compaction.

Because the concrete of dam need to be crushed, we cannot take the method of extubation to form pathway of cooling. Moreover, it should be cooled in advance. Hydration heat can be realized by planting in advance as well as cooling the mains in warehouse. We should use the main with its pattern: 425. As well as one layer on surface level of each warehouse, until the temperature of concrete block be cooled to

designed request.

‘ **The construction of normal concrete.**

Normal concrete includes the foundation of dam: C20, overflow weir C25 and apron concrete C25, the total volume is 5779m^3 . It can also be finished by transporting the concrete by rope machine, artificial paving and vibration device.

(2) Construction of diversion pressure tunnel.

‘ **Excavation of tunnel**

The length of the tunnel which is used to create electricity is 2897.2m. diameter should be dug into 3.6m; the volume is 26300m^3 .

Dug of entrance and exit: Pneumatic cutting back will be need from top to bottom and it should be dug from outside to inside with the entire fault, Rack cars loaded caster will be used to give out ballast.

Excavation of cave body: air- leg pneumatic drill will be used to do the drilling, and smooth blasting will be need to the full-face, ballast will be loaded by person with the Vehicle Anti-Doo which the volume is 0.5m^3 . Ballast transportation by motor vehicle. There is one in the branch hole of construction, and its length: 80m, mainly be used to put out the ballast and Ventilation hole.

Making Wind and electricity in the hole: Apart from the constructive branch can be used partly create wind in the hole, it will also need a kind of fan called JBT-52 Axial Explosion-proof hybrid fan. Burst-type hybrid fan, the fan is located out of the hole, and the nozzle is made to extend casually and shift gradually. When java is made to come out of shaft while the shaft is being dug, first of all, $2\text{m}\times 2\text{m}$ Square pilot well is need to be done, and then we should blast it by a way of Deep sub-burst.

‘ **Tunnel’s concrete**

Power diversion tunnel paragraph, Compulsory Concrete Mixer which the volume is 0.4m^3 sets in the entrance of the branch hole in order to mix concrete on the spot. Artificial rubber tire vehicle is used to transport vibrated browser plug-in is used to Vibrated. Normal steel template will be used to do the construction. And we must do lining first at the bottom then at hole site, at last at top arch and we should mix the concrete in situ, Concrete pump warehousing will also be needed in the whole process.

As to the concrete tank, concrete mixing system with its volume $2 \times 0.4\text{m}^3$ will also be settled at the height of around 462m. So the concrete tank will be pumped into the warehouse by concrete pump, vibrated browser plug-in will be needed to vibrated, at the same time; we will portfolio the steel into modulus.

(3) Construction of power station

Power plant will be dug into a volume of 8740m^3 .Excavation will be finished by trying just one time. Besides, general blasting excavation will be used to promote the whole process. Two mixers will be needed to mix the concrete plant, after the material coming out; manual or motorized dump trucks are needed to put it into the warehouse. $\Phi 150$ -type vibration device will also be used .Timely conservation and protection will be implemented after pouring.

(4) electromechanical equipment and metal structure installation

The work to install the production of metal structures is mainly for the spillway gates and door equipment system, and pressure steel. Gates was lifted to the destination and installed by the cable car, and then welded. Finished products of gate should be purchased. The main construction procedures are as follows: setting embedded parts →the 1st initiating of Concrete pouring →the 1st installing a concrete gate and door→ finishing the second part of concrete pouring.

Penstock-site installation procedures are as follows: installation of pipe in workshop

→ concrete pouring for embedded pipes in workshop→ installation of the surge tank pressure steel from workshop to surge chamber →coagulation on pouring. Then two hydro-generating unit power stations, a lifting equipment installation and a booster station equipment installation need to set. Mechanical and electrical equipment installed according to the conventional approach.

(5) foundation treatment

Grouting works curtain grouting and consolidation grouting (contact grouting). Curtain hole single-row layout is at the distance separation of 3.0m, the maximum depth of 26.50m, a minimum depth of 15m, the total footage of 2366m (no containing reservoir bank), and grouting pressure to ascertain by on-site test. The method of grouting is top-down drilling hole one off before bottom-up sub-grouting.

Consolidation grouting was plum-type layout, row spacing 4.0m, curtain hole at the distance separation of 3.0m, total length of 2270m. The 150-type exploration drilling rig is used to drill whole one off, grouting pressure to ascertain by on-site test.

2.4.3.2 Power Station

(1) Dam foundation excavation

Slope cutting excavation and Foundation excavation: excavation of the two sides slope cutting is conducted along with the excavation of sand sluicing gate , head gate and No.1 tunnel. Excavation of river bed cover will begin after channel blocking when division ditch and cofferdam have completed together with sand sluicing gate and head gate. Scoop shovel is used to load soil, and self-unloading truck to transport. The banks and the riverbed of dam foundation are to be cleaned up rom top to down with the use of shallow hole blasting of small cannons and manual excavation.

' Dam slurry construction

M7.5 Mortar Masonry adopted in dam slurry construction. Materials of stone stored after being transported by agricultural vehicle dumped at the dam site backup, which is used in the construction of masonry dam by manual transportation.

Masonry construction: according to district requirements, selection of stone and mortar to ratio in which the artificial masonry mixes. Masonry should rise in balanced level, with completion of one masonry one off. Masonry in one row at order and masonry joints front and rear lap by herringbone brickwork.

Concrete dam use compulsory concrete mixer at 0.4m to mix, then transport the mixing substance to warehousing before using plug-in vibration to oscillate.

(2) Construction of Diversion Tunnel

' Import and Export Tunnel Cutting

According to requirements of design adopt pneumatic drill for slopes cutting from top to bottom, then full-face excavation from Exterior to Interior, and agricultural dump truck for mucking.

' Tunnel Cutting

To adopt pneumatic drilling for drilling hole, full-face smooth blasting, loaders for loading ballast, agricultural dump truck for transported ballast to the outside of the tunnel.

' The Ventilation and Electricity in the Tunnel

Construction should be strengthened the ventilation and electricity safety management in the tunnel. In addition to construction teams to solve some parts of the ventilation, it is necessary to adopt anti- rhinoceros hybrid ventilation fan with JBT-52 axial-flow type.

(3) Building Construction under the Forebay

' Earth-rock Excavation

To adopt the top-down excavation, firstly, excavation of forebay, then inclined shaft of penstock, finally excavation of the main and auxiliary plant foundation, which 1m³ excavator to used to loading and 10 ~ 12t dump truck for transporting.

' Concrete Construction

Aggregate processing and concrete mixing systems are difficulties for arranging in plant, and it is not convenient to transportation. Therefore, all the concrete which will be used in forebay, the inclined shaft of penstock and plant should adopt concrete delivery pump for transportation into the warehousing.

' Penstock Installation

When the inclined penstock excavation is completed, the first phrase, concrete pouring of plant → scaffold, bifurcated installation and concrete pouring concrete→ the second phrase, concrete pouring of plant→ penstock installation between plant and forebay →concrete pouring of the inclined shaft of penstock. The transport of penstock installation at the scene should adopt the light rail slide, the winch to traction and swing, as well as artificial auxiliary installation.

2.4.4 Transportation for the Construction and Construction

Arrangement

2.4.4.1 Transportation for the Construction and Construction Arrangement

(1) Transportation Scheme for External Communication

Highway transportation is the adopted means for the project construction. According to current highway condition, partially broadening and maintenance of the rural highways from the Shenzi Plateau to Qilinguan Reservoir, the first and the second class power station can satisfy transportation demand of equipments.

(2) Transportation Trunks in the Construction Area

On the main transportation line from the Shenzi Plateau to the reservoir, the highway extends to groin head on the left bank, and to the quarry and the river bed. The highway is the ordinary road for temporary construction use, which will mainly responsible for transportation of concrete aggregate, rubble, embankment material and large construction machines' entrance to the dam site.

From the previous highway and the new constructed road, a branch will be built to the river bed of the dam site, the river bed at the plant and forebay of the power station for transportation of concrete aggregate and quarry, and construction machine's accession to the construction area. On the basis of village road along the left bank of the Nan River, temporary service road for construction will be built to each structural opening for transporting materials and small equipment to each work zone.

2.4.4.2 Construction Arrangement

In line with the principle of least and no occupation of farm lands, except processing system of sand-gravel aggregate which is the must for construction, concrete mixer system, steel and wood processing system and maintenance factory for construction machines, all steel framework, standard products and steel structures involved in the construction will be provided or processed by special factories. The construction site will be for only use of planning, repairing, maintenance and stacking.

With the consideration of small scale of the project and short construction period, living quarters for builders won't be constructed. Local residential housed in the surrounding area can be rented or temporary construction camp can be put up instead.

(1) The First Class Power Station of the Reservoir

' Excavation and Processing of Concrete Aggregate

Because there is only one aggregate quarry in the construction area, the sand-gravel processing system should be set near the excavation place. On the highway from the quarry to the dam, the processed sand gravel will be transported to consumption in shortest transportation distance.

' Concrete mixer System

To satisfy concrete requirement in different places and different elevations, overall mixture building and mixture machine in the plant area of the power station will be co-used. Ready sand gravel will be piled in the near place. A 3m³ overall mixture building will be constructed in both the dam area and the plant area with two super 2~0.4m³ mixing machine.

' Integrated Processing System

Integrated processing includes that of steel, wood, and prefabricated concrete, which will be conducted in the plant area in the temporary construction camp.

' Repairing Workshop and Its Storage House

The repairing system will be arranged on the vacant land unoccupied by the 540m platform mixing system, and stone blast will be used to fill the low-lying place. Major imported building materials will be kept in rented houses along highway trunks in the work area, at the construction site temporary storage house meeting requirement on strength will be built. And fire work materials will be stored in an appropriate place in line with fire protection

' Spoil Field

Except usable materials from excavation, the total spoil amount reaches to 74.4

thousand m³. Spoil from the dam and the former part of the tunnel will be piled up in the spoil field in the downstream. Spoil dug from the power station will be stored in the near spoil field.

' **Living Area and the Construction Managerial Area**

According to the project scale, construction characteristics and general construction schedule, the number of builders in the busiest construction period will reach to around 200. Living issue will be solved in line with the principle of setting up construction camps and renting local residential houses in the surrounding areas.

(2) The Second Class Power Station

' **Excavation and Processing of Concrete Aggregate**

The plant will be equipped with a sand-gravel processing lot which locates in the elevation of 300 – 310m on the left bank of Shaguandou. Concrete aggregate used in the plant area mainly offered by selection and processing crushed stones excavated from the eighth tunnel exit. The dug crushed stones will be transported by dump truck to sand-gravel processing lot for selection. Unqualified coarse materials go to this process after breaking by jaw crusher with ready aggregates piled up for use. And selected aggregate <5mm will be sand washed by spiral classifier with ready sand sent to storage land for finished materials. Ready aggregate will be transferred to concrete mixer station by 1m³ loader.

Due to large amount and intensive use of concrete in the plant area, the concrete mixer station will be established in the vicinity of aggregate storage land and sand gravel processing lot. Rubbles are less used with main use for plant house construction. Thus they can be excavated in places nearby.

' **Integrated Processing System**

Integrated processing includes that of steel, wood, and prefabricated concrete, which

will be conducted in the plant area in the temporary construction camp.

' **Repairing Workshop and Its Storage House**

The repairing workshop is arranged on the side of the highway to the plant adjacent to the concrete mixer station. Major imported building materials will be kept in rented houses along highway trunks in the work area, At the construction site temporary storage house meeting requirement on strength will be built. And fire work materials will be stored in an appropriate place in line with fire protection demand.

' **Spoil Field**

Except usable materials from excavation, the total spoil amount reaches to 0.12 million m³. Spoil from the dam and the former part of the tunnel will be piled up in the spoil field at the exit of the tunnel and branch tunnel exit. Spoil dug from the power station and the latter part of the tunnel will be stored in the near spoil field.

' **Living Area and the Construction Managerial Area**

According to the project scale, construction characteristics and general construction schedule, the number of builders in the busiest construction period will reach to around 100. Living issue will be solved in line with the principle of setting up construction camps and renting local residential houses in the surrounding areas.

Refer to attached picture 6 for general construction layout of the reservoir; picture 7 for layout of the first class power station plant area; picture 8 for layout of the second class power station plant area.

2.5 Spoil Planning

Spoil planning is constructed in accordance with Project General Arrangement Scheme handed over by the proprietor and project amount written in the *Feasibility Analysis Report*.

According to the water and soil conservation scheme of the project, deserted land and spoil of the first class power station project of the Qilinguan Reservoir is as follows: excavated spoil amount from the dam is 28.5 thousand m³, 7200 m³ from the pressured diversion cave, 9100 m³ from the power station, and 3000 m³ from other projects; 93.8 thousand m³ from earthwork excavation, 57.4 thousand m³ from stonework excavation from above ground, 36.4 thousand m³ from stonework excavation from caves, and 4600 thousand m³ from soil earth excavation. Total spoil reaches 0.1563 million m³, equaling to 56 thousand in loose measure.

Spoil of the second class power station project of the Qilinguan Reservoir is as follows: excavated spoil amount from the dam is 1400 thousand m³, 0.1485 million m³ from the pressured diversion cave, 5200 m³ from the power station, and 1200 m³ from the road construction; 0.17 million m³ from earthwork excavation, 15 thousand m³ from stonework excavation from above ground, 0.145 million m³ from stonework excavation from caves, and 13.7 thousand m³ from soil earth excavation. Total spoil reaches to 0.1563 million m³, equaling to 187.4 thousand in loose measure.

2.6 General Construction Schedule

Taking fund availability and construction quality as premises, we will launch project commissioning and power generation as soon as possible in order to generate profits. After general analysis, total time limit is planned to be 19 months.

Construction starts from December this year to June in the third year with total time length 19 months. Power generation can be started from summer of the third year. Construction time of the second class power station will be controlled within 17 months, of which two months is for project preparation, 14 months for main works construction and one month for project completion.

2.7 Project Management

2.7.1 Management Agency

Proprietor of Qilinguan Hydroelectric Power Station is the Wufeng Nan River Hydropower Development Co., Ltd., which enjoys overall responsibility for unified construction and operation management of the first and second class power station projects of Qilinguan Reservoir.

According to *Trial Standards of Personnel Quota Compilation for Management Unit of Water Conservancy Projects* (SLJ705-81), and actual situation of the project, it is planned to have 36 managerial staff for project operation, of whom 20 people for the first class power station and 16 for the second class.

2.7.2 Management and Protection Scope

With the main function of power generation, the power station of the Qilinguan Reservoir also generates benefits from sand hindrance and culture. The reservoir is of medium size and belongs to III project. The main buildings for water retaining and discharging are designed in accordance with the requirements of the third level building. The project management scope covers the dam, spillway, water inlet, surge tank, plant house of the first class power station, switch station, observation equipment, transportation facility, areas for production and living and reservoir area within the land expropriation line.

The reservoir protection scope: the land above the dam site, and from the land expropriation line on the two banks to the ridge line of the first watershed.

The project protection scope: as for main buildings in the boundary of the project management scope, their protection area should be no less than 200m with ordinary buildings no less than 50m.

2.8 Investment and Benefit

The total static investment of Qilinguan Hydroelectric Power Station is 183.3308 million Yuan, which includes: 106.6174 million for construction, 26.6747 million for electromechanical equipment and its installation, 6.8126 million for metal structures and equipment and its installation, 4.5226 million for temporary project, 13.4196 million for other expenditure, 405.2 thousand for reservoir inundation and other compensation, 440.4 thousand for environmental protection and soil conservation projects, and 7.9770 million for basic preparation .

After completion and commissioning of the project, per kW investment will be 10.83543 thousand Yuan/kW·h and per kW·h investment will be 2.85yuan/kW·h. Payback period is 10.56 years and loan repayment period is 9.6 years. Economic internal rate of return is 12.09%. Economic net present value is 934.4 thousand Yuan. Financial internal rate of return is 10.23%. And financial net present value is 2.7320 million Yuan.

2.9 Figure of Project Feature

Figure 2-1 A Figure for the Features of Qilinguan Reservoir Hydroelectric Power Station Project

Serial Number	Name	Unit	Number	Notes
A.	Hydrology			
(A)	The First Class Power Station of the Reservoir			
1	The Drainage Area			
	Benchmark Station	km ²	836	The Controlled Area by Wuxigou Power Station
	The Address of the Dam	km ²	128.2	
	The Address of the Factory	km ²	142.8	
2	The Hydrological Series Length for Usage	year	35	from 1967 to 2001

3	Multi-year Average Annual Runoff	a hundred million m ³	1.4634	
4	Representative Flow Rate			
(1)	The Address of the Dam			
	Multi-year Average Discharge	m ³ /s	4.64	
	The Standard for Checking flood	%	2	every 50 years
	The Check of the Flood Peak Discharge	m ³ /s	1567	
	The Standard for Designing Flood	%	0.2	Every 500 years
	The Standard for Designing Flood Peak Discharge	m ³ /s	960	
	Construction of the Flood Diversion Standards	%	20	Drought Period: every 5 years
	Construction of the Flood Peak Flow Diversion	m ³ /s	77.4	
(2)	Power Plant			
	Reference Flow for the Power Station Design	m ³ /s	13.8	
	Designed Standard for Flood	%	2	every 50 years
	Designed Standard for Flood Peak Discharge	m ³ /s	1028	
	The Standard for Checking flood	%	1	every 100 years
	The Check Volume of the Flood Peak Discharge	m ³ /s	1174	
5	Sediment			
	Multi-year Average Sediment Discharge	ten thousand t	5.99	
	Multi-year Average Sediment Concentration	Kg/m ³	0.38	
6	Evaporation			
	Multi-year Average Evaporation	Ten thousand m ³	1.5	
(B)	The Second Class Power Station			
1	The Drainage Area			
	Benchmark Station	km ²	836	The Controlled Area of Wuxihou Power Station
	The Address of the Dam	km ²	143.9	

	The Address of the Factory	km ²	247.4	
2	The Hydrological Series Length for Usage	year	35	from 1967 to2001
3	Multi-year Average Annual Runoff	a hundred million m ³	1.6603	
4	Representative Flow Rate			
(1)	The Address of the Dam			
	The Standard for Checking Flood	%	5	every 20 years
	The Check of the Flood Peak Discharge	m ³ /s	843	
	The Standard for Designing Flood	%	10	every 100 years
	The Standard for Designing Flood Peak Discharge	m ³ /s	679	
	Construction of the Flood Diversion Standards	%	20	drought period: every 5 years
	Construction of the flood peak flow diversion	m ³ /s	83.6	
(2)	Power Plant			
	Reference Flow for the Power Station Design	m ³ /s	16.0	
	The Standard for Checking Flood	%	2	every 50 years
	The Check of the Flood Peak Discharge	m ³ /s	1480	
	The Standard for Designing Flood	%	1	every 100 years
	The Standard for Designing Flood Peak Discharge	m ³ /s	1694	
B	Reservoir			
1	Water Level of the Reservoir			
	The Check of the Flood Stage	m	461.0	
	Design Flood Stage	m	460.0	
	Normal Water Level	m	460.0	
	Dead Water Level of Power Generation	m	433.0	
	Siltation Elevation	m	424.5	
2	Reservoir Area at the Normal Water Level	km ²	0.453	
3	Reservoir Volume			
	Total Storage Capacity	ten thousand m ³	1270.12	
	Normal Storage Capacity	ten thousand m ³	1224.35	
	Dead Storage	ten	336.91	Dead Water Level of

		thousand m ³		the Corresponding Power Generation
	Storage Factor	%	8.1	
	Regulation Features			Uncompleted Annual Adjustment
C	Engineering Efficiency Indicators			
1	The First Class Power Station of Qilinguan			
	Installed Capacity	kw	6400	2×4500kw
	The Firm Power (P=90%)	kw	1755	
	Multi-year Average Annual Power Output	ten thousand kw•h	2396	
	Annual Utilization Hours	h	3744	
2	The Second Class Power Station of Qilinguan			
	Installed Capacity	kw	11000	2×8000kw
	The Firm Power (P=90%)	kw	2630	
	Multi-year Average Annual Power Output	ten thousand kw•h	4219	
	Annual Utilization Hours	H	3835	
3	Basin Comprehensive Benefits			
	The Average Increase on the Electricity Consumption of Established Power Stations over the Years	ten thousand kw•h	360.54	Muzhupiao, Daquanke Power Station
	Multi-year Average Annual Energy Output of the First and Second Class Power Station	ten thousand kw•h	6615	
D	Inundation Loss and the Project's Permanent Coverage of the Land	ten thousand yuan	40.52	
(A)	The First Class Power Station of the Reservoir			
1	Flooded Barren Hills	an acreage	150	
2	Flooded Farmland	an acreage	80	
3	The Project's Permanent Coverage of the Land	an acreage	5.5	

(B)	The Second Class Power Station			
1	The Project's Permanent Coverage of the Land	an acreage	3.5	
E	Construction			
1	The Main Volume of the Works			
	Folk Recipe Open Excavation	m ³	22979	
	Stonework Open Excavation	m ³	75600	
	Stonework Intake Tower	m ³	166508	
	Backfilling of the Earth	m ³	5230	
	Grouting Stonework	m ³	14241	
	RCC	m ³	50578	
	Concrete and Reinforced Concrete	m ³	29777	
	Reinforcing Steel Bar Security System	t	578	
	Curtain Grouting	m	13502	
	Consolidation Grouting	m	1448	
2	Main Construction Material			
	Cement	t	25247	
	Reinforcing Steel Bar	t	1022	
	Sand	M ³	51211	
3	Labor Requirement			
	The Peak Number of Workers	per person	300	
4	Motivation and Source of Construction			
	Power Supply	kVA	1600	
5	Total Duration	month	19	Including the Construction Preparation Period
H	Economic Indicators			
1	Static Total Investment	ten thousand yuan	16870.58	
2	Total Investment	ten thousand yuan	18853.64	
	Construction Project	ten thousand yuan	10661.74	
	Electromechanical Equipment and Installation Engineering	ten thousand yuan	2667.47	

	Metal Structures and Installation Engineering	ten thousand yuan	681.26	
	Temporary Project	ten thousand yuan	452.26	
	Land Occupation Compensation	ten thousand yuan	171.22	
	Other Expense	ten thousand yuan	1341.96	
	Environment and Water Conservation	ten thousand yuan	114.25	
	Basic Budget Reserve	ten thousand yuan	797.7	
	Loan Interests during the Construction Period	ten thousand yuan	520.56	
3	Transmission Project	ten thousand yuan	1462.5	
4	Economic Indicators			
	Installation Investment per Unit	yuan/kw	10835.43	
	Electrical Energy Investment per Unit	yuan/kw.h	2.85	
	Economic Internal Return	%	12.09	
	All Investment FIRR	%	10 . 23	After the Income Tax
	Total Payback Period	year	8.8	Before the Income Tax
	Total Payback Period	year	10.56	After the Income Tax
	Net Financial Present Value	ten thousand yuan	273.2	

2.10 Analysis of Project Pollution

2.10.1 Major Environmental Factors and the Countermeasures in the Project

2.10.1.1 Analysis of the balance of cubic meter of earth and stone, construction slag and the domestic waste

(1) Analysis of the balance of the earth and stone, and the means of recycling the construction slag

According to the report of soil and water conservation plan, the volumes of the earth and stone, and construction slag in Qilinguan reservoir, level I and II hydropower station projects are as follows:

Slag of excavating the dam, 29,000 m³;

Slag of excavating the hole of derivation, 155,700 m³;

Slag of constructing the power station, 14,300 m³;

Slag of building the roads, 2,400m³;

Slag from other projects, 1,800 m³;

Slag of excavating the earth, 269,900m³;

Slag of excavating the surface stones, 88,500 m³;

Slag of excavating stones down earth, 181,400 m³;

Used stones and earth, 64,400 m³;

Total volume of the construction waste, 204,100 m³, equals to 248,700 m³ in loose measure. Go to Figure2-2 for the balance calculation of the earth, stone, and construction waste.

Figure 2-2 Balance of the Earth and Stonework Discarded by the Project

Unit: ten thousand m³

Name	excavation			filling	usage	Compacted Abandoned Dregs	Loose Abandoned Dregs
	total	open excavation	digging holes				
dam (including downstream subsidiary dam)	5.38	5.38	0	0	2.3	2.99	3.59
diversion tunnel	18.22	1.2	17.02	0.05	2.6	15.57	18.67
grouting adit	0.48	0	0.48	0	0.38	0.1	0.12
diversion tunnel	0.2	0	0.2	0	0.12	0.08	0.1
power station	2.31	1.87	0.44	0.59	0.88	1.43	1.710.4
construction road	0.4	0.4	0	0.18	0.16	0.24	0.28
total	26.99	8.85	18.14	0.82	6.44	20.41	24.87

The results of balance analysis for the excavating volume of the earth and stone, and the volume of filling stated above, show that the total volume of the slag is

204,100m³, mainly for the remaining stone and material slag. All the slag should be piled up in slag field and properly disposable in time, avoiding the damage of the vegetation on the surface, the water loss and soil erosion, so as to maintain the natural landscape. According to the design, there will set three slag fields along the constructing line of the Qilinguan reservoir and the level I hydropower station, and nine along the level II hydropower station, including the diverting tunnel.

(2) Domestic waste and its treatment measures

There will be 300 working people per day during the construction rush period. The daily volume of the domestic waste, calculated by 1.0 kg, per people per day, will be about 0.30t. The construction will last nineteen months; the average number of working people per day is about 210. The total volume of the domestic waste during the construction will be 120t. The waste, without proper disposal, may lead to the reproduction and the breeding of the mosquitoes and flies, and the second pollution.

Therefore, domestic waste should be stockpiled in special area, classified, and composted after recycling the utilizable parts.

2.10.1.2 Drainage and discharge of water and major pollutants analysis during construction period.

The total amount of water used during construction period is 253540m³, while the total amount of wastewater discharge is 205552m³, including construction wastewater and domestic sewage.

(1) Water consumption for construction, major source of waste water and pollutants

Washing wastewater from construction vehicles and machinery

According to the design of construction organization, the total number of major construction machinery and vehicles in construction area is estimated to be around 30 with concentrated parking, i.e. the number is similar to that of hydroelectric projects at the same scale. The washing of one car would produce around 0.6m³ wastewater. Therefore if daily washing is counted as 50%, the daily oil wastewater would be about 9.0m³ and thus the wastewater produced during the whole construction period would be 5400m³.

The feasibility study of this project did not put forward specific treatment measures for construction wastewater. Referring to the routine countermeasures for wastewater, we suggest the following treatment measures be taken for treating the production wastewater in construction: advection sedimentation tanks for SS which is the main pollutant in wastewater from sand-gravel processing; neutralization sedimentation tanks for the wastewater with pH as high as 11~12 from maintenance of concrete pouring; separation tank for oil wastewater from the washing of construction machinery and vehicles. After these processes, wastewater can reach the discharge standard. Please refer to figure 2-3 for generation and discharge of the construction wastewater and main pollutants from Qilinguan Reservoir Power Station project.

Figure 2-3 Construction Wastewater and Its Main Pollutants

Serial Number	Categories of Wastewater	The Output of Wastewater at Peak Period (m ³ /d)	The Total Output of Wastewater during Construction Period (m ³)	Before Handling	After Handling
1	aggregate processing wastewater	2400	172800(1920)	SS :2.5×10 ⁴ mg/L , 48000kg/d	SS :70mg/L , 134.4kg/d

2	concrete casting maintenance wastewater	100	8000(88)	SS : 5000mg/L 440kg/d	SS : 70mg/L 6.16kg/d
				pH : 11-12	pH : 6-9
3	Washing wastewater for the construction machines and vehicles	20	5400(9)	oil : 15mg/L 0.135kg/d	oil : 5mg/L 0.045kg/d
				SS : 300mg/L 2.7kg/d	SS : 70mg/L 0.63kg/d
total		2520	186200(2017)	/	/

Note : Foundation ditch wastewater, which mainly comes from precipitation and leaking of cofferdam, etc, is counted in the total output of wastewater during construction period. The figures in the brackets represent the average daily discharge amount and the concentration after handling is supposed to reach the standard.

(2) Domestic water and sewage discharge

It mainly comes from the domestic sewage of construction workers. The workers on construction site in one day can reach around 300 in the peak time while the average number of workers is 210 per day. According to the routine, the average water consumption of construction workers per capita is about 200L with total amount during construction period around 23940m³, 80% of which is discharged in the form of sewage with a drainage of 160L/d. Thus, the maximum daily discharge amount of domestic sewage would be 56m³, with daily average amount 33.6m³ and total amount during construction period 19152m³. The main pollutants are COD, BOD₅, SS and NH₃-N.

As the construction site is located in a desolated area which is far away from residential area and urban area, it is in accordance with the local objective conditions and technical level and requirement to build temporary toilets and simplified cesspools. This decision has also taken into account the current overall level and the

state of environment in the region.

Please refer to figure 2-4 for the discharge of domestic sewage and main pollutants.

Figure 2-4 Domestic Sewage and the Main Pollutants during the Construction Period

Effluent		pollutants	Before Handling			After Handling		
m ³ /d	the total volume during construction period×10 ⁴ m ³		consistency mg/L	output		consistency mg/L	Emission	
				kg/d	total T		kg/d	total T
33.6	1.9152	COD	400	13.44	7.661	160	5.376	3.064
		BOD ₅	200	6.72	3.830	80	2.688	1.532
		SS	220	7.392	4.213	66	2.218	1.264
		ammonia category and nitrogen	15	0.504	0.287	15	0.504	0.287

2.10.1.4 Sources of Exhaust Gas and Contaminants during the Project

Major sources of exhaust gas are: dust generated from the concrete ingredient and the making of artificial aggregate, exhaust from digging, blasting and daily coal burning, dust from the transportation of cement and coal ash, tail gas from trucks and dust with chemicals mainly as TSP, SO₂ and CO from the digging of earthwork.

The fuel for the project is majorly fuel oil. The total consumption of fuel oil over the 19 months is estimated to be 300 tons according to the design of the project and by analogy. Figure 2-5 displays the main contaminants generated from the consumption of fuel oil according to emission factors.

Figure 2-5 Categories and Output of the Main Pollutants Generated by the Construction Fuel in the Qilinguan Reservoir Power Station

Eigenvalue	Fuel Consumption (t)	Categories and Volume of the Main Pollutants Generated by the Construction Fuel (t)		
		SO ₂	NO ₂	CO
Daily Emission	0.5	0.564	8.59	14.12
Total Emission during the Construction Period	300	338.6	5154	8474

The scale of the project is small and the construction sites are scattered with low source intensity. As a result, the air pollution caused by the project is slight. But the dust and exhaust may affect the environment of some area and the health of the staff in the construction sites, which requires precaution.

The project will cause no exhaust or dust emission once the construction is finished. Thus the air will no longer be affected.

Graph 9 is the flow figure of the process of the aggregate system of the hydropower complex of Qilinguan.

2.10.1.5 Facilities and noise

Construction facilities for the project are as displayed in figure 2-6.

