1. General Principles

1.1 Origin of the Task and Background of the Project

The reservoir and power plant of the Wangjiahe River Basin are located on the upstream of the Zhisuo River, a tributary of Qing River. Within the area, the length and area of the valley are relatively 11km and 105km^2, with a natural fall of 640m. Since the total hydropower potential is 13,400 kW, very rich in water resources, they are the only and very important water resources for development in Niuzhuang County, Tujia Autonomous County, Wufeng. Wangjiahe Reservoir and Power Plant project is located in Jinshanping, Niuzhuang County, Wufeng Tujia Autonomous County, about 20 km away from Niuzhuang County, 100km away from the downtown of Wufeng County, 270km away from Yichang city and 25km away from the Buya Hydroelectric Power Station of the Qing River to the north. The project comprises Chi'nan Power Plant and the Hydroelectric Hubs on Wangjiahe, including Wangjiahe Reservoir, Wangjiahe □ Hydroelectric Power Station and Wangjiahe □ Hydroelectric Power Station.

The planning report of the cascade development of the Wangjiahe River Basin is implemented by Wufeng County Water Conservancy & Electricity Survey Office in 1999. The original planning of the river basin is to build a three cascade run-off style power plant: Chi'nan Power Plant, Wangjiahe Power Plant and Zhangjiaya Power Plant from upstream to downstream, with a total installed capacity of 8200 kW. Yichang Water Conservancy & Electricity Bureau issued the ***Reply to the Planning Report of Cascade Development of Wangjiahe River Basin of Wufeng County (No.180 Document [1999])*** as an official reply to the above planning.

During the implementing period, Yichang Water Conservancy & Electricity Survey Institute adjusts the original planning of three cascade run-off style power plants into a style of two plants and one reservoir, in accordance with the result of comparing

spot investigation, geological work and office operation. At upper reaches locates the Chi'nan Power Plant with an installed capacity of 2000 kW. The former planned Wangjiahe Power Plant at the secondary cascade will be changed into a reservoir at Jinkouzi for water regulating and storage. At the same time, in order to make full use of hydro-energy, Wangjiahe □ Hydroelectric Power Station with an installed capacity of 630kW will be build at the foot of the dam. The tail water from the power plant and other convergent water, mainly from Wangjiahe Gully 3.2km downstream will be diverted to Wangjiahe □Hydroelectric Power Station, whose installed capacity is 10,000kW, by a diversion channel 5.05 km long. After the adjustment, the total installed capacity will be 12,630 kW, which is 4,430 kW more than original. In addition, the power plant can provide electricity with higher quality as it can regulate when it is necessary. The content of this project is the cascade development of Wangjihe River Basin, with a total installed capacity of 12,630 kW and an investigation of 120,381,100 RMB.

In July 2007, Yichang Water Conservancy & Electricity Survey Studio completed the ***Feasibility Study Report of Wangjiahe Reservoir and Power Plant of Wufeng Tujia Autonomous County of Hubei Province,*** and ***Feasibility Study Report of Chi'nan Power Plant of Wufeng Tujia Autonomous County of Hubei Province***. On October 24th, 2007, Hubei Provincial Water Conservancy Department gave a reply to the ***Feasibility Study Report of Wangjiahe Reservoir and Power Plant, and Chi'nan Power Plant, Wufeng County (No.173 Document [2007])***. On December 23rd, 2007, Hubei Provincial Development and Reform Commission gave a reply to the ***Feasibility Study Report of Wangjiahe Reservoir and Power Plant, and Chi'nan Power Plant, Wufeng County, (No.986 Document [2007], Energy Department of Provincial Development and Reform Commission)***.

On March 20th, in accordance with the relevant national requirements and regulations on environmental protection, Yichang TianRMB Hydroelectric Development Co. Ltd. entrusted China University of Geoscience to implement the environmental impact

assessment of this project. The assessment range is Wangjiahe Reservoir and Power Plant Project, and Chi'nan Power Plant. Therefore, professionals from the university have accomplish the on-the-spot investigation, survey, and collection of information, and worked out the ***Report of Environmental Impact Assessment for Wangjiahe Reservoir and Power Plant and Chi'nan Power Plant made by Yichang TianRMB Hydroelectric Development Co. Ltd.***. It is in accordance with ***Law of the People's Republic of China on Evaluation of Environmental Effects***, relevant regulations in ***Regulations on the Administration of Construction Project Environmental Protection*** (Promulgated by Decree No.253 of the State Council) and ***Technical Guidelines for Environmental Impact Assessment***, the standard of environmental protection industry in the People's Republic of China. Now it is presented to the construction company and submitted to the environmental department for examination and approval.

1.2 Assessment Purposes

By doing on-the-spot investigation, survey and monitoring of the current situation of environment and public participation, the natural and social environment of the effected areas of the project will be investigated, and the major environmental problems will be analyzed. A comprehensive and systematic assessment on both positive and negtive impacts to the natural, social and ecological environment from the activities of the project such as project construction, reservoir submersion and project operation will also be made. As for the negtive environmental impacts from the project, practical measures for environmental protection will be proposed. It is ensured that the project construction will not only promote the regional social and economic development, but also protect and improve the local ecological environment.

The environmental impact assessment of the project provides a foundation for the demonstration of environmental feasibility of the project, which will make the project

design document more integrated so as to promote the smooth progress of start of the construction; at the same time, it also serves as a scientific foundation for the environmental management, supervision and monitoring of the project.

1.3 Foundation of Compilation

1.3.1 Law and Regulation

1) ***Environmental Protection Law of the People's Republic of China (1986.12)***

2) ***Law of the People's Republic of China on Evaluation of Environmental Effects (2003.9)***

3) ***Law of the People's Republic of China on Prevention and Control of Water Pollution (amended in 2002.8)***

4) ***The Law of Land Administration of the People's Republic of China (amended in 1998)***

5) ***Law of the Peoples Republic of China on the Prevention and Treatment of Infections Diseases (1989.2)***

6) ***Law of the Peoples Republic of China on Water and Soil Conservation (1991.6)***

7) ***Forest Law of the Peoples Republic of China (amended in 1998)***

8) ***Law of the People's Republic of China on the Protection of Wildlife (1988.11)***

9) ***Law of the People's Republic of China on Fishing Industry (2001.10)***

10) ***Law of the People's Republic of China on Prevention and Control of Water Pollution (amended in 2002.11)***

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

Atmospheric Pollution (amended in 2000.4)

12) ***Law of the People's Republic of China on Prevention and Control of Environmental Noise Pollution (1997.3)***

13) ***Regulations on the Administration of Construction Project Environmental Protection (1998)***

14) ***Administrative Measures for the Water and Soil Conservation Plan of the Development of Construction Project (1994.11)***

15) ***Administrative Rules for Public Health (1987.4)***

16) ***Measures for Implementation of Law of the People's Republic of China on the Prevention and Treatment of Infectious Diseases (1991.12)***

17) ***Administration Catalog of Construction Project Environmental Protection (***Promulgated by Decree No.253 of the State Council [1998])

18) ***The Notification on the Increase of Public Participants of the Environmental Impact Assessment of the Construction Project*** (No.2003 Document of the Hubei Environment Office) and other national and local regulations and laws related

1.3.2 Technical Regulation

1) ***Technical Guidelines for Environmental Impact Assessment, Non-Pollution Ecological Impact*** (HJ/T19-1997)

2) ***Guidelines for Environmental Impact Assessment*** (HJ/T2.2~2.3-93)

3) ***Technical Guidelines for Environmental Impact Assessment - Sound Environment (HJ/T2.4-1995)***

4) ***Technical Regulations on the Environmental Impact Assessment of Water***

Conservancy and Hydropower Project (SDJ88-2003)

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

6) ***Technical Regulations on the Medical Assessment on Environmental Impact of Water Conservancy and Hydropower Project*** (GB/T16124-1995)

7) ***Technical Regulations on Water and Soil Conservation Plan of the Development of Construction Project*** (SL207-98)

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

9) ***Technical Regulations on Comprehensive Management of Water and Soil Conservation*** (GB/T16543-1996)

10) ***Catalog of Wild Plants under Special State Protection (the first group)*** (1999.8)

11) ***Catalog of Wild Animals under Special State Protection*** (1989.1)

12) ***Catalog of Wild Terrestrial Animals under Special Protection of Hubei Province*** (1994.6)

13) ***Catalog of Wild Aquatic Animals Under Special Protection of Hubei Province*** (1994.12)

14) ***Technical Regulations on Sterilization*** (Ministry of Health, issued in 1992)

15) ***Technical Regulations on the Supervision on Surface Water and Wastewater*** (HJ/T91-2002)

16) ***Regulations on the Sanitary Quality of Domestic Drinking Water*** (2001.6) and other technical regulations

17) ***Regulations on the Environmental Impact Assessment in Rural Areas***

18) ***Standards of Classification for Soil Erosion*** (SL190-96)

1.3.3 Project Relevant Documents

1) ***Reply to the Feasibility Study Report of Wangjiahe Reservoir and Power Plant, and Chi'nan Power Plant , Wufeng County, (No.173 Document [2007])*** issued by Water Resources Department of Hubei Province in October 24th, 2007. As for details, see Attachment 1.

2) ***Reply from Provincial Development and Reform Commission to the Feasibility Study Report of Wangjiahe Reservoir and Power Plant, and Chi'nan Power Plant, Wufeng County, (No.986 Document [2007], Energy Department of Provincial Development and Reform Commission),*** issued by Hubei Provincial Development and Reform Commission in 2007. As for details, see Attachment 2.

3) Yichang TianRMB Hydroelectric Development Co. Ltd. ***Entrustment Letter for Implementing Environmental Impact Assessment for Wangjiahe Reservoir and Power Plant*** on March 2nd, 2008. As for details, see Attachment 3.

4) ***Reply from Yichang TianRMB Hydroelectric Development Co. Ltd. to the Implementing Standard of EIA of Wangjiahe Reservoir and Power Plant and Chi'nan Power Plant,*** issued by Bureau of Construction and Environmental Protection of Wufeng Tujia Autonomous County in December 9th, 2007. As for details, see Attachment 4.

5) ***Verification and Approval Book for Forest Use of Yichang TianRMB Hydroelectric Development Co. Ltd.(No.372 Document [2007] of Hubei Provincial Forest Land Use Verification Department),*** issued in December 8th, 2007. As for details, see Attachment 5.

1.3.4 Documents of Project Design

1) ***Feasibility Study Report of Chi'nan Power Plant of Wufeng Tujia Autonomous County of Hubei Province, Phase Engineering Report of Geology Investigation of the Feasibility of Chi'nan Power Plant Project of Wufeng Tujia Autonomous County of Hubei Province***

2) ***Feasibility Study Report of Wangjiahe Reservoir and Power Plant of Wufeng Tujia Autonomous County of Hubei Province, Phase Engineering Report of Geology Investigation of the Feasibility of Wangjiahe Reservoir and Power Plant of Wufeng Tujia Autonomous County of Hubei Province***

1.4 Objective of destruction control and ecological environment protection

1) Water quality: Control the over emission of pollutants, and protect water quality in the reservoir. The concentration of wastewater discharge should meet Grade I Standard in the ***Integrated Wastewater Discharge Standard (GB8978-1996)***, and water quality should meet Grade □ Standard in ***Environmental Quality Standard for Surface Water (GB3838-2002)***.

2) Ambient air quality and sound environment

No significant deterioration of the ambient air quality and sound environment within the construction area will be caused by project construction. And to make the ambient air quality of the construction area meet the Grade □ Standard of ***Ambient Air Quality Standard*** (GB3095-1996), the sound environment the Grade □ Standard of ***Urban Regional Environmental Noise Standard***(GB3096-93).

3) Soil erosion: As for the lands which have been lessened or even lost capability of

water and soil conservation because of the activities such as excavation, filling, and occupying during the construction, immediate project and planting measures aiming to recover or improve the capability of water and soil conservation will be taken. This will enable more than 95% soil erosion be controlled and prevent and control the additional soil erosion; and this will also ensure more than 70% disturbed land being treated. The dregs from the construction will be properly treated and with more than 95% of them being protected.

4) Vegetation and aquatic organisms: Reduce the destruction to the vegetation during the construction, and rehabilitate the vegetations on the surface of exposed land after the work. Try to make the vegetation coverage more than 90% and grass coverage within the scope of responsible area above 20%. It will alleviate the negative impact to the aquatic organisms because of changes in hydrological conditions.

5) Land resource: Reduce the amount of dregs as much as possible and reclaim if conditions permit so as to ease the pressure of local land resource reduction as a result of the construction.

6) Social economy: Have a good planning for people's health during the construction period to avoid outbreaks of all kinds of diseases. Try to ensure that the builders and residents in surrounding areas be less influenced by the air and noise pollution.

To see key objects for environmental protection, please refer to Figure 1-1.

Figure 1-1 Figure of Environmental Protection Goal for the Reservoir and Power Plant of Wangjiahe River Basin Project

Object of protection	Distance	Orientation	Scale	Grade of protection
Wangjiahe Reservoir	-	-	From the 2 km point upstream the dam site to	Grade □Standard of Quality Standard of Surface Water

			the whole course downstream	
Construction area of the power plant	Construction activities and effecting range	Precinct	Within an area of 1 km from the precinct of the construction site	Ambient Air: Grade □ ; Noise: Grade □ ; Soil erosion has been slowed down and controlled and plants have been recovered.

1.5 Assessment Grade and Range

1.5.1 Water Environment

During the operation period, little wastewater will be discharged by the Reservoir and Power Plant of the Wangjiahe River Basin. The water environment will be only effected to a certain extent during the construction period and initiate period of water storage of the reservoir.

Foundation for the water environment grading: □ Sewage waste water discharge: According to the project feasibility study report, the waste water during the construction period mainly comes from the washing water from the sand and stone system, concrete production system and the regular discharge of the foundation pit. Domestic sewage mainly comes from the living sewage from the builders. At peak period of construction the waste water discharge stands at nearly 2100m^3 /d; □ The complexity of the wastewater quality: the major pollutant in the wastewater from the production during the construction is SS, while the main pollutants in domestic sewage is BOD_5, COD and NH_3-N. The complexity of the quality of wastewater of this project is at medium level; □ Scale of surface water: the multi-year average flow of Wangjiahe Reservoir dam site is 2.16m^3 / s, so the scale of surface water is a small river; □ Requirements for surface water quality : As the water quality of the

effected areas of the project is Grade □Standard of ***Environmental Quality Standard for Surface Water (GB3838-2002)*** , and according to the classification principles of evaluation of ***Technical Guidelines for Environmental Impact Assessment on Surface Water Environment***(HJ/T2.3-1993), it is determined that the environmental assessment level is three.

1.5.2 Ecological Environment

Hydroelectric Power is green power. During the operation period of the hydroelectric power station, it will discharge little pollutant, and the impact from the project construction is non-pollution ecological effect to the environment. According to preliminary investigations, the reduction rate of the biological species biomass and species diversity caused by the construction of the project is far less than 50%, which will not lead to the disappearance of endangered species. Although the degree of terrestrial connectivity will be deteriorated, if the reduction rate is lower than 50%, basically it will not lead to the deterioration of soil and water as well as the physical and chemical properties of the land. And there are no sensitive areas within the region. The affected area of the project is less than 20 km^2, thus, in accordance with the ***Technical Guidelines for Environmental Impact Assessment- Non-pollution Ecological Impact*** (HJ/T19-1997), it is determined that the rate of environmental impact assessment of ecological impact of the project is at Grade 3.

1.5.3 Atmospheric Environment and Sound Environment

Because of the construction of the main project and simple roads for it, the atmospheric environment and sound environment in the construction areas and the roads nearby will be effected to a certain extent during the construction period. According to spot survey, within an area of 2 km, there is no a resident, nor activity venues; along the road under construction, there is no gathered settlements, schools or other sensitive receptors; therefore, on the atmospheric environment and sound

environmental impacts only briefly evaluation will be given. The range of the assessment will focus on the construction area and its surroundings, which is within a range of 1 km outside the construction area.

1.6 Assessment Standards

1.6.1 Environmental Quality Standard

1) Grade □ Standard of ***Environmental Quality Standard for Surface Water (GB3838-2002)***

2) Grade □ Standard of ***Ambient Air Quality Standard (GB3095 - 1996)***

3) Grade □ Standard of ***Standard of Environmental Noise of Urban Area (GB3096-93)***

1.6.2 Pollutants Emission Standards

1) Grade □ Standard of ***Integrated Wastewater Discharge Standard*** (GB8978-1996)

2) ***Noise limits for Construction Site*** (GB12523-90)

3) Grade □ Standard of ***Integrated Emission Standard of Air Pollutants*** (GB12523-90)

1.7 Assessment Period

The environmental impact assessment period of the project comprises construction period and operating period. The assessment level year of status quo is set as 2008, and the assessment level year of prediction is 2013.

1.8 Focal Assessment Point

In accordance with the characteristics, scale and the effected range of the project, as well as evaluation of the environmental effects on the same kind of hydroelectric projects, the focus of the assessment this time comprise water environment, ecological environment and the construction environment. Other factors such as local climate, hydrology, silt particle, geology and human health will be given general assessment.

2 Engineering Situations

2.1 Basin Overview

Wangjiahe Basin is located in the upper reaches of Suohe on the right bank of the Qingjiang, administrative divisions under the Wufeng Tujia Autonomous County Cow Township, across the East longitude 110 ° 15'-110 ° 28 ', North latitude 30 ° 10'-30 ° 18'. The basin originates in Piantaiya which is 2082m above sea level, running through Yu forests, Sunjiawan, forming rivers on Guanbao. The upper reach of Guanbao is named as Laolonggou, north of which can be supplied by Yanjiagou and Kanglinxi. Yanjiagou originated in the land ridge 1972m above sea level, running through Dayang, Chinan, runs into the main stream at an elevation of 980m; Kanglinxi originated in Songshuao 1927.5m above sea level, running through Anshuitang, Zhaojiawan, runs into the main stream at 918m above sea level. The main stream runs into Hefeng County in Zhangjiaya, joining Qingjiang. The area of river basin in Wufeng Tujia Autonomous County is 105.6 km^2.

The elevation of northern, southern and eastern watershed of Wangjiahe is more than 1900m, Zhangjiaya is of the minimum elevation in Wufeng Tujia Autonomous County, only 560m, the elevation of the eastern basin is higher than the western basin, with a difference of about 1700m. The longitudinal slope of the river is larger, among which the upper reaches enjoy the largest segment, that is 242 ‰, lower reaches is relatively smaller, but there is still 46.5 ‰, the average gradient is 68.9 ‰, providing excellent natural conditions for building a hydropower station.

Chi'nan Power Station is located in the upper reaches of Wangjiahe; catchment area at the dam site is 33.8 km^2. Wangjiahe Reservoir Dam and □-Hydroelectric Power Station is located in upper and middle reaches of Wangjiahe, catchment area at the dam site is 68.2 km^2. Wangjiahe □- Hydroelectric Power Station is located at the lower reaches of Wangjiahe, with a dam site catchement area of 102.2 km^2.

2.2 Project Location, Mission Development, Size and Layout

2.2.1 Project Mission and Scope

(1) Engineering Task

Chi'nan Hydroelectric Power Station is a division runoff type Hydroelectric Power Station, as base load in the system. Wangjiahe Reservoir power stations mainly adopt reservoir water regulating for power generation, shoulder the peak load and waist load in the power system. The main task of the project is power generation, to provide much-needed electricity for the local life and production. The construction of Wangjiahe Reservoir power plant will improve the local living and production status of the electricity for the local forestry, medicine, special, deep processing of mineral products industry.

(2) Projects Scale

Chi'nan Hydroelectric Power Station is installed with pools of 2 × 1000 kw, which ensures that the output is 358 kW, hours in use is 4090h, multi-year average capacity is 8,180,000 kW • h; station at first cascade is installed with 1 × 630 kw, which ensures an output of 264 kW, hours in use 4128h, the average generating capacity for many years is 2,600,000 kW • h; Two stations are installed with 2 × 5000 kW, which ensures that output is 3613 kW, hours in use are 3764h, multi-year average generating capacity is 37,640,000 kW • h. Reservoir's regulating capacity is 3,372,500 m3, which is small in size and can partially regulate along the year.

2.2.2 Project Layout

2.2.2.1 Chi'nan Power Plant Project Layout

The purpose of this project is to generate electricity. Chi'nan Power Plant located at upper reaches of Wangjiahe River, consists of dams, water lines, fore bay, penstock, plant, booster station and transmission lines, etc. The barrage consists of a main dam and three auxiliary components, the main dam is a masonry gravity dam, with a maximum height of 10.31m; water lines branch is 2660m long, and the main trunk length is 2170m; the fore bay is 3m in width, 8m in length; penstock length is 409.8m, diameter of the main pipe is 0.7m; plant plane size is 23 × 13m; A 3150KVA transformer will be arranged at the booster station; line length is 6 km, and voltage rating is 35KV.

Water used by the station is from the two auxiliary power plants, a water culvert and a dark composition of the main dam. Yanjiagou Dam is auxiliary dam □, Kanglinxi Dam is auxiliary dam □. Moshigou is the water ditch, Hanchi Wan main dam. The elevation of auxiliary dam□and engineering geology, topography of the valley, the auxiliary □ is located at a narrower place of Yanjiagou, where the riverbed elevation is 1130 meters. Auxiliary dam II, taking into account the elevation, topography of Conlin River and the engineering site, will be located at the place with narrow riverbed, which is at an elevation of 1140.5 meters.

The altitude of the main dam is decided to be 1114.8 m. Dam type: two auxiliary dams are of bottom-grating type; and masonry gravity dam for the main dam.

Diversion canal layout: there will be a 1440 m long tunnel extending from auxiliary dam II to the auxiliary dam I, with a designed discharge of 0.45 m^3/m. The cross section is 1.2 m in width and 0.4 m in height. Besides that, there will be another 1220 m of tunnel and channel, which is 570m, to be specific. The designed discharge is 0.75 m^3/m, with a cross section of 1.2 m in width and 0.9 m in height.

The overflow weir crest of the main dam is 1117.0 m in height, which is also the inlet level of the diversion canal. At the inlet, there are water diversion corridor and sedimentation basin.

The main water diversion canal is 2170 m long, which includes two tunnels with a total length of 2075 m, taking up 96% of the total length. The cross section is 1.5 m in width, 1.35 m in height, with a designed discharge of 1.28 m^3/s.

Layout of the fore bay: on the plane, the angle between the axis of No. 4 tunnel and the axis of the penstock is 140 º47 '32". As there is no specific requirements on the directions of the siphon intake and the water flow in the tunnel, the penstock can stretch straightly into the pool without any inversion on the plane. The center of the siphon inlet will be located at the junction of the axis of the tunnel and penstocks, which is at the contour of 1120m. The chamber of the forebay will enlarge the width of the tunnel from 1.5 m to 3m where the number of the poles ranges from 2+122 to 2+162 (40 meters long in total). The width of the tunnel will remain the same from No. 2+162 to No. 2+170, where the outlet locates. The forebay outside the tunnel will be arranged in pentagon in accordance to the terrain. Ensuring that the distance from the side wall to the siphon center will be no less than 1.4m and the length of overflowing front, 3.7m, we can minimize the size of outside part of the forebay. The normal water level is 1115.877m, the lowest 1114.527m and the elevation of the bottom 1111.800 m. What's more, there are also overflow weir, emptying valves and other facilities.

The penstock will be equipped with siphon water inlet. As the siphon can take a turning above the forebay surface, the front length along the water flow direction, gradient length and damping sections are upright instead of horizontal. Thus the forebay length (perpendicular to the slope direction) has been shortened sharply, so does the excavation volume (over the sidewall of the forebay). The layout of the penstock is 55º43'36" from the plant vertically. The penstock lines cross the contours, which alleviate the gradient of them. In terms of vertical layout, the principle to bear in mind is that applying channel and reducing the excavation; reducing the height of the anchor blocks by avoiding setting them at lower place. Following this principle, the main channel is divided into four sections according to

the terrain. In vertical direction, the total length is 409.840m, including 6.87m of siphon, 358.124m of the main tube and 51.716m for the branches (including gradient one). The diameter of the main tube is 0.7m, and sub-tube 0.4m.

The plant areas of the power station includes main plant, auxiliary plant, installation house, tail water channel, booster station and roads to the plant, etc. The main plant and auxiliary one are located along the contour at an elevation of 878.950m. The auxiliary plant is in line with the operation room at the elevation of 880.450m. The booster, taking into consideration of the main gradient line and canal plant, will be located at the right side in the back. The coverage is 23 m × 13 m, at the elevation of 885.000m. Living quarters and office will be arranged in an integrated way with the Wangjiahe Reservoir I and II Hydroelectric Power Stations. To reduce excavation and consider the terrain of the site, the control room, booster station and switch room will be 1.5m higher than the main plant. Main booster station locates near the switch room and control room for the sake of wire connection. The road will lead to the main plant, auxiliary plant and the gate of installation house, which will be helpful for facilities transportation.

Main plant and installation house are at the same elevation, which is 878.950 at the ground and 885.650m at the roof. There will be two sets of hydropower generators, 8.4m from each other, covering an area of 10.8m× 24m. The installation house is on the right side of the main plant, covering an area of 10.8m× 4.8m. The tail water will be discharged directly into Wangjiaya Reservoir. The designed water level of tail water is 878.200m.

2.2.2.2 Project Layout of Wangjiahe River Reservoir

(1) Wangjiahe River Reservoir

Wangjiahe Reservoir is located at Jinkouzi of Wangjiahe River, which is in the middle reaches 20km from Niuzhuang Village of Wufeng County. It is 4km from the planned water intake dam of Chi'nan Hydroelectric Power Station in the upper stream,

8.5km from Wangjiahe II-Hydroelectric Power Station and 9km from the confluence at Hefeng County. This project consists of the dam, side channel of the spillway, flood discharge tunnel, water intake chamber, water diversion tunnel and emptying tube, etc. This is a rock fill dam, applying composite geomembrane and concrete for leakage-proof. The maximum height is 50.95m. The catchment area of upper stream is 68.2km^2. Flood discharge structure locates at the left side of the dam. With the help of diversion channel, water will be discharged through overflowing of the auxiliary dam and flood discharge tunnels (including some water diversion channels). The overflowing dam is 40m in width and 875.0m in height. It is in the shape of WES curve. The water inlet, whose bottom plane is 848.0m in elevation, will be located at the moderate slope at the right side of the bank. Water will be diverted through reinforced concrete tunnel (Φ=1.5m) into Wangjiahe I Hydroelectric Power Station. Trash rack will be set in front of the water inlet. A functional gate will be set at the chamber, using screw hoist to control. The holes on the gate are 1.6m×1.6m in size. The maintenance platform is 877.60m at elevation, which is connected to the bank with a transportation bridge. The control room is 880.60m at elevation. Empty iron tube will be set at the left bank near the water diversion tunnel. The diameter of the tube is 600mm. Covered with RC, the inlet of the tube will be controlled by the gate. The control equipment is at an elevation of 851.65m, 0.65m higher than dead water level. Taking the features of the project into consideration, a sluice valve will be set at the end of the tube, which is controlled by manual butter fly valve with a diameter of 600mm. The designed water height of Wangjiahe I- Hydroelectric Power Station is 19.0m. The designed diversion flow is 4.5m^3/s, with an installed capacity of 1×630kw. The mixed flow turbine (Francis turbine) will be adopted as the generator.

(2) Dam Site

Wangjia River Basin is a typical mountain river, with steep river beds and an average gradient of 68.9 ‰. According to the original planned site and the field

investigation, the project will be located at the medium-upper reaches of the river. The average gradient is 30‰, relatively moderate. The dam site is at Jinkouzi. The river bed turns towards NE78 ° at 100m above the dam in the upper reaches; and turns to NW285° in the downstream. All together it forms a curve to the north. Besides the closed canyon topography at the dam site, the rest of the river runs through flat valleys with a slope gradient of 20 ~ 50 °. The right side of the valley is steeper than the left. It is founded that the coverage of the river bed is 22.4m at most. The elevation of the river bed is around 827.0m, and the width of the river is only around 30m at an elevation of 855.0m. The angle of the slope is 45° at the left side. At some places, the bank takes the shape of an adverse slope, whose angle is about 70 °. The left dam abutment is river erosion terrace at level I. The elevation is 870.0m on top, 43m above the water level.

(3) The diversion canal arrangement

Wangjiahe II-Hydroelectric Power Station water diversion canal will be set along the right bank of the river. The fore bay is at the left ridge of Dongjia Valley. The plant will be located at the platform at Zhangjiaya, on the right side of Wangjiahe River. It is between the two gorges of the river at an elevation between 580m to 585m.

(4) Plant site and layout

Wangjiahe I-Hydroelectric Power Station: restricted by the dam and water intake structures, there is not much choices for the station. The station is located at a slope 100m downstream. With regard to the planning and relations of the two power stations, the ground elevation of the primary station is around 845.0m, where the riverbed is at an elevation of 821.2m.

Wangjiahe II-Hydroelectric Power Station: as the conjunctions are located at the right bank of the river, the station can only be set at the right bank of Zhangjiaya at lower reaches between the two gorges. With regard to the terrain features, construction and transportation, the site is decided to be at the right bank slope.

The plant layout will be river-side ground power house.

Locations can be seen in Figure 1.

(5) Project Layout

A. Dam type and engineering layout

Rock-fill dam will be applied according to the terrain and geographical conditions of the dam site.

The crest is 6.0m in width and 878.95m in height. Reinforced Concrete anti-wave wall will be set at the upper side of the crest, which is 1.2m above the crest. The dam slope is 1:1.7 above an elevation of 840.0m, and 1:2 below 840.0m. The gradient is 1:1.5 at the downstream side. Dry-stone pitching will be used to shore up the dam at both sides, and rock fill drainage prism will be set the dam toe. The top of the prism is at an elevation of 829.086m, and is 2.0m in width. Water intake structures and water diversion tunnels are set at the right side of the bank. The tunnel is 848.0m in the bottom and 1500mm in diameter. Flood discharge structure and emptying structure will be set on the left bank. The emptying tunnel inlet (Φ=600mm) will be set at an elevation of 835.0m. It is controlled be the cast-iron valve. The flood will be discharged through side channel of spillway dam and flood discharge tunnel. The dam is 40.0m in width and 875.0m in height. The side spillway is 5.0m at beginning and 15.0m at the end. The bottom and side walls are made of C25 RC, which is 0.4m in thickness. The inner diameter is 5.0m, coated with RC 0.3m thick. At the terminal, water flows up. The foundation of the dam will be shored up by RC anti-leakage wall, reinforcement and curtain grouting. The impervious curtain is 0.8m in thickness and 22.0m in depth. The top is 830.0m in elevation and the bottom is 0.3m beneath the bottom rock. The curtain grouting holes will set in one line every 3 m. The total footage is 3950m. The fixed grouting holes are 3m apart and the total footage is 1650m.