Figure 2-6 Main construction machinery equipment

Category	Equipment name and specifications	Unit	Number
Loaded Class	shovel excavator , electromotion3m ³	a set of	5
		a set of	2
	car loader 1.0m ³	a set of	5
	shovel excavator , oil moving 1m ³		
Chisel Class	hand-held pneumatic drill	a set of	15
	DTH drill 100	a set of	4
	jack equipment	a set of	3
	bulldozer (120kW)	a set of	1
		a set of	2

Drill and Irrigation Class	shot bit CZ22	a set of	2
	geological drilling rig , hydraulic hand-style 150	a set of	3
	grouting pump (used for low-pressure mud)	a set of	5
	slurry mixer	a set of	2
	mortar mixer	a set of	5
Aggregate Processing Class	jaw crusher 600×900mm	a set of	1
	the bottom of the cone crusher φ1650mm	a set of	1
	the bottom of the cone crusher φ1750mm	a set of	1
	ball mill φ2150mm×φ3600mm	a set of	1
	single crew of the sand washing machine φ1200mm	a set of	1
	spiral classifier φ1200mm	a set of	2
	heavy shaker 1500×3000	a set of	1
	heavy shaker 1750×3500	a set of	1
	feeder disk DB-1600	a set of	2
	feeder trough K3-500t/h	a set of	1
electromagnetic feeder 45DA	a set of	1	
Concrete Construction	concrete mixing plant (HZ75.0A , 45kW)	a set of	1
	concrete mixer material 0.8m ³	a set of	2
	volume of the concrete mixer 3.0m ³	a set of	2
	concrete pump 30m ³ /h	a set of	5
	concrete jet 75L	a set of	1
	vibrated rods 2.2kW	a set of	1
	volume of the concrete hanging pot 0.25-1.0m ³	a set of	3
	wind (sand) squirt (with air consumption for sand 2-6m ³ /min.)	a set of	2
slip form pressure equipment			
Transportation Class	cable machine 20t radiation	a set of	1
	truck gasoline type 5t	a set of	5
	rear dump truck diesel type 28.5t	a set of	2
	rear dump truck diesel type 14.6t	a set of	5
	tire rack car	a set of	50
	mobile tire machine 500mm	a set of	10
	spiral air pump 65t/h	a set of	1
Other Machinery	hoister 2t	a set of	1
	centrifugal water pump 10kW	a set of	1
	centrifugal water pump 15kW	a set of	1
	mobile air compressor 6m ³ /min	a set of	4
mobile air compressor 10m ³ /min	a set of	1	

	welding machine	a set of	2
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According to the figure, the main sources of noise are 173 machines including:

1. machines for digging earthwork such as down hole drill, excavator and loader,
2. machines for casting concrete such as crawler crane, concrete pump and concrete bucket,
3. machines for drilling and grouting,
4. machines for making concrete such as crusher, screener, clay washer and concrete mixer, and
5. Other processing equipment such as carpentry, repair, air compressor, water pump and transformer.

The sources of noise can be categorized as stationary and motional according to how they function.

Figure 2-7 shows the intensity of different sources of noise during the project. The figures were from on-site measurement and empirical estimation.

Figure 2-7 A Sheet of the Project's main noise source and level

Type of Sound Source	Mechanical Name	equivalent acoustic level
fixed point source	excavator, Car loader, truck mixer, grouter	95-100
mobile line source	truck, bulldozer	85-95
demolition noise	Demolition	130

The construction will be operated in a gorge, and the transmission of the noise will be cut off by mountains and hills. As a result, the impact of noise will be confined to the construction site and areas next to it. To some extent, the noises from such as tunneling and blasting will affect the staff and the wildlife in the gorge. But the impact will no longer exist once the construction is finished.

2.10.2 The Submergence Caused by the Reservoir

The hydropower station being located in the gorge, much of the land to be submerged is wild or covered by plantations. And only one town will be affected by the submergence. The maxim storage level of the reservoir is 462 meters high, submerging an orange plantation of 80 mu (approximately 486 acres) with 6800 orange trees two kilometers away from the dam. No farming land, resident, house, mine or cultural heritage will be submerged by the reservoir. So the issue of migration will not be brought up.

The design of submergence for the dam meets the requirement of the *Regulation of Design of Submergence Treatment of Hydropower Stations*. The land to be submerged will be defined strictly according to the normal storage level of the reservoir. And indexes of objects submerged will be offered by the owners of the land.

Part of vegetation will be submerged by the reservoir, which will reduce the number of plants in the area. And the enlarged aquatic habitat will affect the number, species and distribution of aquatic organisms. The land submerged means the habitat for terrestrial animals diminishes. Not long after submerged, the organic matters will be destructed and nutritive substance given out into the water, which may affect the environment. What's more, geological problems such as landslide and leakage may occur during the storage of water.

In general, the impact of the submergence is mainly on environmental factors such as terrestrial plants and animals, aquatic environment, geological environment and the

way the land is exploited.

2.10.3 The Operational Period of the Project

The project is operated through storing water, generating power and water discharging. No waste water or other contaminants will be discharged. After the construction is finished, the reservoir will be put into operation and the dam will function to cut off the current. This will cause irreversible impact on the environment.

The reservoir may silt up after water is stored in it, since the water level is raised and velocity slows down. And the environmental factors will alter from the original state after the reservoir is put into operation. Besides, an artificial lake will be formed in the upper reach of Nan River because of the dam of the second grade power station built by the mid course of the river, leading to changes in hydrographical factors such as water level, velocity, water temperature and silt. The quality of water may worsen, since the velocity slows down and the self-purification capacity of water is thus weakened. The conservation of water will also affect the environment of aquatic organisms on both sides of the dam. At the same time, the riparian area by the reservoir basin will also be faced with ecological challenges due to the operation of the reservoir.



3 The Current State of the Environment

3.1 A Brief Introduction to the Natural Environment

3.1.1 The Natural Environment

As a branch of Wei Shui water system, Nan River crosses Dongting Lake before it merges into Yangtze River. It's course in Wufeng Tujia Autonomous County is 44 kilometers long, accounting for one of the longest rivers in the county. Qilinguan River is in the middle reaches of Nan River under the jurisdiction of Heping Town, Wufeng Tujia Autonomous County. Stretching from 110°04'09"to 110 °08'53"East of longitude and from 30°03'46"to 30°04'52"North of latitude, from its source in Beiyamen with an altitude of 1,260 meters, the river flows eastward across Qingshuiwan, Shengziping and Renhe Plateau before flowing into the City of Songzi at Huangyanlin. The riverbed of the mouth is 147 meters above the sea level. The reaches of Nan River in Wufeng Tujia Autonomous County are as large as 310 square kilometers with an average channel bed slope of 15.23‰.

The river is surrounded by mountains and deep gorges. Most of the sheds are 1,200 meters above the sea level. In the west, the mountain of Yuzhanhua is 1,380 meters above the sea level. In the south, the shed of Lilinkou is as high as 1,430 meters. In the north, the shed of Huangjiatang is as high as 1,350 meters. The reaches is 1,100 meters higher than the east. With a length of 245 meters, Qilinguan River accounts for 58% of the reaches of Nan River with concentrated water fall. Qilinguan River is also a site for constructing a dam because it contains the most hydro energy in Nan River.

The area where the dam is to be built belongs to gorge geomorphology with dissolution and erosion in medium and low hills. Having been undergoing erosion and denudation for such a long time and separated by the watershed, the general topography of the area is complex based on a third- level karst terrace with an altitude of 1,000- 1,300 meters formed in the late Tertiary Period. Outside the valley, the

highest part of the mountain massif is by the place called Yanquanzi south to the survey area, which is as high as 1,272 meters. The highest site within the survey area is at the Ridge of Nan River in the northwest with an altitude of 910.7 meters. The lowest site within the survey area is the Valley of Nan River, whose downstream is 385 meters at an altitude. The maximum relative difference in elevation is about 526 meters. The western part is generally higher than the eastern part. The mountain massifs on both banks keep stretching, between which there develop many micro-topographical features such as karst trench, uvala, terrace and karst trough valley.

The linear distance between the site of the dam and the backwater at Yangmudong Bridge is about 6.2 kilometers. The course between the two sites is about 7.8 meters long and is in a meandering shape, stretching in an E- W trend. The river flows eastward through the area of the project. According to the trend, the river can be generally divided into four parts, including one reach and three meanders. The general trend of the reach is from 90° to 95°. The trends of the meanders are respectively 40°, from 165° to 175°, from 130° to 140°.

Most areas of the banks consist of precipices. The precipices are of different elevations. The highest is of more than one hundred meters. Most of the precipices pose a dip angle of more than 60° or are even vertical, with bedrocks exposed in the air. The topography is mostly because of erosion, but dissolve corrosion also plays a part in it. The course is narrow, the width of which is between more than 10 meters to more than 50 meters. And where the river runs through in the area are mostly V-trough valleys. The elevation of the riverbed of the course beneath Yangmudong Bridge is about 516 meters, and that of the course by the dam is 390 meters. The drop is more than 120 meters.

Most of the riverbed is covered with alluvial and colluvial deposit, part of it with pebbles or boulders. The thickness of the deposit is one to two meters. Most of the riverbed is with exposed bedrocks, with many troughs, some of which are as deep as three to four meters. This shows that the area was in a period of **orographic uplift in**

recent times. The riverbed was formed mostly through erosion. The general hydraulic slope of the riverbed in the reservoir basin is about 12%.

3.1.2 The Meteorological Characteristics

The Nan River flows in the mountains of Southwest Hubei Province, belonging to subtropical monsoon climate. The four seasons alternate with quite distinct characters. It's hot and humid in summer and cold and foggy in winter. The climate there is also greatly affected by the geographical position and can be divided into several vertical climate zones. There is no meteorological station in its reaches. The nearest meteorological station is Wufeng Meteorological Station, whose meteorological statistics displayed in detail in Figure 3- 1 can be referred to for the design of the project. And the statistics of the average temperature in each ten-day period of a year are displayed in Figure 3- 2.

Figure 3-1 A Figure of the Related Meteorological Eigenvalue of Five Peak Weather Station

Serial Number	Items	Unit	Number
1	yearly mean temperature	°C	13.5
2	highest temperature	°C	37.1
3	lowest temperature	°C	-15
4	yearly average absolute humidity	pa	1270
5	yearly average relative humidity	%	76
6	yearly average wind speed	m/s	1.3
7	maximum wind speed	m/s	15
8	prevailing wind direction		ESE、 SE
9	yearly average sunshine hours	h	1533
10	yearly average frost-free period	d	247

**Figure 3-2 Multi-year Average Temperature by Ten-day period at First Class
Dam Site Area**

Month	January			February			March			April		
By Ten-day Period	The First Ten-day of a Month	The Second Ten-day of a Month	The Third Ten-day of a Month	The First Ten-day of a Month	The Second Ten-day of a Month	The Third Ten-day of a Month	The First Ten-day of a Month	The Second Ten-day of a Month	The Third Ten-day of a Month	The First Ten-day of a Month	The Second Ten-day of a Month	The Third Ten-day of a Month
Average	1.8	1.8	1.8	2.5	3.3	3.6	6	8.7	9.5	11.3	13.3	15.2
Monthly Average	1.8			3.13			8.07			13.27		
Month	May			June			July			August		
By Ten-day Period	The First Ten-day of a Month	The Second Ten-day of a Month	The Third Ten-day of a Month	The First Ten-day of a Month	The Second Ten-day of a Month	The Third Ten-day of a Month	The First Ten-day of a Month	The Second Ten-day of a Month	The Third Ten-day of a Month	The First Ten-day of a Month	The Second Ten-day of a Month	The Third Ten-day of a Month
Average	15.9	16.8	19.1	19.9	21	22	23.4	24.4	24.8	24.1	23.4	22.8
Monthly Average	17.27			20.97			24.2			23.43		
Month	September			October			November			December		
By Ten-day Period	The First Ten-day of a Month	The Second Ten-day of a Month	The Third Ten-day of a Month	The First Ten-day of a Month	The Second Ten-day of a Month	The Third Ten-day of a Month	The First Ten-day of a Month	The Second Ten-day of a Month	The Third Ten-day of a Month	The First Ten-day of a Month	The Second Ten-day of a Month	The Third Ten-day of a Month
Average	21.1	18.8	17.7	15.4	13.9	12.5	10.4	8.9	6	5.2	4	2.4
Monthly Average	19.2			13.93			8.43			3.87		

3.1.3 A Brief on the Geology of the Area

3.1.3.1 The Tectonic Setting of the Area

The area for all the construction work is tectonically in the east of Changyang Platformal Belt which is southwest to Bamianshan Platformal Belt of Yangtze Paraplatform. Changyang Platformal Belt is distributed in an arc of NE- NEE- EW strike, consisting of two anticlinal zones and a synclinal zone between them. Changyang- Zhongying Anticlinorium Zone stretches from the west to the northwest of the belt. It includes Changyang Anticline and Zhongying Anticline in an echelon. The core stratum of the zone is Ordovician and Cambrian. In the east and the southeast part lies a Ma'anshan- Liushumiao fold of anticlinorium, including Ma'anshan Syncline, Liangshan Anticline, Renhe Plateau Syncline and Ziliangping Anticline. The folds are in a structure of echelon, of which the anticlines are saddle-like and synclines trench-like. Between the two anticlinal zones is Hefeng- Wufeng synclinorium zone with fractures. The site where the reservoir is to be built is in Renhe Plateau Syncline of a younger tectonic generation. Graph 10 is the tectonic map of it.

Renhe Plateau Syncline is tectonic dominative in the survey area. The syncline stretches from the east to the west with the axial plane of 60 kilometers long and of 10 kilometers wide overturns southward. The core stratum mainly belongs to Jialingjiang Formation of Lower Trias. The flanks of it are mainly formed from the Period of Daye Formation to Ordovician Period. The dip angle of the strata in the north flank is gentle from 10° to 20°, but the part of it near the trough is steep and can reach 60°. However, the part near Yuyangguan is gentle and its attitude is not in order because of the faults. The south flank of the syncline overturns. It first inclines northward then southward, with a dip angle altering from 80° to 20°. There are developed secondary folds along

the flanks of the syncline. And there are Menbantang Anticline and Xiangumiao Anticline in the survey area.

Ziliangping Anticline is asymmetrical to the south of Renhe Plateau Syncline. Its axis stretches from east to west and the axial plane leans southward. The core stratum is Cambrian. The flanks consist of geological features from Ordovician to Dyas Period. The northern flank of it has been disturbed by Quchihe Fault.

The faults of the survey area can be divided into three categories of NNW strike, NE strike and EW strike according to the different directions.

1. The fault of NE strike mainly exists in Liujiachang which is east to Renhe Plateau. It consists of several smaller faults and stretches about from one kilometer to 10 kilometers. Its strike is from NNE to SN. The fault crosscuts the east end of Renhe Plateau Syncline. The dip angle of the section generally reaches 70° to 40° . The fault consists of developed breccias rocks of various sizes, most of whose diameter is one to two meters. There are strias on the surface of the section. This fault is mostly normal horizontally thrust and is in a large scale. The dip angle of the east part can reach 70° . The tectonic features of the fault vary from Paleozoic to Cretaceous and are arrayed in gentle waves. Some of them get branches. The rocks fractured zone of the fault was destroyed. The grains of the breccia were aligned. There are vertical strias on the section. Because of the fault, the rockbed in the southwest overturns with diminished thickness and reverses on the Cretaceous bed. This shows that Tianyangping fault mainly belongs to compressive structure.

2. Yuyangguan Fault is on the north of Renhe Plateau Syncline and stretches on the land from Shatuya to Yuyangguan, parallel to the axis of the syncline. The fault is about 40 kilometers long. West to Yuyangguan, the strike of the fault is NEE. The strike changes to EW with its way eastward. The dip angle of it is from 40° to 60° to the south or southeast. At Yuyangguan, the fault is imbricately structured with parallel reverse faults and the features of its rockbeds are from Cambrian to Sulfuric. There

formed rocks of breccia varying from less than a meter to several meters wide along the fault. The rock bed near the fault was strongly pressed and there formed drag folds along the fault. The fault can be defined as mainly compression and scissor fault.

3. From Renhe Plateau to the oblique south wing of Quchihe lies the Quchihe fault. It is about 5,000m long and of a gentle undulating shape, roughly parallel to the anticline of Ziliangping axially and approximately striking the E-W direction. It inclines towards south with a 70~80° dip angle. The strata of along faults sustain strong compression (e.g.: a series of drag folds and parallel reverse faults appear in the Ordovician and Silurian formation of Quchihe, Ziliangping and Wangjiahe). The fracture zone of the fault is 20~30m wide and of breccias development, belonging to pressure-shear fault.

3.1.3.2 Stability of Regional Structure

(1) Features of Neotectonic Movement

The general performance of neotectonic movement in the planning area is led by regional intermittent upheaval-depression movement and accompanied by the gradually weakening differential movement. The western mountainous area in the region ascends intermittently as a whole, forming multi-level denudation planation surface and valley terrace. Eastern Jiangnan plain subsides inherently with its subsidence center gradually moving towards east. The movement is mainly manifested as tilting movement between the upheaval and depression. In uplifted area, as well as in subsidence area and transition area, the differential movement is relatively weak and mainly appears as a few fractured reactivation movements. There's no evidence of quaternary fault's existence.

The manifestations of regional neotectonic movement include denudation planation surfaces, stream terraces, multi-level karsts, active faults and earth quakes. According to regional data, there develops Grade V denudation planation surfaces and

stream terraces of Grade I to Grade VI. The elevations of denudation planation surfaces are 1,700~2,000m, 1,250~1550m, 950~1,200m, 750~900m and 350~700m. Terraces mainly develop in big rivers. For instance, there is Grade VI terrace in the main stream of Yangtze River, a Grade IV terrace in the main stream of Qing River. Among them, terraces of Grade I and Grade II are mainly accumulation terrace while those of Grade III to Grade VI are mainly seat terraces.

In this region, karsts are well developed in the carbonate rock stratum with obvious feature of multi-phase. Basically its time of stage is in accordance with the development stage of geomorphy. It can be divided into five stages, among which Stage V (i.e. Three-gorge Stage) is the latest and karst forms in this stage are relatively complex and are best preserved. During that stage, the earth crust had several short pauses during its ascent. Therefore, corresponding to the terraces, karst forms, like multilayer karst caves and underground rivers, developed. For example, there are multilayer horizontal karsts on both banks of Nan River.

There are several active faults in this region. Those which are large and may affect reservoirs are: Fairy Mountain fault (or Duzhenwan fault), Tianyangping fault, Yuyanguan fault, Xinhua fault and Sun Mountain fault, etc. These faults have been acting in some degree since the Tertiary. But according to the research done by Yangtze River Water Resources Committee and other units, the main period of their activities is in N_2 ~ Q_2 period (equal to 200,000 years~100,000,000 years) and the displacement of their activities is not very big. And their activities have been weak or have ceased since Q_4 .

The aggregate level of regional ground stress is not high. And from the displacement analysis of crustal deformation in three gorges area and analysis of

earthquake focal mechanism, we can conclude that the dominant direction of this region's maximum principal stress is NE. This region could be used as a reference.

To sum up, the intensity of neotectonic movement in this region is low and the activity intensity goes on weakening. The general feature presents that large-area intermittent lifting is the major activity mode while the fracture differential movement is weak with distinct characteristic of inheritance.

(2) Regional Tectonic Stability

Qilinguan Reservoir is at the eastern margin of the terrain's second stair in China. It's high in the west and low in the east. On the west side is the continuously ascending low-medium mountainous area; on the east side is Jiangnan plain of large-area depression. In between, Longgang hilly region serves as the transitional zone.

In this region, the earth crust is of good integrity and the vertical stratification is clear. It can be divided in to upper crust, middle crust and lower crust. The upper crust includes crystalline base and overlying sedimentary cover; and the buried depth of basal surface is about 6~16km. The middle crust is granodiorite with steady thickness; the buried depth of basal surface is about 20~29km. The lower crust is basaltic rock and has a relatively stable velocity of transversal wave in general. It also belongs to marginal structure of stable platform.

According to the standard of *Seismic Ground Motion Parameter Zonation Map of China of PRC* (GB18306-2001), the seismic ground motion peak acceleration in the area to the west of Wufeng County is less than 0.05g range (it equals to Grade VI in earthquake basic intensity). In eastern and northern part of the town the seismic ground motion peak acceleration equals to 0.05g range. Among them, the seismic ground motion peak acceleration in the area from Changde to Jinshi in Hunan

Province and the area from Zhushan to Zhuxi in Hubei Provinces in the 0.1-0.15g range. The seismic ground motion peak acceleration of Qilinguan Reservoir pivot is 0.05g. The earthquake basic intensity is Grade VI and the corresponding seismic ground motion characteristic period of response spectrum is 0.35s.

3.1.4 Engineering Geological Conditions of the Reservoir basin

3.1.4.1 Topographic Features

Due to the intermittent lifting of earth crust, multi-stage platform, corresponding uvala and horizontal karst cave system have formed in the survey area. Typical platforms can be divided into six grades. Below are the development elevation, distribution position and geomorphic features:

(1) Grade VI Platform (elevation: 950-1,200m)

It is distributed in the periphery of survey area. South bank is distributed along the area of Zhangchiling, Wayanjing, Dafengya and Heping, 2~3km away from Nan River; north bank is distributed along the area of Liujiaping, Youjialing, Wujianao, Paolunao and Baiping. The platform erosion has formed the highest grade topographic watershed of Nan River basin. The platform is approximately equal to the Nagorye period product in the Yanshan movement Episode III at the end of Paleogene in the area.

(2) Grade V Platform (elevation: 800m)

It is mainly distributed in the margin of survey area. The southern platform is roughly spread in the east-west direction and is about 500-800m wide. The northern platform, 3.4km away from river valley at its broadest, has a wide distribution. The platform has been basically destroyed with only residual flat-station geomorphology

in the local site, like Fangjiadun in the periphery of southern survey area, Shengjiachong and Dalishu. The original appearance of platform is still distinct. The platform of this period is approximately equal to the mountain-basin period product in the Xishan movement Episodellat the end of Neogene in the area.

(3) Grade IV Platform (elevation: 610-660m)

It is relatively well-developed in the area with a gentle slope. It is of wide shape and contrasts violently with the topography of areas above the elevation. It presents a distinct macro morphology pattern, forming a gentle slope and flat open geomorphology. The width of terrace at the dam site reaches 1,700m at its broadest. In contrast with the area, the elevation is approximately equal to the cloud-basin period product in the last episode of Xishan movement at the end of early Pleistocenein

(4) Grade III (elevation: 560-580m)

It is distributed on two banks of Yangmudong, Xiangshuitang, spots near river bank to the south of Labadong, Heiyanzui and Tonggubao, etc. The platform is generally covered with quaternary eluvial clay, most of which is arable land.

(5) Grade II Platform (elevation: 480-540m)

It is sporadically distributed on both banks of river valley. The relatively large sections include Yangmudong, Liujiahe, Menbanchong, Heiyanzui and Tonggubao, etc. The platform is generally covered with quaternary eluvium of small thickness, all of which is arable land.

(6) Grade I Platform (elevation: 440-480m)

It is not well-developed and of small size, mainly distributed in Jianjiatai, northeast of Gumudong, etc.

3.1.4.2 Formation Lithology

The bedrock of Triassic Jialingjiang Formation and quaternary sediments are distributed in the survey area. The introduction is as follows:

(1) Layer of first rock property is made up of gray earthy dolomitic limestone with microcrystalline phanero-crystalline texture. The monolayer is 5 ~ 15cm thick in thin-bedded or medium-thick bedded shape.

(2) Layer of second rock property comprises three parts. The upper part is made up of dark gray and grey-black laminated limestone; the monolayer is 8 ~ 20cm with microcrystalline texture. The middle part is made up of purplish red and brick red solution collapse breccias of thick layer; rocks are hard in this part. The bottom is made up of argillaceous limestone of ultra-thin bed and calcareous shale with unstable distribution.

(3) Layer of third rock property is made up of argillaceous limestone and limestone. Most monolayer is 0.5-4cm thick with interlayers made up of limestone and multi-layer calcareous shale which are 5 ~ 10cm thick and are tabular in shape.

(4) The fourth lithologic layer can be divided into three layers according to bed thickness and lithologic character. Ranged in the order from old to new, they are: First is limestone of medium thickness seam in charcoal grey with 30 ~ 40cm-thick monolayer and the development of argillaceous stria belt. Second is thin-bedded limestone with monolayer which is about 15cm thick. It is intercalated by thin-bedded limestone and limestone of medium thickness seam, with dolomitic limestone, argillaceous limestone and solution collapse breccias developing in part. Third is limestone of medium thickness seam in charcoal grey. With stylolite developing on it, it has 30 ~ 50cm-thick monolayer and is mixed with a small amount of thin-bedded limestone and argillaceous limestone.

(5) The fifth lithologic layer is mainly made up of dolostone. In the bottom is ultra-thin-bedded argillaceous limestone which is more than ten meters thick and mixed with one layer of solution-collapse breccias. The middle part comprises thin-bedded and ultra-thin-bedded argillaceous limestone. The upper part is made up of dolomitic limestone.

(6) The sixth lithologic layer is the main composition of bedrock at the dam site. Rock is mainly made up of thin-bedded limestone with 8 ~ 15cm-thick monolayer.

(7) Eluvium and residual sola, which are mainly maroon loam with a few fragments of stone, are distributed extensively in uvala and through valley. They are mainly equal to or less than 3 ~ 4m thick, most of which are about 1 ~ 2m thick.

(8) Alluvium: uplifting and erosion of modern age plays a major role in Nan River. The thickness of Quaternary deposits there is not big.

(9) Developing in the steep-dip-angle rock section of Shunhe (Shun River), the deposits of collapse and slide in survey area are mainly distributed in the B1, B2, B3 and B4 region. Most of them are mega block stone. Because their cubic amount is not big, they only exert a little influence on the reservoir.

3.4.1.3 Geologic Structure

(1) Fold

Renhe Plateau Syncline

The axis of Renhe Plateau syncline goes through the line of Hujiawuchang, Yaomona, and Nan River Ling (South Water Ridge), extending on East-West direction. Though the axial plane reverses and dips towards south on the whole, distortions appear in different parts. Therefore the axial plane changes a lot. Those characteristics show the complexity of structure in this area, the possibility of later

reformation, and the asymmetry of tectonic forces on different parts of Renhe Plateau syncline structure.

' **Menbanshang Anticline**

Menbanshang anticline is a sub-level fold in this area, only next to Renhe Plateau syncline. The fold's axis approximately strikes the East-West direction, roughly parallel to Renhe Plateau syncline, and goes through the whole region. It's on the line from the spot which is 400m south to Meijiahe (the river by the Mei's), Menbanshang to the spot which is 300m south to Niujiashang. The core formation is comprised by argillaceous limestone, breccias and limestone. Two limbs are mainly made up of ultra-thin-bedded limestone. The occurrence on two limbs of anticline dips moderately, appearing gentle and broad compared with Renhe Plateau syncline. This anticline decides the structural morphology of the south bank of Nan River.

' **Complex Fold**

During the formation of big fold, many small-sized complex folds develop between the Renhe Plateau syncline and sub-level Menbanshang. The complex folds, the majority of which are gentle-shaped, develop in limestone of thin bed and ultra-thin bed. Most are open folds with a few tight folds. The axis is roughly parallel to the big fold.

(2) Fault

The comparatively large fault of this area, which mainly develops in the core section of Renhe Plateau syncline, is mainly distributed on the north bank of Nan River. Therefore it only has a little influence on the forming of reservoir.

3.1.5 Geological Conditions of Dam Site and Secondary Power Station Area

3.1.5.1 Geological Conditions of Dam Site

(1) Lithologic Features of Strata

Most outcropped rock in the dam site is limestone of Jialingjiang Formation with Quaternary system cropped out in a very few areas.

A. Slope Deposits

The slope deposits are distributed on one side of river bend's concave bank in the lower reach of dam site. They are mainly pebbly sand, mixed with clay. The slope deposits are 1~3m thick, containing products of Nan River's alluviation and eluvial.

B. Eluvium

Distributed in the gully in the lower reach of right abutment and on the ramp at the river bend in the lower reach of left abutment, the eluvium is mainly made up of loam and mixed with a small amount of gravel. The thickness of eluvium is generally 2~3m.

Bedrock

The outcropped bedrock in the dam site belongs to the fifth stage stratum and the sixth stage stratum of lower Triassic Jialingjiang Formation. The analysis of the rock property is as follows:

A. The Fifth Stage Stratum of Jialingjiang Formation

It is made up of argillaceous dolomitic limestone, dolomitic limestone and siliceous dolomitic limestone. The outcrop of it is at river bend in the lower reach of dam site with an outcrop width of around 90m. Striking East-West direction, the rock is roughly vertical with a dip angle of around 80°. It dips towards north on the whole while part of it is reversed, dipping to south.

A. The Six Stage Stratum of Jiajingjiang Formation

It is made up of thin-bedded limestone, dolomitic limestone and argillaceous limestone, with a thick bottom layer. It can be divided into four layers from top to bottom:

The first layer: In the first layer is made up of grey and charcoal grey limestone, thick-bedded and huge-thick-bedded dolomitic limestone. A large number of siliceous lumps develop in the bottom. In light of region, the diameter of a lump can be as large as several meters. It is distributed 170m downstream of the dam site. The outcrop is more than 20 meters wide and the stratum is 15 meters thick. Striking East-West direction, the rock dips steeply towards north on the whole with a dip angle of around 70-80°.

The second layer: In the second layer is grey thin-bedded and medium-thick-bedded limestone. In general, the monolayer is 8-15cm thick while bed thickness in some parts is 20-30cm. The bedding is well-developed. It is distributed 120m downstream of the dam site. The outcrop is 70-80 meters wide and the stratum is 46 meters thick. The rock strikes East-West direction with small folds developing between the layers. The dip angle of stratum varies greatly within the range of 20-80°. It dips towards north on the whole while part of it dips to south. Usually, there are small fractures developing in small tight anticline.

The third layer: This layer is grey ultra-thin-bedded limestone mixed with thin-bedded limestone, containing a small amount of argillaceous limestone and dolomitic limestone. Distributed 50m downstream and 20m upstream of the dam site, it has a monolayer thickness of 3~8cm, acting as local aquifuge. Influenced by its structure, two bands cropped out in the two limbs of this syncline. The outcrop width of each is around 28 meters. The stratum is 21 meters thick. The rock strikes East-West direction, with steep dip angles which are mostly in the range from 40° to 90°.

The fourth layer: It is grey thin-bedded limestone, mixed with a small amount of thick-bedded limestone. The monolayer is 8~15cm thick. It is distributed on the dam site and at the upper reach and the lower reach of the dam. The stratum is 59m thick. Striking East-West direction, the rock dips steeply towards north on the whole with a dip angle of around 70-80°.

3.1.5.2 Geological Structure

The general distribution in the dam area is stable and on East-West direction. Most strata have high dip angle while some part is relatively gentle. The general structural outline is decided by Renhe Plateau syncline. In storage area, the river's main body, which is of longitudinal valley structure, flows in East-West direction, approximately consistent with major trajectory direction. However, the river, which is of oblique crossing valley structure, strikes NNW-SSE direction, intersecting the stratum strike in large angle. The major structural features are folds, faults, joints and fissures.

(1) Folds

The Dam site is in the core section of Renhe Plateau. In general, it is regional inverted syncline. The axial part dips toward south. There is sub-level fold structure, which is associated with one anticline and two synclines, in the middle part of this syncline. The dam site is located in the syncline area near the southern side where more sub-level anticlines and synclines develop. The dam site is on the southern limb of a tight anticline. Consistent with the regional syncline axis, those sub-level folds is distributed on East-West direction. The folds are tight and the axial plane deflects towards south. At the meantime, because the rock is mostly thin-bedded, it experiences strong tectonism. Therefore, on both banks in the upper reach and lower reach of the dam site emerge small interlayer folds which are often accompanied by small fractures.

(2) Faults

Five faults develop on the dam site. The overall size of these faults is small. The faults, formed by strong dislocation of rock which bears compression, usually appear in the hinge zones of small interlayer folds. The dip angle of fault surface is relatively large. Except for f1 fault, the separation is relatively small. The f1 fault is a low-angle reverse fault which is located in the dam abutment, affecting the antiskidding stability of dam abutment.

(3) Fissure System and Its Characteristics

Due to strong tectonism, the folds are tight and the rock is both hard and brittle. Meanwhile, the river valley is deep cut, both river banks are high and steep, and unloading is relatively strong. Therefore joints and fissures develop.

3.1.5.3 Hydrological and geographical Conditions

(1) Development Characteristics of Karst in the Dam Site

Much as the same way in storage area and periphery of the dam site, the karst development on the dam site is very regular. The karst phenomena can be divided into two categories: surface corrosion phenomena and underground corrosion phenomena. The surface corrosion phenomena include uvala, corrosion through and corrosion bud, etc. The underground corrosion phenomena include horizontal karst cave, ponor, corrosion crack and corrosion pore, etc. The development degree of karst depends on lithologic characteristics, rock structure and activity history of crustal uplift.