B. the main buildings and the overall layout of the project

Reservoir main structures

Water retaining dam: the crest is 6.0m in width. Reinforced Concrete anti-wave wall will be set at the upper-stream side of the dam. The wall is 1.2m above the crest. The gradient is 1:1.7 in the upper-stream side above 840m, and 1:2 below it. The gradient of downstream side is 1:1.5. Both of the upper and lower side of the dam will be shored up by dry stone pitching. The top of the rock fill drainage prism is 829.086m at elevation and 2.0m in width. The axis length of the dam is 136m, and the total filling amount is 281,000 m3.

Districts of the dam: filter, cushion, transition layer, drainage body, sand and gravel areas and rock-fill areas downstream. Vertical drainage body will be set within the rock-fill areas, and horizontal drainage body will be laid at the lower part of the dam. Comprehensive geomembrane will be used for leakage prevention. The thickness of the geomembrane will be 0.5mm at the part above 854.0m; and beneath the height, the thickness will be 0.8mm. The sand and gravel layer at the riverbed will adopt concrete impervious wall. The strength of the concrete is C25W8F100. And it is 0.8m thick and 22m in depth. The foundation beneath this layer will be fixed and tackled with curtain grouting measures. The horizontal projection length is 357m, covering an area of 28530m^2. Drilling amount is 11,260m in total and grouting footage is 8948m. Fixed grouting drilling is 5830m and grouting footage is 345m.

Water release structure: The overflowing weir is of WES type. The side weir is 40m in width and the crest is at an elevation of 875.0m. The bottom of side channel is 5m wide at the beginning and 15m at the end. The vertical slope gradient is 2%. The gradient of the side channel on right (near the weir) is 1: 0.5, while the left side 1:0.3. The side channel is followed by the adjusting section, whose bottom is 15m wide at the beginning and 5m at the end. The gradient of the slope is 1:0.3. To ensure smooth water flow, the bottom of the adjusting section is curve in shape, whose radius

is 42.25m and central angle 45°. The top is tangent to the end of the side channel, while the terminal is tangent to the inlet of flood discharge tunnel. Side channel, bottom of the adjusting section and side slope will all adopt C25 concrete as the coat, which is 0.4m in thickness. The outlet section of water diversion tunnel can be used as the horizontal section of the flood discharge tunnel, which is 5.0m in diameter. Reinforced concrete of 0.3m thick can be used as the inner lining, and the total length is 108m. The slanting section is 46m long, whose inlet is at an elevation of 868.3m and outlet 824.254m.

Water intake and emptying structure: Water intake structure: It is located at the right bank at the dam site. The the inlet is 121.5m away from the dam axis. Water diversion tunnel is arranged horizontally in L-shape along the riverbed and in Z-shape vertically. The tunnel is 253.61m away from the center of the butter fly valve of Wangjiahe I Hydroelectric Power Station. The diameter of the tunnel is 1500mm. The water intake structure consists of deep water intake, intake tower, hoist control and maintenance platform, bridge and water diversion tunnel, etc. Trash rack and functional gate will be set inside the chamber. The maintenance platform is at an elevation of 877.60m, and the control platform 880.60m.

 Emptying structure: It is located at the left bank. Covered by RC of 0.2m thick, the iron tube whose diameter is 600mm will be applied and arranged at the left side of water diversion tunnel. Water intake chamber will adopt a plane cast steel gate, with pores of 1.0m×1.0m in size on it, as well as mobile 15T manual hoister. The transition section is 1.2m in length, through which, square hole 1.0m×1.0m in size will gradually transit into round hole 600mm in diameter. The bottom of the chamber is at an elevation of 835.0m. The size is 5.1m×4.0m×0.8m. Hoist is at the elevation of 851.65m. It is supported by RC bent, whose size is 0.4m×0.4m. The angle between the axis of the bridge and the water diversion tunnel is 47°. The entrance of the bridge is connected with the road up to the dam.

C、Wangjiahe I-Hydroelectric Power Station

Layout of the powerhouse: axis of the plants and main, auxiliary plant are basically disposed in accordance with contour line and the plant generally parallels to riverbed. Seen from the above, auxiliary plant stands in a row with the main one to the left. The plant is 30.02m long, 10.0m wide and 15.2m high (from bottome of the tail water to the top). Main and auxiliary plant are both of one-floor dispositions at an elevation of 845.897m, while the auxiliary plant is 4.5m high. From the view of façade, the whole plant is divided into two layers and from up to down is mainframe room (including auxiliary plant) at an elevation of 845.897m; installation house lies on downstream side of riverbed. Road to plant entries from downstream. Auxiliary plant stands in two rows: to the mountain side lays high-low voltage switch room and bathroom; to the riverside, central control room and compressed air machine room. This power station will not have a booster station in particular, thus it supposed to be interneted through the booster station in Chi'nan Power Station 0.4m from the dam

Main plant: 9.85m long, 10m wide mainframe room is 15.2m high at an elevation of 845.897m. A LD10t electric beam crane will be used as hoisting device whose maximum hoisting weight is 10t, span 8.5m, and utmost slinging height 9.0m. The elevation of crane rail is 852.937m. Water entering side of set's central line will lay a butterfly valve with diameter 1000mm. Ventilation duct will be set under floor while cable duct is disposed in line with riverbed side. Installation house is 5.15m long, 10m wide and 10.3m high (from the ground to the top) at an elevation of 845.897m. The front door is set near downstream side with 4.2m×3.6m dimension.

Auxiliary plant: central control room is set at the external side of the main plant in the upper-stream side at an elevation of 845.897m, covering an area of 10.0m×5.0m. The high-low voltage switch room is set at the internal side of the main plant on the upper stream. It is behind the control room covering an area of 12.6m×5.0m at the elevation of 845.897m. The compressed air machine room will be set at the

upstream of auxiliary plant, on the side near the riverbed. It covers an area of 5.0m×5.0m at the elevation of 845.897m.

Tail water structure: the normal tail water level of the station is 845.0m and lowest level 844.410m. Tail water room floor's elevation is 841.297m while its façade is connected with discharge spillway of downstream and its side is connected with diversion tunnel of secondary power station.

D Wangjiahe II Hydroelectric Power Station

system：water diversion system has a total length of 5050m, in which the tunnel takes up 4610m. The station diverts water into Channel No. 1 (stake number 0+000～0+400）through the tail water regulating sluice of Wangjiahe I Hydroelectric Power Station. This is 400m long in total, constructed with C20 reinforced concrete. Then, water runs through Tunnel No. 1, which is 700m long（stake number 0+400～1+100）;Tunnel No. 2，1480m long (stake number 1+100～2+580)；Tunnel No. 3, 590m long (stake number 2+580～3+170）; water diversion structure of 20m long(stake number 3+170～3+190)in C25 reinforced concrete structure; Tunnel No. 4, 870m long,（stake number 3+190～4+060）; Overflow weir, 20m long, (stake number 4+060～4+080） in C20 reinforced concrete structure; Tunnel No. 5, 970m long,（stake number 4+080～5+050） and finally into the fore bay.

Water diversion connection structure: It is located in the ditch of Wangjiahe River. It has an approximate ground elevation of 840.0m and lies between Tunnel No.3 and No.4, with stake number ranging from 3+170 to 3+190. The total length is 20m and designed drainage volume is 0.2m^3/s. UPVC tube is used to divert water, whose diameter is 250mm and designed flow velocity 1.0m/s. Altogether there will be five tubes with four tubes in working condition and one to back-up. The water diversion

connection structure adopted the C20W4F50 reinforced concrete. The whole cross section is closed and flood will flow upon the top. The bottom is 2.1m wide and the height of the side wall is 2.7m.

Overflow weir: It is similar with the open tunnel in structure and style, with a super elevation of 0.05m. The elevation of the weir crest is 840.72m, and the width of a single side weir is 20.0m. Flood can runs through both sides and the maximum overflow depth is 0.19m.

Fore bay: The entrance of the fore bay is connected with the exit of the No.5 tunnel, whose stake number is 5+050 and bottom elevation is 837.4m. Total length of antechamber is 10m and the width changes gradually from 2.1m to 5m. The bottom of the antechamber is 834.400m in elevation. The size of water intake chamber is 1.55m (length) ×3.2m (width), and the bottom elevation is 835.07m. The trash rack is placed in front of the inlet of the chamber, with an angle of 70 degree from horizontal plane. The main gate is placed at the end of the transition section of the penstock entrance. The size of the hole is 1.6m (width) ×1.4m (height). The working platform of the chamber is at an elevation of 841.6m; while the hoist platform 843.6m. The main gate is made of steel, and controlled by LQ-10t screw type hoist.

Steel penstock: Associated water supplying system of two machines and one tube is adopted. The 392.826m-long main tube (from the entrance to the center of bifurcated pipe) is composed by two parts. The former part is exposed pipe while the second half is tunnel pipe covered by concrete. The steel tube in the range of stake number 0+000 to 0+157.334 in fore bay is exposed pipe with a total length of 207.618m while from stake number 0+157.334 to side wall outside the plant is underground pipe with a total length of 185.208m. The whole branch pipe is 29.306m long. The main pipe and the branch are connected in “Y” shape. Stake number of bifurcated pipe center is 0+291.863. After furcating, main tube’s diameter will gradually become the same with branch tube, 800mm, and branch tube’s

central elevation is 579.570m. Anchor blocks are all in closed structure and with C15 pouring, with altogether three expansion joints. Rest pier are in sliding saddle shape. The distance in between can be 6m or 8m.

Power house: the generator hall is 15.43m high (from the bottom of the tail water to the roof), covering an area of 220 m^2 at the elevation of 581.000m. Parallel to the riverbed, the central line of the generator sets is 3.7m from outside wall of the room at riverbed side and 7.3m to the other side. Installation house is 10.8m high (from the ground to the top) covering an area of 70m^2 at the elevation of 581.000m. The entrance gate to the upper stream is 3.7m×4.2m in size, while a drainage sump 4.5m×3.0m in size is set near the mountain side, whose bottom is at an elevation of 576.00m.

Central control room is set in the downstream side of the power house. The coverage of the room is 66m^2, and the height 4.5m. It is located at the elevation of 585.500m. High-low voltage switch room is set behind the power house. The height is 4.5m and the elevation 585.500m. From up to downstream there are 35KV, 6KV and low voltage switch rooms in succession.

Normal tail water level of the station is 580.040m and lowest level 579.440m. Tail water room, 3m×3m in size, is located at an elevation of 576.770m.

A platform excavated between 35KV switch room and mountain body can be used as a major booster field. Two main transformers will be set at the platform at an elevation of 585.200m.

2.2.3 Hydropower mechanism

(1)Chi'nan power station

Hydropower planning outcome of the station is as follows: net head is 230m; diverted volume of the generator set is 1.07m3/s and installation capacity is 2×1000kW.

CJA237—W—100/1×10.5 hydraulic turbine and SFW1000—10/1430 matching hydro-generator are chosen for the station.

Φ400mm butterfly valve, operated electrically, is adopted as the water intake main valve with a nominal pressure 3.0MPa. According to the selected parameter and automation demand, micro-computer governor for impulse water turbine is adopted. Meanwhile, a LD—10 electric calabash beam hoist crane will be used based on the information of selected set.

In line with the connection plan of the station and power output requirement, main transformer is decided to be S_9—3150/35 type (including 630kw from power stations downstream of Wangjiahe Reservoir). Station transformers are decided as S_9—50/35 38.5/0.4KV and S_9—50/10 6.3/0.4KV, one for each.

According to the short circuit current calculation, ZW8—40.5-25 Bulk Oil Circuit Breaker is chosen as switch device for 35kv voltage level and ZN40A—10 vacuum circuit breaker for 6kv. Other electric facilities are in conformity with common practice.

(2) Wangjiahe I Hydroelectric Power Station

According to the water head and installed capacity of the station, HL260/D74-WJ-88 hydraulic turbine and SFW630-16/1730 matching hydro-generator are applied to this station considering the productions of national medium-and–small sized factories at present. Designed water head of this power station is 19.0m and installed capacity 1×630kW. Based on the data from the factory, the actual draft head of turbine H’s=+1.797m. Designed tail water level is decided according to the normal water level at the tunnel head of Wangjiahe II Hydroelectric Power Station downstream, which is 845.0m. Therefore, the setting elevation of turbine is 846.797m.

Main valve adopts a DN1000 electric butterfly valve, PN0.6MPa with electric operation. There is a main gate set at the water inlet. Meanwhile, in order to

ensure electricity generation in secondary station when accident occurs in the set of this one, a DN500 manual buttering valve will be set in front of set valve. YWT—600 governor will be used. And a LD10—10 electric beam hoist crane with a hoisting weight of 10t will be adopted, which can be operated by a control box on the ground. In line with the layout of the power house, span will be 8.5m and utmost slinging height 9.0m. There is no oil processing and storage device in the station; thus local electric system will provide paid services in this regard. Water consumption for one single set is $10m^3/h$ and water supply for production the whole station is $15m^3/h$. Water will be supplied by natural water flow, taking water diversion penstock as the source. Main pipe for fire-fighting water supply is turbocharged by a centrifugal pipe pump and water source is from the main pipe of water supply for production. Due to the fact that the lowest floor elevation of generator hall is 842.5m, which is higher than 824.765m, the checked flood level of this area. Thus water leakage and bearing cooler drainage are directly discharged outside the plant. According to the breaking requirement, a movable low voltage air compressor will be set.

(3) Wangjiahe II Hydroelectric Power Station

According to the water head and installed capacity of the station, HL100-WJ-73 hydraulic turbine and SFW5000-4/1430 matching hydro-generator are selected for this station considering the production situation of national medium-and–small sized set factories at present.

The permitted draft head of turbine Hs=+2.33m , while actual one is H’s=+1.965m. Due to the narrow downstream river of this area, designed flood level is 8m higher than normal water level. Lowest elevation of the generator pit inside the room should be higher than check flood level. The check flood level in this region is 578.270m and elevation of generator room is decided to be 581.000m according to check flood level and depth of generator’s turbine pit. Thus the installed elevation

of the turbine is 581.770m. Based on the H's value of the set, the lowest tail water level of the station is controlled at an elevation of 579.440m.

Main valve adopts a Z942-40 electric valve , DN800mm and PN4.0Mpa electric operation valve. There is a main gate set at the water inlet. YWT—1000 governor, the auxiliary set from the factory has been selected. LD16—10 electric operation beam hoist crane will be used. The hoisting weight is 16t and it can be operated by a control box on the ground. The span is 9.5m and utmost slinging height 12.0m. There is no insulating oil processing and storage device in the station; thus local electric system will provide paid service in this regard. There are 10 spared 200L oil barrels and corresponding oil processing services will also be provided by local electric power system for fees. Water system in this station is mainly for technical usage. Set bearing cooler and some domestic needs are the major consumption ways. Water consumption for one single set is $30m^3/h$ and the technical water supplying for the whole station is $70m^3/h$. Water from the tail water tunnel will be used by water pump. Three are three sets of 150RJC40-13.5 deep well pumps to be used, including one for spare. Fire fighting water takes from the main pipe of technical water supply while spared water source is from steel penstock. Due to the fact that the lowest floor elevation of generator hall is higher than 578.270m, the check (P=1%) flood level in this region. Water leakage and bearing cooler drainage are directly discharged, without any other facilities, to the outside of the plant house. Two V-0.9/7 air compressors: one for work and the other for backup are in automated control. Meanwhile, $4.0m^3$ gas storage tank should be set.

Wangjiahe project layout can be seen in the attached figure 2; Wangjiahe key project dam layout can be seen in figure3.

figure4: Power House Layout of Wangjiahe I Hydroelectric Power Station; figure5: Power House Layout of Wangjiahe II Hydroelectric Power Station.

2.3 Reservoir submerging and project permanent land occupation

Wangjiahe Reservoir power station is in Niuzhuang Township of Wufeng Tujia Autonomous County. Wangjiahe River, which locates in the upstream of Qingjiang basin Zhisuo River, belongs to Qingjiang basin. Project mainly occupies some permanent land, which refer to farmland and forest, so no relocation problems concerned. According to the design requirements and data provided by Niuzhuang township government, the project occupies land 35mu and forest 220mu.

Niuzhuang township government will be in charge of the organization and correspondingly works of land occupation, while business owners will pay for it, according to relevant agreements on Wangjiahe River Basin development and construction between the two parties.

2.4 Engineering construction

2.4.1 Construction condition

（1）External transportation

Wangjiahe River is located in the middle of nowhere with backward transportation condition. At present, road transportation is the only way available. There are three major roads: secondary YA-lai Road from Yichang to Wufeng County covering a distance of 170km; tertiary township road, 80km long, from Wufeng County to Niuzhuang Township; and a township mud-stone road from Niuzhuang Township to Wangjiahe River, covering a distance of 20m. There is no road available from Niuzhuang Township to secondary power station (Zhangjiaya reach). Therefore, it plans to build a township mud and stone road in the charge of Wufeng government, which is supposed to open to traffic by the end of 2009. The road condition from

Yichang to Niuzhuang can meet the needs of project's transportation, except that some sections from Niuzhuang to Wangjiahe River needs maintenance in order to satisfy the transportation requirement of large scale device.

（2）Project layout features

Wangjiahe River basin reservoir power station project is composed by Chi'nan Power Station, Wangjiahe River reservoir and two power stations downstream.

Chi'nan Hydroelectric Power Station is located in the upstream of Wangjiahe River. With 7.0m high, the intake dam is pulp masonry overflow dam. On its left bank, an intake sluice will be set, thus water flows into the tunnel through diversion corridor and silting basin. Consisted by diversion open channel, underground tunnel, silting basin, tunnel, and others, the diversion engineering line is 4830m long. At the exit of No. 4 tunnel, a 15m long and 3m wide fore bay is set in connection with 416.760m long open penstock. The water-diversion power station is made up of main plant, auxiliary plant and booster station, covering a total area of655km^2. Chi'nan power station and downstream Wangjiahe Reservoir Power Station will be construct at the same time while employee housing, culture and welfare device will be taken into consideration. Production duty room, office and tool production warehouse will be set within the station, covering an area of 200 m^2.

Wangjiahe Reservoir dam is located at Jinkouzi of Wangjiahe River, which is sand and gravel rock filling dam with maximum height of 50.95m, crest elevation 878.95m and crest length136m. Water intake and water diversion tunnel of Wangjiahe I-Hydroelectric Power Station are on right bank while flood discharge structure is set on the left bank. Water runs through the overflow weir side channel and flood will be discharged through the flood discharge tunnel. First power station is 130m downstream of the dam on the right bank and tail water directly flows into the diversion tunnel of secondary power station. This diversion channel is set along the right bank of Wangjiahe River, with a total length of 5.05km. Fore bay and the

power house are located in Zhangjiaya Reach of Wangjiahe River. The bottom of the fore bay is at an elevation of 834.4m. Water will be diverted to it through a penstock (open channel+ buried duct) 422.132m long. The plant site is on the right bank of river at an elevation of 581.0m.

（3）Condition on the construction site

Construction site of Wangjiahe River Basin power station cascade development project can be summarized as three spots and two lines. Three spots includes: construction sites of Chi'nan Station, the dam and the secondary station; while two lines refer to diversion tunnels of Chi'nan station and the secondary station. Three spots are not the favorite sites for construction because of the deep cut and narrow valley, which is 15 to 20m in width at the bottom, together with steep bank and slope. However, there is relative moderate slope which can be set as warehouse, work shed and maintenance site, etc. There is moderate slope at nearly every entrance of water diversion tunnels, so work shed, warehouse and pressure station can be set nearby.

（4）hydrological and meteorological condition

Meteorological condition: the basin where reservoir stands is in sub tropical monsoon climate zone, warm, humid and with a lot of rainfall. Multi-year average precipitation reaches 1587.5mm, while monsoon starts from May and ends up with October, contributing 90 percent of the whole year's precipitation. Rainstorms mainly occur in the period from June to September, of which July is most susceptible month and the utmost rainstorm intensity one day is 253mm as actual measure. Multi-year average temperature is 13.5□ and highest temperature 37.1□ ,lowest -15□. Multi-year average relative humidity is 76% with an average absolute humidity 127Pa. Multi-year average wind velocity is 1.3m/s, maximum wind velocity 15m/s and popular wind direction SE. Multi-year average non frost period is 247d in total. The highest mean temperature of one month appears in July, 27.9□ and lowest in

January , 4.6□ , while highest and lowest monthly average temperature are 33.1□ and 1.3□ respectively.

Hydrological condition: Wangjiahe River basin runoff mainly comes from rainfall and the annual distribution is basically the same. The catchment area of Chi'nan power station is 33.8 km^2 , while the one of Wangjiahe Reservoir reaches 68.2km^2 with multi-year average precipitation of 1587.75mm. Average flow at the dam site is 2.16m^3/s and runoff 68million m^3. Flood in the basin embeds character of mountain river, namely suddenly and sharply water rising and falling. Flood peak is of single peak type and the duration lasts less than two days.

（5）Main construction material

This project is estimated to use 8621t cements. Huaxin cement factory of Yichang which is near Niuzhuang Township produces 42.5MPa and 52.5MPa cements. With a yearly production of 0.6 million, their throughput and quality can fully meet the needs of this project. The concrete irons and steels can be provided either by Yichang or the material company of the county. The lumber resources are available for the project, and an adjacent big Huaping forestry can offer its service at any time. Firewood materials will be provided by the chemistry construction company of the county while construction firewood materials will be offered by the petroleum corporation of the county. In construction, an electric conversion apparatus of 1500kVA to be installed can suffice the requirements of the construction electricity. Now there is an 110KV network electrical connections leading to Niuzhuang booster station. The construction electricity can be ensured, as during the initial phase it is planned to lay down the permanent net circuit from Niuzhuang to Chi'nan, Wangjiahe I, and II Hydroelectric Power Stations.

(6) Natural construction material

Dam body filling: in the range of 1.0km from dam site upstream, there is abundant

storage of sand and gravel material in riverbed, of which available storage reaches 612,000 m^3. Graded nature, except 20% of boulders whose diameter exceed 20cm can't be used in dam construction; the rest can be used directly. Material field is basically exploited above the water. A 74kw bulldozer is adopted to peel overlay and collect material. Then, 1.5m^3 loader cooperates with 15t dump trunk will transport them to the dam.

Aggregate: In the range of 1.0km of dam site downstream in reservoir area, riverbed is mainly made of sand and gravel with boulders whose storage exceeds 200,000m^3. Material layer is so thick that the exploiting and screening will be done by machine. River gravel can be used as coarse aggregate while sand as fine aggregate. Material field can basically be exploited above the water and 1. 5m^3 loader will excavate, load and transfer the material to the site for screening and rinsing. Concrete aggregate in secondary power station site area can be processed and produced with plant excavation dregs.

Rubble material: The rubble consumption of this project is 21342m^3, which is relatively small in amount. Boulders in floating riverbed of dam site up and downstream are all limestone which can be used as masonry material. They can be collected and transported in a collective way. Rubbles for secondary station can employ the excavating materials for the plant house.

2.4.2 Construction diversion

In accordance with "Hydraulic and Hydro-Power Engineering organizing criterion" SDJ339-89, table 2.2.1, the diversion constructions in the project are level V. Considering that the cofferdams are baxite ones, according to Table 2.2.3 provides flood diversion building standards in accordance with Table 2.2.2, it has a lower limit of five years once. During the dam construction period, the temporary flood protection criteria is two decades once.

The cofferdam backfill is completed in the same dry season. Considering the cut-off wall and curtain grouting of the dam and the influences brought by the construction, the diversion tunnel construction period is selected in October to April, which is safer and more reliable. The standard diversion is five years, with the traffic of 35.6 m^3/s. And it is planned to accomplish the cofferdam filling project before 16^{th}, October, and finish the water cut-off wall and foundation construction of curtain grouting before November to 15^{th} March. The dam filling project will be last for the whole year, and the dam flood protection period is designed as two decades once, with the flow of 196.0 m^3/s.

2.4.2.1 Diversion way

Wangjia River is a mountain river, with the characteristic of a fast coming and falling flood. The largest flood peak occurred in June to September, the gap between the volumes of flood peak can be more than 10 times. The dam has a narrow and deep valley, which is slightly asymmetric and has a U shape. The costs of the valley are steep, with exposed rocks. The hillsides above 840m are gentle slopes, and the foundation layer is covered by sand and gravel, with the thickness of 10~25m. According to hydrology, topography, the geological conditions and the layout features, it is not impossible to adopt periodical sectional cofferdam diversion, nor is it possible to adopt digging riverbank for an open channel in Wangjia River project. The only possible way is through cutting the flow by once in the cofferdam and divert the water through the channels. In order to reduce the workload to the minimum, and make it more convenient for the cut-off wall and the bed curtain of water work, the upstream cofferdam is part of the dam, which is designed as the food of the dam, and it is design in the assumption that the flood will come once every two decades.

2.4.2.2 Buildings of diversion

The buildings in the Wangjia River project play a major role of anti-seep dam foundation and will help the diversion of part of the water during the period when dam body comes back to the dam.

(1) Diversion tunnel layout

The topography of the riverbed from the dam site and the layout requires that the diversion tunnel should be set in the left bank. The entrance of the diversion tunnel is located in the upper reaches of 111.0m of the dam axis. The first part of the tunnel length 108m (the rest part length 179.32m, works as the flood discharge tunnel). The diversion tunnel at the bottom is slightly lower than the existing river bed, which is 830.0m, and the bottom exit elevation is 824.254 m. There is a gate for diversion on the up left of the tunnel entrance, the diameter of the steel pipe is Φ600mm, which is arranged along the tunnel. It will be fully accomplished before the end of September. The cross section of the diversion tunnel is round, and the diameter is Φ5.2m. Transition Section of the pressure of the entrance is 15m. Changing from rectangular to circular, the last part of the tunnel is made of 0.3m thick reinforced concrete lining for the use of spillway tunnel. The first part of the tunnel is made of 5cm thick cement mortar, which is used for spray protection, to reduce the roughness erosion of local unstable fracture zone, which is 10cm thick, and to prevent the tunnel from collapsing.

（2）The water-proof cofferdam layout

The upstream and downstream water-proof cofferdams are both parts of the dam. They should meet the requirements of the dam design and construction, and at the same time have a simple structure, and cost as little money as possible. Therefore, the upstream cofferdam is made of sand and gravel, and the downstream cofferdam is made of rubble, which has the diameter of 25 to 400mm, and the water-proof material is made of complex agricere. The upstream cofferdam is made of stone revetment, impermeable layer of material, sand, gravel and rock from the downstream. The

height of the cofferdam is 840.0m; the width of the roof is 3.0m. The proportion of the width of the upstream and downstream is 1:2; the total volume of the dam stone is 10,300 m^3. The downstream is made of rough stone, impervious layer and block stone. The height of the roof is 829.086m, and the height of the bottom is 820.086m, the upstream slope of 1:1, and downstream slope 1:1.5. The water cutting of the cofferdam is through operating from both riverbanks, and pre-building the plug gaps, and before the water cutting, the river division tunnel should meet the condition. The water-cutting is planned to be conducted on 20th September. The tunnel is to be blocked up after accomplishing the dam project. When it is blocked up, a sluice gate will be put in the upstream, and after the water is drained, 3.5m long low heat micro-expansive concrete will be poured into it, and backfilling and grouting will be conducted.

2.4.3 Construction of the main works

2.4.3.1 Excavation of earth and stone

（1）The cleaning and excavation of the dam

As the river bed is narrow, the river banks are steep, and the water level alters great during the flood period and the dry period, the diversion will be conducted in the way of cutting the water near the cofferdam, and diverting the water by the tunnel. The digging work will be started from the top to the bottom. Till the water cutting on 16th September, firstly, the foundation of the dam will be excavated and cleaned, and after the water cutting of the cofferdam in the dry period, the further river bed cleaning work and water-proof wall building work will be conducted, in the height of 828.0m

As for the cleaning work of the toe board of the two banks, if the foundational rock layer is deeper than 4m, then the general slope excavation is appropriate; if the foundational rock layer is less deep than 4m, then it can be conducted by breaker hammer, and the thin layer can be broken. When the foundation of the dam is

excavated, a protective layer should be left, which is 0.5m to the designing line, and the cleaning work can be done by human combined machine. The protecting layer should be excavated before the pouring of the toe board. The stone which is dug out of the dam is mostly used as the stuff material of the dam, the left over part can be tapped by 1~3m^3 digger or loader with 10~15t auto dumper.

(2) The side weir, an intake station, plant, spillway tunnel, diversion tunnel excavation

① The side weir, an intake station, plant

The total volume of the side weir excavation is 10435m^3, the highest is 25m. The total volume of the intake station is 918m^3. The excavation work should be accomplished at one time, through the general explosion way. Part of the stone dug from the digging will be used as the filling stuff of the dam.

② Spillway tunnel, diversion tunnel

The total length of the spillway tunnel is 223.51m, which consists of the oblique section and the horizontal section. The horizontal section is connected to the diversion tunnel; the length of the first part of the diversion tunnel is 108.0m. The cross sections of the spillway tunnel and the diversion tunnel are both round. The diameter of the diversion tunnel is φ5.3m, the spillway tunnel is φ5.6m, and the total volume of the two tunnels is 8240$m^{3.}$ There are pneumatic drill hole in the spillway tunnel and the horizontal section of the diversion tunnel; they are smoothly blasting, 0.5m3 dumps the ballast vehicle. 100 ABM DTH drilling wells and molding, sub-blasting, hand-held pneumatic drills are used in the oblique holes. Diversion tunnel, spillway tunnel excavation will be completed before the closure. The excavation of stone can be used for filling the upstream cofferdam.

(3) Power diversion tunnel excavation

The first-rank power generation station tunnel length 267.0m, with the diameter of Φ2.1m, the total excavation volume is 848.0m^3. The second-rank power generation station tunnel length 4610m, the cross section is like a city gate. The excavation area is 2.1m×2.972m, and the excavation volume is 28102m^3

1. The entrance and exit excavation of the tunnel: in accordance with the design requirements, hammer drill is used from to top to the bottom to cut the slope, and the excavation work is conducted from inner to the outside, and the dreg is moved out by manned ballast cars. There are dangerous stones at the entrances and the exits of the tunnels, therefore they should be moved off before the work begins. What's more, there should be 5~10m range of support near the entrances and exits.
2. Digging the tunnels: hammer drill, full-face smooth blasting, manpower lading ballast, 0.5m3 ballast shipped over the first vehicle. As for the tunnel which is longer than 400m, reversing road would be set in the appropriate position. The cross section of the excavation width 2m, length 3.5m, extending some digging in the bottom concrete lining is required before filled with mortar.
3. There are three construction branch holes, a total length of 155m; they are mainly used for moving out of the main ballast holes and playing as ventilation holes.
4. Ventilation, electricity in the tunnels: except from the ventilation of the constructive tunnels, JBT-52 Explosion-proof hybrid axial fan need to be adopted, an extension nozzle can move forward step by step. During the constructing, we should make sure the ventilation; electrification and security are guaranteed, further enhance the health management. Strictly keep to the "the regulation of Water Resources and Hydropower construction security engineering". Power transformer is linked by the tunnel line from the inside cave to the outside, and there should be person responsible to guarantee the security of the tunnel construction and the electricity, in order to ensure the smooth progress of the tunnel construction.