According to survey, fifteen karst caves develop on the dam site and its periphery, most of which develop in the four altitude zones of 540~560m, 49~492m, 440-460m and 400-408m. Five of them develop on the dam site.

According to the elevation of slight karst lower boundary revealed by boreholes in the dam site, the elevation of karst lower boundary near the river valley on the dam site is

usually within the range of 360m-390m. Basically, there is a certain degree of corrosion above that elevation. The permeability is generally good with an average permeability rate of 8.12Lu. However, karsts do not develop below that elevation. The rock's permeability is relatively poor. The permeability rate is usually 3.01Lu. This part of karsts should be near-bank and near-surface karst boundary, belonging to the type of small corrosion pore and corrosion crack. Routine grouting is easily blocked. The leakage of this karst only exerts a little influence on the reservoir, so there's nothing to worry about.

Besides, according to the situation revealed by the surface survey, boreholes and adit, the karsts, as well as the karst fissures, are better developed on left bank than on right bank. The rock on left bank is relatively crushing and more permeable than the right bank.

(2) Groundwater Recharge, runoff and Discharge Condition

The overall mountain massif of slopes on both river banks in the dam site dips towards south. The meteoric water infiltrates into the underground from the slopes on both river banks. Part of it flows into Nan River through a gully. The groundwater, which is recharged by meteoric water, discharges into Nan River in the form of spring and fracture permeability.

The groundwater runoff in extension mainly flows in the form of fracture vein flow and channel flow. Because the permeability on consequent rock direction is far better than on vertical rock direction, the infiltration flow in the rock is mainly in the form of consequent rock direction. The dam site is large-angle oblique crossing slope, supplying good discharge condition for the groundwater runoff.

As for the engineering geological conditions of dam site and I hydroelectric power station plant, please refer to the eleventh attached drawing.

As for the engineering geological conditions of II hydroelectric power station, please refer to the twelfth attached drawing.

3.1.6 Sediments

The forest vegetation above Qilinguan Reservoir is relatively good. The soil is mainly made up of carbonate yellow soil, mixed with a small amount of limestone soil. We can cite the sediment transport modulus over years from the comparative station Wuxigou Station to calculate the sediment accumulation.

According to the statistical analysis, the sediment transport modulus over years from Wuxizhan is $467\text{t}/\text{km}^2$. This figure can be applied to

3.1.7 Soil

According to the soil survey of Hubei Province and the second soil survey of Wufeng County, soil in the project site can be divided into six categories: red earth, yellow earth, yellow brown earth, mountain meadow soil, limestone soil and paddy soil. Among them, red earth is distributed on gentle slopes or platforms which has a good drainage at a relatively altitude in the tour area. Yellow earth is distributed on top of read earth. Yellow earth, the soil type which is of relatively extensive distribution in the tour area, is distributed above yellow brown earth. Mountain meadow soil is distributed on the local gentle slopes at the mountain top in the tour area. Limestone is distributed from the top to the foot of the mountain. The distribution area of paddy soil is small; it is only distributed sporadically on the banks of river valley. Limestone is endodynamorphic soil developing on the parent material limestone. Its soil layer is relatively shallow, often mixed with gravel. It is suitable for the growth of north subtropical broad-leaved deciduous forest and mixed broadleaf/needle-leaf forest, such as the pine, cypress, and oak.

3.1.8 Land Plants

Wufeng Tujia Autonomous County is located in the western part of Hubei Province at mid-latitude with subtropical humid monsoon climate. There is plenty of plant resource. They comprise 126 families, 132 genera and 1,025 species of seed plants; five families, seven genera, ten species of gymnosperm; 121 families, 425 genera and 1,015 species of angiosperm, making up 63.00%, 31.88% and 17.85% of contribution to the flora of Hubei Province, respectively. As for detailed information about regional plant seeds, please refer to figure 3-3.

Figure 3-3 Regional Seed Plant statistical figure

Items	gymnosperm			angiosperm			total		
	family	genus	species	family	genus	species	family	genus	species
construction area	5	7	10	121	425	1015	126	432	1025
Hubei	9	31	100	191	1324	5550	200	1355	5741
China	10	34	238	291	2940	25000	301	2974	25291
the percentage of the tourist area of Hubei	55.56	22.58	10.00	63.35	32.10	18.29	63.00	31.88	17.85
the percentage of the tourist area of China	50.00	20.59	4.20	41.58	14.46	4.06	41.86	14.53	4.05

Among the 126 families of seed plants, 103 families, 81.75% of the total, like Family Taxaceae and Family Eucommiaceae, etc., contain Genus 1-4. Their existence is of great significance to the Assessment of characteristics of seed plants in this area. Fifteen families, 11.90% of the total, like Family Araceae and Family Araliaceae, and Family Berberidaceae, etc., contain Genus 5-10. Eight families, 6.35% of the total, contain genera above Genus 10. Among them, Family Asteraceae and Family Gramineae, etc. are large cosmopolitan families. Family Lamiaceae, Family Papilionaceae and Family Orchidaceae, etc. are families of medium size. These families are small in number, but they contain lots of genera. Therefore, they are an important source of flora diversity in this area.

3.1.9 Current Situation of Terrestrial Animal Resource

We have conducted a research on diversity of terrestrial vertebrates in Wufeng County, Hubei Province through filed investigation, interview survey and document searching. There are 109 regional terrestrial vertebrates (vertebrates which have no trace in years are not included here), belonging to four classes, 23 orders and 56 genera. There are 29 kinds of mammals which belong to seven orders and 17 genera, 54 kinds of birds which belong to 11 orders and 27 genera, 16 kinds of reptiles which belong to three orders and seven genera, ten kinds of amphibians which belong to two orders and five genera. As for specifics, please refer to figure 3-4.

Figure 3-4 A Statistical Figure of the Regional Terrestrial Animal Resources

Category Class	Order number	Family number	Species number	Protection Rank					
				National Key Point				Provincial Key Point	
				Category I	%	Category II	%	Provincial Level	%
Amphibian	2	5	10	0	0	0	0	7	70.00
Reptile	3	7	16	0	0	0	0	5	31.25
Bird	11	27	54	0	0	7	12.96	19	35.19
Mammalian	7	17	29	0	0	3	10.34	11	37.93

3.1.9.1 Population

The method of quantitative degree has been adopted to show the abundance of various animal groups' quantities. This survey has shown that there are 109 species groups of regional terrestrial vertebrates, which indicates that the survey is no counting of a single species group's quantity. Therefore we can not use the formula above to calculate the quantity of the 109 animal groups one by one. The only way to show the abundance of quantities of various animal groups is to adopt the method of quantitative degree on the basis of our research.

Quantitative degree: an animal population, which makes up more than 10% of the animals studied in unit area, is the local dominant species and represented by “+ + +”; an animal population, which makes up 1~10% of the total in unit area, is the local common species and represented by “+ +”; and an animal population, which makes up 1% or has only one in number in unit area, is local rare species and represented by “+”. As for Assessment standards of quantitative degree, please refer to figure 3-5.

Quantity Rank Evaluation Criteria

Population Condition	Mark	Criteria
Local dominant species	+ + +	Its quantity takes up over 10% of the total investigated animal in a unit area
Local normal species	+ +	Its quantity takes up between 1-10% of the total investigated animal in a unit area
Local rare species	+	Its quantity takes up below 1% or only one of the total investigated animal in a unit area

The statistical result has shown that there are nine local dominant species: *Pelophylax plancyi* (also known as the Eastern golden frog), *Pelophylax nigromaculatus* (also known as the Dark-spotted frog or black-spotted frog), *Zoacys dhumnades*, *Entechimu major*, *Phasianus colchicus*, *Cettia fortipes* (also known as the Brownish-flanked bush warbler), *Lepus sinensis* (also known as the Chinese hare), *Mutela sibirica* (also known as the Siberian mountain weasel, Siberian weasel, Kolinsky or Himalayan weasel), and *Sus scrofa* (also known as the Wild boar). There are 19 local common species: *Euphlyctis limnocharis*, *Paa spinosa* (also known as the Giant spiny-frog), Green japalure, *Eumeces chinensis*, *Elaphe mandarinus* (also known as the Mandarin Rat snake), *Elaphe rufodorsata* (also known as Red-backed Rat snake), *Bambusicola thoracicus* (also known as the Chinese bamboo partridge),

Streptopelia chinensis (the Spotted-necked dove or spotted dove), *Cecropis daurica* (also known as *Hirundo daurica* or the Red-rumped swallow), *Motacilla alba* (also known as the White wagtail), *Spizikes semitorques* Swinhoe, *Phylloscopus inornatus* (also known as the Yellow-browed Warbler or Inornate Warbler), *Parus major* (Great Tit), *Melophus lathami* Crested Bunting, *Rattus flavipectus*, *Rattus norvegicus* (also known as the Sewer rat), *Trogopterus xanthipes* (the Complex-toothed flying squirrel), *Arctonyx collaris* (the Hog badger), and *Muntiacus reevesi* (also known as Chinese muntjac.) The eighty-one left are local rare species.

3.1.9.2 Distribution Characteristics

(1) Horizontal Distribution

① Animal Groups in the Water Space and Its Periphery

a. Animal group reproducing and living in water: The amphibia Caudata animals distributed in the area almost spend their whole life in the water. Though they won't die if they are out of water for a short period, they still live in the water all the time and rarely go on land.

b. Animal group which reproduces in water and lives both in water and on land: The amphibia anura animals distributed in this area, i.e. all frogs, must reproduce in the water. They also go on land to find food. But because their physical structure does not adapt to terrestrial life perfectly, they cannot stay far away from aquatic environment and must go back to water uninterruptedly so as to absorb moisture through skin to add water previously lost on land by evaporation.

c. Animal group which lives and looks for food in the water: Wading birds include birds of Ciconiiformes, Gruiformes and Charadriiformes. They wade across shallow water and irrigated fields to look for aquatic, such as petite fish and little shrimps. We

have discovered that the amount of wading birds is relatively small, which may have something to do with the relatively small water area.

d. Animal group which looks for food in the water: Most kinds of Coraciiformes animals forage in the water. They stand on objects like branches on the shore side and fly to capture petite fish and little shrimps in the water. Besides, a few songbirds of Passeriformes also stand on objects like branches on the shore side and fly to capture petite fish and little shrimps in the water.

② Animal Groups Distributed in the Forest Belt

Animals distributed in the regional forest include: birds, mammals and part of reptiles whose home ranges are in the forest. These groups, which have many species and a large quantity, are the main body of animal groups in the forest. They mainly forage in the forest, shrubs in and along the forest, and the underbrush. Thus, it comprises the complex food web together with other animals and plants.

The species diversity of forest animals is an important factor in the balance of nature. Besides, forest animals are closely related to human life. They can provide human with multiple economic utilization channels. Forest birds, saurian reptiles and serpentry reptiles are important natural enemies of agricultural and forest pests and bandicoot. Therefore forest animals are a precious animal resource in this area.

③ Animal Group Closely Related to Human Economic Activity Area

Rodents are the mammal with most species and largest number (twelve in total, making up 46.15% of all the mammals). The living environment where Gonorrhynchidae and Cricetidae animals inhabit and human economic activity area overlap largely. Some species of Gonorrhynchidae and Cricetidae live alternately in domestic environment and wild environment as seasons change. For example, *Rattus norvegicus* and *Rattus flavipectus* would live in domestic environment in winter when

there's a food shortage in the wild environment; and they would go back to the wild environment in spring when the temperature rises and food is plentiful outdoors. Some species, such as *Apodemu agrarius*, *Rattus flavipectus* and *Rattus norvegicus*, and *Hystrix hodgsoni*, do great harm to agriculture and forest. Besides consuming a great deal of crops such as rice, wheat, corn and sweet potatoes, they also store numerous potatoes and precious herbs in the caves for winter. Some rodents are the main source for the spread of natural-focus diseases. In addition, some species of Passeriformes are important coexistent animals of human. They move and look for food in the residential area, capturing harmful insects and thus purifying environment.

(2) Vertical Distribution

① Vertical Distribution of Poikilothermal Animals

Amphibians and reptiles are poikilothermal animals, regulating body temperature through external temperature. Therefore most species like to move in low-altitude and warm area.

Among all amphibians distributed in the area, *Pelophylax nigromaculatus* (also known as the Dark-spotted frog, or Back-spotted frog), *Pelophylax plancyi* (also known as the Eastern golden frog), *Euphlyctis limnocharis* and *Bufo gargarizans* (the Asiatic toad) are dispersed species. Species of Microhylidae are mainly distributed in mid-altitude highland and water area. Paa frogs and stinky frogs are distributed in relatively high-altitude area.

Most reptiles are distributed in mid-altitude highland. However, among them, *Elaphe carinata* (also known as the King Rat snake or Keeled Rat snake), *Elaphe bimaculata* (also known as the twin-spotted rat snake or Chinese cornsnake), *Elaphe taeniura* (also known as Beauty rat snake) and *Zoacys dhumnades* are dispersed species, distributed at all altitudes.

② Vertical Distribution of Homoiothermal Animals

Birds and mammals are homoiothermal animals, with perfect body temperature regulation mechanism. Therefore they have extensive geographic distribution and vertical distribution. Most species are forest animals, mainly inhabiting areas with relatively good forest vegetation. That's because the forest community has good food web structure with relatively easy food source, providing good cover and inhabiting condition. As the food varies vertically with seasons changing, the animals form the characteristic of seasonal vertical migration. For example, they migrate to low-altitude areas in winter when there's a food shortage at high altitude; they migrate to high-altitude areas in spring and summer when the food is plentiful at high altitude.

3.1.9.3 The Number and Present Distribution of Wildlife Which is rare or near Extinction

There are 52 species of protected animals among regional vertebrates. Among them, there are ten species of wildlife under second class state protection: *Accipiter virgatus* (also known as the Besra), *Buteo buteo* (also known as the Common buzzard), *Falco tinnunculus* (also known as the Common Kestrel), *Purcraasia macrolopla*, *Chrysolophus pictus* (also known as the Golden pheasant or Chinese pheasant), *Glaucidium cuculoides* (also known as the Asian Barred Owlet), *Asio otus* (also known as Long-eared Owl), *Macaca mulatta* (also known as the Rhesus Macaque or the Rhesus monkey), *Ursus thibetanus* (also known as *Selenarctos thibetanus* or the Asian black bear), *Viverricula indica* (also known as the Rasse or the Small Indian Civet). These species amount to 9.17% of the total animal species in the area. There is no wildlife under first class state protection.

There are 42 species of wildlife under special province protection, making up 39.62% of the total species. Among them, there are 7 species of amphibians: *Bufo gargarizans* (also known as the Asiatic toad), *Paa boulengeri*, *Paa spinosa* (also known as Giant

spiny-frog), *Euphlyctis limnocharis*, *Pelophylax nigromaculatus* (also known as the Dark-spotted frog or black-spotted frog), *Pelophylax plancyi* (also known as the Eastern golden frog), *Microhyla ornata* (also known as Ornate Narrow-mouthed Frog). Five species of reptiles also belong to the wildlife under special province protection: Green Japalure, *Elaphe mandarinus* (also known as Mandarin Rat snake), *Elaphe carinata* (also known as the King rat snake or Keeled rat snake), *Elaphe taeniura* (also known as Beauty rat snake), and *Zoacys dhumnades*. Nineteen species of birds are include in the conservation list: *Bambusicola thoracicus* (also known as the Chinese Bamboo Partridge), *Phasianus colchicus*, *Streptopelia chinensis* (also known as the Spotted-necked dove or the spotted dove), *Cuculus micropterus* (also known as the Indian Cuckoo), *Cuculus canorus* (also known as the Common Cuckoo), *Upupa epops* also known as the Hoopoe), *Picus canus* (also known as the Gray-faced woodpecker), *Hirundo rustica* (also known as the Barn swallow), *Hirundo daurica* (also known as *Crecropis duarica* or the Red-rumped swallow), *Lanius schach* (also known as the Long-tailed Shrike), *Oriolus chinensis* (also known as the Black-naped Oriole), *Dicrurus hottentottus* (also known as the Hair-crested drongo), *Garrulus glandarius brandtii* (also known as the jay), *Urocissa erythrorhyncha* (also known as the Red-billed blue magpie), *Cyanopica cyana* (also known as the Azure-winged magpie), *Pica pica* (also known as the European magpie or Common magpie), Melodious Laughingthrush (also known as *Leucodioptron canorum* or the Chinese Hwamei), *Parus major* (also known as the Great tit), and *Melophus lathami* Crested Bunting. Eleven species of mammals are also in the list: *Lepus sinensis* (also known as the Chinese hare), *Trogopterus xanthipes* (also known as the Complex-toothed flying squirrel), *Petaurista alborufus* (also known as the Red and white giant flying squirrel), *Callosciurus erythraeus* (also known as the Pallas's squirrel), *Hystrix brachyura* (also known as the Malayan porcupine or Himalayan porcupine), *Nyctereutes procyonoides* (also known as the Raccoon dog), *Meles meles* (also known as the European badger or Eurasian badger), *Arctonyx collaris* (also known as the Hog badger), *Paguma larvata* (also known as the Masked palm civet or Himalayan palm civet), *Prionailurus*

bengalensis (also known as the Leopard cat), and Elaphodus cephalophus (also known as the Tufted deer).

Affected by the exploitation and development of wildlife resource in years, the quantity of nationally protected animal groups is relatively small, under the due carrying capacity of habitat. The birds of Galliformes are hunted in large number. Though their reproductive ability is relatively strong, their number is largely affected.

3.2 Current Situation of loss and Conservation of Soil and Water

3.2.1 Current Situation of Soil Erosion and Water Loss in the Project Area

The test results of remote sensing technology by Hubei Province Water Resource Bureau has shown that the current area of soil erosion and water loss in Wufeng County is 1058 km², accounting for 44.75% of the total county area. The light loss area is 380 square kilometers and the medium loss area is 527 square kilometers. The two areas are mainly distributed in Wufeng County and Wantan County. Heavy loss area is 112 square kilometers, mainly distributed in Yuguan, Wufeng County, Renhe Plateau County and Caihua Village. The extremely heavy loss area is 39 square kilometers, mainly distributed in Yuguan County and Wufeng County. The annual average soil erosion modulus is 2659 t/km² and 6,372,000t.

3.2.2 Current Situation of Soil and Water Conservation in the Project Area

The soil and water conservation, whose main project is Terracing of Sloping Fields

project, started in Wufeng County started at the end of 1950s. The comprehensive treatment has been carried out in the unit of province administrating Changpuxi, Baiguowan, and small water space of Qianping since 1980s. In recent years, Wufeng County has been listed as a key administration county of ecological environment and national debt on soil and water conservation in central budget.

3.3. Social Environment

3.3.1 Socio-economic Condition of Wufeng County

Located in the southwest of Hubei Province, Wufeng Tujia Autonomous County was originally called Changle County and then changed into the current name. Having obtained consent from State Council in July, 1984, Wufeng Tujia Autonomous County was founded. It has an area of 2,372 square kilometers, administrating five towns and three villages. The Tujia accounts for 67% of the whole population which is 208,000.

Wufeng County enjoys a distinct natural environment, for which it is renowned as "wonderland". Green streams meander through between ridges and peaks of the county. Abundant in natural resources like water energy, minerals, forest specialties, and tourism, Wufeng County promises a bright future for development.

Before the founding of our country, Wufeng County was very backward in its economy and its people suffered greatly. After our country was founded, the production relations and people's living standard have gradually improved. Benefited from the policy on ethnic affairs and the reform and opening up, the national economy has grown rapidly, especially in the twenty years after the Third Plenary Session of the Eleventh Central Committee of CPC. Since then, we have taken on the development path of "promoting the development of industry with agriculture, bringing along the development of agriculture with industry, systematic development in virtuous circle". By the end of 1998, the GDP, fiscal revenue and rural per capita net income of Wufeng County had reached 0.51 billion RMB, 50.18 million

RMB and 1404 RMB respectively. These figures increased by 4.7 times, 15 times and 13.5 times respectively over 1978.

3.3.2 Socio-economic Condition of the Project Area

Located in the east of Wufeng County, Renhe Plateau Town is to the east of Songzi, on the south of Taiping Town, Shimen County in Hunan Province, on the west of Yuguan and on the north of Yidu City. It is the common boundary of six villages (towns), four counties (cities) and two provinces, with an area of 242 square kilometers. The Yu (guan) Liu (Liujiayang) Road goes across the town. The Town Hall is 39km away from Liujiachang, Songzi and 31km west to the Yuguan.

Terrain of the town is high in the west and low in the east. The highest altitude where Fuxingguan, Dalishu is located is 1,172 meters high while the lowest altitude where the estuary of Nan River is located is 158 meters. There are one river and two mountain ranges in the town. Nan River, which originates from Qingshuiwan, Yuguan, enters Songzi territory by way of Renhe Plateau. The whole path covers 24 kilometers. There's plentiful utilizable hydroelectric resource, which can be as long as 24,000kwh if developed to the full. Therefore the development potential is tremendous. Up to now, four power stations have been built up with 4,160kw installed capacity.

The whole town administrates 14 villages, 77 village groups, 7,097 households and 24,485 people. There are 39,081 mu of farmland with 1.59 mu per capita, and more than 400,000 mu of mountainous region with 18 mu per capita. The forest coverage reaches 74%. After reform of taxes and charges, the burden level of peasants in the town has been strictly controlled within the stipulated proportion. After several adjustments, the burden decreased by 379.3 thousand RMB with 16.54 RMB per capita or 10.6 RMB per mu. The burden per capita decreased by 51.34 RMB compared to the actual burden of peasants in 1999. The burden decreased by 139,000 RMB over 1997. Thus the goal of "burden alleviation in every village and zero

growth of burden in every household” is achieved. In recent years, the town party committee and government has been implementing the strategy of “developing agriculture around adjustment, focusing on development of big hydroelectric enterprises, promoting private enterprises through opening and exploitation and invigorating circulation to boost the market”. As a result, the whole town has formed a structure of agriculture pillar industry which focuses on herding, hydroelectricity, fancy fruits, tea, vegetables, herbs and special cultivation. The gross income of rural economy reached 71.283 million RMB in 2002. The rural per capita net income was maintained at 1,468 RMB. The fiscal income also reached 2.57 million RMB.

3.3.3 Population Health and General Situation of Major Diseases

The counties and villages in the reservoir basin of Qilinguan Reservoir Power Station have formed a web of health and medical service, which comprises hospitals in counties and villages, village health centers and village health stations, etc. The main communicable diseases and parasitic diseases in recent years are hepatitis, diarrhea and tuberculosis. Influenza, leptospirosis and hemorrhagic fever break out sporadically.

According to a survey in the construction site of Qilinguan Reservoir Power Station, there’s no natural-focus disease in the circumference of the reservoir.

3.4 Current Situation and Assessment of Environmental Quality

3.4.1 Current Situation and Assessment of Ambient Air Quality

(1) Setting of Monitoring Sites

To know the current ambient air quality in the construction site of project, the Environmental Monitoring Station of Wufeng Tujia Autonomous County monitored

the ambient air quality in the area in five consecutive days from October 26th –October 30th, 2004.

According to regional meteorological characters, the distribution of environment sensitive spots and the trend of valleys, three monitoring spots were set up in the neighborhood of dam and power plant. As for specific locations, please refer to the thirteenth attached drawing. In figure 3-6 below are monitoring points and their functions.

Figure 3-6 A Figure of the Monitor of Positioning Situation

No.	Position of Monitoring	Relative Distance (m)	Position and Function
1 #	quarry	800	north of the dam, key protection object near dam site
2 #	Daquanhe power station	300	south of the first class power station, monitoring point at the first class power station
3 #	the second class power station	100	north of the power plant, monitoring point at the second class power station

(2) Monitoring Project and Methods

The monitoring factors of ambient air quality are sulfur dioxide, nitrogen dioxide and total suspended particles (TSP). Sampling and analysis are carried out according to the methods stipulated by the State Environmental Protection Administration. The setting of monitoring points and sampling height is in accordance with the *Technical*

Specifications for Environmental Monitoring, Atmosphere Part. Please refer to figure 3-7 for sampling and analysis.

Figure 3-7 Environment Air Pollutants Sampling and Analysis Method

Pollutant	Daytime Monitoring Time	Sampling Method	Sampling Equipment	Analysis Method	Analysis Equipment	Citing Standard
TSP	≥12h	filter diaphragm concentration method	Intelligent large capacity sampler TH-1000C for the overall suspended particulate matter	weight method	TG328A analytical balance	GB3095-1996 GB/T15432-95
SO ₂	≥18h	liquid absorption method	microcomputer sampler TH-3000A for the daily average density of air pollution	tetrachloride mercuric salt vice-nine rose aniline spectrophotometer method	721(B) spectrophotometer	GB3095-1996 GB8970-88
NO ₂	≥18h	liquid absorption method	microcomputer sampler TH-3000A for the daily average density of air pollution	hydrochloric acid naphthylethylene diamine color method	721(B) spectrophotometer	GB/T15435-95

(3) The Result and Assessment of Monitoring

The monitoring of ambient air quality obtained 45 valid average daily data, with SO₂, NO₂, and TSP accounting for fifteen respectively. The statistical analysis of monitoring data at three points is listed in figure 3-8.

Figure 3-8 The Result of Ambient Air Monitoring

Items		1# Quarry	2# Daquanhe Power Station	3# The Second Class Power Station
SO ₂	the range of daily average value (mg/m ³)	0.012-0.014	0.014-0.016	0.012-0.016
	the rate of standard meeting (%)	100	100	100
	maximum exceeding standard(times)	0	0	0
NO ₂	the range of daily average value (mg/m ³)	0.040-0.042	0.038-0.041	0.040-0.042
	the rate of standard meeting (%)	100	100	100
	maximum exceeding standard(times)	0	0	0
TSP	the range of daily average value (mg/m ³)	0.082-0.096	0.062-0.068	0.018-0.024
	on-specification rate (%)	100	100	100
	maximum over standard(times)	0	0	0

According to the Assessment of monitoring results, the monitoring values of daily average concentration range of SO₂ in three monitoring points are: 0.012-0.014mg/m³ in quarry, 0.014-0.016mg/m³ in Daquanhe Power Station, and 0.012-0.016mg/m³ in the II power station, all meeting the requirement of daily average concentration limit of 0.15mg/m³ in the secondary standard specified in *Ambient Air Quality Standard*. The monitoring values of daily average concentration range of NO₂ in three monitoring points are: 0.040-0.042mg/m³ in quarry, 0.038-0.041mg/m³ in Daquanhe Power Station, and 0.040-0.042mg/m³ in the II power station, all meeting the

requirement of daily average concentration limit of $0.12\text{mg}/\text{m}^3$ in the secondary standard specified in *Ambient Air Quality Standard*. And the monitoring values of daily average concentration range of TSP in three monitoring points are: $0.082\text{-}0.096\text{mg}/\text{m}^3$ in quarry, $0.062\text{-}0.068\text{mg}/\text{m}^3$ in Daquanhe Power Station, and $0.018\text{-}0.024\text{mg}/\text{m}^3$ in the II power station, all under the daily average maximum concentration of $0.3\text{mg}/\text{m}^3$ in the secondary standard specified in *Ambient Air Quality Standard*. To sum up, the environmental control quality is relatively good in the dam site of project and power plant area.

3.4.2 Monitoring and Assessment on Current Environmental Quality for Surface Water

(1) Setting of Monitoring Section

In order to know the quality of water body containing sewage, the Environmental Monitoring Station of Wufeng Tujia Autonomous County monitored the water quality of rivers in the reservoir basin. Considering the fact that there was no outlet for concentrated sewage discharge in the upper and lower reaches of the dam site, we set four monitoring sections, distributed respectively in the upper and lower reaches of the proposed dam site and the upper and lower reaches of the diversion dam respectively. There is one sampling point in every monitoring section.

The thirteenth attached drawing is the specific locations of these sections. Please refer to figure 3-9 for the names of these monitoring points and their functions.

(2) The Monitoring Items and Analytical Method

In light of main pollutants in the project sewage, the monitoring items of current water quality are determined as PH value, water temperature, SS, DO, permanganate index, BOD_5 , amino nitrogen and total phosphorus.

The item analysis is carried out in accordance with standard method specified in *Environmental Quality Standard for Surface Water (GB3838-2002)* .

(3) Time and Frequency of Monitoring

One sampling was conducted in each of the four monitoring sections in September, 2004.

(4) Result and Assessment of Monitoring

We obtained fifty-six valid monitoring data of seven items. The monitoring result is in figure 3-10 below.

Figure 3-10 The Statistical Result of Surface Water Quality Monitoring s

Cross-section	Index	Pollutant Density (All is m g/L except pH.)						
		pH value	Petroleum class	DO	NH ₃ -N	Permanganate Index	BOD ₅	Phosphorus Total
1 # upstream of the dam	range value	8.23	<0.005	9.56-9.84	0.182-0.194	1.40-1.46	0.62-0.70	<0.005
	actual result	II	II	II	II	II	II	II
2 # Downstream of the Dam Position	range value	8.24	<0.005	8.73-9.03	0.173-0.192	2.04-2.08	0.60-0.90	<0.005
	actual result	II	II	II	II	II	II	II
3 # On the Bridge	range value	8.24	<0.005	9.42-10.32	0.114-0.126	2.08-2.12	0.99-1.43	<0.005
	actual result	II	II	II	II	II	II	II
4 #	range value	8.25	<0.005	8.43-9.13	0.126-0.134	1.38-1.56	0.57-0.85	<0.005

Below the Bridge	actual result	II	II	II	II	II	II	II
Water Quality Type II of GB3838-2002		6-9	≤0.05	≥6	≤0.5	≤4	≤3	0.1 (Lake Reservoir 0.025)

Judging from the monitoring result, seven items in two monitoring sections all reached the secondary standard of surface water quality, which indicated that the section of Nan River in construction area was of good water quality.

3.4.3 Monitoring and Assessment on the Current Situation of Noise

(1) General Situation on Monitoring

To understand the current situation of regional noise environment in construction area, our department entrusted Environmental Monitoring Station of Wufeng Tujia Autonomous County with the monitoring of the noise in proposed dam site, I power plant area and II power plant area. Because the dam site and power plant area were of original ecological environment, we only set one representative monitoring point in each of the two areas.

(2) Monitoring Time

We monitored the environmental noise in the day and at night. Specifically, the monitoring time is from 8 : 00-20 : 00 and 23 : 00 to 6 : 00 next day.

(3) Result and Assessment of Monitoring

We obtained four monitoring figures of equivalent noise. Please refer to figure 3-11 for the monitoring result.

Figure 3-11 Monitoring Result of Environmental Noise

Monitoring No. & Name	Monitoring Time	Equivalent Acoustic Level	The Category of Evaluation Standard	The Value of Evaluation Standard	The Situation of Exceeding and Meeting Standards	Major Influential Factor
1 # dam position	daytime	52.5	1	55	meeting standards	background value
	night	44.5		45	meeting standards	background value
2 # The First Class Power Station	daytime	50.9	1	55	meeting standards	background value
	night	42.4		45	meeting standards	background value
3 # The Second Class Power Station	daytime	51.3	1	55	meeting standards	background value
	night	43.5		45	meeting standards	background value

According to the monitoring result in figure 3-11, the noise in the day and at night of three representative points in the project area meets the requirement of Grade I standard limit which is 55dB(A) and 45dB(A) by the standards in *Standard of environmental noise of urban area (GB3096-93)*.

3.4.4 Assessment of Current Ecological Environment

3.4.4.1 Background Assessments on the Integrity of Natural Ecosystem

(1) Background Productivity of Natural System

The net primary production of natural vegetation shows a plant community's productivity under the condition of natural environment, i.e. the productivity of a natural system with no man-made interference. Many ecological models have developed a model of comprehensive natural vegetation's net primary production.

This model is based on measured data, the physiological characteristics of plants, and the correlation equation of water-heat balance. Compare to others, this model can better reflect the net primary production of natural vegetation. Its calculation formula is as follows:

$$NPP = RDI^2 \cdot \frac{r \cdot (1 + RDI + RDI^2)}{(1 + RDI) \cdot (1 + RDI)} \times \text{Exp}(-\sqrt{9.87 + 6.25RDI})$$

$$RDI = (0.629 + 0.237PER - 0.00313PER^2)^2$$

$$PER = PET/r = BT \times 58.93/r$$

$$BT = \sum t / 365 \text{ 或 } \sum T / 12$$

In this formula:

RDI- radiation dryness index

r- (annual) rainfall, mm.

NPP- net primary production (of natural vegetation), t/ (hm²·a)

PER- potential evaporation rate

PET- potential evapotranspiration, mm

BT- (annual) bio-temperature , °C

t- daily mean (0°C < t < 30°C)

T- monthly mean (0°C < T < 30°C)

According to river basin and the hydrological and meteorological observation data of Wufeng County, the mean annual temperature is 13.5°C and the annual mean rainfall is 1493.1mm. If we use the model above to do computational analysis, the net

primary production of natural vegetation in Assessment area would be $3.16\text{g}/\text{m}^2\cdot\text{d}$ which is at a relatively high level.

(2) The Steady State of Natural System Background

According to the result, the productivity of Assessment area is $3.16\text{g}/\text{m}^2\cdot\text{d}$ ($1153.4\text{g}/\text{m}^2\cdot\text{a}$). By comparing and analyzing the net productivity of ecological system on earth and the research on photomaps, we can conclude that the average net production of this area is close to that of temperate broadleaf forest, which is $1200\text{g}/\text{m}^2\cdot\text{a}$. The vegetation's net productivity is high, i.e. the system has a relatively strong resilient stability. It shows that the Assessment area has a relatively strong stability.

3.4.4.2 Current Maintenance of Ecological Integrity of Natural System Integrity

(1) Current Maintenance of Natural System's Productivity

According to filed investigation and the current situation of vegetation coverage in Assessment area, the vegetation of this area are divided into woodland, shrubbery, farmland and river beach, etc. Based on the result, the average net productivity of this area is estimated to be around $1150\text{g}/\text{m}^2\cdot\text{a}$, slightly lower than the background value of this area-- $1153.4\text{g}/\text{m}^2\cdot\text{a}$. This indicates that there is little man-made interference and destruction in this area.

The comprehensive analysis has shown that although human activities interfere with nature system's productivity in a certain degree, there is no radical change in its number and the natural system still owns a relatively strong capability of recovery and regulation.

(2) Stability State of Landscape

① Resistance Stability of Landscape

Without much man-made interference, the biology sections in this area almost do not change in the degree of differentiation and heterogeneity. We learn from the present land-use map that among all the sections that make up the landscape, woodland section is the one with relatively good connectivity and high frequency of appearance. This shows that the main vegetation type in this area is woodland. Therefore, the natural ecosystem has relatively strong resistance stability.

② Landscape Recovery Ability

Though the vegetation's primary production in the area has declined compared to the background, the vegetation still remains a transitional ecosystem between boreal coniferous forest and temperate broadleaf forest. This indicates that this area's natural system has strong recovery ability.

3.5 Main Environmental Problems

There are no industrial enterprises in the project site and river basin. The population intensity there is small. Besides, this area has a small distribution of arable land and good vegetation with low-level application of pesticides and fertilizers. Therefore, environmental pollution there is low. The main environmental problem in the project site is low-grade roads which restrict traffic. The traffic of dam site and power plant completely depends on the low-grade country roads or mountain roads. The backward traffic has severely hampered the economic development in this area, affecting the construction of project.

4. Predictions and Assessment of Environmental Impact

4.1 Hydrologic Condition and Sediments

The natural traits of water body changes as a consequence of impoundment and diversion in the operation period. This and the construction activity of the project have changed the flow rate, flow velocity, water level at estuary and sediments erosion and deposition in the dam site and the upper and lower reaches of dam site, which would in turn influence the environment directly or indirectly.

4.4.1 Hydrologic Condition

In this project, we will construct a diversion tunnel which leads to the I power plant and the II power plant of Qilinguan Reservoir. The II power plant is located 40m upstream on the dam axis with a diameter of 4.1 meters. The gate center elevation and exit center elevation are 394.233m and 392.05m respectively. The diversion tunnel is circular-arc in the plane. The straight line at its exit is 44.797m long. The intake of II power plant is 362.0m high; the diversion tunnel is 8,788m; the water level of forebay is 352.252m,; and the tail water level us 225.787m. The project is an inter-basin water transfer, which is bound to influence the runoff and water level in the lower reach of related river basin to a certain extent.

The Nan River basin where the hub of Qilinguan Reservoir is located shows all the typical features of a river in mountainous area. The flood characteristics in this area, which features uneven rainfall distribution and many intensive rainstorms, are affected by storm intensity and terrain. The major manifestation of uneven rainfall distribution is that the rainfall concentrates in flood season which is from April to September. The rainfall in this period accounts for 75.1% ~ 75.5% of annual rainfall. The rainfall in the remaining months merely makes up 24.5 ~ 24.9% of

annual rainfall. Another manifestation of uneven rainfall distribution is the high frequency and intensity of rainstorms. For example, the biggest amount of rainfall in 24 hours reached as much as 369.7mm at Qingshuiwan Station on July 11th, 1996. It accounted for 17.4% of annual rainfall back then. The concentrated rainstorm results in uneven rainfall distribution. Because of intensive rainstorm and steep-dipping bed slope, the flood occurring time is concentrated with high peaks and huge volume.

After the reservoir is built up, there will be a big change in the flow velocity of the river section in dam site. Resulting from the block of dam, the reservoir capacity will become much larger than the capacity of original natural watercourse. Thus the flow velocity of river section in dam site will be slower. The flow rate and flow velocity will be related to flood. The average flow rate and the average runoff over years in Qilinguan Reservoir Power Station are 4.99m³/s and 157,360,000 m³ respectively. We did not take discharge volume into consideration in the preliminary plan. The watercourse from dam site to the debouchment of Nan River is tens of miles long. In order to avoid any big sudden change in the ecological environment in the downstream watercourse, we should guarantee a certain degree of minimal discharge volume in dry season. Under this circumstance, there won't be big changes in the hydrologic condition in the lower reach

4.1.2 Sediments and Deposition

Reservoir is man-made still water area. As the river enters the reservoir, its flow velocity becomes low suddenly and the transporting capacity of river declines. Thus the carried sediments deposits and piles on the bottom of reservoir, forming the reservoir deposition. The coarse grain of deposition piles in the upper reach as the fine grain of piles in the lower reach. With time passing by, the deposits move towards dam gradually.

Reservoir deposition, serving as natural bedding, can prevent leakage from reservoir in some degree. However, a great many deposits will make water depth become shallow, affecting the operation of hydroelectric station and shortening the life of reservoir.

The source of sediment runoff which makes up reservoir deposition is related to the lithological characters, geomorphic and exogenic geological processes in the area. The sediment runoff of reservoir deposition mainly comes from sediments carried by rivers, the debris flow in the collection area of reservoir, the deformation damage of reservoir bank, and the sheet-wash substance from slopes in the periphery of reservoir. The deposition problem of Qilinguan Reservoir is not prominent for the reasons below: firstly, the water and soil of Nan River basin is in good conservation, the river only carries a few sediments, and river load decreases largely as a result of multi-stage development in the upper reach; secondly, as the collection area of reservoir is mainly made up of carbonatite, there is no debris flow zone; and thirdly, the reservoir bank is relatively stable with small possibility of large-size deformation damage. All things considered, the deposition problem of Qilinguan Reservoir is not serious.

In reservoir, the backwater length is relatively short. The rainstorm in the gully in the upper reach of reservoir forms a short-duration flood. But the sediments carried by the flood do not have enough time to deposit in the reservoir. Therefore most of them are brought to the lower reach by flood. We can treat the remaining ones with sediment ejection measures.

4.2 Local Climate

When the reservoir is built up and starts to impound water, the reservoir basin will be 0.53 square kilometers. As some land is transformed into water surface, there will be lager amount of evaporation and more vapor entering air in the reservoir basin than there is before the construction of reservoir. The humidity level and temperature

will change in the reservoir basin and its periphery, causing change in the local climate there.

(1) Precipitation

According to relevant researches, the reservoir does not cause obvious change in the precipitation of this area, only slightly changing the precipitation distribution there. The summer precipitation and annual precipitation in the central reservoir basin will decline after the construction while the precipitation in the reservoir's periphery will increase a little. Because the rivers in the reservoir are all storm rivers and rainstorms are frequent here in summer, a small change in precipitation does not exert large influence on the whole reservoir basin.

(2) Temperature

After the reservoir starts to impound water, the underlying surface has changed from land into water body, which causes great change in its physical property. The natural watercourse turns into relatively still water with higher water level, larger water surface and deeper water depth. The change in heat exchange between water and air in reservoir basin increases the post-impoundment temperature. Besides, the temperature change becomes mild as a result of impoundment. The daily temperature range and yearly temperature range becomes smaller; the highest air temperature within a year will decrease a little; and the lowest air temperature within a year will increase slightly. But the degree of all changes is small.

(3) Humidity

After impoundment, the humidity level of reservoir will change due to the increase of water surface evaporation. From the perspective of seasonal distribution, the humidity in summer increases slightly while the humidity in winter decreases slightly; and there's no obvious change of humidity in spring and autumn.

(4) Wind

The proposed project belongs to typical channel reservoir. Controlled by macroclimate and topographic condition, the prevailing wind direction does not change obviously. The reservoir basin is a weak-wind zone. As a result of heat difference between water and land, the frequency of wind at commonly seen scales increases while the frequency of calm wind decreases correspondingly. After impoundment, the originally rolling land will take on smooth surface, reducing the roughness factor and thus increasing the face velocity.

(5) Fog

After the project is built up, the temperature rise in summer and temperature drop in winter are slower in the reservoir than in the air and on the land. The effect of cold and heat source provides favorable condition for the formation of steam fog in winter and radiation fog in summer. But due to the temperature effect, humidity effect and wind effect in the reservoir, temperature rises in winter and drops in summer; humidity decreases in winter and increases in summer; and wind speed become faster around the whole year. Changes in these factors are not favorable for the forming of fog. Tough these factors can exert some influence on the forming of fog; the leading role in the formation is played by atmospheric circulation. It is estimated that the proposed project will not induce obvious changes in the fog of this area.

4.3 Environmental Geology

4.3.1 Analysis of Leakage

Reservoir leakage refers to the situation where reservoir water leaks into the outside of reservoir or the downstream of dam through certain passages. Below are three usual leakage passages: from watershed to adjacent river valleys, from river bend to the downstream of dam, and from reservoir to distant low-lying discharge area. In

the *Report on Engineering Geological Survey of Qilinguan Reservoir in Renhezhen, Wufeng County in Feasibility Study Phase*, a detailed analysis has been conducted on the possibility of water leakage from Qilinguan Reservoir to adjacent river valleys. The report has shown that the reservoir is located in the core section of Renhe Plateau syncline. Daye Formation shale, mudstone and marlstone are distributed in a spot which is 7-8km away from both banks, making up a relative confining bed of regional stability. Moreover, there is no adjacent river valley in the section from Nan River to the confining bed of Daye Formation on both banks. Therefore there is no possibility of water leakage from reservoir to the periphery of north and south banks. To sum up, the only possible forms of water leakage from Qilinguan Reservoir are the two remaining ones.

(1) Leaking from River Bend to the Downstream of Dam

Considering the specific conditions of Qilinguan Reservoir, Jianjiatai, which is on the right bank of Nan River, is a possible location for water leakage from river bend to the downstream of dam. We can see from the engineering geological map of reservoir area that Nan River sticks out towards northeast, forming a river bend. As the dam site is situated in the turning part of river bend, the topographic condition there is possible for water leakage at river bend.

Karsts are very well developed in the river bend. On the east side of river bend develops Jianjiatai karst water system, groundwater flowing towards east; and on the west side develops Majiachong karst water system, groundwater flowing towards west. Menbanchong karst cave system develops in further west. There is thin sub-level watershed in between with certain development of karsts. The development degree of karsts is shown by a series of karst depressions and doline. The permeability rate of ZK29 hole is 6.3~18.6, beyond the mean permeability rate of all holes. And the packer permeability test cannot be conducted because the shallow rock leaks severely. One possible leaking passage is: when the sub-level watershed between Jianjiatai karst water system and Majiachong karst water system disappears,

the water in Majiachong karst system flows backwards, towards east and across the watershed, leaking into W11 spring through the Jianjiatai karst water system. The key success factors in the passage's forming are the disappearance of sub-level watershed between the two karst systems after impoundment and the development degree of karsts. As we have explained above, the karsts there have developed to a certain extent with relatively large permeability rate. Moreover, according to the long-term observation record of water level at ZK9 hole near the watershed, the groundwater level is 455.9~456.4m, below the normal storage level 460m designed for the reservoir.

Though the watershed is still hundreds of meters away from ZK9 hole, it has a gentle water level with relatively well-developed karsts. So it is still possible that the watershed disappears after impoundment, thus producing a run-through percolation zone on East-West direction. If the leakage passage is formed, the leakage direction will be basically parallel to layer's strike because the whole passage is in the limestone strata which is made up of very well developed karsts and there is no effective confining bed. The permeability coefficient is larger on layer's strike than on other directions. The Jianjiatai karst water system mainly discharges into Nan River through W11 spring whose discharge rate is more than 2.0l/s even in dry season. This phenomenon also shows that the karsts in this system are well-developed with good permeability. The Majiachong karst water system, which is mainly distributed in limestone strata, extends on the fault trend. The fact that a karst cave develops at the discharge point also proves the relatively good development of karsts. Despite all this, the leakage amount should not be large as the leakage distance is relatively long.

Besides, there is another possible leakage passage, which starts from dam site, goes south along ZK7 and ZK8 to ZK9, and turns east along Jianjiatai karst water system and finally ends in W11 spring. If the relatively short leakage passage is formed, the leakage amount will be relatively large. Because the water level at ZK9 hole is

456m high, lower than the normal storage level designed for the reservoir, there will be no sub-level watershed between the ZK7~ZK8 zone and Jianjiatai karst water system. Therefore the key success factor in the passage's forming is the patency of leakage passage between ZK7-ZK9. If a infiltration flow is formed from ZK7 to ZK9, its direction will be perpendicular to the rock. Its permeability will be restricted in some degree, because in the middle is T1j5 stratum which can resist water to some extent. However, the T1j5 is of relatively small thickness with a karst depression developing in the middle. This depression is almost as thick as the mine, indicating that the karsts here are relatively well-developed. Thus it becomes a breach of the mine, probably preventing the mine from resisting water. Mineralized limestone develops on both sides of the mine. The mean permeability rate is 13.5 according to the data of permeability at ZK7 hole and ZK9 hole. The figure shows that the karsts have developed in some degree, providing possibility of leakage.

We can learn from the analysis above that leakage at river bed is possible in Jianjiatai, on the right bank of Nan River. According to the existing investigation data, we are not able to draw a reliable conclusion. However considering the specific conditions, the leakage will not be serious even if it happens. As the water level at watershed is around 456 meters, the feasibility report suggests that we leave the issue aside and attempt impoundment first. We will reinforce observation and research during the impoundment process and conduct grouting accordingly when necessary. If the leakage amount is within an acceptable range, we can leave the leakage untreated.

(2) Leaking from Reservoir to Distant Low-lying Discharge Area

In all Qilinguan Reservoir, only Dalishu on the left bank meets the condition for water to leak from reservoir to distant low-lying discharge area. One possible leakage passage is: when the thin watershed between Dalishu karst water system and Nan River disappears after impoundment, water flows from reservoir, enters Dalishu karst water system through Laohudong, and finally leaks into distant Songshuling whose lowest elevation is 420 meters. The leakage passage goes towards the east on

consequent direction of thick limestone. From the aforementioned characteristics of Dalishu karst water system we know that there exists strong karsts zone and groundwater channels. Therefore, the leakage passage can be formed and its leakage amount requires corresponding grouting treatment.

4.3.2 Analysis on Stability of Reservoir Bank

After the reservoir is built up and starts to impound water, the natural conditions change drastically, putting the reservoir bank under new environment and exogenic geological processes which often cause deformation and damage. The destruction forms of reservoir bank include bank slump, landslide and rock fall. The reservoir bank slump mostly happens in banks made-up of loose soil in plain reservoir and basin reservoir. However, as most of banks in Qilinguan Reservoir are made up of hard bedrock, there will not be serious bank slumps in general. Therefore as required in the Assessment opinions of feasibility study, we will discuss the stability of landslide and collapse masses in the following part.

(1) Landslide

Landslide is one of the main destructional forms of reservoir bank. After most impoundment of reservoirs, landslides will happen, only differing in size. According to the location, landslides can be divided into above-water ones and underwater ones, or ones close to dam and ones far from dam. Reservoir bank landslides are mostly transient damage and doing great harm. The above-water high-speed landslide which is close to dam does even more harm, often causing large surge and severely endangering the safety of lives and property in the downstream of dam. Therefore we should attach great important to the research on reservoir bank landslide close to dam. There are two landslides (or collapse masses) close to dam in the area of Qilinguan Reservoir.

① Juyuan Landslide: The rear edge elevation of Juyuan landslide is 510 meters while the front edge reaches Nan River riverbed with an elevation of 408 meters. Most of sliding masses will be submerged when the reservoir starts to impound water. The weight of sliding masses increases and the shearing strength of sliding zone declines, especially when water level in the reservoir is on the decrease. And as a result of water leakage from sliding masses, there appears hydrodynamic pressure pointing to the outside of sliding masses. All these factors will weaken the stability of landslide. The result has shown that the impoundment stability coefficients after impoundment have decreased in different degrees compared to the period during the impounding process. When the water level is at 460 meters high, the stability coefficient is 1.27, indicating a stable state; and when the reservoir sustains rainstorms, the stability coefficient is 1.12 with a certain margin of safety. However, when water level suddenly plunges to 430 meters or when a 6-magnitude earthquake happens in the landslide area, the stability coefficients of slippage are 1.02 and 0.96 respectively, both close to one; the figures show an ultimate state and indicate a possibility of sliding. But the water-level regulation in reservoir is generally smooth. Therefore it's unlikely for reservoir water to discharge too fast. There is a slim chance of a 6-magnitude earthquake (including natural earthquake and induced earthquake) happening in the landslide area. Nevertheless, the possibility of landslide re-sliding cannot be ruled out.

The landslides may not re-slide on the whole, but a bank slump may happen under the washing and erosion of reservoir water as the slip masses belong to quaternary deposits. Different from sliding, bank slump refers to the situation where sliding masses collapse and retreat under the influence of reservoir water, and finally end after reaching a new stable state.

According to calculations, landslide will slide under extreme conditions and slump under general conditions. The ultimate width of bank slump is 179 meters. However, as the landslide area is uninhabited cropland with no important projects

nearby, the sliding or slump of landslide does not constitute great damage to the neighborhood. Bank slump and sliding exert different influence on the reservoir. As a result of bank slump, deposition would pile up in the reservoir; but because the size of sliding mass is small, the amount of resulting deposition is also small. As for bank slump, the water-entry speed is relatively slow and the resulting surge is not violent because the stability coefficient of landslide is close to one. Besides, the landslide is a little far from the dam site (1.5km away). Therefore the bank slump has limited influence on the dam.

For all that, it is still necessary to set up a long-term monitoring station at the Juyuan landslide.

② B2 Collapse Masses: B2 collapse masses are in stable state. As it is located above the storage level of the reservoir, the stability of it is not influenced by the reservoir construction. And under general conditions, the stability will not deteriorate. Therefore the B2 collapse masses do not pose threats to the construction and operation of reservoir.

③ B3 Collapse Masses: B3 collapse masses have a normal degree of stability. It might further creep. However, as they are of small size and relatively distant from the dam, they do not do great harm to the dam and reservoir.

④ B4 Collapse Masses: The collapse masses, mainly made up of rubble with loose structure, are deposited mussily or scattered in the river reach. Under the long-term influence of flood, the accumulated bodies are basically in stable state. In the future, the upper dangerous rock bodies may produce small rock falls under the influence of reservoir water. Nevertheless, as they are of small size and relatively distant from the dam, they will not affect the safety of dam.

(2) Rock fall

Rock fall is a common destructional form of canyon reservoir bank. It usually takes place in the high steep reservoir bank section which is made up of hard rock. After impoundment, due to the softening of rock at slope toe and the deformation damage of lower reservoir bank, the rock falls in the upper reservoir bank. The rock fall is more likely to happen when there's weak intercalation in the water-level changing section.

According to the specific engineering geological conditions, the straight bank, whose layer's strike is approximately parallel to the river, is the main location possible for the occurrence of rock fall. After impoundment, small rock falls, which are mainly 5-50m³ big, may take place in the local river sections. From the fact that there is only a small amount of rock fall deposits in the riverbed, we can infer that large rock fall will not happen after impoundment.

4.3.3 Sectionalizing of Reservoir Bank Stability

According to the lithologic characters of strata and topographic features in the reservoir area plus the forms and possibilities of deformation damage in reservoir bank, the reservoir bank is divided into seven sections which differ in stability:

(1) The first section is lower dam site. This section is mainly made up of thin-bedded and medium-thin-bedded limestone, all of which are uncovered bedrock. The terrain is relatively steep. As the reservoir bank is an oblique crossing valley, it is favorable for the stability of reservoir bank. But joint fissures are relatively well-developed there with unloading fissures developing in some part. The major possible destructional form is small rock fall. In general, the stability of this section is relatively good.

(2) The second section is middle dam site. This section is comprised by medium-thin-bedded limestone. On the left bank is a relatively steep consequent slope with no possibility for bedding-slope. On the right bank is a escarpment slope

with development of unloading fissures and joint fissures, providing external conditions for small rock fall. The stability of this section is relatively good.

(3) The third section is upper dam site. This section is made up of medium-thin-bedded and medium-thick-bedded limestone with the development of Juyuan landslide, providing possibility for post-impoundment slippage. There are a little slope wash on both banks and rock fall deposits in the riverbed. The bedrock is unlikely to slip. The main destruction of reservoir bank is quaternary slippage and collapse. Thus, the stability of this section is relatively bad.

(4) The fourth is the northern part of Majiachong which is a flat and straight section of 600m long. Its formation lithology is medium layer dolomitic rock and limestone in the shape of breccias. On the left bank is escarpment slope with a consequent slope on the other side. With strong tectonism and steep rock, this place provides possibility of rock falls, most of which are small.

(5) The fifth section is from the mouth of Majiachong to Majingkeng, whose terrain is steep with winding rivers. The formation lithology is thin-bedded and ultra-thin-bedded limestone with development of rock falls whose deposits can be seen in many parts of the section. The channel course is narrow at 300-600m point downstream of Majingkeng. The terrain on two banks is high and steep, possible for small rock falls.

(6) The sixth section starts above Majiachong and goes to the reservoir section in the northern part of Meijiahe. In this section, the river is straight. The formation lithology is mainly thin-bedded limestone. The right bank is a consequent slope where collapse deposits, which are mainly of small size, can be seen in many parts.

(7) The seventh section is the reservoir section above the northern part of Meijiahe. The terrain in this area is steep with winding rivers. The formation lithology is thin-bedded limestone. The right bank is a consequent slope where small collapse deposits can be seen in many parts.

In conclusion, there is still danger, which mainly manifests itself as rock falls, lurking in the reservoir bank stability of Qilinguan Reservoir. However, the rock falls are of small size, thus bringing no harm to the reservoir in general. As the stability of Juyuan landslide is relatively low with possibility for slippage and collapse, it will exert certain influence on the reservoir.

4.3.4 Reservoir Inundation

The banks in Qilinguan Reservoir are mainly comprised by steep terrain and outcrop of bedrock. The elevation of terrain on the reservoir bank is higher than the backwater line of reservoir. The formation lithology of reservoir banks is mainly carbonate rock with karsts developing. The embedded depth of groundwater is larger than 20-50 meters. Because the surface water and groundwater discharge smoothly, the embedded depth of groundwater will still be far greater than the threshold value even if the groundwater level rises after impoundment. Therefore, the topographic and geological conditions of Qilinguan Reservoir do not provide necessary conditions for reservoir inundation, i.e. the problem of reservoir inundation is nothing to worry about.

4.4 Prediction (analysis) and Assessment on Aquatic Environment

4.4.1 Analysis on Pollution Source

(1) Agricultural Non-point Sources

According to survey, the reservoir occupies a land area of 650-950mu (we'll take 850mu as the average). The fertilizer consumption in different places is similar with an average application level of 24kg/mu. Limited by the traffic condition and farming level in the proposed construction area, the actual fertilizer level is lower than the average. According to the average fertilizer level, the fertilizer application rate is

20.4t/a in the reservoir area. According to the local application ratio of nitrogenous fertilizer and phosphate fertilizer, the application rates of both fertilizers are about 12.2t/a and 5.7t/a respectively.

According to the analysis of statistical report, the application rate in villages and towns around the reservoir does not vary greatly over the past five years. Therefore, when the reservoir is built up, the application rate in forecast year 2010 is estimated in light of the application rate in 2003. Besides, according to the feasibility study, the amount of soil loss is not large. Therefore, we estimated the loss of phosphorus and nitrogen induced by soil loss to be 10%.

Prediction method: we will adopt the formula of prediction on soil nutrient loss in the *Code for environmental impact of water resources and hydroelectric engineering* (SDJ88 - 2003):

$$E = aS_{NP} + bcdF_{NP}$$

In this formula:

E - prediction on TP and TN entering the reservoir , t/a ;

S_{NP} - TP and TN entering water body and soil (soil entering the reservoir \times content of TN and TP);

a - consumption coefficients of nitrogen (which is 70% and that of phosphorus (which is 95%); and this means the TN and TP entering the reservoir are 30% and 5% respectively;

F_{NP} - application level of fertilizer ;

b - average content of nitrogen and phosphorus in the fertilizer; the average contents of nitrogen and phosphorus in standard fertilizer are 23% and 15%;

c - the fertilizer utilization rate; the fertilizer utilization rate of nitrogen and phosphorus are 30% and 15% respectively, which indicates that 70% of nitrogen and 85% of phosphorus are discharged into water body ;

d - the drain rate of fertilizer when it enters into soil and water body; for nitrogen, the drain rate is 30%; for phosphorus, the drain rate is 5%;

After calculation, the total amount of nitrogen and phosphorus, which are brought into reservoir by agricultural non-point sources, are 1.34t/a and 0.16t/a.

The load of farmland runoff pollution is not only decided by natural factors like precipitation, topography and soil, but also the number of ground surface pollutants and their migration process. By comparing and analyzing the research of farmland runoff pollution in three gorges area, we make a preliminary estimate on the discharge amount of COD and BOD₅, both of which are ground surface pollutants.

(2) Domestic Pollution Sources

According to survey, the reservoir area is sparsely populated with no existence of industrial pollution enterprises. The main source of domestic pollution is domestic sewage. The prediction on domestic sewage discharge is calculated according to the following formula:

$$X_t = L_t Y_0 (1 + \mu)^{t-t_0}$$

In this formula:

X_t — sewage discharge in forecast level year (t/a) ;

L_t — sewage discharge per capita (t/a) ;

Y_0 — population in base year ;

μ — population growth rate (‰)。

According to Code for design of outdoor sewerage engineering, the domestic sewage discharge will be 220,000t/a in 2010 provided that the average domestic sewage discharge per capita is counted as 150L/(d·person). If the discharge of COD, BOD₅, T-P, T-N are counted as 400mg/L, 200mg/L, 2.0mg/L, and 25mg/L respectively in accordance with the routine discharge concentration of domestic sewage, then the discharge of COD, BOD₅, T-P and T-N are 86.7t/a, 44 t/a, 0.44 t/a and 5.5 t/a respectively.

4.2.2 Prediction and Assessment of Water Quality in the Reservoir

4.4.2.1 Overall Water Quality in the Reservoir

(1) Initial Water Storage

In the initial water storage, the water quality of reservoir will sustain unfavorable influence exerted by bleeding and decomposition of organisms in great amount as the release of all sorts of organisms in the flooded area and vegetation. According to the monitoring data from existing reservoirs home and abroad, the dissolved oxygen in water body, salinity, nutrient material and plant hyperplasia are all related to the degree of water storage. Qilinguan Reservoir Power Station has an area of 0.453km² with an even smaller inundated area. At the meantime, as hygienic cleaning for reservoir bed is conducted before impoundment, the amount of organisms in the reservoir declines. Thus the amount of bleeding and decomposition of organisms in the flooded area also decreases, which has small influence on the overall water quality in the reservoir.

(2) Normal Operation Period of Reservoir

The main pollutants during the normal operation period of reservoir are made up of upstream background value, domestic sewage of Xiufengqiao, Langping Town and farmland runoff in the surrounding area of reservoir. The zero-dimension model is adopted to predict the overall water quality during the normal operation period of reservoir.

Prediction model:

$$C_{(t)} = \frac{W_0}{K_h V} + \left(C_h - \frac{W_0}{K_h V} \right) \exp(-K_h t)$$

$$K_h = \frac{Q}{V} + K$$

In this formula:

$C(t)$ - pollutant concentration in calculation interval , mg/L ;

W_0 - warehousing rate of pollutant , g/s ;

K_h - intermediate variable , s^{-1} ;

V - volume of reservoir , m^3 ;

Q - outflow from reservoir , m^3/s ;

K - synthetic attenuation coefficient of pollutant , s^{-1} ;

C_0 - current concentration of pollutant in the reservoir , mg/L.

BOD_5 is selected as the predicator with other items only going through qualitative analysis. In figure 4-1 below is the result of prediction on the average concentration of BOD_5 .

**Figure 4-1 The Average Density Forecasting Value of the Main Pollutant BOD5
in Qilinguan Hydroelectric Power Station**

The Time for Computing	The Time for Computing t (s)		
	1	1000	3600
Forecasting Result	0.011	0.011	0.008

The prediction result indicates that the average concentration value in level year 2010 meets the Class II standard value of the national *Environmental Quality Standard for Surface Water* (GB3838-2002) .

It is clear that the change in hydrologic regime after impoundment will not exert obvious unfavorable influence on the overall water quality of reservoir. Therefore, the overall water quality of reservoir could maintain the same.

(3) Prediction and Assessments of Reservoir Eutrophication

Dillon Model is adopted:

$$[P] = \frac{L(1-R)}{H\rho_w}$$

In the formula:

P—the concentration of nitrogen and phosphorus in the reservoir, mg/l ;

L—load amount of nitrogen and phosphorus entering the reservoir , g/m²·a ;

H—hydraulic mean depth of reservoir , m

In the formula:

$$\rho_{\omega} = \frac{Q}{V}$$

Q—annual reservoir inflow , m³/a ;

V—storage capacity , m³ ;

$$R = 0.246\exp(-0.271Q_i) + 0.574\exp(-0.00949Q_i)$$

In the formula :

Q_i—hydraulic load ,

Q_i = Q/A , m/a ;

A—water surface area of reservoir , m²。

When the reservoir is built up, the amount of phosphorus and nitrogen entering reservoir is calculated according to the amount of both elements currently entering the river. The calculation is conducted under unfavorable case, which means not considering the reduction of fertilizer consumption and soil erosion and water loss that results from land submergence and artificial management. The calculation results of the nitrogen loading and phosphorus loading are 10.7g/m²·a and 1.32g/m²·a respectively. In figure 4-2 is all the computed forecast parameters.

Figure 4-2 The Forecasting Reference data of eutrophication in Qilinguan Reservoir

Items	Q (m ³ /a)	V (m ³)	A (m ²)	H (m)	ρ _ω	Q _i (m/a)	R
Referenc	1.5736×10 ⁶	0.1270×10 ⁶	0.453×10 ⁶	36.0	12.39	347.37	0.0212

e Data	8	8					
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2010 is the forecast year. From the models and parameters above, we can compute the TN concentration of water quality in reservoir and TP concentration at 0.004mg/l and 0.0005mg/l respectively.