(4) The excavation of the buildings beneath the second-ranking station

The buildings beneath the pool consist of the former pool, penstock, power plant and main and booster station, the foundation is rock, and the total excavation volume is. The excavating order is from the top to the bottom, first the former pool, then the penstock; the last should be the main and booster station. Shallow whole blasting is used in the excavation of the foundation, and through the way of splitting from top to bottom layer, manpower loading and trolleys which is used to ballast.

(5) The excavation of the buildings in the south station

Manpower combined machine is adopted in the whole project, in which machine plays the major role. The excavation work make use of the drill rig and manpower setting blasting materials, and trolley to move out the waste, concrete construction by mechanical mixing, manpower loaded mold, dump transport; Masonry works mainly by mechanical mixing mortar, manpower masonry. Two small vice dams are manned mixed. The total length of the tunnel is 4085m; a total of 4, eight steps of construction will be started at the same time. Smooth blasting excavation is used in the tunnel construction.

Check dams, pressure pipelines, factories are fully integral foundation layer, reserved for the protection layer, the first excavation of the construction method is adopted.

The construction is conducted from the top to the bottom. The power station workshop teeming work consist foundation, host layer, hinge jointed frame bent column, plate girder.

2.4.4 Construction Traffic and Construction Layout

2.4.4.1 The traffic and transportation of the construction

(1) The outbound traffic program

Road transport is used as the outbound traffic in the project. According to the existing road conditions, the road from Jinshanpin to Wangjia river should be widened partly, and the road from Jinshanpin to the second-ranking station should be build in time. The road standards should reach the standards of the road which leads to the reservoir, which can meet the transportation requirements of 30tons equipments.

(2) The main traffic layout of the construction

There will be a branch separated from the road from Jinshanpin to the reservoir, leading to the right bank to the head of the dam, the stockyard on the right bank of the upstream, the head of the dam on the left bank, and the stockyard on the left bank of the lower stream. The road is used as the temporary way to the transportation of the bone material, stone and other constructive materials, as well as the big sized machines. Temporary constructive path will be built, leading to the entrances of each branch tunnel, as the path for manpower transportation of the small sized machines.

2.4.4.2 Construction Layout

Under the principle of reducing the occupying farmland to the minimum, the assistant enterprises of the project are best to be decentralized. Except the gravel aggregate processing system, concrete batching system, reinforced wood processing and construction machinery and repair plant, the construction of steel formwork, standard products and steel and so on, the else are all provided by manufacturers, the construction site only stacked venues. Considering that the duration of the works is short, in order to reduce the cost of renting lands and temporary works, we don’t consider to form a new constructive team and rent living rooms for the workers, instead, we will rent nearby rental houses and build up temporary camp for them.

(3) The exploitation and machining of the concrete aggregate

Because there is only one aggregate market in the project area, the system will be set close to the market, which is located between the market and the branch of the

road, which will make the way from the market to the constructive points shortest.

(4) Concrete mixing system

In order to meet the different demands of different areas, and different concrete, we will adopt distributed mixers and dam and second-ranking station to layout the plan, and have a small scale layout of the gravel stockpile. There will be a 2 × 0.4m3 floors, a mandatory mixing building in the dam and one of the two stations.

(5) Integrated Processing System

The integrated processing mainly include: steel processing, wood processing and processing of concrete structures, the dam area, the secondary station plant layout used in the dormitory with the base camp site erection site. The prefabricated parts processing zones will be close to the mixing system layout.

(6) repair and the storehouse

The repair system is mainly used for the mechanical reparation during the building of the dam, which has a short term of usage. It is considered that the system can be built after the water cutting, and the river bed waste are set in the constructive points. As for the major constructive materials which are imported from the other areas, most of them will be kept in the renting house along the road; the rest will be set in the constructive points, which can meet the demands of the daily needs. The Initiators & Pyrotechnics will be placed in the appropriate storehouse, which will be built according to the extinguishing and protection requirements.

(7) Waste disposal area

Apart from the usable part from the excavation material, the waste reach to total of 5.65万m^3 .The waste disposal area will be set in the following places: the waste from the Yichong dam of the south pool can be put to the left bank of the lower stream; the

waste from the river alongside can be set at the entrance and exit of the first branch of the tunnel, the barrage, the exit of the third tunnel, the entrance and exit of the fourth tunnel, and the waste disposal area in the workshop. The waste from Wangjia River and the dam can be put to the waste disposal area near the lower stream, and the waste produced along the tunnel will be put to the first, second, and Wangjia channel, Zhujia channel and other waste disposal areas. The waste from the second-ranking station will be put to the waste disposal area set near the river.

(8) Living areas and construction management areas

According to the scale of the construction and its characteristics, as well as the overall progress of construction, the total amount of worker will reach 300 people during the peak of the construction. Except that the power station is the permanent construction, which will be put into usage immediately after the beginning of the project, all others will be scattered and renting houses will be used.

The reservoir construction project horizontal layout is on page 6, and the second-ranking power station horizontal layout is on figure7.

2.5 Construction progress

In accordance with the characteristics of the project, the total period will be 2 years; the power generation will begin in the third year. The process of the project will be divided into three stages, namely, the preparation period for the cleaning of the dam, the power station building period, and the finishing period.

(1) Preparation period

The period before the cleaning of the dam is the preparation period, which length from April to September of the first year. The major task is to accomplish the reconstruction of the road leading to the outside area, and the building of the main construction lines in the construction area, and the digging& backfilling of the

diversion tunnel. We will also finish the preparation of the bone materials, and pouring concrete spillway tunnel, and dig part of the electricity generation tunnel.

(2) The period of main part of the project

From the September 15th to the end of March of the second year, the following work will be accomplished. The closure of the upstream cofferdam downstream cofferdam (filter body) construction is followed by foundation excavation foundation plinth foundation excavation and backfill treatment and dam. Plinth grouting and curtain grouting; remembrance laid dam should be increased, such as the basic synchronization is complete, the completion of the dam filling to the design elevation; the completion of a power station water intake tunnel in the dam concrete anti-wave wall; the completion of the side spillway weir Excavation and concrete backfill; through the power tunnel to complete the power station foundation excavation and backfill foundation ground plant construction, equipment installation and debugging to unit.

The tasks will be done in turn during this period, except that the diversion of the flood and the backfilling of the dam will exert some influences, other tasks will have little influence to each other. It should be guaranteed that before the middle of April, the height of the backfilling of the main dam should reach 840.0m. In special occasions, other tasks should give way to this task; otherwise there will be fatal damage during the flood period.

(3) The period of completion

This period is from the end of the second year to march of the second year. The major task includes: the construction of the administrative and living facilities, the accomplishment of the environmental protection, the cleanness of the construction point, withdraw of the workers, the watch and test work of the dam in its first period of working, and the improvement of the operation of the power station.

2.6 Engineering Management

2.6.1 Management Organization

According to scale and profit of the project and combining market rules and owners' ideas, company limited is established, and it will unitary manage Chinan Power Station and Wangjiahe Reservoir □ , □。

According to File080(1985), "small scale water conservancy", of Agricultural Machinery Department of Water Conservancy of Hubei Province and the condition of the project, management department establish a company limited, which includes 22 managing professionals and a general director. Financial affairs are centralized managed by the company.

2.6.2 Management and Protection Area

2.6.2.1 Management area

Management area includes Chinan Power Station and Wangjiahe Reservoir Power Station.

□ ,Chinan Power Station management area include dam, water division building, fore bay, penstock, powerhouse and office and living quarter.

(1)Intake dam: a grouted rubble overall dam, the height is 7.0 meters, there is an intake sluice in the left bank, and water is diverted into gallery and desilting basin and finally into tunnel. Area of accepting rain above the dam is 33.8 square kilometers.

(2) Water division project: the project route is 4830 meters, contains diversion channel, covered culvert, desilting basin and tunnel. There are 4 tunnels and total length is 4185 meters, the length of gallery is 15meters, desilting basin is 30 meters

long, diversion channel is 570 meters long and covered culvert is 50 meters long.

(3) Fore bay: there is a fore bay in the tunnel exit $4^{\#}$, 15meters long and 3meters wide.

(4) Penstock: fore bay links with outdoor penstock in the back, total length is 416.760, branch pipe of $1^{\#}$ machine is long, and branch pipe of $2^{\#}$machine is long, the interior diameter of main pipe is 0.7meters and the interior diameter of branch pipe is 0.4meters.

(5) Powerhouse: the division power station contains main power house, auxiliary powerhouse and booster station. The main and auxiliary powerhouse is 38.5 meters long and 10.8 meters wide and the total area is 655 square meters. Booster station is located in the right of power house, takes 299 square meters.

(6) Production and living quarter: Chinan power station and Wangjiahe Reservoir Power Station will be built in the same period, employee apartment and cultural and welfare facilities are also taken into consideration. The power station also has duty room for production and office work, along with tool warehouse for powerhouse production. It is planned to build a 200 square powerhouse.

□.Wangjiahe Reservoir Power Station management area is Wangjiahe Reservoir, and Wangjiahe Power Station □□.

(1) Wangjiahe Dam: a face rock fill dam, the maximum height is 50.96 meters. There are intake sluice and water diversion tunnel in the right bank, the tail water of power station□enter channel 1# of power station □ through regulating lock. The area of accepting rain above dam is 68.20 km^2.

(2) Wangjiahe Diversion project: the route of diversion project is 5050m, contains diversion channel, tunnel, diversion connection building and overflow weir. There are 5 tunnels with a total length of 4610m, the channel is 400m long; the diversion connection building is 20m long, located between hole3＃and hole4＃; the overflow

is 20m long and located between hole 4#and hole5#.

(3) Wangjiahe fore bay: tunnel exit5# is linked to fore bay; the tunnel is 23.5m long and 7.1m wide.

(4) Wangjiahe penstock：the penstock includes exposed pipe and underground pipe, the exposed pipe is in the upper part, with a length of 207.618, while the underground pipe is in the lower part, with a length of 185.208m. Brunch pipe of machine 1# is 14.653m long, and brunch pipe of machine2# is 14.653m long, the interior diameter of main pipe is 1.3m, while the interior diameter of brunch pipe os 0.8m. The designed flow of main pipe is 4.8m^3/s。

(5) Wangjiahe powerhouse: Wangjiahe Power Station at the dam toe, it consists of main power house, auxiliary power house. The total length and width of main and auxiliary house is 30.02m and 10.00m separately, and building area is 640.3 m^2. Booster station is located in the back of powerhouse, takes 48 m^2.

(6) Production and living quarter: production office, flood prevention office, duty room and warehouse are arranged in the production quarter, while employee apartment, cultural and welfare facilities are arranged in the living quarter.

2.6.2.2 Management Content

The main management content is dam, diversion building, safety security of buildings in power station, forecast of water in reservoir and rains and control of operation; operation management and maintenance of electromechanical equipment; business accounting of power station; project material collection and sorting and file.

C. Safety security of project

(1) The dam and diversion project should be checked regularly and irregularly. Take notes of subsidence, displacement and leakage of dam and leakage and disposition of

diversion channel. If anything abnormal happens, take action and research immediately; normal water flow must be guaranteed in the tunnel, and other obstacle must be prevented from falling in the tunnel; keep the sluice maintenance regular.

(2) Equipments like powerhouse, booster station, electromechanical and transmission line should be maintained and checked regularly according to rules and technical requirements in the sector.

D. Management plan for scheduling and operation

(1) Grasp weather change and raining and coming water in the reservoir, make proper water scheduling and operation plan and bring economic and social benefit.

(2) Beyond ensuring integrity and safety of electromechanical equipment, make full use of water resource and try to generate full and more electricity in peak regulation.

(3) Make good use of tree planting in reservoir and keeps vegetation in slope complete, at the same time, do environmental greening well and reduce the influence of water and soil erosion.

E. Operation Management

Manage the company according to requirements and file the information of construction management, usage, and results, so as to analysis the project, summarize experience and improve management efficiency.

2.7 Investment and Profit

(1) Investment and fund raising plan

Chinan Power Station: total static investment of power station and transmission line is

15.4596 million RMB, consisting construction investment of 1.2646 million RMB, electromechanical equipment and installation project of 4.3397 million RMB, 1.2646 million RMB metal structures and equipment, temporary project of 0.2248 million RMB, other cost of 1.4685 million RMB, land compensation of 1 million RMB, 1.2 million RMB environment and water protection costs and 0.7005 million RMB basic preparation cost. The investment o f internet access line of power station is 750 thousand RMB. Loan interest during construction is 1.491 million RMB, and total investment of project is 15.6087 million RMB. The investment and fund raising plan: 60% of total static investment, 1.0541 million Euros or 9.276 million RMB (at the exchange rate of 1:8.8), will be applied from European Investment Bank (EIB), and the interest rate is 2% a year for 20 years and 40% of total statistic investment, or 6.184 million RMB will be raised by ourselves (including capital fund). According to construction design and investment plan, the construction period lasts for one and half years. Investment of 9 million RMB will be finished in the first year, except capital funds, loan of 2.816 million RMB still be needed. In the second year, the rest investment of 6.4596 million RMB will be finished and it's all depending on loans. The interest rate is 2% a year, and interest is calculated on half year of the loan, compound interest. At the end of the construction, designed productivity will be reached.

Wangjiahe Hydropower Pivotal Project: the static investment of power station and transmission line is 10.40308 million RMB, consisting of construction investment of 50.074 million RMB, electromechanical and installation of 2.005 million RMB, metal construction and installation of 8.2664 million RMB, temporary project of 4.615 million RMB, other cost of 5.235 million RMB, inundation treatment of reservoir and other compensation of 6 million RMB, environment and water protection of 4.19 million, basic preparation cost of 4.9224 million RMB and investment on internet access line of 630 thousand RMB. Loan interest during construction period is 771.6 thousand RMB and the total investment is 104.7724 million. Investment and fund raising plan: 60% of static investment, 7.093 million Euros or 62.4185 million (at the

exchange rate of 1:8.8), will be applied from European Investment Bank (EIB), while 40% of static investment, or 41.6123 million (including capital fund), will be from our own. According to construction design and investment plan, the construction period lasts for two years. Investment of 49 million RMB will be finished in the first year, except capital funds, loan of 7.3877 million RMB still be needed. In the second year, the rest investment of 55.0308 million RMB will be finished and it's all depending on loans. The interest rate is 2% a year, and interest is calculated on half year of the loan. At the end of the construction, designed productivity will be reached.

(2) Main Economic Indicator

Chinan Power Station: the profit of power station is calculated according to 0.36 RMB/KW·h. The major results are: financial indicators after tax are financial internal rate of return is 11.56%, financial net present value is 3.58 million RMB and investment recovery period (include construction period) is 9.94 years; before tax, financial internal rate of return is 12.44%, financial net present value is 6.51 million and investment recovery period(include construction period) is 9.13 years. Economic internal rate of return is 13.16% and economic net present value is 6.79 million.

Wangjiahe Power Station: the profit of power station is calculated according to 0.36 RMB/KW·h. The major results are: financial indicators before tax are financial internal rate of return is 10.14%, financial net present value is 19.9249 million RMB and investment recovery period (include construction period) is 11.11 years; after tax, financial internal rate of return is 8.75%, financial net present value is 6.4366 million and investment recovery period(include construction period) is 12.21 years. Economic internal rate of return is 10.32% and economic net present value is 21.48 million.

2.8Engineering properties table

Engineering properties is shown in table 2-1,

Table 2-1 Engineering properties in table 1 (Chi Nan Hydropower Station)

Serial number and Items	unit	quantity	Remarks
□.Hydrology			
1.Drainage area			
The whole basin	Km^2		
Wang Jia River Basin	Km^2	105	Within Wu Feng County
Chi Nan Power Station	Km^2	33.8	
2.Hydrological working length in series	Year	42	1961—2002
3.The average annual flow	Billion m^3	0.0337	
4.Representation of flows			
Kang Lin Xi			
The average flow over the years	m^3/s	0.32	
Designed Flood flow (P=10%)	m^3/s	69.1	
Checked flood flow (P=3.33%)	m^3/s	89.9	
Yan Jia Gou			
The average flow over the years	m^3/s	0.22	
Designed Flood flow (P=10%)	m^3/s	52.7	
Checked flood flow (P=3.33%)	m^3/s	68.6	

Serial number and Items	unit	quantity	Remarks
Mo Shi Gou			
The average flow over the years	m^3/s	0.14	
Designed Flood flow (P=10%)	m^3/s	40.1	
Checked flood flow (P=3.33%)	m^3/s	52.1	
Han Jia Wan			
The average flow over the years	m^3/s	0.39	
Designed Flood flow (P=10%)	m^3/s	78.3	
Checked flood flow (P=3.33%)	m^3/s	102	
5.Sediment			
Multi-year average sediment discharge	t	4,900	
Multi-year average sediment concentration	Kg/m^3	0.145	
□.Buildings' flood level			
1.Kang Lin Xi intake dam			
Designed volume of the largest vent in flood level	m^3/s	69.1	P=10%
Downstream water level of the corresponding	m		
Checked volume of the	m^3/s	89.9	P=3.33%

largest vent in flood level			
Downstream water level of the corresponding	m		
2.Yan Jia Gou intake dam			
Designed volume of the largest vent in flood level	m^3/s	52.7	P=10%
Downstream water level of the corresponding	m		
Checked volume of the largest vent in flood level	m^3/s	68.6	P=3.33%
Downstream water level of the corresponding	m		
3.Han Chi Wan intake dam			
Serial number and Items	unit	quantity	Remarks
Designed volume of the largest vent in flood level	m^3/s	78.3	P=10%
Downstream water level of the corresponding	m		
Checked volume of the largest vent in flood level	m^3/s	102	P=3.33%
Downstream water level of the corresponding	m		
4.Power plant			
Downstream Zhang Jia Ya reservoir			
Designed flood level	m	877.03	P=2%
Corresponding flood flow	m^3/s	348	

Checked flood level	m	877.54	P=0.33%
Check corresponding flood flow	m^3/s	456	
□.Project efficiency indicators			
The installed capacity	kw	2,000	
Multi-year average generating capacity	kwh	8,180,000	
Hours in use per year	h	4090	
□.Permanent area	hectare	0.015	
V. The main buildings and equipment			
1.Branch trunk drainage			
The total length of branch one	m	1440	Tunnel 1440 meters
The total length of branch two	m	1220	Tunnel 670 meters , Nullahs 570 meters
2.The main dam			
Type			bottom grating
Foundation lithology			Group under the kiln、Dalong Formation cherts Series
Earthquake basic intensity / security Intensity		□/□	
Top spillway elevation	m	1117.0	
Spillway	m	10	
Non-overflow dam top elevation	m	1120.31	
Maximum height	m	10.31	

Crest length	m	22.2	
3.Intake			
Type			Diversion corridor
Section size（B×H）	m	1.5×1.5	
Inlet sluice floor elevation	m		
Gate type			Plain Iron
Gateway pore size（bh）	m	1.5×1.5	
Designed flow	m^3/s	1.28	
4. Desilting Basin			
Type			Rectangular single-room-style
The length of the basin	m	26	
The width of the basin	m	3	
The water depth of the front basin	m	1.402	
The size of the sand sluice hole（b×h）	m	0.8×1.0	
Sand sluice bottom elevation	m	1114.508	Intake
5.Buried culvert			
Number of Spans		1	Main canal
Overall Length	m	50	
Cross-sectional patterns			Rectangle + semi arch
Cross-sectional size（bh）	m	1.5×2.1	
Designed water depth	m	1.35	
6.Tunneling			Main diversion canal

Number		2	
Whole length	m	2075	300+1775
Longitudinal gradient		1/2100	
Cross-sectional patterns			
Cross-sectional size	m	1.5×1.8	
Bottom width	m	1.5	
Dwall height	m	1.35	
Rise of arch	m	0.45	
Designed flow	m^3/s	1.28	
Designed water depth	m	1.35	
7.Overflow weir			
Number		1	
Whole length	m	6	
Designed flow	m^3/s	1.28	
Designed water depth	m	0.336	
8. Fore bay			
Style			Outdoor type
Foundation litho logy			Xixia Formation Limestone
Size （Length×Width×Depth）	m		Width 3~4m , Depth 4.9m
Elevation of top of the pressure wall	m	1117.000	
Highest water level	m	1116.313	
Normal water level	m	1115.877	
Lowest water level	m	1114.527	
Front chamber floor elevation	m	1112.100	

Influent room floor elevation	m	1111.800	
Relief hole bottom elevation	m	1111.800	
Size of the relief hole Φ	m	0.20	
9.Steel penstocks			
Style			Exposed penstock on slopes
Number of the main penstocks	Bar	1	
The total length	m	358.124	The length of siphons: 6.87m
Inside diameter	m	0.7	
Quantity of branches	Bar	2	
The total length	m	51.766	
Inside diameter	m	0.4	
Maximum water head	m	300	
Type of the bifurcated pipes			The shape
Bifurcation angle	Degrees	45	
10.Workshops			
Style			Ground water diversion-type
Foundation litho logy			Xixia Formation Limestone
Size of the main workshop（length×width）	m	24×10.8	
Installation elevation of	m	879.650	

hydraulic turbine			
11.Switching Station			
Style			Ground open style
Foundation litho logy			Xixia Formation Limestone
Area（length×width）	m	23×13	Ground level 885.000m
12.The main mechanical and electrical equipment			
Turbine Model		CJ_{A237}—W—100/1×10.5	
Quantity		2	
Rated output	kw	1097	
Rated speed	r/min	600	
Draft height	m		
Water height	m	230	
Units rated flow	m^3/s	0.535	
Alternator Model		SF1000-10/1430	
Quantity		2	
Rated capacity	kw	1000	
Rated voltage	kv	6.3	
Rated power factor		0.8	
Rated speed	r/min	600	
Main transformer model		S_9—3150/35	
Quantity		1	

Capacity	kvA	3150	
Voltage ratio		38.5±5%/6.3	
Inlet valves type			Electric manually butterfly valve
Diameter	m	0.4	
最大水头 Maximum water head	m	300	Aquifer hammer pressure
厂内起重机型号 Factory crane models		LD—10	
Span	m	9.5	
Lifting weight	t	10	
13.Electric transmission line			
Voltage	kv	35	
Loop number	Loop	1	
Transmission destination			Niuzhuang 35kv exchange
Transmission distance	km	6	LGJ-150
□.Construction			
1. The quantity of main project			
Open cut earthwork	Million m^3	88.21	
Open cut stonework	Million m^3	144.97	
Hole dug stonework	Million m^3	90.54	
Rock backfill	Million m^3	10.03	
Dry stonework	Million m^3	16.35	
Mortar stonework	Million m^3	26.85	

Concrete	Million m^3	28.34	
Installation of metal structures	t	91.5	
2.Main construction materials			
Lignum	m^3	152	
Cement	t	1320	
Steel reinforcement 钢筋	t	48.6	
Steel products（including steel pipes）	t	91.5	
3.Temporary housing for construction	m^2	1800	
4.Power supply capacity construction	kw	50	
5.Transportation			
Distance from highway	km	90	Distance to the major materials supplier
6.Construction Diversion			
Diversion methods			Full river by-pass diversion with channel diversion
Structure type			Rock fill dam
7.Construction period	Year	1.5	
□.economic indicator			
1.Total static investment	Million RMB	15.4596	
2.输出工程 Project Output	Million RMB	0.75	

3.Total dynamic investment	Million RMB	15.6087	
Construction engineering	Million RMB	4.5415	
Electrical equipment and installation works	Million RMB	4.3397	
Metal structure equipment and installation works	Million RMB	1.2646	
Temporary works	Million RMB	0.2248	
Other expenses	Million RMB	1.4685	
Environment & Water Protection	Million RMB	1.2000	
Compensation	Million RMB	1	
Basic reserve	Million RMB	0.7005	
Reserve price	Million RMB		
Construction period interest	Million RMB	0.1491	
4、Major economic indicators			
KW unit investment	RMB/kw	78.04	
investment per Kilowatt-hour unit	RMB/kw·h	1.9	
Capital pay-off time	Year	9.13	
Loan repayment period	Year	20	

Economic internal rate of return	%	13.16	
Economic net present value	Million RMB	6.79	
Financial internal rate of return	%	12.44	
Financial net present value	Million RMB	6.51	
On-grid prices for electricity	RMB/kw·h	0.36	

Table 2-1 Engineering properties in table □ (Wang Jia River Hydropower Station)

Serial number and Items	unit	quantity	Remarks
□.Hydrology			
1. Drainage area			
Total drainage area	km2	105	Within Wu Feng County
Dam site	km2	68.2	
Factory site	km2	102.2	
2. Hydrological working length in series	Year	42	1961—2002
3.The average annual flow	Billion m3	0.068	
4.Representation of flows			
(1). Representation of flows			

The average flow over the years	m3/s	2．16	
Flood standards in Normal use (designed)	%	2	One case of 50 years
The corresponding peak flow	m3/s	348	
Flood standards for very use (checked)	%	0.33	One case of 300 years
The corresponding peak flow	m3/s	456	
Standards for construction diversion(checked)	%	20	One case of five years
The corresponding flow diversion	m3/s	196	
（3）Wang Jia River Power Station □			
Designed reduced seepage rate	m3/s	4．6	
Flood standards in Normal use (designed)	%	2	One case of 50 years，Just like the dam
The corresponding peak flow	m3/s	298．33	
Standards for construction diversion(checked)	%	0.33	One case of 300 years，Just like the dam
The corresponding flow diversion	m3/s	406．23	
（3）Wang Jia River Power Station □			
Designed reduced seepage rate	m3/s	4．8	

Flood standards in Normal use (designed)	%	3.33	One case of 30years
The corresponding peak flow	m3/s	415	
Flood standards in Normal use (designed)	%	1	One case of 100 years
The corresponding flow diversion	m3/s	515	
5.Sediment			
Mean annual sediment content	kg/m3	0.145	
Mean annual sediment discharge.	Million t	0.01	
□.Reservoir			
1. Reservoir water level			
Checked flood flow	m	877.54	
Designed Flood flow	m	877.03	
Normal water level	m	875.00	
Dead Storage Level	m	851.00	
2. Corresponding reservoir area with normal water level	Km2	0.14	
3.Volume of reservoir			
Total storage capacity	Million m3	3.3725	
Normal storage	Million m3	2.9324	
Active Storage	Million m3	2.4279	
dead storage	Million m3	0.501	

4.Storage coefficient	%	5.7	
5.Regulating Characteristics			Incomplete annual regulation
□. Reservoir discharge flow and corresponding down stream water level			
1. Maximum discharge flow when designed flood level	m3/s	298.33	
Reservoir discharge flow and corresponding down stream water level	m	824.11	
2. Maximum discharge flow when checked flood level	m3/s	406.23	
3.Rugulation flow	m3/s	4.6	
□. Project efficiency indicators			
1. Wang Jia River Power Station □			
Installed Capacity	kW	630	
Firm capacity (P=90%)	kW	264．5	
Mean annual energy output	Million KW.h	2.60	
Annual utilization hours	h	4128	
2.Wang Jia River Power Station □			
Installed Capacity	kW	10000	
Form power(P=90%)	kW	3613．4	
Mean annual energy output	Million	37．643	

	kW.h		
Annual utilization hours	h	3764	
□.Permanent land occupation	Hectare		
□. Reservoir structures and equipment			
1.Dam			
Style			Rock fill dam (geo-membrane + Concrete anti-seepage wall)
Foundation litho logy			Maokou Formation thick limestone
Seismic basic intensity	Degree	□	
Crest elevation	m	878.95	
Crest length	m	136	
Crest width	m	6	
Bottom width	m	189.51	
Upstream slope		1：1.7	840.0 m Under the elevation 1：2.0
Downstream slope		1：1.5	
Thickness of geo-membrane	m m	0.5/0.8	
geo-membrane unit weight	g/m2	300	
Impervious wall thickness	m	0.8	Depth:22 m
Concrete strength grade of Impervious wall			C25W8F100
2.Spillway			
Style			Side weir free flow +

			tunnel
Foundation litho logy			Gufeng formation siliceous + Longtan coal measures + Maokou Formation thick limestone
Weir top elevation	m	875.0	
Overflow width	m	40	
The largest single-wide flow	m3/(s.m)	10.2	
Designed flood discharge flow	m3/s	298.23	
Checked flood discharge flow	m3/s	406.23	
Diameter of spillway tunnel	m	5.0	
Energy dissipating mode			Trajectory energy
3.Generating diversion structures			
Designed diversion flow	m3/s	4.6	Station □
Intake：Style			Slope deep style intake
Foundation litho logy			Moukou Formation foundation limestone
Bottom threshold elevation	m	848.0	
Gate style			Accident maintenance steel gate
Gate size(B×H)	m ×m	1．6×1. 6	
Hoist style			Water gate's hoister
Hoist capacity	KN	250	
Hoist quantity		1	

Hoist platform elevation	m	879.0	
4. Reservoir emptying structure			
Designed maximize flow discharges	m3/s	1.0	
Blow-down pipe: Style			Horauchi steel reinforcement outsourcing concrete
Length	m	250	
Inner diameter	m m	600	
Intake gate:			
Size of gate hole(B×H)	m × m	1．0×1.0	
Inner diameter	m m	600	
Quantity		1	
Hoist: Style			Manually screw hoist
Capacity of the hoist	KN	250	
Quantity of the hoist		1	
Outlet gate: Style			Manual butterfly valve
Size of the hole （width*length）	m * m	1．0*1.0	
Inner diameter	m m	600	
Quantity		1	
□. Wang Jia River hydropower Station □			
1.Diversion structures			
Structure			Reinforced concrete
Diameter of the main pipeline	m m	1500	

Division flow	m3/s	4.6	
Length	m	259	
Lowest water head	m	10.0	
Weighted average head	m	19.35	
Highest water head	m	28.8	
Designed water head	m	19.0	
The greatest calculated water pressure	m	36．05	
Diameter of branch pipes	m m	1000	
Length of branch pipes	m	7．5	
2.Workshops			
Style			Diversion ground open style
Foundation litho logy			Quartemary talus material
The main plant size (length*width*height)	m	30．02×10×15.2	
Installation elevation of hydraulic turbine	m	846.797	
3.The main mechanical and electrical equipment			
Hydraulic turbine:			
Quantity		1	
Type			HL260-WJ-88
Rated output	kW	670	
Rated speed	r/min	375	
Rated flow	m3/s	4.2	