Nutrient element is the main control factor in the eutrophication of lakes and reservoirs. According to the measurement of AGP put forward by *Code for Lake Eutrophication Investigation* (second edition), most lakes are phosphorus-limited with some nitrogen-limited ones. There's no standard for Lake Eutrophication in our country. Therefore, the eutrophication degree of Qilinguan Reservoir Power Station after its completion will be decided by referring to the classification criteria of Lake Eutrophication for some domestic lakes. Please refer to figure 4-3 for specifics.

Figure 4-3 Eutrophication Standard in the Domestic Water Reservoir unit: mg/L

Nutrition Type	The Index of Water Quality Center		The Index of Taihu Lake		<i>Lake Eutrophication Investigation Standard</i> index	
	Total Nitrogen	Total Phosphorus	Total Nitrogen	Total Phosphorus	Total Nitrogen	Total Phosphorus
Poor Nutrition Type					< 0.25	< 0.02
Poor-average Nutrition Type	0.2~0.4	0.005~0.01	0.16	0.01	0.16	0.01
Average Nutrition Type	0.3~0.65	0.01~0.03	0.31	0.023	0.310	0.023
Average and Rich Nutrition Type	0.5~1.5	0.03~0.10	0.65	0.050	0.650	0.05
Rich Nutrition Type	> 1.5	>0.10	1.20	0.110	1.20	0.11

According to the assessment of current situations in the report, all the water quality indexes in the water body above the dam site are consistent with the requirements of standard II in *Environmental Quality Standard for Surface Water* (GB3838-2002).

Judging from figure 4-3, after the completion of the Qilinguan Reservoir, the water quality in the reservoir is oligotrophic. The population in the banks in reaches between the dam site and reservoir is small and the current load of pollution source in the upstream is limited. Although the water depth increases and the velocity decreases after the completion of reservoir and impoundment, eutrophication will not easily happen due to the frequent water renew. Thus, we can conclude that under the current nutrient loading level, the overall water quality in Qilinguan Reservoir hydroelectric station will not tend to be eutrophic.

(4) Analysis and Assessment of Downstream Water Quality

The topography of river section from Qilinguan Reservoir Power Station dam site to estuary is similar to the upstream, both featuring small population without water intake and discharge outlet for domestic sewage. During operation, the adjustment extent to the downstream runoff and the quality of the discharged water are the main factors affecting downstream water quality.

① Analysis on the change of water quality during flood season

The main objective on flood prevention of Qilinguan Reservoir Power Station dam project is to ensure the safety of the dam and the normal operation of power plant. The normal storage level is the same as flood starting regulation level. When detention exceeds this level, the gates will open for flood discharge. The influence it exerts on the water regime of river section downstream to the dam is almost the same as in natural rivers. In addition, the setting effect of reservoir makes the overall water quality better than it is in natural condition. Through the analysis of the water dispatch operation of constructed reservoir, we can draw a conclusion that the water

dispatch operation in flood season only has a limited influence on the downstream water quality.

② Analysis on the changing water quality during dry season

By drawing an analogy of the comparison result of average annual flow in constructed hydroelectric power station projects, the water dispatch operation and water incoming process under natural condition, we can conclude that when the reservoir starts to impound water after flood, the discharge is smaller than the amount of natural incoming water. Therefore the discharge in dry seasons does not grow greatly, if compared natural condition.

Though, after impoundment, the discharge amount of the dam is smaller than that under natural condition, it is still larger than the flow rate in dry seasons under natural condition. Analyzing from perspective of aquatic environmental capacity, we know that the larger the water flow is, the greater the aquatic environmental capacity will be. Therefore, though the flow rate after flood will be smaller than that under natural condition, it is still larger than or equal to aquatic environmental capacity in dry season under natural condition. Thus it exerts limited influence on the water quality in this river section.

4.4.3 The forecasting of the water temperature in the reservoir

The reservoir water temperature is an important indicator for aquatic environment. The fish in our country is primarily the lukewarm fish, for which suitable water temperature for growth and reproduction is 15 - 30°C. And the change of water temperature in the downstream of reservoir will have certain influence on the aquatic organism under the dam. The water temperature is closely related to the water quality; it exerts the greatest impact on targets like DO, BOD₅, COD, excrement large intestine bacteria colony and so on. Besides, water temperature also provides essential material for the study and monitoring of water seeping and leakage of the

concrete dam. Therefore, study and analysis of the water temperature in the reservoir plays an important role in the comprehensive utilization of water resources, protection of water quality, and the full display of reservoir's comprehensive benefits.

(1) The structure of the water temperature in the reservoir

After impoundment, the water temperature, as one hydrologic factor featuring the thermal conditions, will change. The distribution pattern of water temperature in the reservoir is influenced by an array of factors, such as solar radiation, the reservoir volume, the inflow and outflow, water temperature, the reservoir shape, the silt condition, the utilization way of the reservoir dispatch.

There are usually two ways to decide whether the water temperature in the reservoir has stratified because of detain: by the index α of the number of exchange times of reservoir water and β , the ratio comprised by flood discharge at one time to the actual storage capacity at that time; or by the exponential method of density Ford Fd. In the earlier period of the Three Gorges Project construction, Scientific Research Institute of Yangtze River Water Resources Protection conducted a research on this. And a comprehensive research on the effects of reservoir water temperature was carried out in the *Prediction on Water Temperature at the Three Gorges Hydro-junction* in 1990, which was a national key science and technology problem-solving topic proposed in the “seventh five-year plan”. The water temperature at different depths of the reservoir is different and usually the reservoir can be divided into three types: mixed type, stratified type and transitional type. Please refer to figure 4-4.

Figure 4-4 The Determination Figure of Water Temperature α Value in the Reservoir

α value	The Type of Water Temperature in the Reservoir
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< 10	lamination type
> 20	mixed type
10~20	transitional type

- ' Mixed type: With small gradient, the water temperature is distributed relatively evenly at any time in the reservoir.
- ' Stratified type: Thermal stratification emerges because water temperature is apparently higher on the surface than in the middle and lower part. The gradient can be more than 1.5°C/m while the water temperature at reservoir bottom is generally below 15°C.
- ' Transitional type: The reservoir water temperature has the characteristics of both mixed type and stratified type.

(2) Distinguishing of Water Temperature Type in Reservoir and Impact Analysis

The alpha coefficient method is adopted to distinguish the water temperature type of Qilinguan Reservoir Power Station. Alpha coefficient method is not only simple, but also is in accordance with the actual situation as proved by the examination of reservoirs which have measured data on water temperature. Its form is as follows:

$$\alpha = \text{mean annual runoff} / \text{total reservoir storage}$$

After calculation, the α value of Qilinguan Reservoir Power Station is 12.39 (10-20), indicating that the water temperature structure of the reservoir is a typical transitional structure with no lamination. Besides, obvious seasonal flow and flood flow exist in Nan River. Most floods in the river basin are formed by rainstorm with concentrated rainfall (from July to September). The flood rises and falls sharply with huge volume in short duration. When the reservoir is built up, the water body is in a relative static state. Thus, the effect of heat storage is better than the river, so the

water temperature of surface is higher than that of natural rivers. According to the measured data in tributary reservoir area of Gezhouba Reservoir, the temperature of reservoir water is liable to rise in temperature raising period. The surface water temperature of inflow section in the reservoir head is close to that of natural rivers in the same period. The surface water temperature of reservoir and the upstream to the dam in winter is similar to that under natural situation. In spring, summer and autumn, the surface water temperature of reservoir is usually around 2°C higher than that of natural rivers. However, the water temperature at reservoir bottom does not differ greatly from that on the surface.

(3) Analysis on Discharged Water of Reservoir

The temperature of discharged water from reservoir is related to the location of reservoir outlet, flow velocity of reservoir water and water temperature of inflow and the temperature in that place at that time. According to the measured data from Xin'anjiang Reservoir and Danjiangkou Reservoir, the water temperature of river downstream to the dam is in good corresponding relation with the water temperature at a certain point in the reservoir. Specifically, the point is 15~20m deep. The water temperature in the reservoir is almost the same in all spots of the reservoir, so the water temperature of outflow is also similar to that of natural rivers in the same period.

According to survey, the river section has a rapid flow, with no distribution of large commercial fishes and spawning ground of rare fish. There's no demand for water of life, water of productive use or irrigation. Therefore it won't exert unfavorable influence on the growth and reproduction of fish, water quality and aquatic organisms in the downstream of the dam, and farmland irrigation.

4.5 Eco-environment Impact Analysis and Assessment

The impact of water conservancy project on eco-environment bears clear characteristics: during the construction period, it is mainly negative impact; while during the operational period, the impact is multi-facets. The main negative impact lies in that reservoir inundation may lead to biological species biomass reduction and changes in biological systems. The beneficial impact includes: the development of small hydropower station may change villagers' bad habit of using firewood for energy and reduce the probability of wildlife habitat shrinking resulted from deforestation; the improvement of climate around the reservoir areas will provide favorable conditions for the replacement of vegetation types; the implementation of the project will effectively control man-made soil erosion and water loss and alleviate flood, landslide mudslide and other disasters to varying degree so as to improve the eco-environment.

4.5.1 Eco-environment Integrity Assessment

The impact of Qilinguan Reservoir Power Station project on the integrity of regional natural system comes from reservoir inundation and construction site. There are no migrants within the boundary of reservoir inundation after the establishment of the project and operation of the power station. A citrus garden, 2km away from the dam site, covering an area of 80 mu will be drowned. Reservoir inundation and construction site will result in a direct reduction of greenbelt and change productive force of regional natural system and its stability, which will affect the integrity of the regional landscape ecosystem.

(1) Analysis of the productivity of landscape ecosystem change

Since the productivity of landscape ecosystem is affected by reservoir inundation and construction site, the types and coverage of the landscape patch in the assessment area are changed: the coverage of woodland and scrub originally with high productivity

will be reduced; with the reservoir storage, rivers and bottom land with low productivity will change from unstable river to stable reservoir, biomass of the aquatic ecosystem would be significantly enhanced and level of productivity will gradually improved. But in the short term, regional total level of productivity declines.

(2) Stability change analysis of landscape ecological system

Stability of landscape ecological system includes two characteristics: restoration and resistance. Restoration is the capacity to return to the original state after the change. Resistance is the capacity to resist or prevent change in times of environmental change or potential interference. Terrestrial ecosystems will transit to aquatic ecosystem within the construction site. Productivity of the systems will reach a new equilibrium through short-term fluctuations. Since inundation and permanent area covers an area of less than 5% of the total, resistance capacity of natural system will not degrade to low level systems due to a small amount of submerged forest land. The construction will not significantly affect the stability of landscape ecological system. Therefore the influence of construction and operation of the station on regional landscape is within the ecological capacity, which can be borne by the regional natural systems.

(3) Landscape ecological system qualitative comprehensive assessment

After the construction and operation of Qilinguan Reservoir project, the pattern of land use and dominance of land type will be changed, in which the importance of water pieces will be enhanced, value of scrub dominance will be decreased while that of forest land bears no significant change due to the reservoir inundation. Total surface area of the reservoir is 0.453km^2 , while the regional landscape ecological system is larger than the floating figure. As a result, forest grassland remains the modal land in this region. All these show that the construction and operation exert no significant influence on the quality of landscape in the assessing areas.

4.5.2 Impact analysis of terrestrial plant

During the construction period, the construction activities have affected vegetation to a certain extent, such as quarry and soil material excavation, alteration of traffic line and dumping site and establishment of water diversion and power generation system.

According to field investigation, there is a simple path leading to the construction site, which belongs to rural and mountainous road. Currently it is under upgrading with masson pine forest and scrub-grassland along the way. Within the excavation, vegetation will be destroyed and denudation will be formed, which is easy to cause soil erosion and water loss. The construction site covers mainly shrubbery and grassland.

According to the survey, submerged plants are widely distributed species in reservoir area and in Hubei Province, among which there are no key plants under national and provincial protection. As a result, reservoir inundation will not cause extinction of regional species. Since the construction site covers a small area, forest coverage ratio will not be affected significantly.

After completion of reservoir, with the input of capital and improvement of local climate, favorable conditions will be provided for the replacement of vegetation around the reservoir and positive influence will be exerted on the growth and succession of forest vegetation. Meanwhile, the establishment of project will be beneficial to the growth of plants around the reservoir due to the enlargement of water areas and improvement of local micro-climate.

4.5.3 Impact analysis of terrestrial animal

The construction activities will exert certain influence on the activities of amphibians and reptiles within the construction site. Some animals will move to non-construction and non-flooded areas but their existence will not be threatened. Birds and animals

will be forced to leave their original habitat around the temporarily acquired land. However, the negative influence will be limited within the construction period. With the restoration of vegetation, the habitat will be recovered. The density of snakes will be increased, among which *trimeresurus* are highly toxic, requiring enhanced preventive measures during the construction.

After the establishment of reservoir, distribution area of terrestrial animals will be reduced due to reservoir inundation. The ecological system composed by the original river course, bank vegetation and grassland scrub will be changed to reservoir ecological system. However, since animals living around the reservoir are not local specific, they may migrate to reservoir areas. As a result, the operational period will not threaten the existence of the species. Meanwhile, the rise of surface waters and expansion of water areas provide favorable living environment for water-based amphibians and increase the species. Moreover, waterfowls and sub-waterfowls will be attracted so as to increase the species and the number.

4.5.4 Impact analysis of aquatic organism

(1) Impact analysis of aquatic habitats

Under natural circumstance, Nan River is known as dalles habitats with the characteristics of high speed and high flow and level variation especially during flood and dry season. The bottom sediments are rocks, pebbles and sand-based, which is not conducive to the formation of primary productivity in the aquatic ecological environment. After completion of the reservoir, hydrological situation in the area changes greatly. For example, water level change turns to ease, which results in the transformation of torrent open style aquatic ecological habitat to subcritical flow one and a change of ecological environment in water areas from channel facies to lake facies. When the reservoir reaches normal water level of 460m, a reservoir area of 0.453km² is formed. Compared with natural conditions, water area increases 0.1km² at most while water level in front of the dam raises 30-70m. Water area, depth and water

body are enlarged with speed slowing down, sedimentation and transparency increasing. Increasing nutritional salts due to inundation lead to the enhancement of primary productivity, improvement of food conditions and increase of species adapted to subcritical flow instead of torrent flow.

(2) Impact on the Plankton

The water flow becomes very slow after impoundment that the water turbidity decreases and the transparency improves, which is good for the photosynthesis of Plankton. Meanwhile, because of the prolonged stagnation, the exudates of soluble substance in the submerged area and nutrients of the surface runoff inflowing will provide an abundant substance basis for plankton multiply in the reservoir water area. However, for the primary ecological rivers, the population structures and quantity of plankton will increase obviously in the reservoir area, with corresponding changes in its distribution density and places as well as the growth of its biomasses. At the same time, there will come into being the cladocerans and the copepods which suit to live in the lagging water or in the still water, and such as the chironomid larva and macro-tubificidae which accustom to the deep water and the lacking of oxygen. Their quantities will increase gradually to be the dominant population of the reservoir.

(3) Impact on the benthic fauna

After impoundment, the water level will lift upright in the upstream of the dam, changing the water exchanging capability in the natural river. Sediments deposition will change the sediments and damage the benthic habitat environment. It is predicted that the population structure of the benthic fauna will take on a huge change after the completion of construction, and the species which like the running water will decrease gradually in the original river course. In the shallow water area, the population structures are mainly Mollusks, crustaceas and chironomida larva.

(4) Impact on the fish

After the operation of reservoir, aquatic environment undertakes huge changes in original river course, which directly effects the fish inhabit, multiply and feeding condition, leading to the fish migration that accustoms to live in the valley and likes supercritical flow and shoal. However, the fishes such as carp and crucian carp which have strong adaptability, high reproductive rate and omnivores, will become the dominant species of the reservoir. Some fishes which can adapt to both the running water and the still water will continue to be there in the reservoir. In a word, the composition of fish fauna will evolve from the populations that mainly liking to live in the running water habitats towards those liking to live in the subcritical flow or still water.

The original supercritical flow ecosystem sustains continuous destruction after the construction of barrage dam of Qilinguan Reservoir Power Station, cutting off the fish upstream going and thus reducing the fish recourses. Thanks to the improvement of hydrological conditions and the natural river course as well as the transformation from the original supercritical openness aquatic habitats to the subcritical flow, the primary productivity of water body increases, favorable for the inhabit and multiply of fishes that live in the subcritical water or the still water.

4.5.5 Impact of tunnel construction on the ecological environmental

The length of diversion tunnel is 8793m. One of the main works is the section which goes through the left bank of the Nanhe towards to the downstream and is permeated with the junction of Nanhe. During the construction, 9 adit portals (structural openings) will be set up, and then digging with axial-flow blower to supply air and exhaust smoke. Smooth blasting is also adopted, with artificial wheelbarrow or tractors for slag-removing. The buried depth of diversion tunnel is relatively large, most of which are between 50m and even 100m, so that it will not block the animals'

migration channels. Therefore, impact of tunnel constructions on the ecological environmental mainly is the vegetation destruction caused by tunnel excavation and waste slag, as well water and soil erosion.

The layout of tunnel line takes along the left bank of the dam in the upper reaches of the south side of the Huangjiagang → the north side of Dongjiatai → Paomatang, then goes out of the surface at the Guniu cliff. Steep terrain and gentle terrain appear alternately along the tunnel line. The gradient of slope to the west of Huang Gang is $30 \sim 75^\circ$, presenting steep shape on the whole. With a $15 \sim 40^\circ$ slope gradient, the terrain to the east is relatively gentle at large, made up of gentle slopes and medium-steep slopes. The design of tunnel gradient is 1:250 with the enter elevation of about 429m and exit elevation of about 417m, as well as along the surface elevation 450 ~ 510m and the thickness of minimum coverage of roof greater than the 30m. Surrounding rock of tunnel which strikes 111° is mainly medium-thick-bedded limestone. Main lint to east-west direction of the field and the overall rock strike form an obliquity of $20 \sim 25^\circ$. The entire sequence goes through Xiang Temple anticline on the south side, Yanshuitang syncline and Yeji old house anticline on the north side.

The main stratigraphic features through tunnel: surrounding rock is mainly hard medium-thick-bedded limestone, and in the last paragraph there is a small amount ultra-thin-bedded limestone and massive dissolved collapse breccia. The rock of ultra-thin-bedded limestone may be in pieces because it is cut by dense and small fissures. However, fissures are sparse in most parts of the tunnel. Tunnel, the main tectonic lines and the overall rock strike form a small angle. Although it is a negative combination, it is not enough to cause a large-scale negative influence as the diameter of this small section is merely about 3.0m. In conclusion, the tunnel stability is good. Even if unstable phenomenon emerges, it is mainly small wedge collapse phenomenon.

For the convenience of the construction, it is proposed to set up the first admit patrol at Yanshuitang which is gate-shaped with a width of 2.5m and length of 150m; and the direction of which is perpendicular to the diversion tunnel as well as the main tectonic lines and the overall rock mass strike. Therefore it is conducive to its stability. Surrounding rock is the medium-thick-bedded limestone of which rock mass is solid and integral in good stable condition; the hill portfolio structure is superior to that of main diversion tunnel. With a smaller section, its stable conditions are generally better than the main hole. The abandoned dreg site is located outside of the flooded pond; the region is now barren and flat, suitable to serve as an abandoned dreg site.

In line with the construction division, there are a total of nine abandoned dreg stacking sites located in the vicinity of each admit patrols. We will construct them with three sides open drains, masonry lining, drainage canals connected with nearby graff and desanding site at the exit. Before piling up dreg, the surface mellow soil should be peeled and stacked together at the corner of slag yard. When construction is completed and there's no more dreg, the dreg site will be conceded to forestry. With proposed measures implement, the adverse impact exerted by tunnel construction could be alleviated.

4.6 Analysis and Assessment of Soil Erosion

This passage is based on the *Geological Survey of Qilinguan Hydroelectric Power Station Project in the Initial Designing Stage in Wufeng Tujia Autonomous County of Hubei Province* and the *Geological Survey of Qilinguan Second grade Power Station Project in the Initial Designing Stage in Wufeng Tujia Autonomous County of Hubei Province* compiled by Yichang Survey and Design Institute of Water Conservancy and Hydropower.

4.6.1 The Area of Land with Lowered Capacity to Conserve Soil Because of the Project

The land expropriated for the project includes permanent land occupation, material sites, spoil fields, construction and rehabilitation roads and temporarily land occupation.

According to the report, the land submerged by the project can be divided into five categories of landscape, which are farming land, bush, housing land, riverbed and bare rock.

With regard to the grade one hydropower station, when the water of the reservoir reaches the maxim storage level, it will submerge a orange plantation of 80 mu with 6800 trees two kilometers away, and no farming land will be submerged. The permanently expropriated land is mainly for the plants of the station. The permanent construction of the project, including the dam, the intake and the outlet, takes up 4.18 mu. The plant takes up 2.5 mu. The tunnel takes up 13.4 mu. The whole construction area of the project takes up 19.27 mu. At the left bank down the reservoir , there is a quarry of 4.5 mu, a spoil yard of 1.74 mu and a construction area of 5.75 mu. There is also the road for construction taking up 21 mu. Thus the area for supplementing construction is as large as 33.99 mu. The total measurement of the land expropriated is of 52.71 mu. The area of the diversion tunnels is determined by their projected area, thus excluded from the area of surface area disturbed. As a result, the total surface area disturbed is 39.63 mu.

For the II power station , the banks are made up of are steep mountains with no farming land or material objects below the elevation of 366.50 meters in the area between water-intake dam site and the I power plant. The steep terrain stretches upward into gentle slopes with much wilderness. Only land above the elevation of 400 meters is cultivated. This is why there is no need to migrate and no farming land submerged. The land expropriated permanently is for the permanent constructions and the plant of the hydropower station. According to the design of the project, the permanent constructions including the intake dam, the inlet and the sand sluice take

up an area of 0.62 mu. The tunnel takes up an area of 47.6 mu. The plant for the station takes up 2.5 mu. The total area of the permanent constructions is 50.82 mu. The construction of the supplementing project requires an area of 25.16 mu. So the overall area for the project is 75.98 mu. The construction of the project will alter the original landform of the area by excavation, disturbance, roller compaction and occupation. The capacity of the area for water and soil will be greatly lowered. The area of the land expropriated is displayed in details in Figure 4- 5.

Figure 4-5 The Statistical Figure of the Land Covered by the Project

Items		covered land squares (an acreage)					
		arable land	grass-shrub land	riverbed	homestead	uncovered rock	sub-total
Main Project	main body of the dam	0	1.35	1.05	0	1.14	3.54
	diversion tunnel	0	0	0	0	0.04	0.04
	tunnel	0	0	0	0	60.64	60.64
	coffer dam	0	0	1.02	0	0.30	1.32
	power station and booster station	0	0	0	2.5	2.5	5.0
Sub-total		0	1.35	2.07	2.5	64.62	70.54
Non-main Project	construction road	0	13.6	0	0	29.0	42.6
	rubbish area	0	1.74	0	0	1.48	3.22

	construction company and living area	0	3.07	0	0	3.67	6.74
	stone materials yard	0	1.2	0	0	3.3	4.5
Sub-total		0	19.61	0	0	37.45	57.06
Total		0	20.96	2.07	2.5	102.07	127.6

The original landform of these areas will be affected and altered to various degrees due to the excavation or the landfill. This means the top stratum and the ground flora will be damaged, the capacity of the land for water and soil will be lessened, thus causing and speeding the soil erosion. Such affected area has been taken into the account of the facilities/ land of soil conservation damaged by the project. The total area of the land damaged in its capacity for water and soil caused by the project is 24.46 mu, which is displayed in details in Figure 4- 6.

Figure 4-6 Damaged Areas of Water Conservation Facilities

Items		covered land squares (an acreage)		
		woodland and grassland	homestead	sub-total
Main Project	main body of the dam	1.35	0	1.35
	cofferdam	0	2.5	2.5
	power station and booster station	0	0	0
Sub-total		1.35	2.5	3.85
Non-main Project	construction road	13.6	0	13.6
	rubbish area	1.74	0	1.74
	construction company and living area	3.07	0	3.07
	stone materials yard	1.2	0	1.2
Sub-total		19.61	0	19.61
Total		20.96	2.5	23.46

4.6.2 The amount of spoil and waste slag

Spoil and waste slag will be generated during both the main construction project and the supplementing project. It is estimated that a total of 204.1 thousand cubic meters (approximately 248.7 thousand cubic meters in loose measures) of spoil and waste will be generated in the excavation and foundation laying of the quarry and the road and the slope flattening. The details are displayed in Figure 2- 2.

4.6.3 Assessment of the Amount of Additional Soil Erosion

4.6.3.1 The Potential Amount of Soil Erosion

Erosion is a process during which the soil and its parent materials is damaged, moved and accumulating through external force exerted either by nature or human beings. For the project, erosion is mainly referred to the amount of accelerated erosion as the result of the spoil from the excavation and the damage of the landform, soil texture and ground flora.

(1) The Assessment of Erosion Caused by the Disposing of Spoil and Waste

The spoil, rocks and waste slag are basic for erosion. But not all the waste slag will be disposed of. Only that is carried away in rivers can be call eroded. The amount of erosion can be calculated with the formula below.

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

In the formula,

W_{S2} stands for the amount of waste slag discharged (t),

D_{ei} stands for the amount of waste slag having accumulated in each spoil yard (t),

W_i stands for the coefficient of the erosion of the spoil in each spoil yard.

The coefficient is affected by a number of factors. But it's mainly affected by four factors, which are the landform of the spoil yards, external force such as storm runoff, the composition of the spoil and waste and the measures for precaution. The result of the spot investigation shows that much of the spoil is soil mixed with gravel. The spoil is piled among the mountains. The coefficient of the erosion of the spoil is reckoned at 0.20 according to the rainfall intensity. There is 201.1 thousand cubic meters of spoil piled within the construction sites. And it is reckoned that 63.3 thousand tons of spoil will be eroded. Thus, a conclusion can be drawn that the large amount of spoil will be eroded if measures are not taken.

(2) The Total Amount of Erosion

The total amount of erosion consists of the erosion caused by the disposal of spoil and the additional erosion emerging during the breaking of the land surface. The total amount of additional erosion caused by the project is 81.3 thousand tons. The annual amount of additional erosion is 78.1 tons.

4.6.3.2 Potential Damages of Erosion

During the construction, the land surface of the construction sites will be damaged to various degrees, the landform of some areas will be greatly changed. If no precaution is taken, the additional amount of erosion can reach 78.1 thousand tons, causing damages to the fertility of the land, the ecology of the areas and the development of the riverbed of Nan River.

1. Impact on the Fertility of the Land

The erosion may make the land of the surrounding area barren.

2. Impact on the Project

The erosion will affect the progress of the project. If not dealt with properly, the spoil will be carried by the rain into the construction sites thus the project may be hampered, and the safety of the staff may also be threatened.

3. Impact on the River

The river course in the lower reaches will be deposited with mud. And the erosion of the spoil will carry hazardous substances into the lower reaches. The pollution will influence the daily life of people on the bank.

4. Impact on the Ecology

The erosion will cause not only economic loss, but also the whole ecology, because the pollution brought by the deposit.

As a result, the plan to conserve soil has been made to deal with the spoil. The plan also comes up with

1. design for draining system of the site where gravel materials are placed temporarily
2. suggestions for the construction of the roads.

In the plan, the 12 spoil yards will be covered by plants including Japan Cedars, lacebark pines and meadows. The erosion will be controlled with no effort spared.

4.7 The Health of the Staff

1. During the Construction Period

The health care condition in the construction sites is not good enough, there being only one simply equipped health care room which is in a village. When the construction work is much, there will be about 300 workers in the sites, 56 cubic meters of sewage and 0.3 ton of garbage will be discharged each day.

The intense physical work outdoor will weaken the immunity of the staff. If the sewage and the garbage are not dealt with properly, staff can be infected with some insect- borne and water- borne diseases. As a result, measures such as physical exams must be taken to strengthen staff's immunity. The drinking water must be kept clean. The number of the people outside coming to the construction sites must be controlled, and sometimes physical exams for them are necessary. The health care condition of the construction sites must be improved. What is more, the food must be safe and clean in order to prevent mass food poisoning.

2. After the Construction

During the storage of the reservoir, polluting substances will be given out into the water as from garbage and excretion and worsen the sanitary condition. The reservoir will increase the area of water surface and weaken the current. The following alteration of the local climate will help the propagation of bacteria, viruses and eggs of insects. So the bottom of the reservoir basin must be cleaned before storage, otherwise when water is first stored, it will probably be polluted and be the source of intestinal infectious diseases for the surrounding areas.

According to the survey, there is no natural focal infectious disease around the reservoir. During the storing of water, rats will migrate along with the rising water level, increasing the incidence of pestilences in the reservoir basin and surrounding areas. The enlarged water area and the weakened current strength will provide favorable conditions for the propagation of mosquitoes and increase the incidence of the prevalence of mosquito-borne diseases. So weeds and bushes in the riparian area of the reservoir must be removed totally before the water storage in order to prevent the propagation of insects such as mosquitoes and flies.

4.8 Analysis of Social and Economic Effects

Qilinguan reservoir power station located in a comparatively backward district in

Hubei province, and the agriculture and industry foundation is weak. Since the implementation of reform and opening-up, as well as the improvement of traffic conditions, China's national economic power has enhanced steadily. However, due to restricted natural conditions, its economic growth is relatively slow compared to other areas in Hubei province, and its national economic index always falls behind.

The establishment of Qilinguan reservoir power station is aimed at exploiting the abundant water power resources of the county and promoting the economic development of the region. After the project going into production, the electricity volume can hit 78,799,800 kw•h, which can bring a huge benefit to the economy. Meanwhile, the vast investment will become the driving force of the economic development of Wufeng Tujia Autonomous County. The project will also partly solve the employment by providing more job opportunities. In addition, the workers will also boost local consuming. Once the project being completed, the residents can make full use of its abundant tourist resources and push the development of tourism, thus increasing access for jobs. In a word, Qilinguan reservoir power station will promote the social and economic development in multi-respects.

4.9 Analysis and Evaluation of the Project Influences

4.9.1 Analysis of waste water influence in construction period

The quality of water is mainly affected by the discharge of construction waste water and living waste water. Rinsing waste water produced by aggregate processing system, discharged water from excavation, rinsing waste water and waste water from concrete mixing for maintaining and repairing the machines constitute major parts of the construction waste water. And the main pollutants include suspended solid, alkaline water and petroleum. Living waste water discharging mainly comes from construction organization and workers, such as BOD₅、 COD and NH₃-N_o.

(1) The predicted model and parameters are all proposed to use the predicted effect of the one-dimensional model and one-dimensional water quality model:

$$Cx = C_0 \exp\left(-k \frac{x}{u}\right)$$

$$C_0 = (C_p Q_p + C_h Q) / (Q_p + Q)$$

In the equation:

C_x —density of the pollutants flowing through a distance of x , mg/l;

C_0 —density of pollutants in the initial section, mg/l;

k - degradation coefficient, 1/d;

u - mean velocity of flow , m/s ;

C_p - discharge density of pollutants , mg/L ;

Q_p - quantity of discharged waste water , m³/s ;

C_h - background concentrations of river water pollutants , mg/L ;

Q - river runoff , m³/s.

Please refer to figure 4-9 for the dry seasons in downstream of the station.

Figure 4-9 forecasting figure of predicted figuring parameters in terms of the water quality of the station

Items	velocity of flow u (m/s)	depth of water H (m)	runoff Q (m ³ /s)	Annihilate coefficient K (1/d)	
				oxygen consumption coefficient	subside coefficient
Figures	2.0	1.0	0.499	0.25	50

(2) Waste water from aggregate processing system

Construction Aggregate crafts include screening and grading etc, and water is added to dust-falling during screening, apart from the water consumed during the production process, most of it is discharged as waste water. During the Concrete Aggregate washing of Aggregate processing system, the slurry and fine sand whose diameter smaller than 0.15mm of quarry rock was carried away by watercourse, the SS concentration is very high during the washing, and for ordinary material field, the sand-gravel aggregate content is among 2.26 ~ 13.6%. The sand-gravel aggregate and sediment concentration of this project is calculated as 8% ,so usually producing 1t concrete aggregate needs 2.7t water. According to the principle of material balance, the SS concentration of the washing water is 2.6×10^4 mg/L, much larger than the permissible suspended solid discharging criteria of *Integrated Wastewater Discharge Standard* (GB8978-1996) . According to engineering analysis, the estimated concrete aggregate waste water discharging amount is 190m³/h. The prediction of impact on water quality of Qilinguan reservoir power station after discharging waste water can refer to figure 4-10.

Figure 4-10 forecasting results of the suspended solid in waste water produced by sand-gravel aggregate processing unit : mg/L

Distance (m)	50	100	200	300	400	500	800	1000	1200
Density (mg/L)	1002.1	833.3	612.6	522.0	432.4	256.7	83.4	43.2	16.9

We can see from the figure that discharging from the aggregate processing system to Qilinguan reservoir power station, the amount of suspended solid reduces after dust fall and so does the density. And the density in lower reaches of 900m will return to the natural level after being fully mixed.

(3) Foundation ditch drainage

Foundation ditch drainage is grouped into initial drainage and usualness drainage.

The drainage contains precipitation, water seepage and construction water supply. Due to the excavation and the maintenance of the concrete pouring, the foundation water has a relatively high suspension content and great pH. According to other hydraulic engineering statistics, the suspension concentration of the foundation ditch drainage is around 2000mg/L with the concentration of suspended substance after sedimentation of about 100mg/L, while the pH of the concrete maintenance water is 11 – 22, all of which will have some influences on the water quality in the downstream reach of the river.

(4) Washing water from the concrete mixing system

Waste water from the mixing system mainly results from the wash of the rotary drum and the charging bucket, which has a suspension concentration of around 5000mg/L and a pH as great as 12. Waste concrete washing water has an intermittent and centralized drainage and a low water discharge volume, thus has a modest impact on the water.

(5) Oily waste water

Equipment repairing station is set on the north side of the construction area, whose function is partly to regularly maintain the construction machines and the transportation vehicles and to match and barter simple components. Oily waste water comes mainly from the machine run shop and car washing wastes, whose most common pollutants are oil and suspension. If oily waste water enters the drainage without treating, the oil film produced on the surface will block the reaeration of the water lead to an unfavorable impact on the quality of water.

(6) Domestic sewage in the working and living areas

It is mainly the sewage of constructors. During the peak date of the project construction, there are a maximum of 300 workers, while the average worker number is 210. According to the regular amount, the per capita daily water consumption of

constructors is about 200L, totaling 23940, of which 80% is drained as waste water with the drainage index of 160L/d. Consequently the maximum of sewage discharge is as much as 56, with the average level of 33.6, reaching a total of 19152 m³. The major pollutants include COD, BOD₅, SS and NH₃-N.

The construction site is located in deserted mountainous areas far from the residential and urban area. With consideration for the comprehensive level and the regional existing environment, to build outdoor toilets and simplified manure pool can meet the objective and technical requirements in the local area. The Purification efficiency of normal manure pool is between 50% and 90%, with the Purification efficiency of BOD₅ is 60% and that of SS is 70%. The emission concentration is still lower than the national discharge standard after the treatment. The project is small-scaled and the buildings are separated from one another, with also a low volume of project waste water discharge. With this measure, there should not be much change in impact. But the peak phase of construction is mainly during in winter, when river flow is the driest. So without the treating of the direct discharge, it will affect partly and intermittently carrying capacity of sewage water.

4.9.2 Ambient air quality

During the construction, the powder dust and flying dust brought by the work such as the excavation base of the main engineering, the backfill of the earth work, the processing and screening of the aggregates and the handling of the materials, as well as the flying dust and automobile exhaust produced by intra and inter transport and the exhaust gas brought by the excavating machinery, explosions and the fossil fuel in the living area will all influence ambient air. The main pollutants in the exhaust gases are TSP, SO₂, NO_x, CO, hydrocarbons and lead components.

According to engineering analysis, compared with other hydroelectric power station project, the daily emission volume of the main pollutants of CO and NO₂ reaches 8474t and 5154t.

(1) prediction model

The existing street canyon model basically can be divided into three types: Experience Model, Box Model, and Gaussian Model. Due to the small scale of the street canyon and complicated boundary conditions and flow field, K theory model is seldom applied in the automobile exhausts proliferation in street canyon. The pollutant concentrations monitored in street canyon can be seen as a combination of two parts: $C=C_b+\Delta C$, in which C_b stands for environmental background concentration and ΔC is the concentration of automobile exhausts dispersion in this street and it can be estimated by the street canyon model.

The construction area of this project has distinct canyon characters and its dominant wind direction almost parallels to the canyon. Gaussian Model is adopted to simulate automobile exhausts proliferation in large scale canyon. Owing to the fact that dominant wind direction of bottom canyon parallels to carriageway and the width of the canyon is larger than the carriageway, Gaussian Model paralleling to the wind with an unlimited line source is applied in the simulation of automobile exhausts proliferation in the canyon.

Predict model :

$$\Delta C = \frac{Q_L}{(2\pi)^{1/2} u \sigma_z(r)}$$

In this formula:

σ_z is vertical atmosphere proliferation parameter; $r=(x^2+z^2)^{1/2}$, $\sigma_z(r)$ takes $0.48r$.

(2) Prediction result and influence analysis

In normal operation situation, the NO_2 utmost concentration per hour with wind and light wind appears in the area about 80m from canyon's centerline on two sides,

0.522mg/m³ with wind, exceeding about 1.2 times of second grade standard limitation 0.24mg/m³; 0.368mg/m³ with light wind, exceeding 0.53 times. The exceeding range is almost within 200m from roadway centerline. Daily utmost concentration is 0.193mg/m³, exceeding 0.61times of second grade standard limitation 0.12mg/m³ and existing at the same place of 80m from roadway and within 220m from roadway centerline as for the exceeding range. From the view of plane layout and environmental background situation in construction area, the over standard range is within the partial region of the construction area and the influence on external environment is in accordance with the second grade criteria of “*Ambient Air Quality Standard*” (GB3838-2002).

4.9.3 Acoustical environment

4.9.3.1 Prediction model

(1) Fixed sound source

Construction noise in the fixed point source of construction source intensity is mainly from aggregate processing system, foundation excavation, concrete mixing plant, comprehensive processing and so on. According to the requirements of “*Technical Guidelines for Environmental Impact Assessment*” (HJ/T2.4-1995), the following prediction formula is adopted.

Calculation formula of noise source in the fixed point source :

$$L_{A(r)} = L_{WA} - 20lgr - 8$$

In this formula:

$L_{A(r)}$ —Loudness of A, which is Am away from the source , dB ;

L_{wA} - Power stage of sound A , dB ;

r - distance between monitoring spot and the source , m。

Noise level can be determined through the formula below:

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

In this formula,

$L_{\text{总}}$ —predicted sound stage , dB ;

L_i —supposition sound stage , dB ;

n — n sound pressure level。

(2) Flowing acoustic source

The noise produced by heavy truck transportation, the bulldozer and so on may be regarded as the flowing acoustic source. Its magnitude is related with factors, such as noise, the traffic flow, the vehicle type, the vehicle speed and the state of roads. It will be planed to use the following model to calculate its decrement.

The predict model of the flowing acoustic source:

$$L_m = 10 \lg(N/r) + 30 \lg(v/50) + 64$$

In this formula,

L_m - Sound pressure level at the place r m away from the source, dB ;

N - amount of vehicles, per hour ;

v - velocity of the vehicles, km/h ;

r - distance between the monitoring place and the source, m.

4.9.3.2 Analysis of the influence

(1) Fixed or continuous point source noise

Considering the most unfavorable situation-----the maximum value of the source, aggregate processing system of 110dB source intensify, concrete mixing system of 88dB, steel wooden processing factory of 105dB, excavation of 112dB; its influence is in Figure 4-11

Figure 4-11 The Forecasting Value of the Fixed Consecutive Noise Point Source in the Construction Area of Qilinguan Hydroelectric Power Station

Sound Source	Source Strength (dB)	Noise Forecasting Value in Different Distances away from the Sound Source (dB)							
		10m	20m	30m	40m	50m	80m	100m	120m
Granulated Substance and Stone Material Processing	110	82.0	76.0	72.5	70.0	68.0	63.9	62.0	60.4
Steel Wooden Processing Factory	77.0	71.0	67.5	65.0	63.0	58.9	57.0	55.4	77.0
Mix-up System	88	60.0	54.0	50.5	48.0	46.0	41.9	40.0	38.4
Foundation for Building	112	84.0	78.0	74.5	72.0	70.0	65.9	64.0	62.4

The noise sources of the excavation of the fundamental ditch in the dam area and the

system of the processing of artificial aggregate processing system are relatively stronger. Therefore they have an unfavorable impact on the workers at close range.

There are no residential areas around the construction site, and the noise effect is mainly imposed on workers in working and living areas. According to the effect caused by different noise origins and backgrounds of acoustical environment, the prediction of comprehensive effect level on workers in working and living areas is achieved. Results are in graph 4-12.

Figure 4-12 The Influential Value of Qilinguan Hydroelectric Power Station’s Construction Activity to the Sensitive Point

Sensitive Point		The Closest Distance away from the Noise Source (m)		noise influence value (dB)
Position	Name	granulated substance and stone material processing system	mix-up system	
north bank of dam position	construction living area	300	1800	<45

The constructors in the quarters are under the noise pollution. The noise value surpass the first standard of “*Standard of Environmental Noise in Urban Area*” (GB3096-93), however, with the hill gap, the actual sound environment is slightly lower than the predicted value.

(2) Flowing noise

The traffic flow of the main lines in the construction area is 80 /h in the daytime, vehicle speed 35km/h; at night, the traffic flow is 40 /h, vehicle speed 15km/h. The influence of traffic noise in Figure 4-13

Figure 4-13 The Influential Range Forecasting on Both Sides of Construction

Traffic Routes

The Time of Noise	The Forecasting Value of the noise in Different Distances away from the Noise Source (dB)								Standard Distance (m)
	5m	10m	20m	30m	40m	50m	60m	70m	
daytime	71.4	68.4	65.4	63.6	62.4	61.4	60.6	59.9	10
night	57.3	54.3	51.3	49.6	48.3	47.3	46.6	45.9	10

It can reach the standard at the place 10m from the path in the construction area both daytime and at night. Since the living quarters are near the path into the factory, they are relatively effect by the noise.

(3) Demolition noise

The demolition noise has characteristics like short-time, fixed time, the fixed-point, the noise intensity may reach 130~140dB (A). This project's demolition points are mainly: left and right Dam Abutment, dam workshop and block stone quarry. The demolition has some influences to the constructors.

4.9.4 Solid waste

The solid waste is mainly the waste and dregs in constructions and the constructors' solid waste

(1) Waste and dregs in constructions

In this project, dregs are mainly from the excavation and foundation clearing, slope cutting, earth material quarry and stone quarry, which the abandoned earth stone is formed as the surface of materials yard being cleaned up. According to the computation of cut and fill balance of cubic meter of earth and stone (Sees Figure 2-2), the dregs caused by the principal project and the construction site smoothing is approximately 248,700 m³, and would be piled up to the planed field. Without being transported to the field in time or prevention measures, the dregs will have an

influence to the environment, and lead to the water and soil erosion, if it is willfully piled up. The waste slag field uses karst depression with enough wasteland; moreover it basically does not destroy the natural landscape.

(2) The constructors' solid waste

During the constructing period, a great number of constructors gather in the area, reaching 300 at the peak. According to the average emission of solid waste (1kg per person per day), 0.30t scrap will be produced at the peak period. If left without proper treatment, it will influence the landscape, cause the air pollution. And under certain climatic conditions, it will cause mosquito and mouse breeding and reproducing massively. It may lead to some insect intermediary diseases, and spread them in the construction area among the dense population, affecting constructors' health. At the same time, the pollutant and the germ in the solid waste enters the river with rain water and the runoff, they may also pollute the river's water body



5. Analysis on the Environmental Risk

5.1 Risk Analysis

The environment risk analysis of the Qilinguan reservoir power station project is mainly analyzing the probability and the possibility of the accident in the future, which is caused by the engineering constructing and applying. Engineering constructing environment risk is potential, only when the risk arises and explodes as an accident, it has the harm.

According to the development mission, the scale, the project arrangement and the main building design, the way of reservoir utilizations, as well as environmental conditions, such as the project in the regional geological environment, the climatic conditions, the landscape vegetation, hydrologic and sediment conditions, water environmental aspects and aquatic organism and so on, the environment risk of the Qilinguan reservoir power station project is dam break risk and environment geology risk. The conclusion considers the engineering constructing environmental effect forecast and appraisal, and undergoes the preliminary risk recognition.

5.2 Risk of Dam Break

5.2.1 Identifying the risks

Once the dam of Qilinguan reservoir power station break will lead to local electric power shortages, waste of project investment, and possibly also raise unpredictable casualties, which will bring about enormous loss to local people. Possible causes are earthquakes, rare flood and oversights in running the power station.

5.2.2 Risk analysis

(1) Earthquake

The new tectonic movement in southwest Hubei inherits the characteristic of the old structure in its intensity or rising range. Since Neoid, the home court's main characteristic is the intermittent uplift in large scale with the break part difference moves. Since the Quaternary Period, the earth's lifting movement has intensified, with its sticking out speed of 2.9~9.5mm ("*The Study of Hubei West Mountainous Area's Mountain Stability and Crag Collapses Landslide Investigation*" according to the Hubei Province hydrological team). The recent Neoid geomorphologic shape such as the region's river valley sincere and the multistage denudation-plantations, as well as the river terrace was formed by the different activity. The region's major active break are the Xiannv Mountain, Tianyangping Break, with its both sides are often turning points of the blister and subsidence. These breaks all belong to the new China structural system, and they are the main active earthquake gestation fault in the area.

With the analogy of earthquake geology and engineering geology, the geologic report shows that the Qilinguan reservoir will not induce earthquake that is beyond the greatest magnitude within its structural system. We may consider magnitude 4 in the near zone as the upper limit. The reservoir district adjusts the size of stress fields, and is the determining factor of the reservoir induced earthquake intensity; the storehouse district's area and the upper limit of induced earthquake's intensity have obvious relations. Considered the example of the nowadays massive reservoir inducing earthquakes, the middle and small area reservoir has not induced microseism, therefore, induced microseism is also impossible for this area. At the same time, the preliminary quantitative analysis and forecast are done, with the two magnitudes of fuzzy synthesis judgment methods, finally indicated that the storehouse district's most greatly possible magnitude is 2.03, possibly with the epicenter the most dangerous area.

In the report, the time of induced earthquakes is predicted in water stress coupling model. In most cases, the predicted time of principal shock or primary earthquake is around several hundreds of days or one thousand days after the water storage. The

analysis shows that the relatively larger scale of reservoir-inducing earthquake will not happen in this area and even it happens, the magnitude is low, which will not bring serious damages to the dam. Besides, as there are some caves like karst caves in the reservoir area, when the water stored in the reservoir reaches to a certain height, the Karst air exploding type can induce earthquakes. However, as the area in the caves and the height of stored water are limited, the magnitude of the induced earthquakes will be rather low (lower than 2 degrees) and the places where earthquakes occurs spread around.

According to the national standard *Seismic Ground Motion Parameter Zonation Map of China (GB18306-2001)*, the seismic peak ground acceleration in the west area to Wufeng County is less than the zone of 0.05g (equivalent to the degree of VI in basic earthquake intensity). In the east and north areas to Wufeng County, seismic peak ground acceleration is in the zone of 0.05g, while in the areas from Changde, Hunan to Jingshi and from Zhushan, Hubei to Zhuxi , seismic peak ground acceleration is between the zone of 0.1-0.15g. At Qilinguan reservoir pivot, seismic peak ground acceleration is 0.05g, the basic earthquake intensity is VI degree, and the relevant spectrum characteristics cycle is 0.35s. However, considering the rupture in Fairy Mountain and Tianyangping in the nearby, we suggest that the design of the project should take the demand of anti-seismic into consideration.

(2) Catastrophic Flood

The flood in this basin is caused by rainstorm, corresponding to the occurring time of flood. The rainfall within a year happens mainly from April to October and the maximum annual peak discharge happens mostly from May to August with a high frequency. In this basin, the mountains are high and precipitous with deep valleys and narrow rivers. The conflux of flood is fast with sudden rising and dropping, which has the characteristics of floods in the mountainous areas. The form of flood peak is mainly single peak with the company of multi-peak. Because of the detention storage of Karst caves, underground rivers and pits as well as the

long-narrow shape of the basin, the flood peak modulus is smaller than that of adjacent basin.

According to GB50201-94 *Flood Prevention Standards*, SL252-2000 *Standard for Classification and Flood Control of Water Resources and Hydroelectric Project* and the project layout, in the project design, the grade of primary power station project is III and the permanent hydraulic structure is in the third grade. The relevant flood standards: the dam is designed by the standards of flood with a frequency of 2% and the check is by flood with 0.2%. The factories around power station are designed by the standard of flood with a frequency of 2% and the check is by flood with 1%. The grade of the second-grade power station project is IV and the permanent hydraulic structure is in the 4th grade. The relevant flood standards: the dam is designed by the standards of flood with a frequency of 5% and the check is by flood with 1%; the factory buildings of the power station are by flood with a frequency of 2% and check is by flood with 1%. As to the flood with a frequency of more than 1%, we can also ensure the security of the dam by prediction beforehand to empty the reservoir capacity in advance. Therefore, the possibility of instability of the reservoir caused by catastrophic flood is rather small.

(3) Management of Reservoir Operation

●Reservoir Regulation during Floods

During the regulation of the reservoir, especially when catastrophic floods happen, if there is a mistake in regulation, the water will not be discharged in time, which will threaten the safety of the dam. The dam overtopping which may be brings out the instability of the dam and accidents. We can see precedents both home and abroad. Now, as the improvement in the levels of weather forecast and hydrologic prediction, the prediction period may be longer and the accuracy of prediction will be further improved, which will save more time for the regulation of reservoir and thus protect the security of the dam effectively.

● Daily Management of Reservoir

In the daily management of reservoir, improper maintenance may cause damages to the dam, resulting in risks of damaging the dam safety. However now, the security maintenance of reservoir buildings is technically reliable. There is extremely slim possibility of dam-break caused by the oversight in management and maintenance

5.2.3 Risk Mitigation

Strengthening management is an effective measure to mitigate the dam-break risk in Qilinguan reservoir power station. The managers of reservoir should operate strictly in accordance with the scientific regulation scheme, pay close attention to regional weather and hydrological forecasting of river basin, and undertake rationality analysis. Daily security maintenance of dam construction should be enhanced and problems and hidden dangers should be settled in time. Management systems and operation procedures are to be strictly executed and supervision is to be enhanced. At the same time, environmental losses should be reduced by implementing various emergency preplans of dam-break.

5.3 Risks of Ecological Environment

According to the report of geological investigation of the project, the major geological risks in construction are as follows:

5.3.1 Geological problems in dam site

According to the standards of geologic classification for rock engineering of dam foundation in *Code for water resource and hydropower engineering geological investigation* (GB50287-99), the dam foundation of Qilinguan Reservoir Power Station belongs to the A_{III}I type. Body of rock, which is moderately developed, shows a sub-massive or medium-thick stepped structure. In the rock mass, there exist

gently dip angle or steep dip angle in the weak gently dipping structural faces or there are arris and wedges that might affect the stability of dam foundation and abutment. Rock mass is complete with some poorly integrated regions, which is highly tenacious. The performance of anti-slide and anti-flexure is subject to the structural faces. Thus, the structural faces that may influence the deformation and stability of rock mass should be treated specially. According to the 16-class classification, the rock mass referred in the excavation of dam site and natural building material field belongs to VIII type. Hence, the construction budget should be made on this level; According to *Geological Exploration Standards for Small, Middle Water Conservancy, and Hydropower Projects* (SL55-93), the rock mass of the dam site and material field is categorized as III strong or H weak

(1) Stability of the side slope in dam site area

According to the survey, the slope grade and both banks of the dam site reaches 50-85° with the development of unloading cranny. But according to the feasibility research and many long-term observations in the primary design period, recent unloading collapsed stones haven't been found in the valleys of the dam site, which shows that the recent unloading activities in the dam site is relatively weak. The unloading crannies in the dam site, in most cases, are short and small with a tight close and a length of about 1-10m. As the trend of the valley is NNW to SSE and the trend of the terrane is SEE with an obliquity of 60-90°, the rivers almost stand in an orthogonal angle with the steep terrane, which is an internal cause for the weak unloading activities in the dam area. Due to the cutting of the dense layer of thin limestone, the unloading crannies seldom go through a large amount of layers to become dangerous crannies. Thus, there does not have the possibilities of the destructive collapsing and landslide because of the combination of grown unloading crannies. The main form of the lack of stability in the side slope is: through the transfixion of layer fracture or small and short unloading crannies, the potential fractured surface may loss stability.

The dam site is located in the south wing of tightly shut synclines made up of T1j6-4 thin-layer limestone with the trend of layer being SEE. The terrane tendency or the inversion tendency 470m below the two dam abutments are both SSW. 470m above the dam abutments, the trend of terrane is NNE or the inversion tendency is NNE. The 470m in elevation of dam site syncline is where the two wings tightly shut but demonstrating the shape of parallel extending, which has the common two transitional points. Both banks of river valley are transverse slopes. The terrain above 470m in elevation of the left dam abutment shows the shape of 45° steep slope and the terrain below it shows the shape of a steep slope with 55-65°. The pitch bedrock is exposed, the surface layer of which is the rock strongly air slaked. And the upper part of it is 3~5m thick and the lower 1-4m thick. The rock weakly air slaked is exposed near the river valley. The slope body is the typical transverse structure. The terrain above 480m in elevation of the right dam abutment shows the shape of a 40° steep slope and the terrain below it shows the shape of a steep slope with the degree of 55-60°. The pitch bedrock is exposed, the surface layer of which is also the rock strongly air slaked. The distribution of the depth in regolith is almost the same as the left bank and the slope body is the also the typical transverse structure. It is investigated that via the cutting of the unloading crannies, the dangerous rock mass with the volume of 100m³, height of 10m, width of 5m, and thickness of 2m, appears at the 440-450m in elevation of the left dam abutment. The dangerous rock mass is not very stable, with the possibility of collapsing and slipping. There is even the unloading cranny of five to ten cm wide behind the dangerous rock mass. The dangerous rock mass is within the scope of cleaning up in dam that it would not have any unfavorable impacts on the project. Besides the slope body here showing the tendency of instability, the other parts don't show any signs of unsteadiness. In order to prevent the appearance of unstable block bodies in the spot slope face related to the security of buildings, partial cleaning-up to the suspected unstable rock mass in the relevant parts of buildings before construction should be conducted.

(2) Anti-slipperiness and stability of the dam abutment

Under the thrust force transmitted from the dam ends of arch dam, there will be changes in the stability of the dam abutment, which need the stability calculation. With the unloading crannies concentrating on the scope of 3-8m, in the excavation of the dam abutment, it would usually be dug out completely. As the unloading crannies are usually short and small and not transfixed, the structural plane, which will have substantive effect on the stability of the dam abutment after stress is put on, should be the steep and infinitely expansive stratification plane structure with the long and big structural crevasse.

The major adverse structural plane of the dam site is its north-east orientated, having a north-west tendency and a low-angle dip of 15-30° mainly inclined to the left bank. In a macro scope, a “multi” type distribution is shown, and no matter the fault f1 or other growing causes should have the same mechanics origin, that is, they are formed simultaneously at the major press in the north-south. 2 groups with conjugate relationship, parallel cracks can be mainly distinguished. Even if adding the state structure with the most mature and intensive in extension, it is almost impossible to form a 3-dimension risky wedge. Therefore the adverse organization of abutment generally has limited affect to its structure. In addition, the rock of the dam site is basically vertical; having a wide-angle of intersection with the river valley, result in the thrust direction of the right dam is vertical to the rock strata. However, the thrust direction of the left dam is parallel to the rock strata, which means the opposite feature of thrust will have significant impact on the design and optimism of the dam. Therefore, the design should pay special attention to the selection of parameters on the different side of characteristics of the arc and abutment stress.

(3) Suggestion on reinforcement

The design should consider the measurements as dug, anchoring, consolidation grouting or set concrete anti-sliding key to the unstable structure. Meanwhile, it is suggested to strengthen geological data catalog work in the construction period in order to provide specific and reliable demonstration to optimize the plan. For the

unstable structure plane and the condition of more severe evaluated structure plane, the treatment plan should be decided after the new evaluation.

Meanwhile, monitoring and observation should be strengthened to understand its stability condition. Make emergency plan for immediate treatment to the abnormal conditions like landslides and bank collapse.



6. Environmental Protection Measures and Recommendations

6.1 Water Environmental Protection Measures and Recommendations

6.1.1 Environmental protection measures and recommendations in construction period

(1) Aggregate washing wastewater

① Scale of treatment

The scale of aggregate washing water is 190m³/h.

② Treatment process

Aggregate washing water can be treated with the method of natural sedimentation, flocculate sedimentation and mechanical accelerated clarification. Considering the maintenance, management and operating fee, natural sedimentation method is a favorable one. While the other two have more advantages in the elimination effect and occupied area, but require high design, construction and management skill. Due to most of the suspended materials are inorganic particles, having quick settlement, so we choose natural sedimentation as the suggested plan.

Combined with the water supply project design in the construction period, the project aggregate processing wastewater treatment process flow, see Figure 6-1

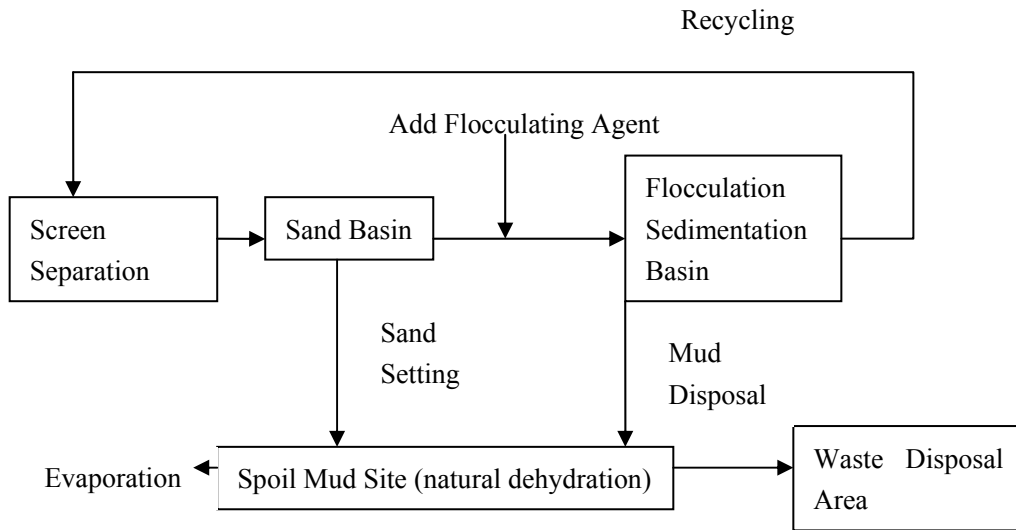


Figure 6-1 the Treatment Process Flow of Wastewater from the Sand-Gravel Processing System

The washing wastewater from screening and sand-making workshop returns to where it is from after flowing into the grid chamber and the flocculation sediment pool where it is treated and reused. The mud discharged during this process will be transferred to sludge drying bed and finally transported to the dumping site. According to the project characteristics of Qilinguan reservoir power station and its construction arrangements, it is decided that sediment mud be dried naturally and delivered to the large dumping site.

③ Scheme Design

The planned size of grid chamber and sediment pool are as follows: the former has an area of 25m², with 10m in length, 2.5m in width, and 3m in height; the latter occupies 180m², with 30m in length, 6m in width and 4m in height. PAM will act as flocculants and flocculation pool is optional.

The grid chamber and the sediment pool will be arranged near the sand-stone

aggregate processing system in the downstream direction. The drying bed can be flexibly built neighboring sewage treatment pool according to the amount of mud production and the topographic condition.

(2) Foundation Pit Sewage Treatment

The concentration of suspended sediment discharged from regular foundation pit sewage is around 2000mg/L, and the Ph value of concrete maintenance water is around 11~12. It is easy to precipitate particles of rock and soil of this type. According to the monitoring results of hydraulic and hydropower projects completed or under construction, after settling for two hours, the concentration of the suspended sediment will basically reach the standard for discharge. If acid is added in this process, the alkalescency of concrete maintenance water can be decreased efficiently. Therefore, the scheme for the foundation pit sewage treatment is to settling for two hours with acid added and discharged after the standard is reached when tested by acid-base indicator.

(3) Washing sewage of Concrete mixing system

The washing sewage of the rotary drum of mixing system and charging bucket has a characteristic of intermittent emission after concentration. The concentration of the suspended sediment is about 5000mg/L with the pH value standing at about 12. Considering the small amount of sewage, a sediment pool is to be built near the mixing system with an area of 2m² and a volume of 2m³. After precipitation, the upper clean liquid will be recycled if possible and the mud timely removed and transported to the drying bed.

(4) Oil-contained Sewage Treatment

With the engineering mechanical repair shop adjacent to the sand and stone processing centre, the discharged water for repairs and washing has a high

concentration of petroleum and the suspended sediment.

' **Sewage Treatment**

Oily sewage can be treated with oil-water separator or by timed placement of flocculants. The former is efficient but with big investment and high maintenance demand. The latter is easy, cost little and convenient to manage. Because the repairing water consumption is little, it is advised to choose the latter to treat the modest emission of sewage.

' **Scheme Design**

Stone drain is to be laid out around the mechanical repair shop for collecting sewage within and guiding it into a rectangular stone treating pool, which will be located near the residential area. The pool will be 6m² in area, 3m in length, 2m in width and 1.5m in height. When the sewage is in the pool, chemicals will be placed in the evening and the treated waster will be discharged on the second day after a whole night's flocculation and precipitation.

' **Operational Management and Maintenance**

With the limited volume of sewage, treating pool is simple in structure, and no mechanical equipment or maintenance is needed. It is only necessary to remove the flocculate regularly.

(5)The disposition of domestic sewage

' **The volume of sewage**

Domestic sewage originates from the living water of construction personnel and the discharge of manure, and there is a living district for office work locating in the construction area. The emission amount of domestic sewage during the peak time of

construction is $56\text{m}^3/\text{d}$, and the major pollutants in the sewage are SS、 BOD_5 、COD and $\text{NH}_3\text{-N}$ 。

' The programs of disposition

Domestic sewage can be disposed by adopting plans as covering ground-buried disposition facilities, using cesspool, micro-power sewage and methane pool, etc. The measures of ground-buried and none-power disposition facilities and cesspool using have their respective advantages, while the key point is that the disposed sewage is difficult to reach the standard . Besides, the methane pool is too large for arrangement.

The construction area is located in the barren hills are far away from the residential area and downtown. on the account of the overall level and the environmental actuality in this area at present, it is in compliance with the local objective conditions and the technical standard requirements to build temporal toilets and facilitated cesspool around the construction area the project construction area. The purifying efficiency of common cesspool is between 50% - 90%, and that of COD、 BOD_5 is calculated as 60%, SS as 70%. It is difficult for COD、 BOD_5 and so forth to achieve the top emission concentration level, while analyzing from the project itself and its estimation on environment, the effect can be limited, featuring locality and regularity.

Take the requirement of environmental protection as a start, it is suggested that dry toilet be put into use and sewage be sent to the surrounding farmers to fertilize the farm land in due time so as to reduce the pollution caused by domestic sewage and minimize its impact.