Suction elevation	m	+1.797	
Rater water head	m	19	
Generators:			
Quantity		1	
Type			SFW630-16/1730
Rated power	KW	630	
Rated voltage	KV	6.3	
Rated speed	r/min	1000	
Power factors		0.8	Hysteresis
Station transformer:			
Quantity		1	
Type			S9-50/10
Capacity	KVA	50	
Voltage	kV	6.3/0.4	
Quantity of intake valve &outlet valve:		2	
Type &diameter of the intake valve	m	1000	Electric butterfly valvePN0.6Mpa
Type &diameter of the outlet valve	m	500	Electric butterfly valvePN0.6Mpa
Quantity of speed governor：		1	
Type			YWT - 600
Quantity of hoisting equipment：		1	
Type			LD10 Electric single-girder
Hoisting duty	t	10	

Span	m	8.5	
Maximum lifting height	m	9.0	
□. Wang Jia River hydropower Station □			
1.Water intake			
Style			Headwork check gate
Size（width×length）	m×m	2.0×1.8	Sluice exit
Quantity		2	Check gate、sluice gate
Bottom elevation	m	843.55	
2. Diversion Canal			
（1）Nullah			
Structure			Reinforced Concrete
Foundation characteristics			Quartemary talus
Length	m	400	
Cross dimensions (B×H)	m×m	2.0×1.85	
Longitudinal gradient		1/1000	
Roughness		0.015	
（2）Tunnel			
Structure			City-type openings
Foundation characteristics			Days formation thin limestone + Xiaxi formation limestone +
Length	m	4610	
Wetted cross section (B×H)	m	2.1×2.18	1＃ - 3＃tunnel (4＃、5

Longitudinal gradient		1/1000	
Concrete lining pattern		Bottom board concrete, wetted cross section cement mortar spray Guarding (the intake , outlet and the fracture zone	
Roughness		0.025	
(3)Diversion connection			
Structure		φ250UPVCBuried diversion to	
Foundation characteristics			Maokou Formation
Designed intake flow	m3/s	0.2	
Length	m	20	
Cross dimensions (B×H)	m	2.1×2.7	
Longitudinal gradient		1/1000	
（4）Overflow weir			
Structure			Practical weir 、
Foundation characteristics			Days formation
Maximum design flow	m3/s	4.8	
Length	m	20	
Cross dimensions (B×H)	m	2.1×2.31	
Longitudinal gradient		1/1000	
Weir crest elevation	m	840.72	
Maximum overflow water	m	0.19	
3.Forebay			
Style			Horage open style

Foundation litho logy			Days formation
Size(length×width×height)	m	23.5×7.1×10.	
Normal water level	m	836.95	
Highest water level	m	840.91	
Lowest water level	m	838.32	
Designed gross head	m	261.3	
Designed net water head	m	256.2	
Antechamber bottom elevatio	m	834.40	
Intake central elevation	m	835.72	
Cistern roof elevation	m	841.6	
4.Steel penstock			
Style			Slope exposed pipe +
Quantity of main pipes	Bar	2	
Total length	m	392.826	Double line
Inner diameter	m m	1300	
Maximize calculated water	m	279.85	
5.Power houses			
Style			Diversion ground open style
Foundation litho logy			Days formation thin limestone
Size of main power house(length*width*height)	m	33.02×19.02 ×15.43	
Installation elevation of	m	581.77	

hydraulic turbine			
6、Switch station			
Style			Ground open style
Foundation litho logy			Days formation thin limestone
Area(length ×width)	m	10×4.8	
Ground level	m	585.20	
7.The main mechanical and electrical equipment			
A. Hydraulic turbine			
Quantity	台	2	
Type			HL100-WJ-73
Rated output	kW	2×5000	
Rated speed	r/min	1500	
The permissible draw height	m	2.33	
Rated flow	m3/s	2.31	
Rated water head	m	256.0	
Rated efficiency	%	88.5	
B. Electric generator			
Quantity		2	2
Type			SFW4000-4/1430
Rated power	KW	2×5000	
Rated voltage	KV	6.3	
Rated speed	r/min	1500	
Power factors		0.8	Hysteresis
Main transformer：Type			S9-6300/35
Quantity		2	

Capacity	KVA	6300	
Voltage	kV	35±3×2.5%/6.3	
Station transformer:			
Quantity		2	
Type			SC9-100/10
Capacity	KVA	100	
Inlet valve：Type			Z942-40Electric gate valve
Diameter	m m	DN800	PN4.0MPa
Speed regulator: quantity		2	
Type			YWT - 1000
Crane：Quantity		1	
Type			LD - 16 Single-beam electric crane
Hoisting capacity	t	16	
Span	m	9.5	
Maximum lifting height	m	12.0	
8、Transmission Line			
Voltage	kV	35	
Circuit	Round	1	
Transmission destination		Wu Feng Power Grid	
Transmission distance	km	5.25	
□.Construction			
1.The volume of major projects			

Open-cut earthwork	m3	37137	
Rock excavation	m3	61682	
Hole dug stonework	m3	3694	
Backfilling of earth	m3	222119	
Mortar stonework	m3	5923	
Dry stonework	m3	11099	
Concrete	m3	15048	
Curtain、backfill grouting	m	11498	
Attachment、joint grouting	m2	2313	
Installation of metal structure	t	434	
2.Main construction materials			
Cement	t	7301	
steel reinforcement	t	643	
Steel products (including steel pipes	t	385	
Lignum	m3	390	
Geo-membrane	m2	3084	
3.Temporary housing for construction	m2	1800	
4.Power supply capacity construction	kW	1200	
5.Transportation			
Distance from highway	km	120	
6.Construction Diversion			
Diversion methods		Cofferdam at one time and tunnel diversion	
Structure type		Upstream with earth-rock dam; Downstream steeling rock dam	

7.Construction period	Months	24	
十.economic indicator			
1. Total static investment	Million RMB	103.3708	
2.Project Output	Million RMB	0.63	
3.Total investment	Million RMB	104.7724	
Construction engineering	Million RMB	50.074	
Electrical equipment and installation works	Million RMB	20.05	
Metal structure equipment and installation works	Million RMB	8.2664	
Temporary works	Million RMB	4.615	
Environment & Water Protection	Million RMB	4.19	
Reservoir inundation and other compensation	Million RMB	6	
Other expenses	Million RMB	5.253	
Basic reserve	Million RMB	4.9224	
Basic reserve	Million RMB	0	
Construction period interest rate	Million RMB	0.7716	
4.Major economic indicators			

KW unit investment	RMB/kW	9856	
Investment per Kilowatt-hour unit	RMB /kWh	2．603	
Capital pay-off time	Year	11.11(include construction period)	
Loan repayment period	Year	20	
Economic internal rate of return	%	10.32%	
Economic net present value	Million RMB	21.48	
Financial internal rate of return	%	10.14	
Financial net present value	Million RMB	19.9249	
On-grid prices for electricity	RMB /kW·h	0.36	

2.9 Analysis of project pollution

2.9.1 Major environmental factors and the countermeasures in the project

2.9.1.1 Analysis of the equilibrium of the earth and stone, construction slag and the domestic waste

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

The total volume of the excavated earth and stone is 168,800m3,

Separately from:

Excavating the Chinan hydropower dam, 32,000 m3;

Excavating the dam pivot, 63,300 m3,

Excavating the tunnel, 29,000 m3

Excavating the head race, 5,400m3

Excavating for building the diversion connecting facility and the down flow weir, 1,100m3

Excavating the fore bay, pipeline and the plant, totally 36,900m3

Excavating for building the roads and temporary pavement to the plant, 5,000 m3.

Parts of the excavated earth and stone can be used for dam filling, road paving and anti-dust wall building.

Go to Table2-2 for the equilibrium calculation of the construction slag, earth and stone.

Table2-2 Equilibriums calculation of the construction slag, earth and stone

NO	Project	open	open	hole	Backfil	Real

.	Name		excavation of earth m^3	excavation of stone m^3	excavation of stone m^3	ling of the earth and the stone m^3	volume of the slag m^3
1	rock-fill dam	dam	8870	35480	0	40000	4350
		flood-discharge tunnel	734	9504	6118	14350	2006
		Unloading tunnel	95	561	194	0	850
		hydropower tunnel	131	787	848	105	1661
2	Wangjiahe level-I Hydropower station		11412	0	0	5400	6012
3	head race of level-II Hydropower station		7240	0	28266	26500	9006
4	Fore bay of level-II Hydropower station		280	410	0	142	548
5	Penstock of level-II Hydropower station		2735	1780	1514	0	6029
6	Plant building and booster stations of Wangjiahe level-I Hydropower station		5640	13160	0	4500	14300
7	temporary roads to the plant		5000	0	0	4000	1000
8	Chinan hydropower station		8821	14497	9054	21654	10718
	Total		37137	61682	36940	94997	56480

The results of equilibriums 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 56,500m3, mainly consisted of the remaining stone and waste material. All the slag should be piled up in slag field and properly disposed in time, avoiding the damage of the vegetation on the surface, the soil erosion, so as to maintain the natural landscape. There should set up slag fields concerning the landscape , in the entrance and exit of the tunnel 1# in branch 1, in the exit of the tunnel 2# in Branch 2, barrage , the exit of the tunnel 3# in main channel, the entrance and exit of the tunnel 4# ,and the plant area, for the piling up of the slag. The slag produced by excavating the rock-fill dam of the Wangjiahe hinge project should be collectedly piled along the slope of the open channel 2# in down reach. The slag produced along the channel or tunnel should be piled up, concerning the landscape, separately in the slag fields in tunnel branch 1# and 2#, Wangjiahe ditch and Zhujia ditch, and other places. Slag fields have also stetted in the fore bay of the Level-II hydropower station and the plant areas. Go to attached picture 12 for the setting of the slag and the measures of the erosion and torrent control works.

(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 20 months; the average number of working people per day is about 200.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.

2.9.1.2Analysis of the water supplying and draining and the discharge of

the pollutants during the construction

The total required volume of water for the construction of the hydropower station in Wangjiahe basin is 253,600m3.The total volume of the waste water is 205,600m3, including the waste water from the construction and the domestic sewage.

(1) Construction water, main sources of waste water and pollutants

The total required volume of water for the construction of the project is 229,600m3. The total quantity of wastewater discharge is 186,400m3. The total volume of the waste water is 186,400m3. The waste water mainly comes from the pouring and maintaining of the concrete, flushing of the sand and stone processing system, and the washing of the constructing machines and vehicles. In addition, there will produce massive waste water from the foundation pit, mainly comes from the collection of the precipitation and cofferdam sink water. The peak of the wastewater discharge amounts to about 200m3 / d. Considering the construction can increase the density of the suspended solids, the project intends to build sump hole in the foundation pit. Water will be pumped out when the density of the suspended solids is less than 70mg / L, to reduce the impact of surface water environment.

- **Waste water from the concrete pouring and curing**

The waste water comes from the concrete pouring, curing and cement injection, the density of the suspended solids is relatively high, and the pH value can be as high as 11-12.

- **Washing water of the sand and stone processing system**

The flow of processing the sand and stone is generally as follows: mining → raw material stocking → sieving and screening → semi-finished products stocking → screening field→finished aggregate stocking yard→ yard sand system → refining

sand → mixing → finished sand .

Normally, it will use about 2.7 m3 water to produce 1t concrete aggregate. The water and sediment content calculated by average 8%. In accordance with the principle of material balance, suspended solids concentration in the rinse water is about 2.5 x 104mg/L. In the application of the machining process, due to material surface water evaporation, seepage and water loss caused by such occupied 20% of the water, then the remaining 80% is wastewater; the production quantity is about 190 m^3 / h.

- Flush wastewater from the constructing machines and vehicles

According to the construction organization design, compared with the similar scale hydropower construction project, construction machinery and vehicles in the construction areas are about 30, parking collectively. If it will take 0.6 m^3, water to flush one vehicle, 50% of the constructing machines and vehicles will be washed, 9.0 m^3 oil waste water will be generated. The total volume of wastewater will be 5,400m3 during the whole period of the construction.

The report of project feasibility study did not put forward concrete measures of construction waste water treatment, referring to the conventional treatment countermeasure of the same kind waste water, the suggesting measures evaluation for treating the production water are as follows: the wastewater from the sand and stone processing , which main pollutants in the waste water are SS ,should be treated in horizontal sedimentation tank; concrete curing wastewater ,as 11-12 pH value, should be treated in neutralizing sedimentation tank; oily wastewater, produced by flushing the construction machinery and vehicles ,should be treated in oil separation tank oil pool. After the treatment, wastewater can be discharged accord to the standard. See table 2-3 for the situation of the construction wastewater, main pollutants, and their discharging.

Table 2-3 The situation of the construction wastewater and its main pollutants

NO.	Sources of waste water	Peak volume (m3/d)	Total volume (m3)	Before treatment(m3)	After treatment(m3)
1	From processing the sand and stone	2400	172800(1920)	SS：2.5×104mg/L，48000kg/d	SS：70mg/L，134.4kg/d
2	From pouring and curing the concrete	100	8000(88)	SS：5000mg/L 440kg/d	SS：70mg/L 6.16kg/d
				pH：11-12	pH：6-9
3	From flushing the construction machinery and vehicle	20	5400(9)	petroleum：15mg/L 0.135kg/d	petroleum c：5mg/L 0.045kg/d
				SS：300mg/L 2.7kg/d	SS：70mg/L 0.63kg/d
Total		2520	186200(2017)	/	/

Notes：

The waste water in the foundation pit mainly consisted of the precipitation, cofferdam sink water and so on, is not included in the calculation of the total volume for the construction water. Data in () is the daily average, the density after the treatment is calculated by the standard.

(2) Conditions of domestic water and sewage discharge

Waste water is mainly from domestic sewage produced by the construction personnel. There will be 300 working people per day during the construction rush period and the average number of working people per day is about 200. According to the convention of the domestic water using for the construction personnel, the daily capital water

volume is about 200L, the total volume is about 24,000m3, 80% of which will turn to be sewage and be discharged. If the index of drainage is 160L/d, the maximum daily discharging volume will be 48m3, and the average volume is 32 m^3. Total sewage discharge volume is 19,200m3 during the construction. The main pollutants are COD, SS, and NH3 - N.

Construction areas are located between the barren hills and mountains, far away from the residential and urban areas. Considering the general current level of the construction areas and the regional environmental situation, to build the temporary toilet around the construction site, and set up a simple septic processing tank are in compliance with the local conditions and the request of the technical level.

See table 2-4 for the discharging situation of the sewage and major pollutants.

Table 2-4 The discharging situation of the domestic sewage and the main pollutants

Volume of waste water		pollutants	Before treatment			after treatment		
				Total volume			Discharging volume	
m3/d	Total volume during the whole construction×104m3		density mg/L	kg/d	Total T	density mg/L	kg/d	Total T
32	1.92	COD	400	12.8	7.68	160	5.12	3.072
		BOD5	200	6.4	3.84	80	2.56	1.536
		SS	220	7.04	4.224	66	2.112	1.267
		NH3 - N	15	0.48	0.288	15	0.48	0.288

2.9.1.4 The exhaust sources and pollutants during the construction period

The exhaust sources mainly include: raising dust from the concrete mixing system, dust from the hand breaking of the sand and the stone, exhaust gas caused by the

mining machine and blasting, and coal burning; raising dust caused by transportation and the exhaust gas produced by automobile; dust caused by the cement and pulverized fuel ash transportation; raising dust produced by dredging, etc. Its main pollutants are total suspended particles (TSP), SO2, CO and etc.

According to the construction organization design and analogy estimation, the fuel in the construction area is mainly the fuel oil; the total fuel use in 20 months is about 300t. According to the pollutants coefficient method, see table 2-5 for the sorts and quantity of the major pollutants caused by the construction fuel.

Table 2-5 The sorts and quantity of the major pollutants caused by the construction fuel of the hydropower station in Wangjiahe basin

eigenvalue	oil consumption (t)	the sorts and quantity of the major pollutants caused by the fuel (t)		
		SO_2	NO_2	CO
Dialy average quantity	0.5	0.564	8.59	14.12
Total quantity during the construction	300	338.6	5154	8474

Due to the small scale of project, in addition to the scattering construction site, so source strength disperses .Thereby the construction may cause little impact to the air condition in that area, while it may influence the regional area and the on-site staff . Therefore prevention measures should be taken to reduce the harm.

The impact to the atmosphere by the project is only limited in the construction period, and will disappear automatically when the project is completed.

See attached picture 9 for the flow demonstration of the sand and stone processing

system for the construction of the hydro-junction in Wangjiahe reservoir.

2.9.1.5Equipments and noise

See Table 2-6 for the main construction equipments

Table 2-6 main construction machinery and equipments

category	Name and specifications of equipment	unit	Number
loading	single bucket excavator，electric 3m^3	set	5
	single bucket excavator，oil 1.0m^3	set	5
	shovel loader 1.0m^3	set	2
	Bulldozers 59KW~74KW	set	4
	Bulldozers 88KW	set	4
rolling	Vibration grinding 13~14T	set	1
	Vibration grinding 12 ~ 18T	set	1
	frog ramming machine 2.8 kw	set	2
rock drilling	hand hammer drill	set	15
	air-feed leg drill	set	4
	DTH drill 100	set	3
	DTH drill 150 type	set	2
	Fix soldering equipment	set	1
Drilling and filling	cable drilling toolCZ22	set	2
	Geological drilling rig, hydraulic hand-held 150 type	set	3
	grouting pump, mesolow grout	set	5
	slurry agitator	set	2
	mortar mixer	set	5
aggregate processing	jaw crusher 600×900mm	set	1
	cone crusherφ1650mm	set	1
	cone crusherφ1750mm	set	1

	globe millφ2150mm×3600mm	set	1
	sand washer, single-screwφ1200mm	set	1
	spiral classifierφ1200mm	set	2
	heavy-duty vibration sieve 1500×3000	set	1
	heavy-duty vibration sieve 1750×3500	set	1
	disk feederDB-1600	set	2
	Trough feeder K3-500t/h	set	1
	electromagnetic feeder 45DA	set	1
Concrete construction	Concrete Mixing Plant （2×1.0）	set	2
	stirring mill, discharge port ,0.8m3	set	2
	agitating lorry, volume,3.0m3	set	2
	delivery (transfer) pump 30m3/h	set	2
	shot Crete machine 75L	set	5
	poker vibrator 2.2kw	set	1
	hoist bucket, volume,0.25~1.0m3	set	1
	Wind（sand）squirt gun, air consumption 2~6m3/min	set	3
	Hydraulic slip form equipment	set	2
transportation	camion ,Gasoline type	set	5
	5t	set	15
	Autodumper, diesel fuel 10~12t	set	15
	Auto dumper, diesel fuel 15~18t	set	4
	tractor 59KW	set	4
	tractor 74KW	set	50
	Plastic core-rubber-tires rack truck	set	10
	mobile sealing-tape machine 500mm	Set	1
	Spiral air pump 65t/h	set	
Other machinery	windlass 5t	set	2
	centrifugal water pump 14KW	set	3

	Centrifugal water	set	1
	pump, single stage, biabsorption 20LW	set	2
	propeller fan 14KW	set	2
	propeller fan 37KW	set	2
	welding machine		

From table 2-6 and other major construction units**, w**e can see that the major construction noise comes from the machinery for earth and stone (such as DTH drill, excavator, loader, etc.), and concrete casting equipments (such as, crawler cranes, concrete pump , hoist bucket, etc.), concrete drilling and filling equipment, concrete producing equipment (crusher, screening and washing machine, and concrete mixing station), and the auxiliary processing equipments(carpentry, machine maintenance ,air compressor, water pump, transformer, etc) and other 200sets of equipment. According to the characteristics of mechanical equipment operation, the source of the noise can be categorized as fixed source and flow source.

According to the measured value and **empirical estimation of the** noise produced by the similar construction machinery and equipment operation, see table 2-7 for the main source strength of the project.

Table 2-7 Tables for the main noise sources and noise level

Type of the source	Name of the machine	equivalent sound level dB（A）
Fixed source	grab、shovel loader、stirring mill、grouter, etc	95-100
Flow source	camion、bulldozer	85-95
noise of blasting	blasting	130

For the construction area lies in valley, the diffusion of noise is blocked by the surrounding mountains; therefore the noise mainly influences its vicinity. During the

construction period, certain influence will be exerted on the builders; Mountain tunnel digging, blasting and so forth will disturb the quietness and agitate the wild animal, but only during the construction period.

2.9.2 Inundation period **of the reservoir**

The reservoirs and hydropower station in WangGuHe basin covering scope only involves a NiuZhuang township in Wufeng Tujia people autonomous county. As the project site is mainly located in deep valley, the main types of the occupied and flooded land are economic forest and barren hills; the physical indicators of the flooded covering mainly are cultivated land and forests. According to the document of the design project, the occupied area of farmland is 35 mu, of forest is 220 mu. According to the survey, the reservoir range does not involve immigrants, minerals and cultural relics, etc.

According to the regulation of ***water conservancy and hydropower project reservoir processing design specification*** (SD130-84), submerged processing design criteria for the project area: the standard for the requisition covered mountain is the normal storage level. The submerged scope is determined by the stated water level. The owners are responsible for researching and providing the object index.

Reservoir impounding flooded parts of vegetation, causing the changes of plant biomass; the expanded habitat area for aquatic creatures caused the change of types and distribution of aquatic organisms and fish resources; Reservoir impounding caused the loss of the wildlife habitat. During the early period of reservoir impounding, the submerged soil and vegetation release the nutrients to the water by organic decomposition, which may cause problems to water environment. In addition, there may emerge landslides, leakage and other environmental and geological problems during the process of reservoir impounding.

Overall, the impacts of reservoir impounding are mainly on terrestrial plants,

terrestrial animals, land use means, water environment, and environmental geological and other environmental factors.

2.9.3 Project operation period

The operation of the project is the process of water storage, electricity generation, and draining. There is no discharge of waste water and other pollutants caused by the project itself. However, after the completion of the project, the reservoir operation and dam blocking will bring some irreversible environmental impact.

After the initial impoundment of the reservoir, the water level may rise, the flow may be retarded, sediment deposits in the storehouse. Environmental factors such as temperature are different from the natural state. Such changes make the natural waters above the dam site of the Wangjiahe hydropower in the middle level of Wangjiahe river turn out to be artificial lakes, bringing changes to water level, water flow, and sediment and other water regime**.** Due to the sluggish reservoir velocity, self-purification of water may abate, and cause deterioration of water quality .At the same time, the reservoir impounding will change the connectedness of river downstream in some parts of the dam, greatly influencing the habitat environment of aquatic organisms. Meanwhile, due to the operation of reservoir, there may form some falling zones, which may bring certain influence to the ecological environment of the falling areas.

3. Current Situation of Environment

3.1 General Situation of Natural Environment

3.1.1 Natural Conditions

Wangjiahe river basin is in the upper reach of Suohe River on the right bank of Qingjiang River under the jurisdiction of Niuzhuangxiang in Wufeng Tujia Autonomous County, stretching from 110°15′to 110 °28′East of longtitude and from 30°10′ to 30°18′North of latitude. The river basin originates from Piantaiya at an altitude of 2082m and goes through Yushulin and Sunjiawan, taking on the shape of river in Guanbao. Laolonggou, the part above Guanbao, gets supply from Yanjiagou and Kanglinxi which are to the north of Laolonggou. Yanjiagou originates from Tudiling at an altitude of 1972m and enters the main stream at an altitude of 980m through Dayangpo and Chi-nan; Kanglinxi originates from Songshuyou at an altitude of 1927.5m and enters the main stream at an altitude of 918m through Anshuitang and Zhaojiawan. The main stream enters Qingjiang in Hefeng County at the point of Zhangjiaya. The river basin covers an area of 105.6km^2 in Wufeng Tujia Autonomous County.

The watersheds of eastern side, southern side and northern side of Wangjiahe river basin are all above 1900m. As for the river section in Wufeng Tujia Autonomous County, it comes to its lowest point at Zhangjiaya. At an altitude of 560m, the river basin is high in the east and low in the west, with an E-W elevation of 1700m. The longitudinal slope of watercourse is relatively large, coming to the largest in the upper reach with 242‰ while becoming relatively small in the lower reach with 46.5‰ hydraulic slope. The average hydraulic slope is 68.9‰, thus providing superior natural conditions for the construction of hydroelectric station. Chi-nan Power Station is located in the upper reach of Wangjiahe River with a catchment area of 33.8 km^2 in the dam site. Wangjiahe Reservoir Dam and Wangjiahe I Hydroelectric

Power Station are located in the middle and lower reaches of Wangjiahe with a water capacity of 68.2 $km^{2\ in}$ the dam site. Wangjiahe II Power Station is located in the lower reach of Wangjiahe with a water capacity of 102.2 $km^{2\ in}$ the dam site.

3.1.2 Meteorological Characteristics

Wangjiahe river basin is in the mountainous area in the southeast of Hubei Province, experiencing subtropical monsoon climate. It enjoys distinctive seasons with muggy rainy summer and cold foggy winter. Climate here is apparently controlled and influenced by the geographical position, featuring characteristics of vertical zoning to a certain extent. There's no weather station in the river basin. However, Wufeng Weather Station is nearby. Thus its characteristic values of meteorology can serve as a reference for the design of project in Wangjiahe river basin. As for specifics, please refer to figure 3-1.

Figure 3-1 Table of relevant characteristic value of meteorology from Wufeng weather station

Number	Items	Unit	Figure
1	Annual average temperature	℃	13.5
2	Extreme maximum temperature	℃	37.1
3	Extreme minimum temperature	□	-15
4	Annual average absolute humidity	pa	1270
5	Annual average relative humidity	%	76
6	Annual average wind speed	m/s	1.3
7	Maximum wind speed	m/s	15
8	Prevailing wind direction		ESE、SE
9	Annual average hours of sunshine	h	1533
10	Annual average nonfrost period	d	247

3.1.3 General Situation of Regional Geology

3.1.3.1 Regional Tectonic Stability

The project area of the reservoir power station of Wangjiahe river basin is located in the compound position of E-W tectonic zone of Yangtze River and NNE Neocathaysian tectonic zone. In the periphery of project area develop Xiannvshan fracture, Yuyangguan fracture, Xianfeng fracture, Laifeng fracture and Tianyangping fracture, etc. most of which are compresso-shear fractures accompanied by folds. These fractures mainly took shape in the Yanshan Movement and their activities were relatively weak in the later stage. Moreover, even the part of fracture closest to the project area is still over 30km away from it, indicating that these fractures exert negligible influence on the project. Therefore, the project area is relatively stable from the perspective of geology.

3.1.3.2 Earthquake

There have been 57 earthquakes of Ms≥4.7 in area which is within 200m from the project site since the historical records began, according to relevant seismic data from State Seismology Bureau and Hubei Province and investigation data of Maduhe Hydroelectric Station from Qingjiang geological team of Yangtze River Water Commission. Influence intensity of these earthquakes is lower than Grade VI. There has never been an earthquake greater than Ms 3.0 in the near-project region, and most earthquakes are of low frequency and intensity. The basic intensity can be determined as Grade VI according to the earthquake intensity of Maduhe Hydroelectric Station project site and the ***Seismic Intensity Zoning Map of China***. Therefore, the design of protective measures in Wangjiahe cascade development project can refer to Grade VI.

3.2.3.3 Formation Lithology

There are many outcropped strata in the project site of reservoir power station in Wangjiahe river basin. In a sequence from old to new, they are:

(1) Shamao Formation of lower-middle Silurian system ($S_{1\text{-}2}s$): It is made up of yellowgreen shale, argillaceous siltites, and argillaceous siltite mixed with sandstone or mixed with fuchsia packsand. The total thickness is around 590m with 160m-thick outcrop in the area.

(2) Middle-upper Devonian system ($D_{2\text{-}3)}$: It contains thick quartz sandstone or quartz sandstone in blocks of Yuntaiguan Formation ($D_{2\text{-}3}y$), yellowgreen shale of Huangjiadeng Formation (D_3h), chiltern shale, limestone of Xiejingshi Formation (D_3C_1x) and sand-shale. The outcrop is 150m thick.

(3) Carbonic system (C): It contains grey-cinereous bioconstructed limestone of medium-thick layer, yellowgreen-**dove color** siltite with granule quartz sandstone of Gaolishan Formation (C_1g), and dolostone in blocks of Dapu Formation (C_2d) and bioconstructed fragmental limestone of Huanglong Formation (C_2h). It is about 80m thick.

(4) Lower Permian system (P_1): It comprises mudstone of Liangshan Formation, carbonaceous shale of Qixia Formation mixed with three layers of inferior coal, thick-bedded bioconstructed fragmental limestone which contains flint nodule and is mixed with siliceous, mudstone, coal and nodular limestone in charcoal grey, medium-thick-bedded bioconstructed fragmental limestone of Maokou Formation (P_1m) containing a little flint nodule in lightgrey to charcoal grey, and black ultra-thin-bedded siliceous of Tonggufeng Formation (P_1g). It is 330m thick.

(5) Upper Permian system (P_2): It contains mudstone of Longtan Formation (P_2l), shale mixed with coal bed, zebra limestone of Xiayao Formation (P_2x) comprising flint, carbonaceous shale mixed with marlite of Dalong Formation or microcrystalline

limestone phacoid. It is about 90m thick.

(6) Daye Formation of lower Triassic system (T_1d): It is mainly made up of lightgrey thin-bedded limestone. In the lower part is limestone which contains some pelite and yellowgreen shale. In the middle and upper part is medium-thick-bedded and thick-bedded limestone. And in this part oolitic limestone, dolomitic limestone and dolomitized limestone can be found now and then. The total thickness exceeds 800m.

3.2.3.4 Geological Structure

(1) Fold Structure

□ Jinshanping anticline

Jinshanping anticline is on SW-NE direction on the whole, with its axis going through Xiangguoshu, Sunjiawan, Jinshan Power Station, Jinshanping, and Xujiawan. The strike of axis is N60~70°E and the overall axial plane is approximately vertical. There is no bending deformation. In the survey area, the outcrop length of Jinshan anticline is about 5km while the relatively gentle part at the top is about 1.2km wide. The core stratum of anticline is made up of siltite of Shamao Formation of lower-middle Silurian system ($S_{1\text{-}2}S$) and Devonian (D) quartz sandstone stratum. In the two wings are carbonic fragmental limestone and limestone of Daye Formation of Permian system.

□ Chi-nan syncline

With a total length of 6.5km in the survey area, the axis is distributed on the line of Yanlongwan, Niuzuibajian, and Middle School-Zhoujiaping. The bottom of syncline and center rock, about 2.0km wide, is flat and gentle. The core stratum of syncline is comprised by Daye Formation (T_1d) of lower Triassic system; on the two wings of thin-bedded limestone is made up of Qixia Formation limestone (P_1q) of lower

Permian system. It is worth noticing that thin-bedded limestone of Chi-nan syncline provides condition for water catchment, which is utilizable.

□ Santaiping anticline

Santaiping anticline lies to the south of Chi-nan syncline. Its axis is distributed on the line of Dengzhanwo, Santaiping, and Sunjialing. The strike of axial plane is N65°E, dipping towards S25°E with an angle around 70°. In the anticline area, the outcrop is about 3.0km long and 1.5km wide, with unsymmetrical wings. The occurrence of south wing is generally 225°□37° in a relatively gentle shape; the representative occurrence of section in north wing close to core part is 330°□70° in a relatively steep shape. Thus it presents characteristics of a box-shaped anticline.