6.1.2 Protecting measures and suggestions in the operation period

(1) The clean-up work at the bottom of the reservoir should be strengthened. The project construction units have to strictly reach the relevant requirements of the clean-up criteria at the bottom of reservoir and completely clean up the various sorts of water pollution sources within the reach of submerged area in order to avoid the water quality being deteriorated in the beginning period of reservoir impoundment. Meanwhile, floating and rinsing job should be timely conducted during the operation period.

(2) Strengthen the operation on the source of the pollutant at the segment. In order to reduce the adverse effect of the unbearable load source water, local water conservancy, agricultural and forestry sectors should enhance and speed up the soil erosion operation at the upper reaches of the dam site and the surrounding areas. Level terrace of farmland should be implemented, the land above 25° of slope should be returned to forestry. Project construction units should take greening measures to ensure the forest coverage rate of the affecting region to reach 40%. Enhance the management on the use of pesticides and chemical fertilizers, scientifically and effectively fertilize according to varied soil type, crop features and seasons in an attempt to reduce water quality pollution caused by particles and fertilizer erosion.

(3) Domestic Wastewater treatment. After the project is put into use, the main sewage would come from employee, the emissions are relatively small, but it is still excessive discharge if without a treatment. So, it is necessary to build the treatment facility of domestic sewage with the small-sized dynamic device in construction projects, ensuring to meet the discharge standards.

(4) The capacity of reservoir is relatively small for carrying out fish-farming; otherwise, it would cause water eutrophication easily.

(5) Prohibit building the new wastewater outlet in reservoir area and upper reaches.

(6) Provide regular water quality monitoring and forecast to provide scientific foundation for the reservoir environment management.

6.2 Measures and Proposals for Air Pollution Control

(1) reduction and control of fuel exhaust gas

Strengthen the management on the over-size construction machinery and vehicle; project contractor's mechanical equipment shall be equipped with corresponding smoke-reduction equipment, inspect and maintain regularly to ensure various environmental indexes meet the exhaust emissions requirements.

(2) Reduction and control of dust in construction process

Give priority to use of low-dust process of wet crushing so as to reduce dust. Advocate wet operation in Drilling and blasting. In dam area, stock ground and other construction areas where excavation and blasting operations are focused, it is advised to take measures of sprinkler to reduce dust. Use water spray, add ventilation in underground project to improve conditions of pollutants dispersion and reduce the density of dust in operation area.

(3) Reduction and control of dust in transportation

It is advised to harden the permanent road surface with concrete so as to reduce dust caused by transport. Carry out the regular maintenance and cleaning of the road to keep the normal operation. Carry dusty materials which should be humidified or be covered with canvas, delivery vehicles, storage tank of bulk cement should be sealed well, bags of cement must be covered and sealed, and clean transportation vehicles regularly. Keep spray water in construction area by 2-3 times per day in Sunny and windy day.

(4) Health protection

The workers who are affected by pollution seriously, should take personal protective measures, such as wearing dust mask and so on. Afforest in both sides of the road of

working and living area to reduce dust, limit the speed of vehicles within 15km/h.

6.3 Noise Control

Strengthen the control of noise source, repair and maintain construction machinery regularly, select the low-noise machinery and equipment, the larger vibration device should install damping device base. Construction areas and major transport roads should be afforest in order to reduce noise pollution. The high-noise construction works should be avoided in the time-out. Strengthen the labor protection of construction personnel. Workers, in high-noise environment, whose working hours should be less than 6h and be provided with noise-proof supplies.

6.4 Solid Waste Disposal

(1) Waste treatment

Construction Waste should be sent to the designated locations, and take protective measures to prevent water and soil erosion. Look for more in the Soil and Water Conservation section.

(2) Solid waste treatment

In the peak season, 300 workers could make domestic waste up to 0.3t per day, setting up sanitation facilities such as dustbins and toilets in the designed location of the construction area to collect domestic waste of the work. Dustbin needs regular cleaning and disinfection to prevent flies, mosquitoes and other insects breeding. Project construction management departments should organize or commit the local sanitation department to clean the construction area every day so as to improve the sanitation conditions of the construction area.

6.5 The Protection of Ecological Environment

6.5.1 Terrestrial Organism

(1) Plant Protection in Construction Sites During the construction, forest vegetation destruction in construction area should be alleviated to the greatest extent in earth and stone excavation, and the surface soil is ought to be kept for re-cultivation and vegetation restoration. As to construction site and the powerhouse and dam area of the power station, environmental plan and design should be carried out, and according to which greenery construction will be implemented to create a new and more beautiful environmental landscape.

(2)Vegetation Restoration in Reservoir Areas and Its Surroundings

After the impoundment of Qilinguan Reservoir, 80mu's orange orchard will be submerged; displaced tree planting measure should be adopted to restore vegetation for the submerged forestland. Local forestry department should plan the vegetation restoration positions and forest types according to actual site condition. According to altitude, reservoir area forest belt will be cultured with an order from top to bottom as water-source forest, water and soil conservation forest and then shelter belt in a staged manner, so as to create ecological shelter forest, and further expend forest coverage, protect and ameliorate the landscape and ecological environment of the reservoir area. Ecological project such as changing slope land to ladder, live fence, and planted forest can be adopted to build new landscape ecological system of the reservoir area.

(3) Forest closure will be implemented, and destructive lumbering banned, and measure that Grain for Green on slope that larger than 25° will also be carried out, then the nature shall recover to its original ecological system, and a favorable environment for terrestrial organism shall be created, so that in reservoir area, animals and plants flourish, and new water and soil loss shall be avoided.

(4) Destructive forest lumbering in reservoir area is strictly prohibited to protect the habitat environment of wild life; Law of the People's Republic of China on the Protection of Wildlife must be extensively publicized and strictly carried out, the protection of rare or endangered species is ought to be intensified, particularly the

state and provincial level key protection wildlife, so as to maintain the stability of regional biodiversity.

6.5.1 Aquatic Organism

(1) Mainly by Natural Growth, Cage Culture Prohibited Considering that after the reservoir has operated for a period of time, fish population structure in reservoir will reach a new balance; because of the small storage capacity of the reservoir, cage culture should be banned in order that water quality will not be polluted.

(2) Enhance Monitoring on Aquatic Organism

After the reservoir has been built, the population structure of food organism, water environment, fish resource will undergo changes, and according to monitoring and investigation, tendency in the change of fish resource in reservoir will be determined, so that in-time adjustment on concerning protective measures can be done.

6.5.3 Other Ecological Protection Suggestion

(1) To ensure the safety of lives and works by downstream reach of the dam, water storage of the first reservoir is prohibited for production and domestic water usage, and related publicity and supervision measures are to be adopted.

(2) To ensure that the current ecological environment of downstream watercourse will not be damaged after dam completion, it is suggested certain discharge volume maintained according to actual condition and season.

6.6 Water and Soil Conservation Measures

Yichang Design Institute of Water Conservancy and Hydroelectric Power was commissioned by project construction unit to compile water and soil conservation plan report, and carried out prediction on water loss and soil erosion by the project

and raised prevention and control scheme on water loss and soil erosion. This report cited the main content of the water and soil conservation plan report.

6.6.1 Responsibility Area of Water and Soil Loss Prevention and Control

According to statistics computed from FS Report, the responsibility area of water and soil loss prevention and control of the project reservoir and first cascade power station area covers 39.63mu, specifically: project construction area 6.64mu, construction communications 21mu, stock ground 4.5mu, waste disposal area 1.74mu, construction firm, life and administration area 5.75mu; the responsibility area of water and soil loss prevention and control of the second cascade power station is 28.38mu, specifically, project construction area 3.22mu, construction communications 21.6mu, waste disposal area 2.57mu, construction firm, life and administration area 0.99mu.

6.6.2 Guiding Suggestion

Additional water and soil erosion volume is mainly the waste produced by project construction; therefore, focal prevention and control sections are project construction area, the transition point of waste disposal area, and the waste disposal area itself.

Viewing from the intensity of water loss and soil erosion, the engineering measures should be adapted to barricade waste, assisting with planting measure. Discharge facilities must be set up in the temporary stock point of waste disposal field to prevent the waste being washed away by rain.

From the intensity of water and soil erosion and total loss value prediction, it can be seen that the focal period of monitoring is in construction period, and focal sections are the temporary stock point of waste and waste disposal area.

6.6.3 Prevention Objectives of Soil and Water Conservation

Relevant regulations in accordance with *Technical Regulation on Water and Soil Conservation Plan of Development and Construction Projects* (SL204-98) stipulate that this project's overall goal of preventing water loss and soil erosion can be summarized as: Control over the prophylaxis and treatment of responsible water and soil erosion through the governance, and protect project production security and environment construction of engineering zones as well. The specification is as follows:

(1) Restore and reconstruct damaged farmland, woodland and other soil and water conservation facilities as far as possible which caused by engineering construction, to protect environment and decrease water loss and soil erosion by making the fluctuant land management rate reach over 70%.

(2) Take engineering and cultivating measures in due time on land that was damaged by excavating, reclaiming and occupying processes and lost its water and soil conservation capability during the project construction to restore or improve its water retention so that the management and the controlling of incremental of soil-water erosion can both get to a higher level by reaching over 95%.

(3) Build a central repository for project offal. Make a dual protection by taking engineering and cultivating measures to incompact accumulation of offal to prevent the loss of residues prevention and treatment by increasing the protective rate over 95%.

(4) Implement greening measures on abiding or temporary appropriation of land that has a greening condition which is built or still under construction, such as second plowing, trees planting and rehabilitation, to restore the vegetation for more than 90% while the prevention and control responsibilities within the scope of forest and grass coverage rate of 20%. This process is conducive to improve the local ecological environment, and effectively prevent and treat both original and new soil erosion.

6.6.4 Overall Layout of Soil and Water Conservation Measures

According to its topography, geology, soil conditions and regional water and soil erosion status of the construction zone, adopt different prevention programs combined with the constructing characters, disposal, short-range and long-term development planning of the built-up areas by contra posing its frondose peculiarities of water-soil loss sub-area as well as the impacts and preventing objectives resulting from the erosions.

6.7 Health Protection

6.7.1 Better Clean-up Operation

Take clean-up measures in construction area, and reduce various pathogenic microorganisms and entomophilies density to prevent and control the prevalence of various infectious diseases.

(1) Space Disinfection

Do cleaning-up and antiseptis jobs mainly in construction camps and masses louses such as toilets, cesspits, corrals, scrap heaps, cemeteries and so on. Remove all these temporary living quarters after construction. Disinfect the construction areas and clean castoffs by using mobile sprayers stuffed with carbolic acid medicament according to the requirement of *Disinfection Technical Specifications*.

(2) Vector Extermination

Accomplish unified extinction in annual spring and autumn during the construction period, especially the extermination of rats, flies and mosquitoes, to prevent various

infectious diseases and source of infections and cut off the route of transmission by using rattraps. Distribute drudgery and tools to builders under the guidance of sanitary and ant epidemic technicians.

6.7.2 Health and vaccination program

(1) Health and Quarantine

Construction personnel on the need for pre-admission health quarantine, detection and control of carriers and to enter the construction area of new diseases to prevent the construction of the crowd and local residents caused by the mutual transmission and prevalence. According to the survey sample quarantine situation, the project mainly includes viral hepatitis, hemorrhagic fever, and malaria and so on. Quarantine frequency as follows: Construction of staff and managers must be carried out before entering quarantine, after construction during the construction period by 20 percent the number of secondary sampling. During the construction period, construction personnel regularly carry out health surveys and the epidemic archiving.

(2) Health Check

Project after the construction area and gradually change the situation of environmental medicine, construction personnel and the larger physical labor intensity varies, there may be new infections occur. Crowd during the construction period, construction observation and physical examination will help the construction period to master the different state of health of the labor force, the timely prevention and control of diseases and spread to ensure that the construction carried out normally. Health checks to determine the basis of specific circumstances, the construction area restaurant workers, dust exposure, high-noise construction personnel and other injuries on the human body engaged in the construction trades larger staff, an annual physical examination to check the results of the establishment of the file.

(3) The prevention of immune

As a result of the construction area is densely populated, with a greater intensity of construction operations, in order to improve the crowd during the construction period of the construction's resistance to diseases, the prevention of typhoid fever, hemorrhagic fever, malaria, infectious diseases during the construction of cross-infection with the popular crowd on the need for construction immunization program. Based on disease characteristics and construction law of disease prevalence which in the water conservancy project, take preventive medication, vaccination, etc. In addition, the district medical units during the construction of enough reserves tetanus immunization agents and poisonous drugs, so that timely rescue personnel may be affected by tetanus infections and snakebite construction personnel.

(4) Health Promotion and Management

Construction units and construction units should be clearly responsible for health and epidemic prevention, responsible for its management of the scope of population health, sanitation and hygiene promotion and management; establish and improve disease reporting network and found that the epidemic timely report to higher authorities . Regularly carry out the works area of food hygiene supervision and inspection of the works area and check the health of employees in food and beverage certificate. Strengthen the construction of the district and monitoring of drinking water disinfection.

6.7.3 Public Health Facilities

Construction of the layout of the district public health facilities should be based on the overall layout of the construction, the combination of project management and construction of the actual distribution of staff, the construction of temporary sanitary latrines. Temporary public toilets set up requirements: the choice of site should be more than 30m away from the canteen, at the same time should also consider ease of use; kneeling-squatting position settings should be based on National Labor

Administration of the Ministry of Health and the promulgation of the "hygiene standards for the design of industrial enterprises" (TJ35 -79) requirements; the number of toilet, the toilet every few kneeling-squatting position visualization of the surrounding population density.

According to the distribution of the staff and the settlement of the living camp, rubbish bins are set respectively in the living area ; the sanitary trash should be cleared in time and carried outside . Pouring trash into the gull or river is forbidden as to avoid pollution.



7. Environment Monitoring and Environment Management

7.1 Environment Monitoring Plan

7.1.1 The Purpose and Requirement of the Monitor

The environmental change and influence during the construction and movement of the Qilinguan hydropower station should be monitored. And the change of each environmental factor that the project influenced and the effect of the environmental protection measures should be mastered in order to identify certain environmental problems in time and state relevant strategy, release the adverse effect and provide scientific evidence for the environmental management and the completion approval of the project.

The ecological and environmental monitor should utilize the existed cross section (spot) of the local Environment Monitor Station, Health and Epidemic Prevention Station, the Bureau of Aquatic Product, and the Bureau of Forestry. The plan would request certain qualified institutions to proceed.

7.1.2 Environment Monitoring in the Construction Period

7.1.2.1 Water Quality

(1) River Quality Monitoring

Cross section settlement: set one cross section respectively at the ending point of backwater of the reservoir, 200 m point upstream to the dam, 500 m point downstream to the dam, 300 m point downstream to the dam of second-level, of which the cross sections upstream and downstream to the dam would also be used as sections for water quality, total 4 cross sections in the construction area.

Monitoring Items: water temperature, pH, suspension, DO, BOD₅, permanganate index, petroleum class, TP, TN, NH₃-N and fecal colon bacillus flora.

Monitoring Methods: monitoring according to the methods mentioned in the *Technical Standard of Surface Water and Waste Water Monitoring* (HJ/T91-2002)

Monitoring Time and Frequency: monitoring river quality for 1 year before water storage, and the monitoring time in cross sections during the construction area is the 19 months of construction period. The frequency of monitoring is three times per year, respectively in the periods of ample, normal and dry seasons.

(2) Monitoring at pollution outlets

Monitoring point settlement: set one monitoring point respectively at production system of granulated substance stone material, machine repair parking lot, and waste water outlet at concretes mixing station, sanitary sewage outlet, etc.

Monitoring Items: For production waste water, monitoring items are pH, suspension. Other items should be added when necessary. For sanitary sewage, monitoring items are COD, BOD₅, suspension, TP, TN, petroleum class, fecal colon bacillus flora.

Monitoring Methods: monitoring according to the methods mentioned in the *Technical Standard of Surface Water and Waste Water Monitoring* (HJ/T91-2002)

Monitoring time and frequency: construction period synchronized with water monitoring.

7.1.2.2 Atmosphere Monitoring

Place of monitoring: three monitoring points are distributed in construction area of the dam, II Power Station and living quarter's separately.

Target of monitoring: nitrogen dioxide, sulfur dioxide, PM10 (or TSP) .

Monitoring methods: abide by the relevant technical standards in Ambient Air Quality Standard

Monitoring time and frequency: during construction period, monitor five days each time and once a year.

7.1.2.3 Monitoring Noise

(1) Monitoring noise of regional environment

Place of monitoring: six monitoring points are distributed in construction area of the dam, secondary area of the dam, electric power plant, sand-gravel aggregate field, batching plant of concrete, and the part which is near the road to the Plant and sand-gravel aggregate processing system of the living quarters of the staff separately.

Frequency of monitoring: monitor for 24 hours each time and once a year only during the construction period.

(2) Monitoring noise of traffic

Place of monitoring: a monitoring point is set near the main road. The specific location should be in accordance with technical standard of environmental monitoring.

Frequency of monitoring: monitor once a year and record the traffic..

7.1.2.4 Monitoring of aquatic organism

Section of monitoring: three monitoring sections are distributed at 回水末端, 200 meters above the dam and 500 meters under the dam separately.

Target of monitoring: pelagic animals and plants, bottom-dwelling organisms, aquatic advanced plants and fishes.

Time and frequency of monitoring: in April, a year before the reservoir impounds

7.1.2.5 Population Health

Monitoring contents: relying mainly on three-stage network of medical and health, epidemic can be controlled, the relationship between the pollution producing in the construction and people's health can be known through monitoring of population's health. The focuses should be the monitoring of infectious diseases such as natural focus infection disease, water-borne infection, entomophilic infection, endemic disease etc. During the time when infectious diseases are epidemic and in those places where the incidence of the disease are high, random inspection and preventive inoculation will be done toward those people who are liable to infection, at the same time, epidemic report system should be built up. Once modifiable diseases are found, it should be reported in time and investigated, so as to protect the health of the staff.

Scope of monitoring: staff in the construction area.

Monitoring time: monitor during the busiest time of construction and before its completion. It should be carried out by local sanitation and anti-epidemic departments under the relevant requirements by Health Department.

7.1.2.6 Water and soil erosion

Monitoring factor: rainfall, wind, ground slope, slope length, surface composition of substances in the project area, water and soil erosion intensity, characteristics, and hazards of the construction process, growth condition, vegetation and cover of plant, soil loss amount, soil nutrients, the quantity and quality changes of soil and water conservation facilities.

Monitoring contents: Water and soil erosion amount; Water and soil erosion hazard; Soil and water conservation of the project effectiveness.

Monitoring methods: The methods are to survey in the field, and fixed-point monitoring.

Layout of monitoring points: an observation point will be laid in the residue field and the construction material site. For the construction roads, two typical sections of it will be selected to the monitoring sections, each monitoring sections can be laid one ~ two points.

Monitoring time and frequency: to monitor one time during the construction period.

7.1.3 environmental monitoring during the operation period

(1) Water quality

Section settings: to set up one monitoring sections in the upper stream of the dam on the 200m, and in the lower stream of 500m respectively in which the end of backwater of the reservoir.

Monitoring items: water temperature, pH, suspended solids, dissolved oxygen, BOD₅, permanganate index, petroleum class, TP, TN, NH₃-N and fecal colon bacillus flora.

Monitoring methods: according to "*Surface Water and Wastewater Monitoring Technical Specifications*" (HJ/T91-2002) provided for monitoring methods to monitor.

Monitoring time and frequency: to monitor yearly by the three water seasons that are low water season, high water season and tap water season after water storage, then continue to monitoring for two years

(2) water temperature

Layout of monitoring sections: to set up an observation sections in the upper stream and lower stream of the dam on the 300m, as well as in the mouth of in the downstream of the dam.

Monitoring cycle and frequency: continuous monitoring for 3 years after water storage of reservoirs, monitoring 5 times one year which on February April, July, August, and December.

(3) Aquatic organisms

Monitoring sections: to set up one monitoring sections in the upper stream of the dam on the 200m, and in the lower stream of 500m respectively in which the end of backwater of the reservoir.

Monitoring Contents: included plank tonic animals and plants, benthic organisms, aquatic higher plants, fish.

Monitoring time and frequency: after storing water into the reservoirs.

(4) Water and soil erosion

Monitoring factor: rainfall, wind, ground slope, slope length, surface composition of substances in the project area, water and soil erosion intensity, characteristics, and hazards of the construction process , growth condition, vegetation and cover of plant, soil loss amount, soil nutrients, the quantity and quality changes of soil and water conservation facilities.

Monitoring contents: the water and soil erosion amount, water and soil erosion hazard; soil and water conservation of the project effectiveness.

Monitoring methods: the methods are survey in the field, and fixed-point monitoring.

Layout of monitoring points: an observation point will be laid in the residue field and the construction material site. For the construction roads, two typical sections of it will be selected to the monitoring sections, each monitoring sections can be laid one ~ two points.

Monitoring time and frequency: within 3 years, the operation period of hydroelectric power station will be monitoring one times respectively in the annual flood seasons, and winter.

7.2 Environmental Management

Qilinguan Reservoir Power Station project in environmental management is the composed of the project management of it, and runs through the project construction period and operation period.

7.2.1 Environmental management purpose and goals

China's *Environmental Protection Law* stipulates that the purpose of environmental management is "to protect and improve the living environment and the ecological environment, prevent and control pollution and other hazards, protect human health in order to promote the development of socialist modernization." The most significant part of project's environmental management is the ecological environment management. Eco-environmental management objectives are: to protect the ecological environment, prevention and control the ecological damage caused by the period of project construction and operation so that to promote the social, economic and ecological sustainable development. The main ecological environment goals of the project are:

(1) prevent from ecological damage caused by the construction and operation period to protect the overall ecological environment where the impact area of project.

(2) strengthen water quality, air, noise and other environment pollution control in order to prevent eutrophication from the reservoir and unicorn functional degradation of Qilinguan Reservoir Power Station for protection of population health.

(3) do good job on soil and water conservation projects.

(4) protect biodiversity in the evaluation areas

(5) various environmental protection measures to implement the project, so that "he who develops is responsibility for protection; he who destroys is restores; he who utilizes compensation" policy be fully implemented.

7.2.2 Environmental Management mission

(1) go to start implement China's environmental protection laws, regulations and standards as well as the corresponding management system of the local environmental protection administrative departments to establish a sound project rules and regulations of the environmental protection work, clearing the approach to environmental responsibility and its rewards and punishments.

(2) organizes and coordinate the report and each one of the mission put forward by the approval, to take effect the eco-environment compensation and control of the funds for preventing from pollution.

(3) be responsible for handling various types of accidents caused by pollution and destruction of ecological environment.

(4) regulate the plan for implement ecological environment t monitoring programs.

(5) implement the supervision work.

(6) to establish a complete engineering environment management information file.

(7) organizes the project environmental management and professional training for monitoring staff.

(8) strengthen the connection with the local Environmental Protection Agency so as to seek guidance and help.

7.2.3 Environmental management agencies

Environmental management works should be done by the specialized agencies, in accordance with national environmental protection regulations, in the Qilinguan Reservoir Power Station project management set up the Department of Environmental Management Office to accept the inspection guidance from the business, local environmental protection departments; its main function is responsible for day-to-day work environment management, coordination of environmental disputes and deal with environmental accidents, as well as for the environmental monitoring of all stages and supervision plan, the implementation of environmental protection measures, acceptance of environmental monitoring, inspection from the water conservancy, environmental protection and health and epidemic prevention departments and so on. Environmental Management Office is composed of one member; the employment of staff should have professional technology on the environmental protection..

7.3 Environmental Supervision

Environmental Supervision is an important component of the project supervision, it should be run through the entire process. Environmental supervision engineer approved by the Environmental Management Office, mainly carry out environmental protection supervision and inspection for the entire professional sectors which have implemented the eco-project during the construction period to implement the

eco-project for the entire professional sector and the environmental protection of project contractor.

7.3.1 Environmental Supervision mission

(1) in accordance with the relevant laws and regulations and environmental protection project agreement carry out mainly carry out to check and supervision for the entire professional sectors which have implemented the eco-project during the construction period so that to request the demands time limits for completion of the related environmental protection work.

(2) to assist the Environmental Management Office and relevant departments deal with environmental pollution accidents in the project-affected zone and environmental disputes.

(3) the preparation of monthly newspaper by Environmental Supervision and half-yearly report submitted to the Environmental Management Office for summing up the environmental supervision of the work so that to figure out the major environmental problems and give the suggestion to solve them, clearing the arrangement of environmental supervision and the working emphasis.

7.3.2 Management approach

Supervision can be taken to check and instructing the documents.

7.3.3 Supervisors' settings

Under the concept of environment supervision workload of Qilinguan Reservoir Power Station Project needs an environmental supervisor. (Excluding the supervision on Soil and Water Conservation)

8. Environmental Protection and Analysis of Investment and Economic Profit and Loss

8.1 Investment Estimate for Environmental Protection

According to the basic principles of environmental economics and environmental regulations and ecological environment, "he who destroys is responsibility for governance" in order to make that the implementation of the proposed works will not cause significant damage to the environment, to avoid ecological deterioration so that economic, ecological virtuous cycle can achieve sustainable development. It is necessary that for their prediction and prevention on the potential ecological impact, and the defensive and preventive investment budget will minimize environmental risks.

8.1.1 investment principle

In lines with national related laws and politics determines investment principles combining with actual engineering situation

(1)The principle of “those who pollute and develop should responsible for treating and protecting”, establish investment project of environmental protection according to the principle, and guide the investment distribution if necessary.

(2)The principle of “functional protect”: pollution treatment aims to protect engineering functions.

(3) The principle of “functional restoration”: the invest scale aims at protecting or restoring ecological environment before the project construction.

(4) The principle of “disposable compensation”: compensate the ecological environment loss caused by the project in accordance with the principle of disposable compensation.

8.1.2 foundation of evaluation

(1) *Budget Estimate Making Method and the Calculation Standard of Hydroelectric Project Design* (national economics and trade committee NO78 2002)

(2) *State planning commission, national environmental protection bureau announcement about the problem of regulating consulting charge of environmental effect* (Price [2002] No. 25 document of State planning commission)

(3) Design environmental protective measures for Qilinguan reservoir power station project .

(4) Price of related material accords to the market price in the first half year of 2004.

(5) Provisional charging regulation and management method of charging the environmental monitoring were adopted by the Environmental protection industry.

8.1.3 Division of investment project

According to the related regulation of environmental protection in the project, equipments, monitoring methods and engineer facilities, which are used for pollution treatment and environmental protection, belong to environmental protective facilities.

Investment evaluation of environmental protection facilities should be listed in all projects.

The project needs environmental protection with its special investment, comprised

environmental protection in construction areas, environmental monitoring and management, water quality protection in reservoir and etc. Environmental protection investment from other sources such as cleaning the bottom of reservoir, submergence and compensation of reservoir, environmental protection facilities in construction and the like should be listed in the engineering investment without accounting into the special environmental protection investment.

8.1.4 Main environmental protective investment

According to the environmental protection effect, protective measures and relative implemented foundation unit price and comprehensive unit price of Qilinguan reservoir power station project, as well as the principle above, estimates that the total investment of environmental protection in this project is 1.092 million yuan, wherein, investment of environmental protection measures in pivotal project area is 641.6 thousand, which is 33.7% of its total investment; independent charge is 286.9 thousand yuan, which is 15.1% of the static total investment; the total investment of soil and water conservation in the project is 973.5 thousand yuan, accounting for 51.2% of the static total investment.

Table 8-1 the investment estimation of each item of the environment protection project in Qilinguan Reservoir hydroelectric power station

Serial No.	Name of projects or expenditure	Unit	Quantity	Unit price (yuan)	Total (ten thousand Yuan)	Remarks
I .Environmental conservation of the pivotal project					64016	
A	Treatment of sewage and wastewater				23.96	
1	Treatment of domestic sewage	m3	33.6	1,000	3.36	Septic tank + oligodynamic sewage treatment facilities

2	Treatment of oily wastewater	place	1	20,000	2.0	
3	Treatment of the wastewater from processing sand-gravel aggregate				18.0	The expenditure has been included in that of processing sand-gravel aggregate
	(1) Construction cost	place	3	40,000	12.0	The period before construction
	(2) Operation cost	year	3	20,000	6.0	Operation cost of treating the the wastewater from processing sand-gravel aggregate
4	Treatment of wastewater from the concrete production system	place	1	6,000	0.6	Including the operation cost during construction period
B	Protection of ambient air quality				10.3	
	(1) Water spraying	year	2	25,000	5.0	Including wages and water fee, etc
	(2) Bag type dust collector of the concrete mixing system	set	1	50,000	5.0	
	(3) Dust mask	set	300	10	0.3	
C	Noise Prevention and Treatment				0.3	
	Individual protection against strong noise	set	300	10	0.3	
D	Domestic rubbish disposal	t			0.78	
	Garbage bin		6	500	0.3	
	Domestic rubbish disposal		120	40	0.48	
E	Protection of population health				6.32	
1	Hygienic cleaning	m2	20 ,	0.3	0.6	One time each when entering

			000			and exiting the construction field
2	Health quarantine	People/time	2×300	60.0	3.6	
3	Epidemic prevention	People/piece	2×300	25	1.5	
4	Deratization and mosquito eradication	Year/people	2×300	5.0	0.3	Comprehensive unit price
Serial No.	Name of projects or expenditure	Unit	Quantity	Unit price (yuan)	Total (ten thousand yuan)	Remarks
5	Sanitary privy	place	4	800.0	0.32	
F	Protection of aquatic organisms	year	6	20,000	12.0	
G	Monitoring of ecology and environment				10.5	
1	Water environment				3.0	
2	Ambient air quality				1.5	
3	Noise				0.4	
4	Aquatic organisms				5.0	
5	Epidemic surveillance				0.6	
II Extra expenses					28.69	
A	Expenditure of construction and management				18.53	64 . 16
1	Ordinary expenditure of environmental management personnel				1.92	Counted as 3%of the part I
2	Expenditure of (scientific) research , survey and design				15.0	
3	Publicity of environmental protection and technical training				1.61	Counted as 2.5% of the part I
B	Cost of environmental superintendence	People/year	1×2	50 , 000	10.0	
C	Cost of project quality monitoring				0.16	Counted as 0.25% of the part I
Total static investment of					92.85	

environmental protection					
III Total static investment on soil and water conservation				97.35	In accordance with the soil conservation plan
Total investment of environmental protection				190.2	

8.2 Ecological Influence and Economic Profit and Loss Analysis

8.2.1 Economic Benefit

Power generation takes the dominant part in Qilinguan reservoir power station project, benefits of which mainly manifest in the two following aspects: direct economic benefit and social benefit—improvement of regional surrounding environment.

With installed capacity 17400kw, firm power 4385kw, and multi-year average electric energy 66.15 million kW•h, the power station can take part in peak-load regulation despite of small capacity scale. Thus, it will be an adjustable power that can conduct long-term self dispatching in Wufeng County electric system, which is very favorable for alleviating conflict between local system power consumption and peak regulation as well as improving systematic power supply quality. The development of electric power will definitely promote regional economic construction and development of industrial and agricultural production.

After completion, financial internal return rate of total investment is 10.23%, larger than financial basic return rate 10%, and financial net present value reaches 2.732 million Yuan within 10.56-year investment payoff period (construction period included). National economy adopts shadow prices in investment adjustment and beneficial adjustment. From national economy's point of view, this project is also

feasible as the analysis and calculated result show that its internal return rate 12.09% is higher than social discount rate 12%.

Referring to the estimate of industrial and agricultural output value created by kwh electric quantity of central and east China, Wufeng County can annually create industrial and agricultural output value over 250millionRMB.

8.2.2 Social Benefit

Making full use of local natural geological conditions and advantages, this project which adopts trans-basin diversion power generating will produce good social benefit:

(1)After completion, flood, landslide and debris flow can be alleviated in different degrees, creating a safe environment of living and production for people in the neighborhood. Through forest and grass measures construction, we can make the mountains and rivers more beautiful and provide an elegant working environment for power station's staff as well.