(2) Faults

Major faults of survey area mainly develop in the anticline-syncline interface zone and wings of anticlines. Generally, faults can be seen on the edges and junctions of river valleys. Please refer to geological investigation report for main fault characteristics and its influence on this project.

(3) Fractures

The difference of the direction and scale of fracture development stems from the difference in tectonic position and lithology. Most sections have two groups of fractures alongside with layer fractures, but a few have three or four groups of fractures. Fractures developing in thick-bedded limestone are relatively long, some of which extend to as long as tens of meters. However, due to the limit of layer cutting, fractures which develop in thin-bedded limestone have a large density and a relatively short length, thus forming rock masses in cloddy pulverescent shape.

3.2.3.5 Hydrogeological Conditions

(1) Division of aquifers

Aquifers in the area can be divided into karst cave fissure aquifer, fissure aquifer and pore aquifer.

(2) Migration law of groundwater

The general generation rule and migration law of groundwater in this region are: after receiving supply from atmospheric precipitation, the surface aquifers first change into fissure water or pore water; part of the pore water can supply fissure water of bedrock. Under special geomorphy or certain tectonic conditions, some fissure water of bedrock supplies pore water. However, under most conditions, it's the pore water that supplies fissure water. The pore water and fissure water will turn into karst water when entering the feeding zone, and then flows to the ultimate base level of karst erosion. Finally, it will flow into the surface and change into surface runoff.

According to the data of spring outcrop, we can conclude that: firstly, the watertight rock masses of this region increase from lower reach to upper reach, which is favorable for the formation of reservoir; secondly, many high springs with large flow (which are above 10l/s**)** crop out in this region, indicating that the river valley is of supplying type which is favorable for the forming of reservoir; thirdly, the development of three large springs, W3, W9 and W12, in core part of Chinan syncline provides a good condition for water catchment.

3.1.4 Engineering Geologic Condition of Reservoir Area

(1) Topography and geomorphy

Terraces develop on the left bank. The part below the edge of 870m terrace presents a steep slope with an angle of 40~50°on the whole while the part above through which is formed after local erosion, is a slope body with a 35~45° angle. The right bank is a bedrock slope dipping towards left with a 45° angle. In the reservoir end is

a high overbank and neat bench-shape terrace. Its trailing edge is bedrock covered with eluvium of shallow slope. The sloping surface is of medium-steep with a 25~35° angle. The reservoir area is about 1.2km with the riverbed of 3.0% sloping. The reservoir head is 40m wide while the reservoir end is 40-80m wide.

(2) Formation lithology

In a sequence from old to new, the outcropped strata below 1,000m elevation in the reservoir area are: Qixia Formation, Maokou Formation, Gufeng Formation, Longtan Formation, Xiayao Formation, Dalong Formation, Daye Formation and Quaternary system. As the reservoir area is relatively small, the strata of it and dam area are basically in conformity. As for details, please refer to the description of strata in the dam area.

(3) Geological structure

Reservoir area is located in the transitional zone which belongs to the wing part of two tectonic zones between Chinan syncline and Jinshanping anticline. The area presents characteristics of a monocline on the whole. On the right bank is the occurrence of steep bedrock. It inclines towards 170~182° with a dip angle of 43-47°. Far away from reservoir bank, the bedrock of left bank has changed slightly in the occurrence, inclining towards 170-182° with a 23-33°dip angle. According to the analysis, there is no fault zone in the reservoir dam area.

(4) Hydrogeological Conditions

The left bank cuts wing part of Chinan syncline longitudinally. The left-oblique deep bedrock is of unfavorable water retaining structure. The left bank of reservoir is mainly made up of terrace deposit with a certain degree of permeability. The analysis result shows that the surface water of left bank recharges reservoir in the form of confined water through two permeable petrofabrics which are above and below the aquifer respectively. The right bank is located in the wing of Jinshanping

anticline. Though the traditional permeable rockmasses are well-developed on the right bank of reservoir, they are still blocked by watertight rockmasses in the core part of Jinshanping anticline. The surface runoff and groundwater below surface watershed on right bank all discharge into Wangjiahe. Thus the right bank provides the basic forming condition for reservoir. To sum up, the reservoir dam area is of supplying type.

3.1.5 Engineering Geologic Condition of Reservoir Dam Site

3.1.5.1 Topography and Geomorphy

The recommended dam site is at Jinkouzi of Jinshanping Village, which presents the geomorphy of tectonic eroded canyon. In the dam site, the river valley strikes approximately NE80° in the upper reach and NW280° in the lower reach. The river flows from east to west. The dam site sticks out towards north slightly while the point 100m to the upper reach sticks out towards south a bit. The riverbed width of river section in dam site is 20~28m. However, the width rises above 40m and increases to 50~120m during the section from upper reach to the reservoir end. The average sloping from reservoir end of riverbed to lower dam is 3%. Though the sloping is relatively large, it is still a rare storage place of hydroenergy compared to the 6.89% average sloping of the whole river basin. The riverbed elevation of recommended dam site is 826~828m and 828~880m in the reservoir.

3.1.5.2 Formation Lithology

In the order from the old to new, the lithology of major strata distributed in the dam site are:

(1) First section P_{1q}^{1} of Qixia Formation: cinereous thick-bedded carbonaceous limestone mixed with coal bed; it is 36.3m thick.

(2) Second section P_{1q}^{2} of Qixia Formation: charcoal grey asphaltine mixed with thin-bedded carbonaceous limestone, and cinereous asphatene medium-thick-bedded microcrystalline limestone; it is 53m thick.

(3) Third section of Qixia Formation: thick-bedded microcrystalline bioconstructed limestone mixed with two beds of stone coal, shale, nodular limestone; it is 66m thick.

(4) Fourth section of Qixia Formation: cinereous thick-bedded microcrystalline limestone containing flint nodule; it is 37m thick.

(5) First section P_{1m}^{1} of Maokou Formation: reddish-light grey microcrystalline limestone in blocks which contains dolomitic blocks masses and dolomitic bands; it is 14.3 thick.

(6) Second section P_{1m}^{2} of Maokou Formation: light grey-gunmetal medium-thick-bedded limestone in blocks which contains flint block masses; it is 8.0m thick.

(7) Third section P_{1m}^{3} of Maokou Formation: charcoal grey thick-bedded microcrystalline bioconstructed limestone which contains flint blocks masses and is mixed with carbonaceous limestone and silicalite; it is 24.1m thick.

(8) Fourth section P_{1m}^{4} of Maokou Formation: reddish-light grey medium-thick-bedded and thick-bedded microcrystalline limestone; development of pure karst cave K10; it is 37.3m thick.

(9) Fifth section P_{1m}^{5} of Maokou Formation: charcoal grey thick-bedded microcrystalline bioconstructed limestone which contains flint blocks masses and is mixed with carbonaceous limestone and a little silicalite; it is 27.2m thick.

(10) Gufeng Formation P_{1g}: pinkish-cinereous and lark ultra-thin-bedded silicalite; it is 36m thick.

(11) Longtan Formation P_{2l}: charcoal grey and tan lutaceous shale and siltite interbed; it is 43m thick.

(12) Xiayao Formation P_{2x}: charcoal grey-black thin-medium thick-bedded limestone containing flint bands and blocks masses; it is 42m.

(13) Dalong Formation P_{2d}: grey purple and cinereous silicalite, and cinereous calcareous shale; it is 20m thick.

(14) Daye Formation T_{1d}: light grey thin-bedded argillaceous limestone and yellowgreen ultra-thin-bedded clay shale interbed; several hundred meters thick in total.

3.1.5.3 Geological Structure

Dam area is located in the wing of Jishanping anticline tectonic zone presenting the characteristics of a monocline. On the right bank is the occurrence of steep bedrock. It inclines towards 170~183° with a dip angle of 43-48°. The bedrock of left bank has changed slightly in the occurrence, inclining towards 170-180° with a 33-36°dip angle. According to the regional geological map, F9 should be a section where there is a regional fault striking NE direction and which goes to downstream through dam area. From field investigation and analysis of borehole data, it is clear that the NE regional fault should be en-echelon. As there is no trace of fault zone on the mountain massif of bedrock on right bank or in the seven boreholes in the dam area, it is safe to say that there is no fault zone in the dam area. The result of analysis demonstrates that two main groups develop in the dam area. One strikes 347°,

inclining towards NE with a 70°dip angle. The group, which is 20~30m long, is distributed at 880~910m elevation on the right bank with a 5~10m spacing. The second group strikes 75°, inclining towards NW with a 58°dip angle. The group is 5-20m long with 5-20m spacing. Most fissures are tight with bad connectivity.

3.1.5.4 Hydrogeological Conditions

The right bank, mainly made up of thick-bedded limestone of Qixia Formation and Maokou Formation, is a traditional permeable layer. According to analysis, right bank has a better water-resisting condition. Firstly, these two permeable petrofabrics are not completely permeable layers; the mixed rock masses have a relatively high capacity of water insulation. For example, Qixia Formation P_{3q}^{3-2}, P_{3q}^{3-3}, and P_{4q}^{4-1}. Secondly, thick-bedded carbonate rock would be able to conduct water only when there's development of fissures which have water flowing meaning. However, the fissures do not develop in the dam area and are of bad connectivity. Thirdly, according to the observation of upstream and downstream gullies and spring in the dam site area, the appearance height of runoff on right abutment is above 1,000m. There's no water interception around the whole year, providing a macro-condition for water insulation. The longitudinal river valley is unfavorable water retaining structure. The permeability rate of rock masses below 780m elevation of upper dam is less than 3Lu and the permeability rate of most boreholes declines as the depth increases. Therefore the bedrock below 3Lu line in the two sites can serve as reliable aquifer of dam foundation. The shallow part of left abutment is made up of coal measure strata and ultra-thin-bedded silicalite, providing good condition for water resistance. It is out of question for deep karst which is caused by concentrated erosion on impervious boundary to arise in the left abutment.

Please refer to Attachment 10 for the engineering geological condition of dam site and I power station.

Engineering geological condition of II power station is in Attachment 11.

3.1.6 Sediments

Vegetation above dam site of Wangjiahe Reservoir is in a relatively good condition. The earth there is mainly carbonate yellow earth mixed with a little limestone soil. As there's no actually measured data for the sediment discharge rate of suspension load in Wangjiahe river basin, the sediment transport modulus from neighboring Yuyangguan Hydrometrical Station is used to calculate its storage capacity for sedimentation. According to the annual average sediment transport modulus from Yuyangguan station which is 145t/km^2, the annual average sediment discharge is more than 10 thousand tons and annual average sediment concentration 0.145kg/m$^{3.}$ The elevation of deposition upstream to the dam is 847.5m.

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, with a soil type of relatively extensive distribution in the tour site, is distributed above yellow brown earth. Mountain meadow soil is distributed on the local gentle slopes at the mountain top in the tour site. 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/needleleaf

forest, such as the pine, cypress, taxodium, and oak.

3.1.8 Terrestrial plants

Wufeng Tujia Autonomous County locates in the west of Hubei Province. Situated in the medium latitude, this place enjoys sub-tropical humid monsoon climate. Plant resources are abundant here. Spermophyte plants in these areas cover 126 families, 132 genera and 1025 species, including five families, seven genera and 10 species of gymnosperm; 121 families, 425 genera and 1015 species of angiosperm. They account for 63.00% of total families, 31.88% of total genera and 17.85% of total species of spermophyte plants in Hubei Province respectively. Details can be seen in the table 3-2 below:

Table 3-2 Spermophyte Plants in These Regions

Item	gymnosperm			angiosperm			Total		
	family	genus	species	family	genus	species	family	genus	species
Construction area	5	7	10	121	425	1015	126	432	1025
Hubei Province	9	31	100	191	1324	5550	200	1355	5741
China	10	34	238	291	2940	25000	301	2974	25291
Percentage in Hubei %	55.56	22.58	10.00	63.35	32.10	18.29	63.00	31.88	17.85
Percentage in China	50.00	20.59	4.20	41.58	14.46	4.06	41.86	14.53	4.05

Within the total 126 families of spermophyte plants, 103 families contain one to four genera, taking up 81.75% of the total. These families, including Taxaceae and Eucommiaceae, are of great significance to the assessment of the spermophyte flora in these regions. Fifteen families, such as Araceae, Araliaceae, berberidaceae, etc., contain 5-10 genera, taking up 11.90% of the total. Eight families contain more than

10 genera, accounting for 6.35% of the total. There are large families in the world, such as Compositae, Gramineae, as well as families of medium size, including Labiatae, Papilionaceae, Orchidaceae, etc. These families are small in total numbers but contain abundant genera and species. Thus they are an important source for the species diversity of flora in these regions.

3.1.9 Terrestrial animal resources

Investigation on terrestrial vertebrate animals in Wufeng County, Hubei Province has been conducted through field investigation, interview and literature research. According to the result, there are 109 species of terrestrial vertebrate animals (excluding the ones unfound for years). They belong to four classes, 23 orders and 56 families. Among them, 29 species out of seven orders and 17 families are mammalian; 54 species out of 11 orders and 27 families are aves. There are also 16 species of reptile in 3 orders, 7 families and 10 species of amphibia in two orders and five families. Details can be seen in Table 2-3.

Table 3-3 Terrestrial Animal Resources in These Regions

Categories (classes)	Num. of orders	Num. of families	Num. of species	Protection level					
				at national level				At provincial level	
				Grade I	%	Grade II	%	Provincial level	%
Amphibia	2	5	10	0	0	0	0	7	70.00
Reptile	3	7	16	0	0	0	0	5	31.25
Aves	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 Number of species

A numerical grading system has been adopted to demonstrate the abundance of

various animal species. According to the survey, there are 109 terrestrial vertebrate species in these regions. Thus it is far from population counting of one single species in these regions. As it is impossible to apply formulas and calculate the population of species groups one by one, a numerical grading system has been adopted on the basis on survey result to demonstrate the abundance of different species.

Numerical grading: If one animal species whose population per unit area takes up more than 10% of the total under the survey, it will be regarded as endemic dominant species, mark it with a sign "+++". While endemic common species, marked by "++", take up 1% to 10% of the total. Endemic rare species, marked by "+", take up 1% or lower of the total.

Table 3-4 Standard of Numerical Grading System

Status of the species groups	Signs	Standard
Endemic Dominant Species	+ + +	Its population per unit area takes up more than 10% of the total number of animals under the survey.
Endemic Common Species	+ +	The percentage of its population per unit area is between 1% and 10% of the total number of animals under the survey.
Endemic Rare Species	+	The percentage of its population per unit area is lower than 1% of the total, or there is only one animal living in these regions.

According to the survey, there are nine dominant species in these regions. They are Rana limnocharis, Pelophylax nigromaculata, Zaocys dhumnades, Cyclophiops major, Phasianus colchicus, Cettia fortipes, Lepus sinensis, Mustela sibirica and Sus scfofa, etc. Endemic common species amounts to 19 in total. They are: Euphlyctis limnocharis, Rana spinosa, Japalura flaviceps, Eumeces chinensis fomosensis, Elaphe mandarinus, Elaphe rufodorsata, Bambusicola thoracica , Streptopelia chinensis , Hirundo daurica, Motacilla alba, Spizxos s.semitorques, Phylloscopus inornatus, Parus major, Melophus lathami, Rattus flavipectus, R..Novegicus, Trogopterus xanthipes, Arctonyx collaris and Muntiacus reevesi. With a total of 81 species, the rest

species are endemic rare ones.

3.1.9.2 Features of distribution

(1) **Horizontal distribution**

① Fauna living in the water areas and their riparian zones

a. Fauna living and reproducing in the water. All species of endemic Amphibia Urodela animals live their whole lives in water. Although they will not die if they leave water for a while, these animals always stay in the water and rarely get to the land.

b. Fauna reproducing in water, but living both in water and on land. All species of endemic Amphibia Anura animals, in other words, all ranid species, have to reproduce in water. Although they could get off the water to prey, they are not able to get far away from the water environment due to their limitations of their physical structure, which is not fully adaptive to the terrestrial environment. They have to get back to the water from time to time, absorbing water through their skin to make up for the moisture lost on land.

c. Fauna moving around and preying in water. Aves of Ciconiiformes, Gruiformes, and Charadriiformes are waders (shorebirds). They wade through shallow waters or irrigated farmlands to pick out aquatic animals, such as fish and shrimps. Only a few waders are spotted in field investigations, which may be attributed to the relatively small water areas.

d. Fauna preying in water. Most Coraciiformes species prey in water. They stand on the branches near the water, and catch fish or shrimps when flying over them. In addition, some Oscines of Passeriformes species also stand by the water and prey upon fish or shrimps when flitting above.

② **Fauna living in the forests**

Animals live in the forests of these regions include: aves whose nests are in the forests, mammals and some reptiles. These faunas are numerous in species and large in population, making up the main body of the endemic faunas. They mainly move around and prey in forests and in shrubs within or beside the forests as well as on prata. They form the complicated food web together with other animals and plants.

The diversity of the forest fauna is an important parameter of ecological balance. Besides, forest animals are of close relationship with human beings for the various economic functions that they could provide for human beings. Aves in forests and lizards and serpentry of Replita are important natural enemies of injurious insects and rodents on farmland and in forestland. Thus, forest animals are valuable animal resources of the regions.

 Faunas closely related to economic cultivation regions of human beings

Rodentia animals are the largest group of mammalian in terms of both the species and the number. There are 12 species in total, taking up 46.15% of total mammalian. They are important accompanying animals for human beings as well. The habitat and living environment of Muridae and Cricetidae species, to a large extend, overlap with our economic cultivation areas. Some species are able to live both in domestic and wild environment. They can change their habitat in line with the alternation of the four seasons. Taking R. novegicus and Rattus flavipectus for example, they move to the domestic environment when the food outside are sparse in winter, while come back to the wildness in the next spring when the weather becomes warmer and food is sufficient. Some species may cause great damage to agriculture and forestry. For instance, Rattus flavipectus, R. novegicus, and Hystrix hodgsoni (Porcupine) may feed on large amounts of crops, such as rice, cereal, maize and Ipomoea batatas. They may also store plenty of potatoes and herbs in their burrows for winter. Some species of Muridae family are the sources of many natural focal infections. What's more, some species of Passeriformes are also important companions of human beings.

They live and prey in the residential areas, kill injurious insects and refine our environment.

(2) Vertical distribution

□Vertical distribution of poikilothermal animals

Amphibian and Reptile are poikilothermal animals, relying on temperatures of the surroundings to adjust their own. Thus, most of them prefer to live in low altitude, where the weather is much warmer.

Among the amphibian in these regions, Pelophylax nigromaculata, Rana limnocharis and Bufo gargarizans are cosmopolitan species. Species from Microhylidae mainly distribute on water regions in medium-altitude hills. Euphlyctis limnocharis and Rana Margaratae are usually found in high-altitude areas.

Most Reptile distribute on hills of medium altitude. Among them, Elaphe mandarinus, Elaphe bimaculata, Elaphe taeniura, Zaocys dhumnades, etc. are cosmopolitan species, which can be found in a wide range of altitude.

□ 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 vegetation. That's because the forest community has good food net 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 are rare or near Extinction

There are 52 species of protected animals among regional vertebrates. Among them, there are ten species of wildlife under the second class of 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), Purcrasia 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 provincial protection, making up 39.62% of the total species. Among them, there are 7 species of amphibians: Bufo gargarizans, Paa boulengeri, Paa spinosa, Euphlyctis limnocharis, Pelophylax nigromaculatus, Pelophylax plancyi, Microhyla ornate. Five species of reptiles also belong to the wildlife under special province protection: Green Japalure, Elaphe mandarinus, Elaphe carinata, Elaphe taeniura, and Zoacys dhumnades. Nineteen species of birds are included in the conservation list: Bambusicola thoracicus, Phasianus colchicus, Streptopelia chinensis, Cuculus micropterus, Cuculus canorus, Upupa epops, Picus canus, Hirundo rustica, Hirundo daurica, Lanius schach, Oriolus chinensis, Dicrurus hottentottus, Garrulus glandarius brandtii, Urocissa erythrorhyncha, Cyanopica cyana, Pica pica, Melodious Laughingthrush, Parus major, and Melophus lathami Crested Bunting. Eleven species of mammals are also in the list: Lepus sinensis, Trogopterus xanthipes, Petaurista alborufus, Callosciurus

erythraeus, Hystrix brachyura, Nyctereutes procyonoides, Meles meles, Arctonyx collaris, Paguma larvata, Prionailurus bengalensis and Elaphodus cephalophus.

Affected by the exploitation and development of wildlife resource for 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 greatly affected.

3.2 Current Situation of Soil Erosion and Water loss and Conservation of Soil and Water

3.2.1 Current Situation of Soil Erosion and Water Loss

The test result of remote sensing technology by Water Resource Bureau of Hubei Province has shown that the current area of soil erosion and water loss in Wufeng County is 1058 $km^{2,}$, accounting for 44.75% of the total area in the county. 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, Renheping 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/km^2 and 6,372,000t. The situation in Niuzhuang County is moderate.

3.2.2 Current Situation of Soil and Water Conservation in Project Area

The soil and water conservation, whose main work is Terracing of Sloping Fields project, started in Wufeng County 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 that state treasury bonds will be expended to treat ecological environment in the central budget.

3.3 Social Environment

3.3.1 Socio-economic Conditions 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 approval from State Council in July, 1984, Wufeng Tujia Autonomous County was founded. It covers an area of 2,372 square kilometers, with a population of 208,000, administrating five towns and three villages. The Tujia people account for 67% of the total population.

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 People's Republic of China was founded, Wufeng County was backward in its economy and people there suffered greatly. After the foundation of the People's Republic of China, the productive relationship and people’s living standard have been gradually improved. Benefited from the policy on ethnic affairs and the reform and opening up, the national economy has grown rapidly, especially during the twenty years after the Third Plenary Session of the Eleventh Central Committee of CPC. Since then, the country has 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”.

3.3.2 Socio-economic Conditions in Project Area

Within the range of Wufeng County, the towering mountains, beautiful scenery, mild climate and abundant rainfall, all brings ample water, forest, tourist and mineral resources. The local government of Wufeng County, in order to accelerate the transformation of resource advantages into economic advantages, proposed a strategic goal of constructing a county with abundant hydropower resources, strong in forestry, famous for tea products and attractive in tourism. In the past, present and future, hydropower resources are always the mainstay of all industries.

Located in remote areas, agriculture and industry in Wufeng County remain in backward situations. Economic development still stays in primary phase, thus it is one of the key poverty alleviation county. According to the statistics, GDP in 2006 was 1.682 billion RMB, and per capita production value was 8626 RMB and per capita consumption level was only 3271 RMB. The industrial foundation in Wufeng is fragile. Industries are intensified in hydropower development, agricultural and livestock processing and mining product development, etc. The total industrial output of 2006 amounted to 454 million RMB. Dry land crops maintain the major proportion of agricultural sector, and major crops include: wheat, maize, potato, sweet potato, tobacco, rapeseed and some rice. In 2006, total grain production was 10125 tons; oil plants 5190 tons, tobacco 4501 tons, contributing to the total agricultural production value of 566 million RMB. The tertiary industry—service industry develops rapidly in recent years with a total production value of 662 million RMB.

The location of the project is at the west of Wufeng Tujia Autonomous County, where is the junction of two regions—Yichang and Enshi, as well as four counties, namely Wufeng, Changyang, Badong and Hefeng. The total area is 154km^2, including nine towns and one forest land. There are 71 villager groups with a total population of 7,911, taking up 92.6% of the total population in the county. Arable land accounts for 12554 Mu, and per capita level is 1.6 Mu. In 2006, total economic revenue in rural areas amounted to 29 million RMB, and farmers' income was 2,013 RMB per

capita. Fiscal revenue in the county budget was 2.06 million RMB.

Due to its high altitude and cold weather, numerous mountains interspersed with few people; Niuzhuang Town is regarded as “Tibet in Yichang”. The current land for forestry reaches 129345 Mu, including forest land of 105946 Mu. The forest coverage is 81.9%; timber reserve amounts to 252857m3 in total and annual felling amount is 1700m3. Mineral resources are mainly coal and stone-coal, extending along Meitangou (Coal Valley) and Zhaojiadun in Niuzhuang County. Major grain crops are maize and potato while major cash crops include tea, herbs, tobacco, rhizoma gastrodiae, merchandise vegetables, etc. Live stocks in the form of domestic feeding maintain a certain proportion in the economic volume.

3.3.3 Regional hydroelectric power development and planning

There are six main streams in Wufeng County together with more than 30 tributaries. Total river basins are 1956km^2 with hydropower storage of 340,000 kW. Among them, 300,000 kW are available for development. At present, 140,000 kW has been developed, 80,000 kW is being developed while another 80,000 kW hasn’t been developed. By the end of the 11th Five-Year Plan, the installed capacity will reach 220,000 kW, and annual electricity output will be one billion degree. As the hydropower stations in Wufeng County are mainly running water power station, which lacks adjustment capacity, the electricity supply is severely short in dry seasons and peak times for electricity consumption.

According to the plan for the following five years, the electricity consumption will soar up. It is planned that by 2010, industrial output will amount 11.72 million RMB and industrial electricity consumption will increase by 1020 kW, and electricity consumption of small-sized processing industry in rural areas will increase by 600 kW. Along with the popularization of television, the domestic electricity consumption will increase by 200 kW. It is predicted that by 2010, maximum electricity consumption load will be 4750 kW. At that time, the shortage of electricity supply will become

more and more extreme. It is of great significance to take advantage of Wangjiahe River and further develop hydropower development and optimize electricity supply network.

3.3.4 Population Health and General Situation of Major Diseases

The counties and villages in the reservoir basin of Wangjiahe Hydroelectric Power Station have formed a network of health and medical service, which comprises hospitals in counties and villages, village medical centers and village medical stations, etc. The main infectious diseases and verminoses in recent years are hepatitis, diarrhea and tuberculosis. Influenza, leptospirosis and hemorrhagic fever break out interspersedly.

According to the survey at the site of the construction areas of Wangjiahe Hydroelectric Power Station, there is no source of natural focal infections around 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 investigate the current ambient air quality in the construction site of project, the institution has entrusted the Environmental Monitoring Station of Wufeng Tujia Autonomous County to monitor the ambient air quality in the area for five consecutive days from May 22nd to July 26th, 2008.

According to regional meteorological characters, the distribution of environment sensitive spots and the trend of valleys, three monitoring spots have been set up in

vicinity of dam and power plant. As for specific locations, please refer to the attached picture No. 12. In Table 3-6 below are monitoring points and their functions.

Table 3-6 Location of the monitoring spots

No.	Position	Relative distance (m)	Locations and funtions
1＃	quarry	800	South-side of the dam, where the key protective targets locate.
2＃	dam	300	North-side of Wangjiahe I Power Station, for monitoring the power plant.
3＃	Wangjiahe II-Hydroelectric Power Station	100	West-side of the Power plant, the background monitoring spot for the Wangjiahe II Hydroelectric 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.

Table 4-3 Environment Air Pollutant Sampling and Analysis Methods

Pollutant	Daily Monitoring Time	Sampling Method	Sampling Apparatus	Analysis Method	Analysis Apparatus	Standards

TSP	≥12h	Filter Membrane Concentration Method	Intelligence large volume suspended particle sampling machine TH-1000C model	Weight Measuring	TG328A Analysis Balance	GB3095-1996 GB/T15432-95
SO_2	≥18h	Liquid Absorption Method	Micro computer atmosphere pollution average daily concentration sampling machine TH-3000A model	Spectrophotometer Analysis	721(B)Spectrophotometer	GB3095-1996 GB8970-88
NO_2	≥18h	Liquid Absorption Method	Micro computer atmosphere pollution average daily concentration sampling machine TH-3000A model	Hydrochloric acid naphthalene ethylene diamine 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 SO_2, NO2, and TSP accounting for fifteen respectively. The statistical analysis of monitoring data at three points is listed in Table 3-8.

According to the results, the range of daily average concentration of SO_2 in three monitoring points are: 0.022-0.024mg/m^3 in quarry, 0.024-0.026mg/m^3 at the dam site, and 0.022-0.026mg/m^3 in the Wangjiahe II Power Station, all within 0.15mg/m^3 the limit of daily average concentration for the secondary level, which is specified in *Ambient Air Quality Standard*. The range of daily average concentration of NO_2 in three monitoring points are: 0.036-0.045mg/m^3 in quarry, 0.042-0.046mg/m^3 at the dam site, and 0.033-0.042mg/m^3 in the Wangjiahe II power station, all within 0.12mg/m^3 the limit of daily average concentration for the secondary level, specified in *Ambient Air Quality Standard*. The range of daily average concentration of TSP

in three monitoring points are: 0.080-0.094mg/m^3 in quarry, 0.065-0.088mg/m^3 at the dam site, and 0.036-0.078mg/m^3 in the Wangjiahe II Power Station, all within 0.3mg/m^3 the limit of daily average concentration for the secondary level, which is 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.

Table 3-8 Monitoring result for ambient air quality

Item		1# quarry	2# dam	3# Wangjiahe II Hydroelectric power station
SO_2	range of daily average concentration (mg/m^3)	0.022-0.024	0.024-0.026	0.022-0.026
	Qualified rate (%)	100	100	100
	Exceeding times (times)	0	0	0
NO_2	range of daily average concentration (mg/m^3)	0.036-0.045	0.042-0.046	0.033-0.042
	Qualified rate (%)	100	100	100
	Exceeding times (times)	0	0	0
TSP	range of daily average concentration	0.080-0.094	0.065-0.088	0.036-0.078

	(mg/m^3)			
	Qualified rate (%)	100	100	100
	Exceeding times (times)	0	0	0

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. Given the fact that there was no concentrated sewage outlet in the upper and lower reaches of the dam site, four monitoring sections have been set up, distributing 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.

In the thirteenth attached drawing are the specific locations of these sections. Please refer to Table 3-9 for the names and functions of these monitoring points.

Table 3-9 Location of monitoring sections of water quality

Section No.	Name	Relative distance	functions
1#	Upper reach of the dam	500m upstream of the dam	Compare sections
2#	Lower reach of the dam	1000m downstream of the dam	Control sections
3#	Upper stream of secondary water	at upper reaches 300m from the bridge	Compare sections

	diversion dam		
4#	Lower stream of secondary water diversion dam	at lower reaches 500m from the bridge	Control sections

(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

Fifty-six valid monitoring data of seven items have been obtained. The monitoring result can be seen in Table 3-10 below.

Table 3-10 Result of surface water quality monitoring

sections	index	Pollutant density（mg/L is the unit for all except pH）						
		pH	Petroleum	DO	NH_3-N	Permanganate Index	BOD_5	Total phosphorus

1# upper reaches of the dam	Range	8.11	<0.005	9.66-9.98	0.178-0.184	1.30-1.45	0.72-0.98	<0.005
	Actual level	II	II	II	II	II	II	II
2# downstream of the dam	Range	8.20	<0.005	9.43-9.63	0.172-0.192	1.84-2.18	0.84-0.90	<0.005
	Actual level	II	II	II	II	II	II	II
3# upper reaches of water diversion dam	Range	8.08	<0.005	9.12-10.22	0.154-0.196	1.65-2.42	1.22-1.65	<0.005
	Actual level	II	II	II	II	II	II	II
4# lower reaches of water diversion dam	Range	8.12	<0.005	8.65-9.53	0.128-0.177	1.48-1.78	0.87-1.18	<0.005
	Actual level	II	II	II	II	II	II	II
Water Quality Grade II according to GB3838-2002		6-9	≤0.05	≥6	≤0.5	≤4	≤3	0.1（lake and reservoir 0.025）

From the monitoring result, seven items in two monitoring sections all reached the secondary standard of surface water quality, which indicated that water of Wangjiahe

reaches within the construction areas was of good 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, Environmental Monitoring Station of Wufeng Tujia Autonomous County monitored the noise in proposed dam site I power plant area and II power plant area at later August, 2005. Because original ecological environment were well preserved at the dam site and in the power plant area, only one representative monitoring point was set 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

Six monitoring figures of equivalent noise have been obtained. Please refer to Table 3-11 for the monitoring result.

Table 3-11 Environmental Noise Monitoring

Monitoring Sites	Monitoring Time Period	Equal Sound level	Type of Evaluation Standard	Standard Value	Result	Major influential factors
Power House and 1＃Dam Site	daytime	48.6	1	55	Qualified	Background Value
	nighttime	43.5		45	Qualified	Background Value
2＃Power	daytime	46.9	1	55	Qualified	Background Value

House of first cascade power station	nighttime	42.3		45	Qualified	Background Value
3＃Power House of second cascade power station	daytime	47.6	1	55	Qualified	Background Value
	nighttime	43.6		45	Qualified	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 □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 demonstrates 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, which 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:

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

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

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

$BT=\sum t / 365$ 或 $\sum T / 12$

In this formula:

RDI- radiation dryness index

r- (Annual) rainfall, mm.

NPP- net primary production (of natural vegetation), $t/(hm^2 \cdot a)$

PER- potential evaporation rate

PET- potential evapotranspiration, mm

BT- (annual) bio-temperature，□

t- daily mean （0□ < t < 30□）

T- monthly mean （0□ < T < 30□）

According to river basin and the hydrological and meteorological observation data of Wufeng County, the mean annual temperature is 13.5□ and the annual mean rainfall is 1587.75 mm. If we use the model above to do computational analysis, the net primary production of natural vegetation in the assessment area would be $3.16g/m^2 \cdot d$, 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 $3.16g/m^2 \cdot d$

（1153.4g/m^2·a）. By comparing and analyzing the net productivity of ecological system on earth and the research on phytomass, we can conclude that the average net production of this area is close to that of temperate broadleaf forest, which is 1200g/m^2·a. The vegetation's net productivity is high, i.e. the system has a relatively strong resilient stability. It shows that the assessment area enjoys high 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 1150g/m^2·a, slightly lower than the background value of this area--1153.4g/m^2·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 to a certain degree, however, 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

□ 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. The present land-use map shows 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.

 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 Major Environmental Problems

There are no industrial enterprises in the project area and river basin. The population density there is sparsel. Besides, this area has a small distribution of arable land and good vegetation with low-level application of pesticides and fertilizers. Therefore, there is comparatively less environmental pollution. The main environmental problem in the project area 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 laggard traffic has severely hampered the economic development in this area, affecting the construction of project.

4. The prediction and appraisal of environmental impacts

4.1 Hydrology and Sand

The natural property of water body has been changed due to the operation activities during the construction period and retains and the pilot during the working period. Consequently, this has led to the changes in the appraisal of the water level, the current capacity, the speed of flow and the circumstances of silt flushing of the storehouse districts, the lower reaches of dam and the river mouth, which will have direct or indirect impacts on the environment.

4.1.1Hydrology

The project builds the water tunnel at the dam site which extends to the Wang Jiahe second-level power plant. The building and the interception and water adjust of the dam will certainly have a certain impact on the amount of runoff and water level of the lower reaches of the basin where water is adjusted.

Wang Jiahe basin where the key position of its reservoir is located is the typical mountainous river. The flood there is influenced by the rainstorm intensity and terrain, whose features are the uneven distribution of rainfall in four seasons, the large volume of rainstorm and the high intensity. The uneven distribution of rainfall can be mainly demonstrated in the following aspects. On the one hand, there is a lot of rainfall from April to September in the flood seasons, during which period the rainfall volume accounts for 75.1% ~ 75.5% of the annual rainfall volume. However, the volume from January to March and from October to December is only 24.5 ~ 24.9% of the annual volume. On the other hand, there are numerous rainstorms with extreme intensity. And the centralization of rainstorm brings about the uneven rainfall distribution in the whole year. The sudden rise and fall of flood is not only caused by the extreme

intensity of rainstorm, the steep river bed slope, but the short time of flood afflux.

Great changes will take place in the water speed of the river section of the storehouse districts after the building of the dam. Reservoir capacity formed by the block of dam is much larger than that formed by the natural river course, so the speed of flow in the river section of the storehouse will become much slower. Speed of flow and current capacity are also related to the scale of the flood at that time. The average current capacity and amount of water flow in many years at the dam site of the Wang Jiahe reservoir power plant is respectively 2.16m^3/s and 68million$m^{3.}$ The 4610m tunnel passed by the excreted tail water is one of the places where water can be provided to the second-level power plant. According to the investigation on the scene, there is respectively a ravine gutter in the 50-100m near the right bank of the dam site. And there is afflux of branch rivers around 600m under the left dam bank, the current water flow of which is nearly 0.2m^3/s, larger than the excreted current water flow of 0.15m^3/s in the most waterless period of Wang Jiahe. So it can be clearly seen that other water sections except for those within 50m of dam will never close after the completion of the project.

4.1.2 Sand and Deposit

The reservoir is the artificial region of still water. When water runs into the reservoir, its speed will slow down substantially and the carrying capacity will become weaker, thus the sand carried along sinking down at the bottom of the dam, forming the deposits in the reservoir. The larger grain of deposits will float upstream, the smaller grain accumulating downstream. As time goes by, the deposits will move towards the front part of the dam.

To a certain extent, the deposits in the reservoir can be regarded as the natural bedding to prevent the leaking of reservoir, but plenty of deposits will affect the reservoir capacity, thus the depth of water becoming lower, affecting the operation of the hydroelectric power station and shortening the life span of reservoir.

Solid runoffs which cause the deposits in the reservoir have something to do with the litho logical characters, landform and power geological process in the region. And the resources are mainly the sand carried along, the mud-rock flow in the catchments area of reservoir, the misshaping and devastation of storehouse shore and the laminar flow washout material in the storehouse pitch. The sinking-up problem in Wang Jiahe reservoir is not very serious. There are mainly three reasons for it : firstly, the water and soil in Wang Jiahe basin is well-preserved and the water carries less sand with it; secondly, within the reservoir catchments area are mainly carbonate rocks and there are no debris flow growth area; thirdly, storehouse shores relatively stable with little distortion or destruction of large scale.

4.2 The local climate

After the reservoir has been built and can store water, the square of it is 0.14km^2. Due to the original land being turned into water surface, the transpiration rate is larger than that before the building of dam. As a result, the air will contain more water vapor and the humidity and the temperature will also be influenced in the storehouse districts and the surrounding areas. Thus there will be changes in the local climate.

(1) Precipitation

According to the relevant research, the reservoir can't change the rainfall in this region substantially. There will only be small changes in the distribution of rainfall. The rainfall in the central regions of the reservoir in summer becomes less than that of before its building and the annual rainfall is also lower, while the rainfall in the nearby area becomes more. Rivers in the storehouse districts being the Rainstorm Rivers, rainstorm will occure frequently in summer. So small changes in the rainfall will have few impacts on the whole reservoir.

(2) Temperature

After the storehouse districts begin to store water, the next pad surface has become water body from the land and its physical property has also changed a lot. The natural water course turns into the relatively still water surface with the water level higher, water surface wider and water depth deeper. The interchange of heat between water body and air has changed, resulting in the rising of temperature after the storage. Besides, the climate change is much gentler due to the water storage. The temperature daily range and annual range is much smaller, the highest in the year being lower and the lowest being higher with the small change scope.

(3) Humidity

After the storage of the project, compared to that before the construction of storehouse, the reservoir humidity will change a little because the transpiration rate of water surface has increased and the average annual relative humidity will increase a little. In terms of seasons, there will be a small increase in summer and a small reduction in winter with no obvious changes in spring and autumn.

(4) Wind

The project planned to be constructed is the typical water course reservoir. Controlled by the macroclimate and topographical condition, the prevailing wind in the storage districts will not change obviously. The storage district belongs to the weak wind area, and the common wind frequency will correspondingly increase and still wind frequency will decrease because of the hot differences between the water surface and land surface. The rough parts become fewer when the original fluctuated land surface is replaced by the smooth ground, thus an increase in the wind speed.

(5) The fog condition

After the project is completed, the elevation of temperature of reservoir in summer and in the daytime and the decrease of temperature in winter and at night are much gentler than the change of air and that on the ground. So this cold heat source function can contribute to the formation of steam fog in winter and radiation fog in summer. But because of the temperature, humidity and wind effect of reservoir, the temperature in summer will rise and decrease in winter; the humidity in winter reduces but increases in summer; the wind speed will increase all the year around. All these are not good for the formation of fog. Although the above factors have certain influence on the formation of fog, the atmospheric circulation plays the leading role. So it is predicted that the construction of the project planned to be built will not change the fog condition obviously.

4.3 geographical environment

4.3.1 Leakage Analysis

The reservoir leakage means that the storehouse water leaks to the outside part of reservoir or the lower reaches of dam through certain leakage channels. Generally speaking, it has the following three ways: from watershed to neighbouring valley, from river bend to the lower reaches behind the dam, from storehouse trough to the distant low-lying excretion area. The detailed analysis of the possibility of Wang Jiahe Reservoir leaking to the neighbouring valley can be found in “The engineering geology reconnaissance report in the conceptual phase of the Wang Jiahe reservoir power plant project of Wufeng national minority autonomous county in Hubei Province”. It proves that there are the Daye group shales, the mudstone and the marl 7-8km near the north and south banks of the storehouse area of Wang Jiahe reservoir which is the relative water-resisting layer with the regional stability. And, in the aquiclude between Wang Jiahe and Daye, there is no neighbouring valleys.Thus from the great scope, there is no possibility of leakage from the reservoir to the distant areas in north and south. So in terms of the leakage forms of the leaking of Wang

Jiahe reservoir, there are only the following two forms.

(1) The leakage of the dam abutment

Upside the left shoulder of dam is the Longtan coal formation and the Gufeng silicon rock series and there is no leakage. The lower part is the Maokou limestone and there is no central leakage channel between the water-prevention rock series and the water-percolation rock series. The big leakage downside the left shoulder and small crevasse leakage can be got rid of through the conventional grouting. The right shoulder is the Maokou limestone and the leakage in the shallow parts is serious. Three water-seperation rock layers □□、P_{3q}^{3-3}、P_{4q}^{4-1} are formed 100-160m in the mountain massif of the right abutment. Taking advantage of one or several layers of them, we can solve the problem of crevasse leakage through irrigation.

(2) Leakage in the base of dam

According to the analysis of the hydro geological conditions in the dam areas, this river valley is the supplied river valley and the low water level in the right bank is unlikely to be caused by the excretion to the neighbouring valley through the aquifuge rock body but by the leakage along the river in partial areas near the bank. And channel should be in the left side of the aquiclude. Drilling indicates that here is a topically central leakage.

4.3.2 The stability analysis of the reservoir shore

After the reservoir completes the storage, the storehouse shore has rapid changes in the natural condition, causing it to be in the new environment and under the power geological process, which will cause the distortion or destruction.of the storehouse shore. The three forms of destruction to the the reservoir bank slope are the collapses of the shore, the landslide and the avalanche. The collapse usually occurs in the plain or the basin reservoir whose storehouse shore is composed of the loose soil layer. The

right bank of Wang Jiahe reservoir is the natural stratification plane of the maokou limestone and the crevasse is scarce. The main two groups of crevasses are the steep dipping angle tending towards the inside of mountains, whose connectivity is bad, but natural angle of slope is 30-40° with good stability. The right bank of the storehouse's front parts has the few terrace deposits, and the clay is dense from the perspective of excavation of holes and road-building and the clay assumes the model of hard plastic the whole year. Its thickness is only 1-5m and relatively thin. The basis is the bedrock saccade with uneven weathered surface and the big friction coefficient, which make it impossible for the terrace material to slide. Therefore the whole stability condition in the storehouse right bank is good.

The storehouse head of the left bank of Wang Jiahe reservoir is the reversed bedrock slope, where the 0.3-1.0m thin layer slope residuals distribute fragmentarily. The stereographic projection analysis in the dam area indicates that the bedrock stability condition is good, but the few slope residuals are also only released into the reservoir by the laminar flow form with no risk of land sliding and few impacts on the reservoir. The storehouse tail of the left bank is the heavy calcareous rock body in the kiln group. The rock mass is hard and completed with no crowded discharge crevasse belt and the stability condition is good. The most parts of the left bank are the I stage steeply shaped side slopes outside the boundary. And the on-the-spot investigation discovered that it was made up mainly of the crushed stone, the rubble stone with sand and the little clay which have holes primarily and it had the good water permeability. The time when the material, the half cemented condition with hundreds of thousands of years'history, was formed was the epipleistocene (Q3), (Q4) hundreds of thousands of years after the epipleistocene and the brand-new world. The agglutination after the examination is calcareous, having the high physical mechanics. The palce above the left bank terrace is covered by the clay coating of the loose slope.Because the basis is the the hole material in the late pleistocene, having the good water permeability.At the same time, the interface is rough and the slope face is gentle, from which we can determine that the stability condition of the material on the terrain is very good.

The investigation discovered that the toe of slope of the left bank has 2 small landslide, which are 4# and 5# landslide. Because their volume is small which are both resulted from the rainstorm in 1950 wash outing the toe of slope with no revival or activities in 50 years, it became more impossible for them to reactivate after the reservoir is completed and located usually below water surface and the condition of the toe of slope washing the eclipse is eliminated. Moreover reservoir siltation increases the boost force for the left bank toe of slope instead and the stability condition of the slope can be improved. Thus the above two landslide insufficiency needs no worry. The slope storehouse tail is slow, mainly composed of the steep crevasse calcareous rock bedrock. The draining water condition is primarily good with no tendency towards the weak bands downstream. The possibility of sliding is small.

4.3.3 Reservoir siltation and reservoir immerse

The average slope of Wang Jiahe is 6.89%. The flood has the strong carrying capacity. The stability of slope condition in both banks and the storehouse tail is good from the storehouse shore stability analysis. So it is impossible to cause the big siltation.

According to the hydro geological conditions analysis of storehouse districts, both banks of reservoir are quite thick, its height almost reaching the height of the aquiferous rock body of the watershed region, impossible to create the immerse to the places outside the watershed. As a result of the steep-slope topography from high to low inside the watershed trapping scope, with no unusual low-lying terrain, therefore in the surface watershed scope not big question of immerse, only will also submerge several Chinese acres in the storehouse both banks near bank spot located at the 875m normal store water level following farmland, only need according to the normal procedure land-levying then.

4.4 The prediction and appraisal of the waterenvironmental impacts

4.4.1 Analysis of pollution sourse

（1）Agricultural surface source

According to the investigation, this reservoir involves the land area the approximately 450 Chinese acres (considere the indirect inlet), the unit area chemical fertilizer employment quantity regional differences are not big, average employment quantity about the 24kg/Chinese acre. Because plans to construct the region traffic conditions and the cultivation level limit, the applying fertilizer level average level is actually somewhat low, by average chino meter, then this reservoir storehouse district chemical fertilizer amount used is 10.8t/a, according to local nitrogenous fertilizer, phosphate fertilizer employment proportion estimate, nitrogenous fertilizer amount used approximately 6.46t/a, phosphate fertilizer amount used approximately 3.02t/a.

According to the analysis of the statistical report, there are not big changes in the chemical fertilizer amount of use in the villages and small towns surrounding the reservoir for five year. Therefore, after the reservoir is completed, it is forecasted that chemical fertilizer employment quantity in 2010 can be determined according to the quantity in 2005. Moreover, according to the report of the feasible study, soil erosion in the storehouse districts doesn't measure in a big way. And the nitrogen, the phosphorus lose in the soil erosion can be considered to be 10%.

Forecasting: method: Measures based on the soil nutrients outflow forecasting equation provided by "the appraisal standard of hydrological and water and electricity project environmental effects (Implementation)" (SDJ88-2003)

Namely: E=aSNp+bcdFNp

in the formula:

E- Forecasting the total quantity of the nitrogen and the phosphorus outflow in the soil entering the reservoir, t/a;

S_{NP} – the total quantity of entire nitrogen and phosphorus entering the water body soil. The result can be got through the entire nitrogen, the entire phosphorus content multiplying the total soil into the reservoir.

a- The along regulation consumption coefficient of nitrogen and phosphorus: The nitrogen is 70% and the phosphorus is 95%. It means that the ratio of the two elements which enter the water body corresponds to 30% and 5%;

FNP- The level of employing chemical fertilizer;

b- The average amount of chemical fertilizer. For nitrogen and phosphorus, the average content in the standard chemical corresponds fertilizer to 23% and 15%, respectively.

c- The utilize ratio of crops to the chemical fertilizer. The nitrogen is 30% and the phosphorus is 15%. It means that the ratio of the two elements which was discharged from the water body corresponds to 70% and 85%.

d- The dissolve ratio of the chemical fertilizer entering the soil and the water body. The nitrogen is 30% and the phosphorus is 5%.

According to the calculation, the total amount of the nitrogen and the phosphorus which will be brought into storages through the agricultural source could reach 0.71t/a and 0.08t/a in 2001.

The farmland pathway flow pollution burthen was not only influenced by the rainfall, the terrain, the soil and other natural factor, but also determined by the amount of the ground pollutant as well as the related transfer process. After making the analogy analysis between the research results of the farmland pathway flow pollution in the

Three Gorges area and Wangjiahe reservoir district, we can estimate elementarily that the discharge amount of COD and BOD5 (belongs to the farmland pathway flow pollutant) will approximately achieve 13.3t/a and 6.4t/a in 2001.

(2) demestic pollution

According to the investigation, due to the quite small population (involving in almost 600 resident populations) and the absence of industrial pollution enterprise in the reservoir district, the main life pollution source can be considered to be the emissions of the sanitary sewage. The prediction of the emission amount of the sanitary sewage will be calculated by the following equation.

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

In the formula: - forecast the discharge amount of sewage in the average year (t/a);

- Average per person sewage discharge (t/a);

- The population in the standard year;

- The growth rate of population (‰).

Based on the outdoor draining water design standards, the average sanitary sewage withdrawal per person is 150L/（d/person）. The main pollutants COD, BOD5, T-P, T-N , according to the conventional emission strength of the sanitary sewage is respectively 400mg/L, 200mg/L, 2.0mg/L, 25mg/L.It is estimated that in 2010 the volume of contaminated water waste is approximately 33,000 t/a with the main pollutant COD release amount is approximately 13.0t/a, BOD_5 release amount is approximately 6.0 t/a, T-P release amount is approximately 0.06 t/a and T-N withdrawal approximately 0.75 t/a.

4.4.2 Reservior Water Quality Prediction and Assessment

4.4.2.1 General Water Quality of the Reservior

(1) Initial Storage Period

At the initial storage period, the liberation of various organic matters in parts of the drowned land and vegetation, the great amount of outflow and decomposition of organic matter will cause unfavorable impact on the reservior water quality. According to the monitoring statistics of the built reservior home and abroad, those all have business with the reservior storage level, which are dissoluted oxygen of water body、salinity、nutritions and hyperplasia of plants. The area of Wangjia He reservior generating plant is 0.14km^2 ,with a less drowned area. Meanwhile, due to the sanitation cleaning of the reservior bottom before storage, the amount of organic matter is decreased, and also the dripping and decomposition amount of various organic matters of the drowned land after the storage, which will reduce the effect of the reservior on general water quality.

(2) Normal Running Period of Reservior

Within the normal running period of Wangjia He reservior generating plant, the main pollutants consisted primarily of the background level of upstream river、domestic sewage of Jingshan Ping village, Niuzhuang town and also the farmland runoff around the reservior. To the general water quality in reservior running period, we planned to predict with zero-dimensional model.

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) - Viscosity of Pollutants during Planned Period, mg/L ; W_0 - Entering Speed Rate of the Pollutants, g/s ; K_h - Mid Variable, s^{-1} ; V - Reservior Volume, m^3 ; Q - Outflow Rate of Reservior, m^3/s ; K - Comprehensive Weaken Coefficient of Pollutants, s^{-1} ; C_0 - Current Viscosity of Reservior Pollutants, mg/L.

Choose BOD_5 to be the predicted factor, other items are only to be qualitative analyzed. The prediction result of BOD_5' average viscosity in 2010 after storage, see also Table 4-1.

Table 4-1 Average Viscosity Prediction Value of the Main Pollutant BOD_5 in 2013 of Wangjia He Basin Reservoir Generating Plant Item

Time	Time of calculation t (s)		
	1	1000	3600
Predicted Result	0.008	0.007	0.005

The predicted result shows that, the average viscosity value of BOD_5 in 2013 of the reservoir has met the Ⅱ water standard of ***Surface Water Environment Standard*** (GB3838-2002) .

It's clear that, the change of hydrological situation after the running of Wangjia He reservoir generating plant storage will not obviously because obviously negative impact on the general water quality, the water quality in this area can remain what it used to be.

(3) Eutrophication Prediction and Assessment of the Reservior

Use the Dilong Model:

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

In this formula: P— Nitrogen、Phosphorus Viscosity of the Reservior, mg/l；L— the Entered N、P loading Amount, g/m^2·a；H— Average Depth of Reservior Water, m.

In this formula: $\rho_{\omega}=\frac{Q}{V}$

Q—Annual Inflow Water Quantity, m^3/a；V— Reservior Volume, m^3；

R= 0.246exp (-0.271Qi) +0.574exp (-0.00949Qi)

In this formula: Qi—Water Power Onus, Qi = Q/A，m/a；A— Reservior Water Surface Area, m^2.

After the establishment of the reservior, in case of the unfavorable conditions, namely ignoring the soil and water loss also the fertilizer use quantity caused by land submerging or the reduction of artificial treatment, the N、P inflow quantity are calculated according to the current inflow amount. We get the N、P loading quantity are respectively 5.07g/m^2·a and 0.57g/m^2·a. All the calculated prediction parameters are listed in Table 4-2.

Table 4-2 Predicted Parameter of the eutrophication of the water in Wangjia He Reservior

Item	Q（m^3/a）	V（m^3）	A（m^2）	H（m）	ρ_{ω}	Qi（m/a）	R
Parameter	0.59×10^8	0.03375×10^8	0.14×10^6	30.0	17.48	414.29	0.0113

The prediction year is 2013, according to the model and parameters above, we can calculate the whole N viscosity out to be 0.004mg/l、while that of P is 0.0005mg/l.

In the eutrophication of lakes and reserviors, the nutritious elements are the main control factors. According to the AGP evaluation in ***Lake Eutrophication Survey Standard*** (2nd edition), most of the lakes are P limited, however there are also P limited lakes. There is no standard about entrophication in our nation currently, the assessment this time will analogy with some of other national classification standards, to ensure the degree of entrophication of Wangjia He reservior generating plant after established. Specific standards see also in Table 4-3.

Table 4-3 Domestic Reservior Eutrophication Condition Standard Unit：mg/L

Nutrition Type	Water Quality Centre Index		Tai Lake Index		***Lake Eutrophication Research Standard*** Index	
	Total Nitrogen	Total Phosphorus	Total Nitrogen	Total Phosphorus	Total Nitrogen	Total Phosphorus
Nutrition-Poor					< 0.25	< 0.02
Poor-Middle	0.2~0.4	0.005~0.01	0.16	0.01	0.16	0.01
Middle	0.3~0.65	0.01~0.03	0.31	0.023	0.310	0.023
Middle-Rich	0.5~1.5	0.03~0.10	0.65	0.050	0.650	0.05
Rich	> 1.5	>0.10	1.20	0.110	1.20	0.11

According to the current result of this report, each water quality indexes above the dam address are in accordance with Ⅱ standard require of GB3838-2002 ***Surface Water Environment Quality Standard***.

From Chart 4-3, a judgment can be made that the water quality in Wangjia He reservior generating plant after establishment is poor-nutrition. There is a smaller population living from the dam to the interval reach, the current upstream pollution source pressure onus is highly limited, though the depth is growing while flow rate is decreasing after the establishment, the water body is renewing frequently, and the

eutrophication phenomenon can hardly appear. Therefore there is an infer that, under the current nutrition loading level, the general water quality of Wangjia He reservior generating plant will not transform to an eutrophication one.

(4) Analysis and Assessment of Downstream Water Quality

The topography and physiognomy from Wangjia He reservior generating plant dam address to the river mouth reach is similar to that of upper reaches, the population is small along sides, no domestic drinking water intake mouth and sewage discharge mouth. The adjust degree of the reservior running to the downstream dam runoff and the quality of its outflow water, are the main factors which affect the water quality of downstream reach.

□ Changes Analysis of Water Quality during Flood Season

The duty of Wangjia He basin reservior generating plant projest is to ensure the safety of the dam and the normal running of the generating plant factory. The starting level of the flood is the normal storage level, when the flood water is over the level, strobes will be lifted and discharge the flood freely. The hydrological impact on the downstream reach of dam is almost the same as the natural river way conditions, in addition, the sink and clear function of the reservior makes the discharge water quality better than the natural condition, which is good for the improvement of the downstream water quality. According to the transformation running analysis of the other built reserviors, the transformation running during flood season has little impact on the downstream reach water quality.

□Changes Analysis of Water Quality during Non-flood Season

Analogizing the average runoff of other built hydroelectric power station project after the establishment, the dispatch and running result and the natural condition, the reservior begins to store water after flood, and the outflow quantity is less than the

natural water quantity, there is little obvious increase than that in the dry season.

Reservior water stores after the flood, and the discharge quantity is less than that under the natural condition, however basically greater than the flow rate in dry season. Analyzing from the angel of water environment capacity, when the flow rate is big, the water environment capacity is big. Therefore, the flow rate after the flood has decreased in various degrees, and is has some impact on the water environment capacity of the downstream reach of dam, but it's bigger than the water environment capacity during dry season under natural condition, which also has little obvious impact on the water quality condition in this reach.

4.4.3 Reservior Water Temperature Prediction

Reservior water temperature is an important index to the water environment, the fish in China are mainly temperate-water fishes, the suitable water temperature for living and propagation is 15 - 30□ , the change of the downstream water temperature will affect the aquatic creatures in the lower dam; water temperature has close relationship with water quality, especially close to DO、BOD_5、COD、fecal coliform and so on; water temperature is also an essential information for investigating and supervising the concrete dam seeping、leaking. Therefore, investigating and analyzing the comprehensive benefit for comprehensive use of water resource、water quality protection、fully use of reservior is very important.

(1) Reservior Water Temperature Structure

After the reservior began to store water, water temperature, as a hydrological symbol to show the heat condition, is about to change. The reservior water temperature distribution type is affected by some factors, such as solar radiation、reservior volume、in and out quantity and temperature、reservior shape、sediment condition、

reservior dispatching operation ways and so on.

Judging whether the water temperature in reservior should be delaminated for resorting, there are two methods: judge by the exchange index α of reservior water and the ratio of flood quantity and the current actual reservior volume β; or by the density Ford index method Fd. During the preceeding period of the construction of three gorges project, the Yangtze River water resource protect scientific research institute has studied on it, and the national key scientific and technical problem ***Three Gorges Water Conservancy Hinge Water Temperature Prediction*** raised in 1990 has undertake overall research on the reservior water temperature effect. The water temperature in different depth is various, and it can be generally divided as mixed、divided and transited. See also Table 4-4.

- Mixed: The water temperature in different place of reservior is even, the temperature grads are small.
- Stratified: During the T-raising period, the surface water temperature is obviously higher than that on the mid and bottom part, which causes some kind of division, the grads can be higher than 1.5□/m. The bottom reservior water temperature annual disparity is less than 15□.
- Transited: Water temperature has the characteristics of mixed type and divided type.

Table 4-4 α-value of the watertempreture in the reservoir

A-value	Temperature type
< 10	Stratified
> 20	Mixed
10~20	Transited

(2) Reservior Water Temperature Type Judgement and Impact Analysis

This assessment has adopted α coefficient method to judge the water temperature structure of the Wangjia He reservior hydropower station. α coefficient method is simple, after some reservior check with some actual measured water temperature information, the judged result by this method is basically in accordance with the reality. There is another expression:

α= years of average annual runoff/ general reservior volume

After the calculation, the α value of Wangjia He reservior hydropower station is 17.48(10--20), which indicates the water temperature structure of the reservior is typically the mixed type, with no layer division, and there are obvious season flow and flood flow in Wangjia He, the basin flood are mainly formed by rainstorms, the rains are gathered in July to Sep., the swing of flood is great, lasting short and flow rate is big. The water body stays still after the reservior establishment, the heat storage effect is greater than rivers, the surface water will be higher than natural river temperature, according to the actual measured information of the tributary of Gezhou Ba reservior, the income of water is easily affected by temperature rising, the surface water temperature along the reservior: the entrance reach of reservior tail、mid reach and upper reach of dam、the exit reach of reservior mouth, entrance rach of reservior mouth are similar to the natural river temperature at the same time before. In winter, surface water temperature of mid and upper reach has little difference with those under natural conditions: there are certain distinguishments in spring、summer and automn, generally, the temperature of surface water is 2℃ higher than that of natural river way at the same time before, however the bottom and surface water temperature has little discrepancy.

(3) Reservior Discharge Water Temperature Analysis

Reservior discharge water temperature has some relations with the factors of

in-and-out mouth、water flow rate、inflow water temperature、local temperature that time and so on, according to the actual measured information in Xin'an River and Dan River Mouth, the downstream reach water temperature has good relations with the temperature in a certain depth, and this depth is about 15~20m. The water temperature differecnce is little in Wangjia He reservior hydropower station, so the outflow water temperature has little difference with that of natural river at the same time before.

According to the research, the water is rapid here in this reach, and there is no distribution of large scale of economic fish and treasured fish lay site, no need for production and domestic water, also no irrigation, therefore, it will no bring harmful impact on the living and propagation of fish in this reach、downstream dam water quality and aquatic creature、farmland irrigation and so on.