(2)Proposed project has positive benefits for protecting and utilizing land resources: enhanced flood storage ability of water supply works can improve flood prevention guarantee rate; due to the completion of intake dam and tunnel, local flood drainage ability will improve to some extent so that submerged area and duration can be relatively reduced.

(3)After operation, the project will provide new job opportunities and improve employment environment which can increase local income and bring good social benefit.

8.2.3 Ecological Effect

During construction, this project will exert certain influence on ecological environment. However, after completion, favorable impact will be dominant. Besides alleviating downstream flood threats, enlarging potential land and increasing flood prevention guarantee rate, the project is also propitious to closed forest in mountainous area, water and soil loss control and ecological environment improvement. In addition, general water quality in reservoir area and under dam site will be better. In a word, the project will bring ecological and environmental benefit after completion.


8.2.4 Environmental Effect

Compared with thermal power generation project of same scale, this project is better for environment. Hydropower is a renewable resources as well as a clean energy. In place of thermal power station, hydroelectric station will reduce the consumption of raw coal by 3.78×10^4 t/a and the emission of SO₂ by 196.5t/a if consuming 480g/kW·h standard coal. And the discharge of harmful substances like NO₂、CO₂、CO, dust and so on also declines. Thus, it will do less harm to the surrounding environment caused by harmful substances from thermal power station entering atmosphere and water body. This hydroelectric station can save 5×10^4 yuan/a pollution charge every year. As there is no need to transport coal, construction will do less damage to the environment while a large amount of transportation device investment and occupied land by special lines will be saved.

8.2.5 Comprehensive Analysis on Environmental Economic Profit and Loss

It is easy to draw a conclusion from the analysis of environmental protection investment and environmental, economic and social effect above: environmental loss is less than profit of the engineering while favorable influence on environment

brought by engineering is obviously greater than disadvantage; social and economic effects mainly embody in the following aspects: power generation, promoting local economy and so on; environmental benefits manifest in lessening of regional ecological damage etc, while losses manifest in land submergence, water and soil loss and so on. However, these losses can be alleviated through corresponding compensation and environmental protection measures. It is obvious that the environmental economic effect brought by engineering is positive.



9. Public Participation

The participation of the public is integral to the assessment of the environmental impact of the project. With the help of relevant organizations, the public was invited to the assessment in various forms in 2004. The conduction of participation of the public was intended to offering the public more accesses to the progress, the operation and the environmental issues of the project and to gathering opinions from the public about the project, thus to help improve the planning and designing by preventing as many environmental damages and optimize the overall utility of the project.

9.1 The Scale, Forms and Content of Public Participation

9.1.1 The Forms, Subjects and Scale of the Participation

Residents near the reservoir and the dam were visited by investigators. They were invited to discussions or were asked to fill questionnaires. People from various walks of life living were involved. Interviewees were from the area near the reservoir, the to- be- submerged area and the urban area.

The subjects come from different organizations and groups such as social groups, government agencies, residents by the reservoir basin. There were 50 people interviewed, including technicians, government officials, and a delegate of the People's Congress of the county, a member of the local CPPCC, residents and migrants. Most of them were people living near the construction sites and the reservoir. Thus the outcome of the survey was relatively in line with the public opinion about the project.

9.1.2 The Content of the Interviews

Displayed below is the form of the questionnaire for the interviews.

Figure 9-1 A Survey of Public Participation

The Basic Information of Participants

Name	Gender	Age	Standard of Culture	Occupation	Nationality
	<input type="checkbox"/> male <input type="checkbox"/> female	age	<input type="checkbox"/> college <input type="checkbox"/> middle school <input type="checkbox"/> primary school <input type="checkbox"/> below primary school	<input type="checkbox"/> cadre <input type="checkbox"/> worker <input type="checkbox"/> peasant <input type="checkbox"/> others	
Name of the Unit					
Family Address					
Telephone Number					

Investigation Content

1、 Do you know this project ?

Yes No

2、 What is your attitude toward this project ?

Approval Not Approval

3、 If constructing this project, when do you think is the best time?

Immediately Slow Construction

4、 What do you think this project will influence the regional economy?

Big improvement

Some improvement but not big

No improvement

5、 What do you think of the ecological environment in the construction area?

Good Fair Bad

6、 What do you think are the benefits that the construction of the hydropower station will bring?

Important benefit to the whole development

Improvement to local economy

Improvement to regional environment

Promote the flood prevention ability of downstream

Improvement to regional ecological environment

Improvement to living conditions

Increase of job opportunities

Improvement to transportation situations

Others: _____

7、 What do you think are the negative influence of the construction of the hydropower station? ?

Immigration

Land submergence

Submergence of rare animals and plants

Aggravation of water and soil loss

Others: _____

8、 What is your opinion of emigration and settlement?

Do not wish to emigrate

Difficulty but could overcome

Would like to emigrate

9、 What is your requirement for emigration ?

Near the original place to other places

10、 What are the environmental problems in your residing place ?

Inconvenience of transportation

Water and soil loss

Natural disasters

Other: _____

11、 What are the rare and precious animals and plants in your living place?

(1) Rare and precious animals : _____

(2) Rare and precious (including raw material for medicine) : _____

12、 Your supplement opinion ?

9.2 The Outcome of the Survey

9.2.1 The subjects of the Survey

There were 50 questionnaires given out and all of them were filled out and given back, which means the recovery rate is 100%. And the distribution of the subjects is as Figure 9- 2 below.

Figure 9-2 Distribution of the Participants

Survey Object \ Category		Peasant	Worker	Officer	Soldier	Other Occupation	Total	
		Gender	male	17	6	4	4	
	female	4	3	5	0	2	18	
	sum-total	21	9	9	4	7	50	
Standard of Culture	college	0	0	5	0	2	7	50
	middle school	10	7	4	4	3	28	
	primary school	11	1	0	0	2	15	

The statistics of profession shows that the majority of the subjects are farmers, taking on 42.0%. They are from local villages. Among them there are 16 dwelling near the area submerged, taking up 76.2% of all the farmers. Government officials and workers both account for 18% of the subjects, being the second largest group of subjects. The statistics of gender shows that the majority of the subjects are male, taking up 64.0%. The statistics of educational background shows that most subjects- 56.0% of them- are of middle school educational background. 30.0% of them are of

primary school educational background. 14%- the smallest proportion of them are of college or university educational background.

There is a delegate of People’s Congress of the county and a member of the local CPPCC.

9.2.2 Analysis on the Answers Given in the Questionnaires

The answers are categorized in Figure 9- 3.

Figure 9-3 A Statistical Figure of Public Opinions

No.	Content of Opinions		Number(person)	Number in Groups	Percentage
1	Do you know about this project?	yes	50	50	100%
		no		0	0
2	What’s the proper time for the construction of this project?	immediately	50	49	98%
		later		1	2%
3	What’s the influence of this project to the regional economy?	a great promoting effect	48	45	93.75%
		a not great effect		3	6.25%
		no effect		0	0
4	How is the ecological environment now?	very good	50	38	76%
		just so-so		12	24%
		bad		0	0
5	what kind of environmental problems are there in your living places?	inconvenience in traffic	50	50	100%
		water and soil erosion		0	0
		natural disaster		0	0
6	What effects will the construction of	great effect to the overall development	50	50	100%

No.	Content of Opinions		Number(person)	Number in Groups	Percentage
	hydroelectric power station make?	the promotion of local economic development		50	100%
		the improvement of local environment		26	52%
		the improvement of the flood prevention ability		12	24%
		the improvement of ecological environment in this area		32	64%
		the improvement of people's living standard		48	98%
		the improvement of job opportunities		26	52%
		the improvement of traffic condition		46	92%
7	What side effects does this hydroelectric power station make?	migration	50	0	0
		submergence of the land		42	84%
		submergence of the rare animals and plants		0	0
		aggravation of the Soil and water erosion		0	0
8	What's your opinion on the migrants' relocation and placement?	reluctant to move	0	0	0
		have difficult but can conquer		0	0
		willing to migrate		0	0
9	What's your requirement for removal?	nearby	0	0	0
		to other place		0	0
10	What rare animals do you have in your living place?	rare animals: giant salamander, Golden pheasant	50	41	82
		rare plants :none		0	0

1. There are 50 of the subjects, which is 100% of the subjects who know that the Project of Qilinguan Hydropower Station is in its preparative stage. This shows that the project is relatively influential and all the subjects have known about and do care about it.
2. Forty-nine of the subjects believed that the project should be started at once, taking up 98% of the total number. One of them believes that the project should be put off, taking up 2% of the total number. And the reason given by that one subject is the problem of investment. This shows that people care about economic issues of the area and are demanding changes in the region.
3. 76% of the subjects think highly of the ecology of the construction area now. According to them, the scenery is beautiful and worth sight- seeing and the environment is livable. 24% of the subjects think that the ecology of the construction area is average, because the measures against soil erosion and the supplementing facilities are not effective enough, leading to frequent landslides.
4. 100% of the subjects regard the major problem in the daily life as difficult road travel, which is hampering development in other areas.
5. Most of the subjects value and expect the positive effect brought by the project. 100% of them think the project will accelerate the comprehensive development of the region and will inject incentives in local economics. 52% of them think it will improve the local environment. 98% think people's living standard will be improved by the project. 92% think the project will lead to the bettering of the conditions for transportation.
6. The negative effect of the project is sorted into four categories, being the issue of migration, the issue of land to be submerged, the issue of rare fauna and flora and the deterioration of soil erosion. The subjects have proposed no issues except for the second one. 42 people say they have a problem of the land, taking up 84% of the subjects.

This shows that the public pays closely attention to the issue of migration and the issue of the land submerged. The fact is that there are no residents living in the area influenced by the construction and the operation of the project, thus there's no need of migration.

7. The subjects know more about the rare animals than the rare plants in the region. 82% of the local residents know well about the rare animals and are active in protecting them, while no one knows or has answered the question of whether there is rare flora in the region.

9.2.3 The Issues that Attract the Most Pubic Attention

Visits to and interviews with people of various professions in the village were conducted to collect their opinions. The response of the questionnaires is sorted into the four issues that attract the most public attention as follows.

1. The issue of compensation for the submerged land. The interviewees hope that the government and the construction organizations come up with a plan for the expropriated land. The price of compensation should be determined according to the national policies and standards and the local situation. The opinions and requirements of the villagers should also be taken into account. This issue must be appropriately and totally settled.

2. The issue of the project's quality. The quality of the project has far- reaching influences. Thus the public demand that the project be a high- quality one.

3. The issue of the project's utility. To go along the project, the public ask that the government to come up with plans to develop infrastructure such as road and telecommunication and welfare facilities, and plans to improve people's livelihood and to raise fund for the project. Through these measures, the project will effectively give impetus to the local economics in the long run.

4. The issue of water release and adequate flood protection after the project is finished. The public hope the government will watch closely the issue by carefully examining the relevant measures and suggestions in designing and environmental evaluation of the project.

9.3 The Conclusion and Suggestion

The results of the survey shows that most subjects know about and support the project, believing it will help improve their life, thrust the local economy and provide more jobs. But they are also concerned about the issues of land compensation, pollution and the damage to the ecology.

From the public opinion, conclusions can be drawn that the proprietor should implement the anti- pollution measures strictly to reduce the pollution of air, water, noise and solid waste. And it should try hard to prevent serious soil erosion and damage of ecology.



10. Conclusions and Suggestions

10.1 Conclusions from the Assessment of the Main Environmental Factors

1. About the Local Climate

After the reservoir is built up, some land will be covered by water. The increased water area will have a larger evaporation, adjusting the solar radiation and the humidity and temperature of the reservoir basin and adjacent areas, thus changing the microclimate. The fluctuation of temperature will be mitigated. The diurnal range and the annual range will diminish. The maximum annual temperature will slightly drop and the minimum annual temperature slightly rising. The enlarged water area will decrease the roughness of the underlying surface, thus increasing the air velocity of the surface. However, the alteration of climate is only confined to the areas next to the reservoir basin and is quite moderate.

2. Hydrology and Silt

Nan River is a river in the mountain ranges. Its flood is affected by the storm intensity and the terrain. The river valley has a strong storm intensity and a steep hydraulic slope. So the flow concentration time is short and the velocity of the current is high. All these factors cause flash floods of the river. The project will alter the original conditions of the course. Sediment will accumulate in the reservoir as it operates. And the water level of the reaches near the reservoir will thus be raised, and the hydrographical factors such as flow rate and velocity of current will be affected. The fluctuation of mean annual water level of the reaches near the reservoir will get greater, and mean flow velocity will get lower than it originally is.

The water for Qilinguan Hydropower Station is gathered into the reservoir basin from

solution cavities. So there is little silt in the water, which will cause no problem of sediment in the reservoir basin.

3. The Geology

There is very little incidence of cavity leakage or fault leakage. The inclination of the side slope on the left bank of the reservoir is basically in line with that of the strata. And the dip angle of the side slope is larger than that of most of the strata. There may be more collapses and small- scale landslides instead of large- scale landslides in just a few places after the project is finished. And there will be no serious safety risks after the storage of the reservoir. There is no mineral resource of exploitation value or cultural heritage in the reservoir basin, thus no problem will emerge from the submergence. The area is in a microseismic region with a good geological structure. As a result, the project is very unlikely to induce a strong earthquake though the project should be designed as quake proof.

4. The Quality and the Temperature of the Water

The alteration of the hydrographical factors mentioned above will not impose serious damage to the quality of the water in the reservoir basin. Generally the water will maintain the quality level as before. The discharge of the small amount of domestic sewage in the upstream side will not affect the general quality of the reservoir's water, which is oligotrophic .

According to the analysis, the reservoir is a mixed one, no spawning site of large commercial fish or rare fish at the downstream side of the dam. The power station does not function to irrigate or to provide water of domestic or productive use. Consequently, the low temperature water of the reservoir in summer time will have little impact on the downstream.

5. The Terrestrial Ecology

The utility of land will be affected after the project is finished, because some fertile woodland will be submerged. The general productivity of the regional ecosystem will remain the same though the productivity of some typical area will diminish. And the project imposes little impact on the local landscape ecosystem.

The construction and the following submergence will do harm to the flora. However, the major plants to be submerged are bushes, and no native vegetation, large commercial forest or rare plant will be covered by the water. The population structure and the diversity of the local wild animals will not be seriously affected by the project.

6. The Aquatic Ecology

The submergence by the storing of water will increase the amount of nutritive salts in the reaches near the reservoir, improve the primary productivity of the reaches near the reservoir by improving the bait condition. It will also be favorable for the regeneration for fish inhabit the slack water.

When water is restored, the dam will be an obstruction of the river, damaging the integrity of the logic ecosystem. The dam will restrict the migration of fish and diminish their number in the reservoir basin.

There are nine waste yards for the construction of the tunnels, each located by the major dam or the branch tunnels. Gutters in the waste yards is designed as ... and will be lined with mortar laid stones. The gutters are connected with ...s with an settling basin built in the outlet. Mellow soil on the surface will be removed and placed in the corner of the waste yard before the waste is put on the ground. After the waste is all disposed of, the waste yards will be recovered with forestry or farming. The measures mentioned above are very helpful in mitigating the impact on the ecology.

7. The Impact on the Environment of the Construction Sites

The construction will be going in the mountainous region with quality air and a good acoustical environment. The dust and exhaust gas from the operation of machinery and vehicles will not impose obvious influence on the quality of the air. Instead, the influence is worth attention on the staff on site. So relevant measures must be taken to protect the staff. During the construction, water will be polluted mainly because of the sewage such as from the processing of aggregate, the excavation of the foundation ditch, the cleaning of machinery, the mixing of concrete and the daily life. The sewage will pollute part of the river. The domestic garbage will also be a source of pollution. The sewage, exhaust gas, noise and domestic garbage will influence the environment, but not seriously. The influence will disappear with the completion of the project.

8. Soil Erosion

The construction of roads, the excavation of earth works and the exploitation of rocks, the disposal of spoil will all cause damage to ground flora and lead to soil erosion. The volume of additional erosion will be as large as 78.1 thousand tons if proper measures are not taken. This will harm the productivity of the land, the deposit of the river and regional ecology to various extents.

9. The Health of the Staff

The intense physical work outdoor will weaken the immunity of the staff. sewage and garbage not dealt with properly can be an easy place for the propagation of hazardous insects, thus the staff can be infected with some insect- borne and water- borne diseases. Incidence of water- borne diseases and natural focal infectious diseases may increase during the initial stage of the dam's operation. So the precaution must be taken seriously. There no sign that the construction has influence on endemic diseases.

10.2 Conclusions for Measures of Environmental Protection

1. Measures of Environmental Protection on the Construction Sites

The major pollution on the water environment is from sewage from aggregate processing and domestic sewage. For sewage from aggregate processing, settling basins will be built as a major treatment. And field latrines and sewage tanks will be built to treat the domestic sewage. Measures such as protection for each individual workers, water sprinkling and speed restriction will be adopted to treat dust and noise pollution. The impact on the air and the acoustic environment imposed by the project will be mitigated once the measures mentioned above are taken.

2. The Ecological Environment

The project poses potential hazard to the aquatic ecology. So measures such as fish release, monitoring aquatic organisms, ensuring water required by the ecosystem downstream. In light of the impact on terrestrial ecology by the project, the designers have come up with measures such as recovery of vegetation and strengthen advocacy and management. The discharge volume of the dam should be designed at a certain level in order to protect the ecology downstream from damage caused by the dam.

3. Conservation of Soil and Water

Plans for conserving soil and water have been designed for the project. There are a number of plans to treat soil erosion in different places of the project, such as the construction sites, the roads, the waste yards, the quarry and the plants.

4. The Health of the Staff

Since there's migration caused by the project, the main concern of health should be

for the staff on site. Measures to ensure their health include cleaning up the workplace, controlling the vectors, examining the infectious diseases, vaccinating and advocacy.

5. Monitoring of the ecology and the environment

The Plan of Ecological and Environmental Monitoring of Qilinguan Hydropower Project has been formed to monitor the changes of the environmental factors such as water, air, noise and aquatic organisms and the outcome of the measures for environmental protection.

10.3 Conclusions for the Comprehensive Assessment

The project will meet the demand for electricity by the electric network of Wufeng Tujia Autonomous County and relieve the intense between supply and demand of electricity, thus good for the regional economic development. Moreover, there are other benefits. The huge generating capacity of the power station will bring direct revenues to the county such as tax income. The enormous investment into the project will give impetus to the local economics. The construction of the project and the large number of workers will push the local consumption.

The negative effects of the project will be: the submergence of terrestrial vegetation, the potential hazard to the ecology downstream, the pollution by sewage, exhaust gas and waste residue and soil erosion during the construction. The negative effects can be avoided or mitigated through relevant measures.

In conclusion, there are both positive and negative effects caused by the project. The natural environment of some areas will be worsened. However, the economic, environmental and social benefits of the project are obvious in the long run. And the general environment will not deteriorate. So the analysis of environment shows that the Qilinguan Hydropower Project in the charge of the Wufeng Nan River Hydropower Development Company Ltd. is feasible.

10.4 Suggestions

In order to minimize the negative effect of the project and maximize the social, economic and environmental benefits, Suggestions as follows have been brought forward.

1. The management of environment should be strengthened and the environmental protection of the construction sites should be seriously carried out.
2. The measures and plans to conserve soil and water should be well implemented.
3. A special agency of environment protection should be set up to formulate and enforce regulations of environmental protection.
4. Supervisory mechanism should be set up to keep the investment earmarked for environmental protection from being appropriated.

Picture 1: Sketch Map for Geographic Position of the Qilinguan Reservoir Hydroelectric Power Station Project

Picture 2: Sketch Map for General Layout of the Qilinguan Reservoir Hydroelectric Power Station Project

Picture 3: Sketch Map for Junction Project Layout of the Qilinguan Reservoir Hydroelectric Power Station Project

Picture 4: Sketch Map for General Layout of the First Class Power Station of the Qilinguan Reservoir Hydroelectric Power Station Project

Picture 5: Sketch Map for General Layout of the Second Class Power Station of the Qilinguan Reservoir Hydroelectric Power Station Project

Picture 6: Sketch Map for General Layout of the Reservoir Construction

Picture 7: Sketch Map for General Layout of the Construction of the First Class Power Station Plant Area

Picture 8: Sketch Map for General Layout of the Construction of the Second Class Power Station Plant Area

Picture 9: Flow Figure for Technological Process of the Sand Aggregate System of the Qilinguan Reservoir

Picture 10: Picture of Regional Geological Structure of the Qilinguan Reservoir Hydroelectric Power Station

Picture 11 Engineering Geological Map of the Dam Site and the Plant Area of the First Class Power Station

Picture 12 Engineering Geological Map of the Location Area of the Second Class Power Station

Picture 13 Sketch Map of Surface Water Monitoring Sections and Ambient Air Monitoring Points of the Qilinguan Reservoir Hydroelectric Power Station

Yichang Development and Planning Committee Document

YDPC Energy [2003] NO. 448

Project Proposal Approval of the Integrated Hydroelectricity

Development of the Nan River Reaches in the Wufeng County of YDPC

Planning Bureau of Wufeng Tujia Autonomous County:

[2003] No.51 document from Wufeng Development and Planning Bureau of your county has been received. After research and discussion, your proposal of the integrated hydroelectric development of the Nan River reaches was agreed, the exact approval is as follows:

The Nan River is one of the five large river in your county. Its integrated development is the key project of your county construction in hydroelectricity universalization. Preliminary work started from the beginning of the 2001, and in November of 2001 Yichang Water Conservancy and Hydroelectric Power Bureau delivered approval on basin planning in [2001] NO. 176 document from Wufeng Water Resources Department.

According to your electricity development plan, it is agreed to construct Qilinguan reservoir in the Nan River reaches and adopt cascade development. The total installed capacity is 27,000 KW of integrated development in the basin with years annual power generation 85 million KWh and total investment 0.11 billion yuan.

At receipt of the document, preliminary work such as project feasibility analysis and proprietor appointment should be quickly held. Submission for approval should follow basic procedures for construction approval.

2003.7.29

Key words: Energy Power Station Project Establishment Approval

Forward to Municipal Water Conservancy and Hydroelectric Power Bureau

Yichang Development and Planning Committee Office

Print and Distribute on July 29th , 2003

10 Copies in Total

Entrusting Letter

Xiangfan Environment Scientific Research Institute,

Yichang Environmental Protection Research Institute,

To improve environmental protection of the water environment in Qing River reaches and adopt scientific management of the pollution sources, in accordance with *Environmental Protection Management Regulation of Construction Project* (the State Council, Decree. 253), you are commissioned to shoulder the work of environment impact assessment of our construction project, Qilinguan Reservoir Hydroelectric Power Station Project. The consequent reports meet regulations and requirements of related technical specifications of environmental impact assessment and environmental protection management department. Detailed issues will be specified in the contract.

Entrusting Party: (seal)

year month date

Legal Representative of the Entrusting Party:

Liaison Person:

Tel:

Document of Construction and Environmental Protection

Bureau, Wufeng Tujia Autonomous County

[2004]NO.64

Approval from the Construction and Environmental Protection Bureau on
Execution Standard of Environmental Impact Assessment Program on
Qilinguan Hydroelectric power station Project Held by Wufeng Nan
River Hydropower Development Co., Ltd.

Wufeng Nan River Hydropower Development Co., Ltd.,

Following assessment standard should be observed in your environment
impact assessment of the Qilinguan hydroelectric power station project.

I. Environment Quality Standard

1. II Standard of *Environmental Quality Standard of Surface Water* (GB3838-2002)
2. The second class standard of *Ambient Air Quality Standards* (GB3095-1996)
3. I standard of *Urban Regional Environment Noise Standards* (GB3096-93)

II. Pollutant Discharge Standard

1.The first class standard of *Integrated Discharge Standard of Wastewater*
(GB8978-1996)

2. The second class standard of *Integrated Discharge Standard of Air Pollutant*
(GB16297-96)

3. *Noise Limit in Construction Site* (GB12523-90)

Hereby approve

2004. 10. 18

Key words: Environmental Protection Standard Approval

County Construction and Environmental Protection Bureau Office

Print and distribute on 18th 2004

Five copies in total

Expert Evaluation Opinions of the Environment Impact Assessment for
the Qilinguan Reservoir Hydropower Station Project Held by Wufeng
Nan River Hydropower Development Co., Ltd.

On October 20, 2004, Yichang Environmental Protection Bureau held meeting for *the Environment Impact Assessment for the Qilinguan Reservoir Hydropower Station Project Held by Wufeng Nan River Hydropower Development Co., Ltd. (Program* briefly as follows). There are totally nine representatives attending the meeting ,who are from Wufen Environmental Protection Bureau, Yichang Environmental Protection Research Institution,(assessment units) , and Wufeng Nan River Hydropower Development Co., LTD(construction unit), including relevant experts. In the meeting construction unit and environmental assessment unit respectively introduced the relevant condition about the proposed project and the main contents of the *Program* .Through the careful discussion of the experts and other meeting participants , the following evaluation opinions have come into being.

- I. The *Program* was compiling strictly based on the *Law of Environmental Impact Assessment*, the *Environmental Protection Regulation of Construction Projects*, and the *Guidelines of Environmental Impact Assessment* .Outline The quoted state laws, regulations and standards, technical specification in the *Program* are systematic, comprehensive and accurate.
- II. The *Program* , whose proposed technical route and the evaluation method of the environmental assessment are clear and of practical, preliminary identified the environmental factors on the basis of fully analyzing the regional environment of the project construction. The affected and environmental risk factors estimated are nearly accurate.
- III. The *Program*, with strong evidence, clear thinking, regulated compiling, and the prominent key aspects of the proposed assessment, adequate content,

and the clear statement of the overall situation of the proposed project ,can be submitted to Yichang Environmental Protection Bureau for approval after certain modification.

IV. Related issues are suggested to be noticed in the process of modifying the *Program* and the assessment.

1. Add the assessment report of the geological disaster for the project to relevant documents. Take the assessment of the reservoir bank stability after the initial impoundment as one of the important environmental impact factor.

2. Pay attention to the analysis of the environmental factors during the construction, and put forward feasible measures to protect environment. In order to prevent the water eutrophication and guarantee the living of the aquatic organisms ,the reservoir without being impounded can be suggested as on of the environmental protection measures.

3. Survey the minimum ecological flow of Nan River in the proposed project area, and guarantee the downstream channel will flow in the reservoir operation period. Appropriately add the quality monitoring section of discharging water, monitor the soil organic matter, providing basis for the water quality assessment.

4. Pay attention to the analysis of the excavation for project construction , and natural landscape changes caused by the setting up of the material yard and slag field ,as well as of the potential soil erosion . Appropriately analyze the sand flowing trend and the sediment conditions .Pay proper attention to the estimation of risk brought by the fault of the potential earthquake and its

seismic intensity in the proposed project area, as well as the flood risk analysis in construction.

Leader of the panel: signature:

2004.10.2

Wufeng Nanhe Water and Electricity Development Limited Company

**Project Environmental Effects Appraisal Committee of Electricity Plant of
Qilinguan Reservoir**

The Name List of Experts

October 20th, 2004

Name	Working Place	Duty Title	Telephone	Signature
Liu Yancai	Yichang Environmental Protection Bureau	Senior Engineer	6446395	
Wang Xiongwu	Yichang Geology and Minerals Research Institute	Researcher	13339796008	
Mao Xiaodong	Yichang Geology and Minerals Research Institute	Researcher	1386652987	

**Examination and Registration Form
of Construction Environmental Protection**

The bureau filling in the form (Stamping) : Yichang Environmental Protection Research Institute

Person filling in the form: (signature): Huang Yongwen Manager (signature) :

Items of Construction	Name of Item	Qilinguan Reservoir Electricity Plant Project			Place of Construction	Renheping Town in ChangYang National Minority Autonomous County								
	Content and Scale of Construction	Installed Capacity 25000kw, annual power rate 7879.980 thousand/kwh			Construction Nature	œnewly-buildingJ œReconstruction and Extention œTechnological transformation								
	Profession Category	Water and Electricity			Environmental Protection Management Category	œ Establishment report J œ Establishment account œFilling-in and Registration Form								
	Total Investment (Ten Thousand)	11257.51			Environmental Protection Investment (Ten Thousand)	190.2	proportion (%)	1.69						
	Department Initiating A Project	Yichang Development and Planning Committee			Authorized Document Number	Yichang Energy (number)[2003]448	Time	July 29 th , 2003						
	Report Examination Department	Yichang Environmental Protection Bureau			Authorized Document Number		Standard Time							
Place of Construction	Name of Working Place	Five Peaks Nanhe Water and Electricity Development Limited Company	Telephone	13972019788	Appraisal Bureau	Name of Working Place	Yichang Environmental Protection Research Institute	Telephone	0717-6445349					
	Mailing Address	Renheping Town in ChangYang National Minority Autonomous County	Zip Code	443400		Mailing Address	Number 48 in the Shengli Fourth Road in Yichang	Zip Code	443000					
	Representative of The Legal Person	Jin Jian	Contactable Person	Jin Jian		Certificate Code	No.2606 Certificate of National Environment Assessment	Appraisal Funds	60 thousand yuan					
The present situation of	Rank of Environmental Quality	Ambient Air: second level Surface Water: second level Ground Water: Environmental Noise: first level Sea Water: Earth: Others:												
	Sensitive Characteristics of Environment	œTap water source protectorate œnature protection area œplaces of interest œForest Park œProtection area of basic farm land œProtection area of ecological function œThe prevention area of soil erosion œSensitive and fragile areas of ecology œdistricts with dense population œ Key Cultural Relic Reservation Organ œAreas with three rivers , three lakes and two kind of controlling œ Three Gorges Reservoir Region												
Pollutant (detailed information about the industry items of basic construction)discharge standards and total quantity control	Pollutants	Existing projects (projects having been constructed and being constructed)			This project (planning to be constructed)					Total projects (those having been constructed, being constructed and planned to be constructed)				
		Actual emission-n strength	Emission-n strength That is allowed to discharge	The actual total quantity of emission-s	Checked total quantity of emission-s	Predicted emission-n strength	Emission-n strength That is allowed to discharge	Production quantity	The reduction quantity	Predicted total quantity of emissions	Checked total quantity of emission-s	The reduction quantity of "old replaced by the new"	Predicted total quantity of emission-s	Checked total quantity of emission-s

Natural and human remains							invest ment(te n thousa nd yuan)								
							desired effect								
Forest park							invest ment(te n thousa nd yuan)								
							desired effect								
Important eco-faction areas							invest ment(te n thousa nd yuan)								
							desired effect								
Biological protection	Rare animals						invest ment(te n thousa nd yuan)								
							desired effect								
	Rare plants						invest ment(te n thousa nd yuan)								
							desired effect								
	Unique biological species						invest ment(te n thousa nd yuan)								
							desired effect								
	Important cash species						invest ment(te n thousa nd yuan)								
							desired effect								
	Exotic species						invest ment(te n thousa nd yuan)								
							desired effect								
									off-site	backward	other				
	Dismantlement of Houses and Relocation of People	Migration population of project cover	0		Way of placement			invest ment(te n thousa nd yuan)	—	—	—				
Migration of population affected by environme nt		0		Way of placement			desired effect	—	—	—					
Soil erosion	39.6	Project	Biological control :					Noise	noise	Move	Sound-pr	Low-noi	Project	Contro	Oth

land that will be controlled	3mu	administration : 39.63mu			barriers	reduction by foliage		roof windows	se equipment	avoidance	land management	er	
Project greening area	/	The rate of green coverage	noise	Operation period	investment (ten thousand yuan)								
Waste water during construction SS	deposit	Physico-Chemical			desired effect								
Biomass of project cover ton (air-dry weight) hectare	before the construction	after the construction		Construction period	investment (ten thousand yuan)								
Project earth-rock 10 ³ m ³	265.087				desired effect								
Land		Total land coverage		Cultivated land occupied				Basic farmland	Forest land	Grass field	Fish farm		
	Property	Temporary	Permanent	0				0	9mu	0	0		
	Area of land coverage		9mu										
	Addition												
	Area of rehabilitation												