4.5 Ecological Environmental Impact Analysis and Assessment

Water conservancy project has distinct effect on the ecological environment, during the project construction period, there are mainly unfavorable impacts on the ecological environment, and however the impact by the running period is many-sided. The unfavorable impacts are mainly the decrease of creature quantity and change of creature system. While the beneficial ones are: the development of small hydroelectric power may change the bad habit of villagers firing the woods for energy, reducing the rate of wild animal habitant area shorten caused by the villagers' cutting; along with the local climate improvement in the reservior area, it will bring beneficial conditions to the vegetation variety exchange around the reservior; the implement of the project will cause artificial soil and water loss, also effective control to the original soil and water loss, various degrees of reducing floods、landslide、mud-rock flow and other disasters, so that to improve the ecological environment.

4.5.1 Ecological Environment Integrity Assessment

The natural system integrity impact by Wangjia He basin reservior generating plant project is rooted by reservior drowning and project occupation. The establishment of Wangjia He basin reservior generating plant project and the direct land-occupation after construction as well as the reservior submerged scale need to occupy t 35 mu of arable land, 220 mu of forest. The submerge and project occupation will directly reduce the regional greenland area, and directly cause the change of regional natural sysytem productivity and stability, which will bring a certain degree of impact on the regional landscape ecological system integrity.

(1) Regional Natural System Production Capability Change Analysis

Sight ecological system production capability is affected by the submerge of reservior and occupation of land, which changes the joint piece type and its area, the formerly low capability woods and sands will be changed into stable reservior from unstable mountain-river, the organic matter quantity of aquatic ecological system will apparently increasing from small quantity, the production capability level will be gradually improved. However the regional general production capability in short time will drop.

(2) Sight Ecological System Stability Change Analysis

The stability of landscape ecological system includes two types of characteristics, recovery and resistance. Recovery is the capacity of system recovering to its formal condition after being changed; while resistance is the capacity of system resisting and preventing changes after the environmental variations. After the regional terrestrial ecological system drowned in the project area, it will transfer into a new aquatic ecological system. A new balance will be made in the productivity power of each system after a shortime of undulation, for the drowned and internal occupied land are

less than 5%, it will not cause a lower to level Ⅱ natural system due to the submergence of a few woods by the reservior storage. This hydroelectric power station construction has little influence on the stability of the landscape ecological system. Therefore, the construction running impact to its regional landscape will not run out of its ecological bearing capacity, which can be withstood by the regional natural system.

In this formula:

Equation: L总—Sound level forecast，dB；

Li - the superposition sound level, dB;

N-n a sound pressure level.

(2) Mobile Sound Source

All kinds of heavy-duty transport vehicles and bulldozers and other noise can be regarded as a mobile sound source，The sound of the noise is related with the vehicle flow, type of veciles, vehicle speed, road conditions and other factors. We plan to use the following model to calculate the attenuation.

Mobile sound source forecasting model：

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

Equation: Lm— Sound source distance r (m) Department of sound pressure level, dB; N-traffic flow, vehicles / h;

v— Speed, km / h

r — Measuring point with the distance from the sound source, m

4.10.3.2 Impact Analysis:

(1) Fixed, Continuous Point Source of Noise

Considering as the most disadvantageous situation, namely taking the maximal number, the sandstone material processing system source intensity is 110dB, concrete mixing system 88dB, wheel-wood processing factory 105dB, and foundation pit excavation 112dB. Its impact range can be seen in Chart 4-9.

Chart 4-9 Wangjia River Basin Hydroelectric Power Station Construction Area Fixed Continuous Noises Source Prediction Value

Sound Source	Strength (dB)	Prediction Value of Various Distance from Sound Source(dB)							
		10m	20m	30m	40m	50m	80m	100m	120m
Sandstone Material Processing	110	82.0	76.0	72.5	70.0	68.0	63.9	62.0	60.4
Wheel-Woods	77.0	71.0	67.5	65.0	63.0	58.9	57.0	55.4	77.0
Concrete Mixing	88	60.0	54.0	50.5	48.0	46.0	41.9	40.0	38.4
Foundation	112	84.0	78.0	74.5	72.0	70.0	65.9	64.0	62.4

The foundation pit excavation, artificial sandstone material processing system and so on has relatively stronger noise source which will exert unfavorable impacts on the workers nearby.

There are no residents living near the construction area; the noise is mainly affecting the construction workers in this section. Based on various background situations from various noise source and sound environment, we can predict the various degree

of impact on the workers in the construction area. The calculation results can be seen in Chart 4-10.

Chart 4-10 Impact Value of Wangjia River Basin Hydroelectric Power Station Construction Activity to the Sensitive Point

Sensitive Point		Nearest Distance to Sound Source（m）		Noise Impact Value（dB）
Location	Name	Sandstone Processing System	Concrete Mixing System	
North Bank of the Dam	Living Area during Construction	250	1500	<45

The workers in the construction area are affected as the noise value is above the Ⅰ standard of ***Urban Regional Environment Noise Standard***（GB3096-93）. But due to the interruption of mountains, the real acoustic environment is a little lower than the prediction value.

(2) Flow Noises

The day and night vehicle flow of the project construction traffic routine is considered as 80/h, the speed is 35km/h; the vehicle flow at night is 40 /h, the speed is 15km/h. The traffic noises impact range, see to Chart 4-11.

Chart 4-11 Impact Range Prediction of Construction Traffic Routine Flanks

Time	Noise Prediction Value from Various Distance（dB）								Standard Distance（m）
	5m	10m	20m	30m	40m	50m	60m	70m	

Day	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

The construction zone can meet the standard 10m away from the road both in the daytime and at night for the construction domestic area is located at both sides of the factory road with greater influence of the noise.

(3) Blasting Noise

The blasting noise has the characteristics of short time, fixed-time, definite-located, with a range of strength of 130～140dB(A). The blasting point of the project is mainly the left of the main dam, right dam bank, factories of the dam, and block stone factory. The blasting has certain impact to the construction workers.

4.10.4 Solid Abandoned Waste

The solid abandoned properties are mainly construction abandoned soil, dregs and the domestic rubbish of the construction staff.

(1) Construction Abandoned Soil and Dreg

The abandoned dreg during the process of project construction is mainly from the spoiled soil and stone square by the main body project foundation excavation, foundation clearing, slope shaving and the surface clearing of the soil material site. According to the earthwork excavation filling balance volume, the main body project and the construction area plating and so as the piled waste dregs' total volume are 45,800 m^3 , which are planned to the big abandoned dreg site. If the construction-abandoned dreg wouldn't be carried to the pointed place and not adopt prevention measure, arbitrary pile will not only affect the surrounding environment, but also lead to soil erosion and water loss. The great pit abandoned wastes site utilizes carsts depression with enough wasted piling space and it is almost barren

fields with enough room for piling up. So it almost causes no destruction to the vicinal natural landscape.

(2) Domestic Rubbish of Construction Workers

Many workers are gathered in the construction area during the construction period, the number has reached 367 at the peak time. Accounting the per capita daily domestic rubbish as 1kg, the daily domestic rubbish output at peak time is about 0.367 t. If the domestic trash isn't treated in time according to the environmental health requirement, it will not only affect the landscape, pollute the air, in some certain climate condition, it's easy for the living and propagation of mosquitoes, flies and rats to cause the occurrence and propagating of various insect transmitted disease,even in the high population density construction area, which would affect the health of workers. At the same time, after the various kinds of pollutants and germ in the domestic trash inflowing towards the Lou River along with the rainfalls and runoff, it will also pollute the river water body.

5. Analyses of the Environment Risk

5.1 Risks Identification

The environment risk analysis of the Wangjiahe River Basin Hydroelectric Power Station Project is mainly analyzing the probability and the possibility of accident in the future, which is caused by the project construction and operation. Engineering construction's environment risk is potential, only when the risk arises and breaks out as an accident, the harm will be cast.

According to the development task, the scale, the project layout and the main building designs, 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, the hydrological silt condition, water environmental quality, aquatic organism and so on. By integrating the prediction and assessment of the environmental impact from project construction, and upon initial risk identification, it is determined that the main environmental risk of Wangjiahe Reservoir Hydroelectric Power Station is on dam breach and other environmental and geological risks.

5.2 Dam Break Risk

5.2.1 Recognition of Risk

Once the Wangjiahe River Basin Hydroelectric Power Station dam is undergoing breach, the local electricity contradiction becomes prominent; the project investment wastes, and also possibly causes the unpredictable casualty, bringing inestimable loss to the locality. Possible causes for the reservoir dam breach are mainly: earthquake, catastrophic flood and improper reservoir operational management.

5.2.2 Risk Analysis

(1) The Earthquake

The new tectonic movement in southwest Hubei inherits the characteristic of the old structure in its intensity or the increase rate. Since 5 to 10 million years ago, the local main characteristic is the intermittent swell in large scale and the re-movement of part of fault diversity. Since the Quaternary Period, the earth crust's swelling movement has intensified, with a speed of 2.9~9.5mm ("The Investigational Study of Hubei West Mountainous Area (Yichang)'s Mountain Stability and Rock Collapses Landslide" by the Hubei Province Hydrology Team). This kind of swelling and the different activity has shaped the region's landform that bear the feature of those formed about 5 to 10 million years ago, such as deep-cutting of river valley and formed the multistage altiplanation surface and the river terrace.

With the analogy between earthquake geology and engineering geology, the FS geologic report shows that the Wangjiahe Reservoir will not induce earthquakes that are beyond the greatest magnitude within its structural system. We may consider historical magnitude 4 in the near zone as the limit. The reservoir district adjusts the size of stress fields, and is the determining factor of the reservoir induced earthquake intensity; the reservoir district's scale and the limit of induced earthquake's intensity have obvious relations. Considered the example of the nowadays' many reservoir induced earthquakes, the middle and small sized reservoir has not induced macroseism, therefore, induced macroseism is also impossible for this area. At the same time, the preliminary quantitative analysis and forecast are done, with the dual-grade fuzzy comprehensive assessment methods, finally indicated that the reservoir district's most greatly possible magnitude is 2.03, possibly with the epicenter being the most dangerous area.

The aquiferous rock coupling model is used; the report predicts that the main or the initial earthquake occurs mostly several hundred to more than one thousand days after water impoundment. The analysis indicated that this area will not produce induced earthquake of high magnitude, even if it happens, its magnitude will be very

small, bringing the reservoir and dam no serious harm. Moreover, because of the many limestone caves in the storehouse districts, when water rises to a certain elevation, the karst gas explosive induced earthquake would possibly occur. But as the cave scope is limited, and so is the impoundment elevation, the induced earthquake magnitude will be very low (lower than 2 degrees), and earthquake points will not be centralized.

According to the People's Republic of China national standards ***The Chinese Seismic Parameter Zonation Map (GB18306-2001)***, the seismic peak acceleration is smaller than 0.05g (equal to the earthquake basic intensity of VI) in the region west of the Wufeng County; that in the east and north of the Wufeng County is equal to the 0.05g, while the area from Changde to Jinshi of Hunan and from Zhushan to Zhuxi of Hubei, the acceleration is 0.1-0.15g. The Wangjiahe Reservoir is located on area with seismic peak acceleration of 0.05g, the earthquake basic intensity is VI, and the corresponding seismic motion response spectrum circle is 0.35s.

(2) Catastrophic Flood

The flood in this basin area is formed by the rainstorm; therefore the flood period is in accordance with the rainstorm periods. Rains mainly concentrate in months from April to October, and the peak of floods of the year mostly appears in June to August, with high frequency. In the basin area, high mountains accompanied by steep slopes, deep valley filled with narrow rivers; rapid flood afflux, sudden rises and drops show the characteristic of the mountain stream flood. The shape of the flood peak is primarily unimodal, while the multi-peak also appears. Because of the blocking function of the limestone cave, the underground river, the karst topography, as well as the long and narrow basin shape, the flood peak’s modulus is slightly fewer than the nearby basin.

According to the national ***Flood Control Standard（GB50201-94）*** and ***The Grading***

and Flood Standards of Water Conservancy and Hydropower（SL252-2000）, the total storage capacity is between 100 and 100 million cubic meters , the construction scale is minor (1) type and the corresponding project grade is IV. The total installed capacity is between 10 to 50 million KW, which falls to the (1) type construction of category IV. In this regard, the construction is IV. The dam is designed as a 4 degree building, so are the fore bay, the pressure pipes, the powerhouse and booster stations of Wangjiahe II Hydroelectric Power Station. Chi-nan Power Station, Wangjiahe I Hydroelectric Power Station and some secondary buildings in the Wangjiahe I and II Hydroelectric Power Station are designed as 5 degree. The powerhouse of Chinan power station are designed for flood of "30 years return period" and checked for flood of "50 years return period". The bottom trash rack dam is designed for flood of "10 years return period" and is checked for flood of "30 years return period". The designed flood control standard for Wangjiahe dam is for flood of "50 years return period". With a relatively far distance from the dam, the designed flood control standard for the II power station is for flood of "300 years return period". The flood control for the powerhouse in Wangjiahe I Hydroelectric Power Station is the same with that of the dam. The designed flood control standard for the secondary power station powerhouse is for flood of "30 years return period". And the checking flood control standard is for flood of "100 years return period". Therefore, the possibility of instability caused by rare flood at the reservoir dam is fairly tiny.

(3) Reservoir Operational Management

- **Reservoir Operation during Flood Period**

During the reservoir operational process, especially in the catastrophic flood period, if the flood cannot be discharged in time due to the operational fault that threatens the safety of the dam. It may also lead to the dam overflow, causing dam instability, moreover, disasters and accidents. Precedents exist domestically and abroad. At present, along with the improvement of the weather and the hydrologic forecast, the

forecast cycle will be lengthened, the accuracy further enhanced, winning a longer time for the reservoir operation, and guaranteeing higher dam security standard.

- **Reservoir Daily Management**

In the reservoir daily management, if inappropriate maintenance occurs, the dam is possibly damaged, bringing security risk to the dam. But the present reservoir building's safety maintenance is technically guaranteed, so that the dam breach probability caused by the management carelessness is negligible.

5.2.3 Risk Alleviation

Strengthening reservoir management is an effective measure that alleviates the dam breach risk of Wangjiahe Reservoir Hydroelectric Power Station. The reservoir operational managerial staff should operate strictly according to the scientific operational plan, pay close attention to the regional weather forecast and the river basin hydrologic forecast and carry on the rational analysis. And to strengthen the dam building's daily security maintenance, find problem and the hidden dangers in time, fulfill exactly the formulated managerial system and the operational regulation, and strengthen the management by supervision. At the same time, formulates various kinds of dam breach emergency procedures and pre-plan, reduce the environment loss.

5.3 Risks on Environment and Geology

According to the project geological reconnaissance, the main environment and geological risks of the project construction has the following aspects

5.3.1 Geological Problems in Dam Site Area

According to the ***Code for Water Resources and Hydropower Engineering Geological investigation (GB50287-99)***'s engineering geological classification

standard for the dam base rock masses, the dam base rock for Wangjiahe Hydroelectric Power Station should be categorized as AIIII type. The rocks resemble a sub-block or mid-thick layer structure. The structural face is relatively developed. In rock masses, there are gentle or steep inclination (abutment) in the weak strucure plane, or they see wedges or polyhedron which may jeopardize the stability of dam base or abutment, the rock masses are relatively complete, and weak in part of the area, with high solidity, and the slide-proof, anti-deformation capacity are, to some extent, controlled by structure plane, which suggests that special treatment should be done on structural plane that affect the rock masses deformation and stability.

(1) Dam Base Stability

The valley where the dam is sited is a vertical valley, the stratum is sloped to the left bank, with a slope angle of 35-40 degrees, there's no downstream detrimental structure face. The base rock is Maokou Formation thick layer solid biological limestone, without weak interlayer. The dame base is generally stable and can bear heavy stress.

(2) The Stability of Dam Shoulder

The both dam abutment dominated by base rock, the head of the dam and dam area do not have disturbance from slope instability. Relative to gravity dam and rock fillng plan, the stability of the dam abutment is good.

(3) The sinking of the dam

The site of the dam is a closed valley, if the rock fill dam type is adopted, much excavation could be saved. 860m below the left abutment is reverse slope cliff, and the side slope of the cliff must be treated to prevent cracking between anti-seepage body and the rock masses, which may harm seepage-proof effect and the safety of the dam.

(4) Dam Abutment and Base Leakage Problem

On the left shoulder are Longtan coal measure and the Gufeng siliceous rock series, without leakage. Lower part is the Maokou limestone, with no centralized leakage channel between the aquiclude and the permeable rock series. The big leakage and the small crevasse leakage may be solved by the conventional grouting. The right shoulder is mainly the Maokou Fm limestone, with serious leakage in the shallow part. In the mountain of right shoulder, three water tight rock layer P_{3q}^{3-2}、P_{3q}^{3-3} and P_{4q}^{4-1} are in the 100-160m depth. We should consider using one or several layers of it, solving the crevasse leakage through grouting.

According to the analysis of the hydrological and geographic conditions of the dam area, the valley belongs to the replenishing type. It is impossible that the low water level of the right bank is caused by the draining towards nearby valleys through the permeable rock mass, but near-bank partial consequent river leakage, and the passage is on the left side of the P_{1q}^{4-1} aquiclude, the drilling holes imply that it is a sectional centralized leakage.

（5）Spillway and Sluice Tunnel

Under the dam axis of the left bank 200m is cliff, so excavating the spillway will certainly form the high and steep side slope, and will cause the house moving problem and destructions of the fields. Considering the fact that the cliff belongs to the ultra-thick solid limestone of cliff system, it is suggested that the flood discharging facility use the plan of “spilling the water at top level for the forepart, discharging the flood underground for the posterior part”. The flood releasing tunnel could be used as diversion tunnel as well in the early period. The spillway’s foundation is mainly consisting of Longtan Coal Measure; therefore, the use of slope protection and diversion and energy buffering facilities is suggested in the design.

（6）Reinforcement Suggestions

In the design we should consider construction measures, such as digging out, anchoring, consolidation grouting or setting up slide-proof concrete towards the unsteady structural plane. At the same time, strengthen the editing of geological data in the construction area, provide comprehensive and reliable basis for optimizing treatment plan. New unstable structural planes which are exposed in the construction, as well as those structural planes which have a more serious situation compared to the estimated, should be evaluated and confirmed with the processing plan.

At the same time, we should strengthen monitoring and observation of its stable condition. Formulate the emergency plan, once the unusual circumstance like slides collapse or the shore collapse appears, handle it in time according to emergency plan.

6. Environmental Protection Measures and Suggestion

6.1 Measures and Suggestion Water Environmental Protection

6.1.1Protection Measures and Suggestion in Construction Period

(1) Wastewater from Sand-gravel Rinsing

1) Processing Scale

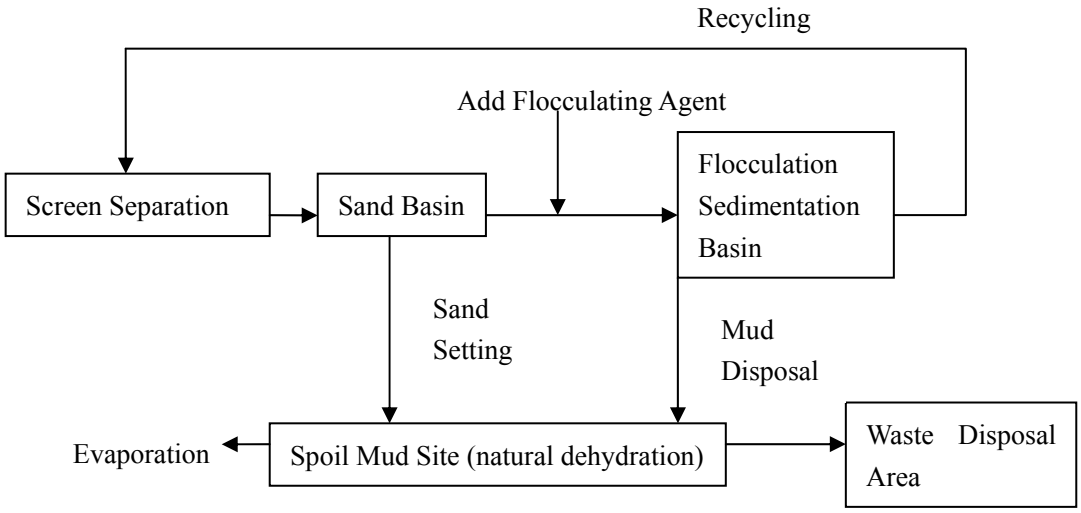
The processing scale of the wastewater from sand-gravel rinsing is 190

2) Treatment Processing Flow

Wastewater from sand-gravel rinsing can be processed by means of natural sedimentation, flocculation sedimentation and mechanical accelerative clarification. In aspects of management and running costs, natural sedimentation is the best measure, in aspects of effects and area occupied; flocculation sedimentation and mechanical accelerative clarification have bigger advantages. Even though mechanical accelerative clarification occupies little land and flocculation sedimentation can save much flocculating agent, the requirement of designing, construction and management standard is very high. And because the suspended solids are mainly non-organic particles, and is quick to settle, flocculation sedimentation method is often the most recommended method for processing waste water of sand-gravel rinsing.

Integrating the water supply project design in construction area, the processing flow of wastewater treatment of the engineering sand-gravel processing system is in Chart 6-1.

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



The waste water from screening and gravel manufacture workshops flow into detritus pit, and can be reused after treated by the flocculation sedimentation pit, normally, a re-entering of the screening and sand-gravel workshop for rinsing is required. The waste mud accumulated from gravel and flocculation sedimentation pits are gathered at drying fields, and will be transported to waste fields after drying. In the case of Wangjiahe River Basin Hydroelectric Power Station, its engineering feature and construction layout, natural drying method is chosen. The waste mud will be transferred to large pit waste disposal field after drying up.

3) Designing plan

The gravel and flocculation sedimentation pits were to build will be sized as follows: gravel sedimentation pit occupies an area of 25 m^2, with 10m in length, 2.5m in width and 3m in height. The flocculation sedimentation pit consumes an area of 180 m^2, with 30m in length, 6m in width and 4m in height. PAM is used as flocculation agent, and a flocculation pit is unnecessary.

(2) The process of the waste water from base pit

The waste water from base pit is regularly at 2000mg/L, the concrete curing agent's PH is about 11-12. The gravel crumbs and concrete fluid that is in regular base pit waste water is easy to deposit. From statistics gathered from other hydroelectric power stations that has been built or are being building, after two hours' static status of the regular water in the base pit, the floating particle level is suitable for emission. During the deposition in the base pit, the waste water will be mixed with acid, which can lower the alkalinity in the concrete curing agent. Therefore, the waste water is to stay at least 2 hours at the base pit for deposition and be emitted after satisfying standards. Use PH indicator to measure PH level of waste water.

(3) Mixing of concrete and waste water from cleansing

The waste water from cleansing mixing drum is intermittently and concentrated emitted. The density of float particles in the waste water is approximately 5000mg/L, PH is 12. Because the small amount is being emitted, it is planned to build a sedimentary pit beside the mixing system, with an area of $2m^2$ and a volume of $2m^3$. The clear liquid should be reused when possible; the mud should be regularly cleaned and be transported to drying field.

(4) The treatment of oily waste water

This mechanic factory is close to gravel process area of the construction site, the waste water from maintaining cleansing vehicles contain a large quantity of petrol and floating particles.

- Wastewater Treatment Plan

After gathering of the waste water, two methods, namely, oil water separation device or mixing with flocculation fluids may be adopted. The advantage of oil water separation device is it has good results in separating the two substances but requires

big investment and high maintenance cost. Periodically mixing with flocculation fluids have an advantage of being cheap, simple and easy to manage. Because of the low waste water emitting quantity, flocculation method is recommended.

- Plan Design

Surrounding the machine maintenance field with cement mortar ditch to collect waste water before discharge them to rectangle cement mortar treatment pit. The treatment pit should be near living quarters, with an area of approximately $6m^{2,}$ 3m in length, 2m in width and 1.5m in height. After oil contained waste water enter the pit, and mixed with flocculation fluid at night, it will be emitted the next day after a whole night's flocculation deposition.

- Operational Maintenance and Management

Because of the small quantity of waste water and simple design of the treatment pit, no machinery and maintenance is required. Only periodically clean up of the floculate is necessary.

(5) Domestic Wastewater Treatment

- The quantity of waste water

Domestic waste water comes from worker's water consumption and emission of excrement. There's one office/living area in the construction site, the waste water emit peak is $48m^3/d$, the main contaminants in the water is SS, SS、BOD_5、COD and NH_3-N.

- Treatment Plan

Domestic waste water could be processed by treatment facilities like burying facility, septic-tank, marsh gas tank, etc. Powerless burying facility and septic-tank process treatment have different advantageous, but the most important matter is the processed

water is not up to the standards for emission. Marsh gas tank takes up too much space, and it is difficult to arrange.

Construction site is in the wilderness far from urban area, according to present situation of the construction area and regional status quo, building temporary bathrooms and simple septic tank are more suitable to local objective condition and technical standard. The average purification efficiency for septic pit is between 50% and 90%. COD, BOD_{5}'s purification efficiency is 60%, SS is 70%. Although the COD, BOD5 content is still higher than standard but from engineer and environmental aspect, the effects are limited, and is staged and sectional.

From the perspective of environmental protection, to maximally reduce pollution caused by domestic waste water, it is suggested to adopt dry bathrooms, and give feces to surrounding farmers as fertilizers.

6.1.2 Protection Measures and Suggestion during Operational Period

(1) Cleaning up the bottom of the reservoir. Construction units must clean the bottom of the reservoir according to reservoir bottom clean up standards prior to impoundment. A thorough cleaning to various pollutant sources must be carried out in submersion area to prevent water quality deterioration in the initial period of reservoir impoundment. In the operational period, regular floating waste cleaning up should be scheduled.

(2) Strengthening the management over reservoir area contamination. To reduce the negative effects done to water quality by area source contamination, local hydrological, agriculture and forest department should cooperate to reduce soil erosion in the upstream of the reservoir. Turn normal farms into terraces farm, cultivated land into forests on slope steeper than 25°. Construction Company should

plant vegetation around the reservoir, to ensure a 40% forest cover rate in the area affected by the reservoir. Strengthen management on fertilizers and pesticides. Apply fertilizer according to different soil types, crops and seasons to reduce consumption of fertilizer and pesticide to improve water quality.

(3) Domestic waste water treatment. Upon completion of the project, the waste water emitted is mainly staff's domestic wastewater. Even though contaminants are small in quantity, but it's still categorized in over proof waste water emission. It is required to build domestic waste water treatment unit while construction. Micro-power small-scale domestic sewage treatment plant could be used to ensure the waste water emit after process.

(4) Because the small capacity of the reservoir, fish farming is not suitable in the reservoir for it can easily cause eutrophication of the water body.

(5) Ban the construction of new waste water emission pipe in the reservoir area or along the upstream of the reservoir.

(6) Provide water quality forecast for the reservoir area periodically to guarantee scientific support for the water environment management of the reservoir.

6.2 Prevention and Control Measures and Suggestion on Atmospheric Pollution

(1) The Reduction and Control of Oil Exhaust Gas

Strengthen the management on large construction vehicles and machinery. All machinery and equipments supplied by the contractor should be equipped with smoke prevention and dust control equipments. Checking and maintaining regularly on all vehicles and machinery to ensure that they satisfy waste gas emission standards.

(2) Reduction and Control of Dust in Construction Period

The sand-gravel processing adopts the low-dust technique of wet crushing in order to reduce dust. Drilling, blast should take wet method. In the frequent excavation, blasting construction site, water spray can effectively reduce dust. Underground projects adopt water spray and ventilation system to improve the spread of contaminates and reduces working area dust density.

(3) The Reduction and Control of Dust Caused by Transportation

The permanent road surface adopts concrete or cement hardening, so as to reduce dust generated by traffic and transport on soil, gravel road. The roads will be under periodical maintenance and cleaning to maintain its normal function. When loaded with dusty material, trucks should be covered by moistened textile or canvas. Trucks with bulk cement or storage tank should be well sealed. Packed cement should be covered when transporting. Vehicle cleansing should be frequent, spay water no less than 2-3 times a day on windy or sunny days.

(4) Health protection

Take measures like wearing masks for those who are exposed to contaminations. Along with soil conservation, plant vegetation around office area and along roads to reduce dust. For vehicles driving around office or living sections, the speed limit shouldn’t exceed 15km/h

6.3 Prevention and Control of Noise

Strengthen control over noise source, regular machinery repair and maintenance, use machinery with low noise, install shock absorption base to intensely vibrating equipments. Planting vegetation surrounding the construction site and on both sides of main transport causeways to reduce noise pollution. The usage of high noise level machines should be limited to time when people are not at rest. Strengthen labor protection of workers, for those who work under high noise, daily working time may not exceed 6 hours. Noise protection equipments must be distributed to these workers

as well.

6.4 Solid Waste Treatment

(1) Waste Disposal

Waste from construction should be collected and gathered at a fixed place, with protection to prevent soil erosion. Please see soil maintain chapter for details

(2) Domestic Waste Disposal

300 people should be working on construction site at peak time, and average domestic garbage produced is 0.3 ton per day. Sanitation utilities should be placed with in construction sites, with fixed garbage cans to gather domestic waste. Garbage can placement is similar to bathroom's placement. Garbage cans must be cleaned and sterilized regularly to prevent pest multiplication. Construction management department should gather manpower or let local environment protection department to clean construction sites and process waste to improve sanitation standard of the site.

6.5 Ecological Environment protection

6.5.1 Terrestrial Organisms

(1) Vegetation Conservation on Construction Area

Do as much as possible to reduce the damage done to harm vegetation within construction site by excavation of soil and rocks, preserve the top layer of soil for re-cultivation and recovery of vegetation. Construction sites, hydroelectric power station area and dam area should be environmentally friendly designed, forestation according to requirements, to establish beautiful surroundings.

(2) Vegetation Recovery of Reservoir and Surrounding Areas

After water impoundment of the Wangjiahe River Basin reservoir Hydroelectric Power Stations, 35mu (1mu=0.667hectares) of cultivated land and 220mu of forest will be submerged. Forest being submerged must be recovered by means of relocation. Local forest department should plan the relocation place and types of forests according to the actual situations. Build a multi-stage reservoir area forest belt according the order of water resource forest, water and soil preservation forest and bank protection forests. Build an ecological sheltering forest, enlarge forested land, protect and enlarge the ecological environment of the dam area. Methods like turning slope into terrace, biological fence, and planted forest can be used to improve the scenic ecological environment of the reservoir area.

(3) Implement forest closure, ban indiscriminate felling of trees, and carry out Grain for Green on all slopes more than 25°, naturally recovering the eco-system, provide terrestrial animals with good living surroundings, to benefit the prosperity of the animal and plants in the reservoir area, preventing new soil erosion to happen.

(4) Ban the indiscriminate felling of trees, protect wildlife habitat, widely publicize wildlife protection law, and strengthen the protection upon endangered species, especially on state and province level endangered species, to maintain the stability of the specie diversity in the area.

6.5.2 Aquatic Organisms

(1) Best to Grow Naturally, Fish Farming Forbidden.

Considering a new balance between reservoir fishes will be reached a period of time after the reservoir runs naturally, because the reservoir's low capacity, fish farming is forbidden within the reservoir, to prevent contamination of the water.

(2) Strengthen Surveillance on Aquatic Organisms

Food organisms, water environment, fish resources and population structure will

undergo change after reservoir's being built. Determine the trend of reservoir fish resource change and adjust protection plans in time, according to the result of surveillance.

6.5.3 Other Suggestions to Environmental Protection

To ensure the living and production safety downstream from the dam, the first impoundment by the reservoir may not be used for living and production, related supervision will be performed.

6.6 Measures to Prevent Water and Soil Erosion

Control soil erosion caused by construction, draft soil erosion prevention report, and clarify responsibilities to prevent soil erosion.

6.6.1 Guidance

Newly added soil erosion is mainly waste from construction process. Therefore, the top priority for prevention of soil erosion is at construction site, waste transport site and waste disposal field.

Seeing from the prevention of soil erosion intensity, engineering measures should be used to round up waste, assisted by botanical measures. Water draining systems must be build around waste piles to prevent it to be washed away by rainfall.

Seeing from the prevention of soil erosion intensity and total amount of erosion, key point in surveillance should be in the construction period. Key area should be temporary waste gather point and waste disposal ground.

6.6.2 Goal toward Water and Soil Conservation

According to the specifications in ***Technical Regulation on Water and Soil***

Conservation Plan of Development and Construction Projects (SL204-98), the overall goal for soil conservation in this project is to control soil erosion within the responsible area and protect the safety of project construction as well as the well being of local ecological environment. The specific methods are as follows:

(1) Recover as much of the cultivated and forested land and other water and soil conservation facilities destroyed by the project as possible, and protect the biological environment; reduce soil erosion, to ensure the recovery rate of disturbed land reaches at least 70%.

(2) Take technical measures to reestablish plant coverage to improve the soil's water retaining capacity that is damaged by constructional activities such as digging and building. Solve the soil erosion problem by at least 95%. Control new soil erosions, achieving a soil maintaining rate above 95%.

(3) Collectively store project waste, and carry out dual-protection of engineering and botanical measures on the loose deposit of waste, so the waste erosion is effectively prevented and controlled, and the waste protection rate reaches over 95%.

(4) For permanent or temporary construction land, re-cultivation and planting shall be performed if possible, to recover vegetation by at least 90%, forest and grass cover more than 20% of responsible area, improve local environment, control soil erosion and prevent new ones.

6.6.3 The Overall Plan for Water and Soil Conservation

Adopt different prevention plans according to the landscape, geological soil condition and soil erosion status. Taking construction features, the long-term develop plan for the construction site, target to prevent soil erosion.

6.7 Protection of People's Health

6.7.1 Strictly Clean Reservoir Bottom

Carry out cleaning activities in the construction area, lowering density of disease-leading microorganisms and pests in construction areas, to prevent the outbreak of epidemics.

(1) Site Sterilization

Mainly includes sterilization in places where workers are concentrated or where there's used to be bathrooms, cesspit, pens, garbage gathering points or cemeteries. After construction, clean up the temporary living quarters, bathrooms and garbage gathering points. Sterilize with mist sprayers with carbolic acid, according to the ***Standard of Sterilization Technique***, take care to clean up the waste as well as carefully sterilizing.

(2) Eliminating Vector Organism

During the period of construction, two pest elimination activities should be carried out each year during the spring and fall. The main objective is to eliminate rats, mosquitoes and flies, in order to exterminate the origin of infection and infectious vector. To eliminate rats, mouse traps and toxic baits should be used, for flies and mosquitoes spray should be used. Distribute the drugs and tools to workers for utilizing under the guidance of anti-epidemic personnel.

6.7.2 Health and Epidemic Prevention Plan

(1) Health Quarantine

Inspect the health status of construction personnel before they enter site and discover and control disease carrier and the bacteria they are carrying, prevent the outbreak of epidemic among workers and local residents. Carry out sample tests according to inspection results for items including virus hepatitis, hemorrhagic fever and malaria.

The frequency of the inspection is: construction and management personnel must receive check ups before entering the site, and two check ups during the construction period which consists of 20% of the whole construction population each. Health check ups for workers during construction period and establish documents recording epidemic conditions.

(2) Health Examination

After beginning of the construction, medical surroundings of the construction site will improve, the labor intensity of workers will also rise and due to the difference of physique, new infectious case might appear. Health check ups and surveillance during construction period helps to acquire the information on health status of workers during different construction periods, prevent and control different kinds of epidemic from spreading, and to keep the construction carry on normally. Health check ups should be according to the actual situation, a yearly check up for catering staff, workers with contact with powder, intense noise and other harmful factors should be carried out and the results should be documented.

(3) The Prevention of Epidemics

Due to the high population density in the construction site and the high intensity of working, planned immunizations were carried out to workers to improve the workers' resistance ability against epidemic, preventing cold, hemorrhagic fever and malaria to spread between workers during the construction period. Pill taking and vaccination should be adopted as methods to prevent epidemic that is dangerous during hydro-project constructions. Moreover, enough tetanus prevention doses and anti-venom medicine should be kept at the construction medical facilities, to treat workers who is infected by tetanus or bitten by poisonous snakes.

(4) Sanitation Propaganda and Management

Construction company and supervising company should clarify the people with the

responsibilities of epidemic prevention, who should be responsible for the health propaganda and management of the population within his/hers responsible range, to build and prefect epidemic reporting system, discover epidemic and report to higher departments immediately. He/she should also supervise the food production process within the construction site periodically and check the health cards of catering staff within the construction site, enforce the supervision over the sterilizing of drinking water on site.

6.7.3 Public Health Facilities

The layout of public sanitation facilities in the construction area depends on the overall construction site plan, taking the construction management reality and the spread of workers into consideration, temporary public bathrooms will be built. The requirements of the temporary public bathrooms are as follows: locating at least 30 meters from canteen, with convenient access. The setting of the toilets should fulfill the requirement of the ***Hygienic standards for the Design of Industrial Enterprises (TJ35-79)***, which is issued by the National Health Administration and the State Bureau of Labor. The number of Bathrooms and the number of toilets bowls in each bathroom depends on the surrounding people density.

Depending on the spread of workers and the living quarters in construction site, garbage bins should be installed in both construction and living sectors. Daily garbage should be disposed on time. Dumping into rivers and drainage ditch are forbidden to prevent contamination of the water.

7.Environmental Monitoring and Management

7.1 Environmental Monitoring Plan

7.1.1 Monitoring Purposes and Demands

Wangjiahe River Basin Hydroelectric Power Station Project should monitor the environmental change and impact in the process of construction and operational period so as to knowing the changing situations of various environmental factors in the scope of construction effect as well as the result of taking effect the environmental measures, in order to find timely the environmental issues, then propose the corresponding measures to relief the disadvantage effects for the project and provide the scientific proof for environmental management, checking the finished project and so on.

The ecological and environmental monitoring should take advantage of the existing monitoring sections (points) of the local environmental monitoring stations, epidemic or diseases prevention stations, fishery bureau, forestry department and so forth. Environmental monitoring plan put into the trust to the corresponding qualification units to do the monitoring.

7.1.2 Environmental Monitoring in Construction Period

7.1.2.1 Water Quality

（1）River Water Quality Monitoring

Sections setting: to set up a monitoring section at the end of backwater in reservoir, 200m upstream and 500m downstream points of the dam, and the 300m point

downstream of the II dam respectively, which included the total four sections in front, under of the sections of the dam, and the water quality section of construction areas as well as construction area itself.

Monitoring programs: Water temperature, pH, suspended load, dissolved oxygen, BOD_5, permanganate index, oil, total phosphorus, total nitrogen, NH_3-N and fecal coliform, etc in total 11 items.

Monitoring method: in accordance with the monitoring methods in ***Monitoring Technical Specifications of Surface Water and Wastewater（HJ/T91-2002）***.

Monitoring time and frequency: before impoundment, river water quality will be monitored one year; the time of monitoring sections in the construction areas is 20 months in construction period. The frequency is 3 times each year by the wet, normal and dry seasons.

（2）Sewage Discharge Outlets Monitoring

Layout of monitoring points: set up a monitoring point at aggregate processing system, machine repairing and parking lots, discharge outlets of concrete mixing stations and domestic sewage respectively.

Monitoring programs: monitoring program of production wastewater is drafted as the PH, suspended loads and so on. Sometimes it can be added with the others' programs if it is necessary. Monitoring program of living sewage is drafted as the chemical oxygen demand, 5 day BOD, suspended loads, total phosphorus, total nitrogen, petroleum, fecal coliform and so forth.

Monitoring method: in accordance with ***Monitoring Technical Specifications of Surface Water and Wastewater（HJ/T91-2002）***.

Monitoring time and frequency: Construction period and water quality monitoring

carried out simultaneously.

7.1.2.2 Air monitoring

Layout of monitoring points: set up a monitoring point at construction area of Chi-nan Hydroelectric Power Station, Wangjiahe River Dam Construction Sites and Wangjiahe II Hydroelectric Power Station, as well as living area.

Monitoring program: nitrogen dioxide, sulfur dioxide, PM10 (or TSP)

Monitoring method: in accordance with the concerning technical specifications of monitoring in ***Ambient Air Quality Standards***.

Monitoring time and frequency: the monitoring will be done one time each year, which lasted five days in one times. The monitoring time is construction period.

7.1.2.3 Noise Monitoring

（1）Regional Environment Noise Monitoring

Layout of monitoring points: set up a monitoring point at construction area of Chi-nan Hydroelectric Power Station, Wangjiahe Dam Sites, Wangjiahe II Hydroelectric Power Station, Sand-gravel aggregate field, Concrete mixing tower, and the workers' living area where is next to the entering factory highway, as well as the aggregate processing system respectively, in total 8 points.

Monitoring frequency: monitoring will be done one time each year which takes 24h, the monitoring working period is construction period.

（2）Road traffic noise monitoring

Layout of monitoring points: set up a monitoring point besides the main road, the specific monitoring sites should meet the requirements of ***Technical Specifications of***

Environmental Monitoring.

Monitoring frequency: monitoring will be done one time, and record the transit vehicle flow.

7.1.2.4 Aquatic monitoring

Monitoring sections: set up a monitoring section at the end of backwater in reservoir, 200m of upstream and 500m of lower stream of the dam respectively.

Monitoring content: zooplankton and phytoplankton, bottom-dwelling organisms, aquatic advanced plants and fishes.

Monitoring time and frequency: monitoring will be done a year before impoundment of the reservoir, in April.

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, entomophilies 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 and Quarantine 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 benefit of the project.

Monitoring methods: The methods are field survey and on-the-spot monitoring.

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

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

7.1.3 Environmental Monitoring during Operational Period

(1) Water quality

Section settings: to set up one monitoring section at 200m upstream of the dam, and in the downstream 500m respectively, as well as the end of backwater in the reservoir.

Monitoring items: water temperature, pH, suspended solids, dissolved oxygen, BOD_5, permanganate index, oil, total phosphorus, total nitrogen, NH_3-N and fecal coliform, etc. in total of 11 items.

Monitoring methods: in line with the monitoring method in ***surface water and wastewater monitoring technical specifications*** (HJ/T91-2002).

Monitoring time and frequency: to monitor every year in the three water seasons of high, middle and low after impoundment, then continue to monitoring for two years

(2) Water Temperature

Layout of monitoring sections: to set up an observation section at the 300m upstream and downstream of the dam, as well as in the mouth of the downstream of the dam.

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

(3) Aquatic organisms

Monitoring sections: to set up one monitoring section at 200m upstream of the dam, and downstream 500m, as well as the end of backwater of the reservoir.

Monitoring Content: include zooplankton phytoplankton, benthic organisms, aquatic higher plants, fishes.

Monitoring time and frequency: after impoundment.

(4) Water and Soil Erosion

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

Monitoring contents: water and soil erosion amount; the damage from water and soil erosion; the benefit of soil and water conservation project.

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

Layout of monitoring points: an observation point will be laid in the waste disposal

area 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 to two monitor points.

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

7.2 Environmental Management

7.2.1 Environmental Management Purpose and Goal

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:

 Prevent from ecological damage caused by the construction and operation period and protect the overall ecological environment where is affected by the project.

 Strengthen water quality, air, noise and other environment pollution control in order to prevent eutrophication from the reservoir and functional degradation of Wangjiahe River Hydroelectric Power Station for the protection of population health.

 Do a good job on soil and water conservation project.

 Protect biodiversity in the assessment areas

 Various environmental protection measures to implement the project, so that "he who develops is responsible for protection; he who destroys must restores; he who utilizes compensates" policy be fully implemented.

7.2.2 Environmental Management Missions

 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, clarify the environmental responsibility system and its rewards and punishments.

 Organizes and coordinate the report and each one of the mission put forward by the examination suggestion, to take effect the eco-environment compensation and control of the funds for preventing pollution.

 Be responsible for handling various types of accidents caused by pollution and destruction of ecological environment.

 Formulate the plan for implementing ecological environment monitoring programs.

 Implement the supervision work.

 Establish a complete project environment management information archive.

 Organizes the project environmental management and professional training for monitoring staff.

 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, the management department of Wangjiahe Reservoir Hydroelectric Power Station Project set up environmental management office to accept the inspection guidance from the business, local environmental protection departments; its main function is daily work on environmental management, coordination of environmental disputes and dealing with environmental accidents, as well as the environmental monitoring from 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 department which have implemented the eco-project during the construction period to implement the eco-project for the entire professional department and the environmental protection of project contractor.

7.3.1 Environmental Supervision Mission

(1) According to relevant laws and regulations and environmental protection project agreement, carry out check and supervision for the entire professional sectors which

have implemented the eco-project during the construction period, demand time limits for completion of the related environmental protection work.

(2) Assist the Environmental Management Office and relevant departments deal with environmental pollution accidents in the project-affected zone and environmental disputes.

(3) Prepare monthly and half-year report of environmental supervision and submit to the environmental management office for summing up the environmental supervision work so as to figure out the major environmental problems and give the suggestion to solve them, clarify the arrangement of environmental supervision and the working emphasis.

7.3.2 Supervision Method

Supervision employs the methods of checking and directive documents.

7.3.3 Supervisors Setting

According to environment supervision workload of Wangjiahe River Basin Power Station Projects, an environmental supervisor is needed. (Excluding the supervision on Soil and Water Conservation)

8、Environmental Protection Investment and Economic Profits and Loss Analysis

8.1 Environmental Protection Investment Estimation

According to environmental economic principle and environmental laws and regulations as well as the basic principal “anyone who damages it has the responsibility for regulation” of ecological environment, it is necessary to make environmental risk the lowest in order to make less loss to the environment because of proposed project, avoid ecological deterioration and make economic, ecological virtuous circle and sustainable development a reality.

8.1.1 Investment Principle

Considering actual situation of project and in line with related laws, regulations and policies issued by the state, we have determined some principles on investment:

(1) Principle of “those who pollutes treats while those who exploits protects”: ensure environmental protection investment project based on this principle, which can guide investment distribution if necessary.

(2) “Functional protection” principle: treatment towards pollution takes protection for project function as the target.

(3) “Functional recovery” principle: investment scale takes protecting or recovering the ecological environmental function as it was before construction as the aim.

(4) “One-time compensation” principle: ecological environment damage caused by the project should be compensated in a standard way of one-time compensation.

8.1.2 Basis for estimation

□***Design of Water Resources and Hydroelectric Project estimated compilation principles and calculation criteria*** (State Economic and Trade Commission, 2002)

□***Notice of State Planning Commission, State Environmental Protection Administration on Regulating Environmental Influence Consultation Charge*** (State Planning Commission 2002/No.125 Document)

□Environmental Protection Measure Design of Wangjiahe Reservoir Hydroelectric Power Station Project

□Related material can be based on market price in the first half of 2007;

□Interim charge provisions of environmental protection industry and environmental superintendence charge management method of Hubei province.

8.1.3 Investment Project Division

According to the regulations of environmental protection on construction project: all the equipments devices, monitoring means and project facilities that pollution treatment and environmental protection need, belong to environmental protection facilities.

Construction projects with environmental protection facilities should list their investment estimation.

Environmental protection projects that need special protection investment of this project mainly include environmental protection in construction area, environmental monitoring and management, water quality protection of the reservoir and so on. For environmental protection investments from other sources, such as reservoir cleaning up, reservoir submerging and compensation, environmental protection facilities in construction and so on, are not involved in special environmental protection investments which need another list in project investment.

8.1.4 Major Environmental Protection Investment

In accordance with the foundation unit price and comprehensive unit price that are based on environmental influence of Wangjiahe River Basin Reservoir and Power Station project, environmental protection measures and related measures, the total investment of this project environmental protection is 5.39 million RMB estimated on above principles: junction project area environmental protection measure investment 1,224,400RMB, accounts for 22.7% in total environmental protection investment; independent fees 369,700RMB, takes up 6.9%; water and soil conservation total investment 3,795,900RMB, 70.4%. Compensation fee for occupied land is not included in project environmental protection investment. Project environmental protection investment is as table 8-1:

Table 8-1 table of Wangjiahe basin reservoir power station environmental protection subentry investment estimation

No.	Names of Project or Charge	unit	quantity	Unit price (RMB)	Total (10,000RMB)	remarks
□Environmental protection of power station and reservoir junction project					122．44	
I	Waste water treatment				23.8	
1	Domestic sewage treatment	m^3	40	2500	10	Cesspool + oligodynamic domestic sewage treatment facility
2	oily waste water treatment	spot	1	60000	6.0	
3	waste water treatment of sand and stone processing				18.0	this charge is already in the list of sand and stone processing system
	□construction fee	Spot	4	90000	36.0	construction prophase
	□operation fee	Year	3	60000	18.0	operation charge of waste water treatment of sand and stone processing
4	Wastewater treatment of concrete production system	spot	1	18000	1．8	include operation fee during construction
II	environment and air quality protection				4.3	

No.	Names of Project or Charge	unit	quantity	Unit price（RMB）	Total（10,000RMB）	remarks
	□Spray	year	2	60000	12.0	include salary, water rate and so on
	□Dust mask	set	900	10	0.9	
III	Noise prevention				0.9	
	Personal protection of strong noise	set	900	10	0.9	
IV	household garbage dealing				2．44	
	Trash		10	1000	1．0	
	Household garbage dealing	t	120	120	1．44	
V	Public health protection				21	
1	Hygienic cleaning	m^2	20000	1	2	before and after entering construction site, once for each
2	Health Quarantine		2×300	180.0	10．8	
3	Prevention and Immunity		2×300	100	6	
4	Rat and mosquito destruction		2×300	20	1．2	comprehensive unit price
5	Sanitation toilet	spot	5	2000	1	
VI	Aquatic organism protection	year	6	60000	36	
VII	Ecological and environmental monitoring				34	
1	Water environment				10	
2	Environmental air quality				5	
3	Noise				2	
4	Aquatic organism				15	
5	Epidemic surveillance				2	
□ independent fee					36.97	
I	Construction management fee				26．67	
1	The overhead of Environmental management personnel				3．67	3% of first part
2	Designing fee of scientific research and reconnaissance				20.0	
3	Environmental protection publicity and technical training				3．1	2.5% of first part
二	Cost of environmental superintendence		1×2	50000	10.0	
三	Project quality supervision fee				0.3	0.25% of first part
Environmental protection static total investment					159．41	

No.	Names of Project or Charge	unit	quantity	Unit price (RMB)	Total (10,000RMB)	remarks
□	Water and soil conservation static total investment				379.57	
	Environmental protection total investment				539	

8.2 Ecological Influence and Economic Profit and Loss Analysis

8.2.1 Economic Benefit

Power generation takes the dominant part in Wangjiahe basin reservoir power station project, whose benefits are mainly from two aspects: direct economic benefit of power generation and social benefit by protecting and improving regional surrounding environment.

With installed capacity 12630kw, multi-year average electric energy 48.432million kWh, power station can take part in system peak regulation despite its small capacity. Thus, it will be an adjustable power that can conduct long term self operation among Wufeng County electric system, which is very favorable for alleviating conflict between local system power consumption and peak regulation as well as improving system power supply quality. The development of electric power will inevitably promote regional economic construction and the development of industrial and agricultural production.

After completion, Chi-nan Hydroelectric Power Station financial indicators after the income tax is as follows: financial internal rate of return 11.56%, financial net present value 3.58million RMB, investment payoff period (include construction period) 9.94 years; before the tax income, financial internal rate of return 12.44%, financial net present value 6.51million RMB, investment payoff period 9.13 years (include construction period). Economic internal rate of return is 13.16% and economic net

present value is 6.79million RMB.

Financial index before the income tax of Wangjiahe water and electricity hinge project is as follows: financial internal rate of return 10.14%, financial net present value 19,924,900 RMB, investment payoff period (include construction period) 11.11 years; after the income tax, financial internal rate of return 8.75%, financial net present value 6,436,600RMB, investment payoff period (include construction period) 12.21 years. Economic internal rate of return is10.32% and economic net present value is 21.48million RMB.

Referring to industrial and agricultural output value estimation created by kWh electric quantity of central and east China, Wufeng County can annually create industrial and agricultural output value of over 300million RMB.

8.2.2 Social Benefit

Making full use of local natural geological conditions and advantages, this project will earn relative good social benefit:

（1）After completion, flood, landslide and debris flow can be alleviated in different degrees, which creates a safe environment of living and production for people in the surrounding area to live and work in peace and contentment. Make the mountains and rivers more beautiful and provide an elegant working environment for power station's staff as well through forest and grass measures construction.

（2）Proposed project has positive benefits for protecting and utilizing land resources: enhanced flood storage capacity of water resource project can improve flood prevention probability; due to the completion of intake dam and tunnel, local flood drainage ability can be improved to some extend so submerged area and duration can be relatively lessened.

（3）Upon operation of the project, job opportunities and employment environment will be provided which can increase local income and bring good social benefit.

8.2.3 Ecological Effect

During construction of this project, there will be certain influence on ecological environment. However, after completion, favorable impact will be dominant. With downstream flood threats alleviated, potential land enlarged and flood prevention probability increased, the project is propitious to forest closure 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, there will be better ecological environment benefit after completion.

8.2.4 Environmental Effect

Comparing with thermal power generation project of same scale, this project has better environmental benefit. Water and electricity are renewable resources as well as clean energies. Producing same power, hydro power station replaces thermal power station with standard coal consumption 480g/kW·h, means 2.3×10^4t/a less raw coal consumption, 113t/a less SO_2 emission , and less harmful substances like NO_2、CO_2、CO, dust and so on. Thus, it will do less harm to the surrounding environment caused by harmful substances from thermal power station entering atmosphere and water body. This hydropower station can save 4×10^4RMB/a pollution charge every year. Thanks to the non-transportation of coal, construction will do less damage to the environment while a large number of transportation device investment and occupied land by special lines will be saved.

8.2.3 Comprehensive Analysis on Environmental Economic Profit and Loss

It is easy to draw a conclusion from environmental protection investment and environment, economy and social benefit situation mentioned above: environmental loss is less than profit of the project while favorable influence on environment caused by project is obviously greater than disadvantages; social and economic benefits mainly embody 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 soil flood, 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 benefit brought by project is fairly good.

9. Public Participation

Public participation is an important part of environmental influence assessment. It will better inform the public of the construction procedure, operation features and the environmental issues related to the construction of Wangjiahe Hydroelectric Power Station and thus the opinions and suggestions from the public can be heard. At the same time, the negative effects from the construction on the environment can be avoided as much as possible and the design of the construction can be bettered and improved to take full use of its comprehensive benefits. Under the assistance of the local relevant departments, the assessment units can organize various activities for public participation.

9.1 Area, Approach and Content of Public Participation

9.1.1 Approach, Participants and Area of Participation

Hold interviews and informal discussions in the reservoir areas and the dam areas to distribute investigation forms of public participation to the people and carry out investigation in people with different professions in the reservoir areas, submerged areas and the towns.

The participants include social communities, administrative departments and the local residents in the reservoir areas. Altogether 50 people are included including technicians in the project, government officials, NPC deputies, representatives of CPPCC, ordinary masses and residents who will move their houses. Among them, there are more people from the construction site and reservoir areas influenced by the construction, which thus objectively reflects the willingness from the public in the construction site.

9.1.2 Contents for Investigation

The content and format of investigation form can be seen in Table 9-1

Table 9-1 Investigation Form of Public Participation

- Basic Information of the Participants

Name	Gender	Age	Education	Profession	Nationality
	□ M □ F	Age	□ University □ Secondary school □ Primary school □ Primary school unfinished	□ Cadre □ Worker □ Farmer □ others	
Name of the workplace					
Dwelling place					
Telephone					

- Contents of investigation

1、Do you know this project?

Yes□ No□

2、Your attitude to the project?

Approval □ Disapproval □

3、If you are in favor of the project, when do you think is the best time for construction?

immediately □ later □

4、What do you think are the influences from the construction on the regional economy?

great promotion function□ no great promotion function□ no promotion function at all□

5、How do you think of the current ecological environment in the construction site?

very good □ not bad □ bad □

6、What do you think are the aspects of the positive influence from the construction?

important for the general development;□

stimulate the local economic development□

improve regional environment □

enhance the flood control ability in the downstream □

improve regional ecological environment□

boost locals' living standards□

create job opportunities□

ameliorate the transportation □

others：_____

7、What do you think are the negative effect of the construction?

submerge land□

submerge rare plants and animals □

aggravate soil erosion and water loss □

others ：_____

8、What are the environmental problems in the places you are living?

inconvenient transportation □ soil erosion and water loss □ natural disasters □

其他 others ：_____

9、What are the rare plants and animals in the places you are living?

（1）rare animals：_____

（2）rare plants including medicinal materials：_____

10、Other suggestions?

_____

9.2 Analysis of the Investigation Results

9.2.1 Basic Information of Participants

We have altogether distributed 50 investigation forms to the public and received 50 with the callback rate of 100%. The distribution of the participants can be seen in Table 9-2.

Table 9-2 Distribution of the Participants

respondents / category		Farmer	Workers	Cadre	Army man	Other professions	Total	
Gender	M	17	6	4	4	5	32	50
	F	4	3	5	0	2	18	
	Total	21	9	9	4	7	50	
Education	University	0	0	5	0	2	7	50
	Secondary school	10	7	4	4	3	28	
	Primary school	11	1	0	0	2	15	

According to the results of the professions of the respondents, farmers take up a large percentage of 42.0%, who are mainly the local villagers. Among them, there are 16 farmers near the submerged areas, accounting for 76.2%. Next is the percentage of cadres and workers respectively with a percentage of 18.0%. Judging from the genders, males take up 64.0% of the total. Judging from the education, people with secondary school education take a relatively larger percentage of 56.0% and the people with education higher than primary and secondary schools take up 30.0% and the percentage of the people receiving university education is lowest, only 14%.

Among the respondents, there is one NPC deputy of the county and one NPPCC representatives of the county as well.

9.2.2 Analysis of the Feedback

The statistics of the investigation contents are seen in Table 9-3.

Table 9-3 Statistics of the Investigation Contents

No.	Contents		Number of people	Assorted people	Percentage
1	Do you know the project?	Yes	50	50	100%
		No		0	0
2	When do you think is the best time for construction	Immediately	50	49	98%
		Later		1	2%
3	What do you think are the influences from the construction on the regional economy?	Great promotion function	48	45	93.75%
		No great promotion function		3	6.25%
		No promotion function at all		0	0
4	How do you think of the	Very good	50	38	76%
		Not bad		12	24%

No.	Contents		Number of people	Assorted people	Percentage
	current ecological environment in the construction site?	Bad		0	0
5	What are the environmental problems in the places you are living?	Inconvenient transportation	50	50	100%
		Soil erosion and water loss		0	0
		Natural disasters		0	0
6	The positive influences of the construction.	Important for the general development	50	50	100%
		Stimulate the local economic development		50	100%
		Improve regional environment		26	52%
		Enhance the flood control ability in the downstream		12	24%

No.	Contents		Number of people	Assorted people	Percentage
		Improve regional ecological environment		32	64%
		Boost locals' living standards		48	98%
		Create job opportunities		26	52%
		Ameliorate the transportation		46	92%
7	What are the negative effects of the construction?	Submerge land	50	42	84%
		Submerge rare plants and animals		0	0
		Aggravate soil erosion and water loss		0	0
		Unwilling to move		0	0
8	What are the rare plants and animals in the places you are living?	Rare plants: none		0	0

(1) Among all the respondents, 50 people know that the early preparation of Wangjiahe Hydroelectric Power Station is being carried out, accounting for 100% of

the total, which shows that most of the people being surveyed know the construction of the project, the great influence of the project and the great concern of the public.

(2) 49 people suggest the project be constructed immediately, 98% of the total and there is one suggesting the delay of the project, 2% of the total. It demonstrates that the local are active in the regional economic activities and they have a strong desire to change the regional current situation.

(3) 76% of the respondents hold the opinion that the quality of current regional ecological environment is good with green mountains and pretty waters, which is suitable for living and traveling. 24% think the quality of the current ecological environment is just so-so mainly because that the control of the regional soil erosion and water loss is not powerful enough with the occasional occurrence of geological disasters like landslide, and the supporting facilities are not well equipped.

(4) In terms of the major problems in real life, 100% of the residents think the transportation is so inconvenient that it hinders the development of all other causes.

(5) Most of the respondents hold a positive view of the positive effects of the power station. 100% of them think it will be important for the general regional development and also 100% of them agree that it will facilitate the local economic development. 52% of them think it will improve regional environment, 98% support it will boost people's living standards and 92% think it will improve the transportation.

(6) Assorted information of the potential negative influence after the construction

No one thinks it will cause the problem of immigration, 0% of the total;

42 think that it will submerge the land, 84% of the total;

No one considers it may submerge rare plants or animals;

No one believes it will aggravate the soil erosion and water loss.

(7) In the investigation of the rare species in the local, people are more familiar with the animals than the plants. 82% of the local are familiar with the major rare animals and they take part in protecting them. No one knows and can answer whether there exist rare plants in the local.

9.2.3 Issues Concerned Most by the Public

Hold interviews in the reservoir areas with the villagers and conduct informal discussions with people from different professions to listen to the public opinions. Gather several issues and opinions concerned most greatly by the public from the feedback of the investigation form of public participation.

(1) The issue of the land compensation in the reservoir. They hope that the government and construction units will constitute compensation plans and implementation plans following the state policies. The land compensation should combine the state policies with the actual regional conditions to make sure the proper price of land expropriation. Also we need to go to the reservoir areas to know the thoughts and demands of the villagers thus to resolve the problem effectively without further problems.

(2) The construction quality. The quality of the construction is of vital importance and the public hopes that it will not become a jerry-built project.

(3) The exploitation after the construction. That is the issue of taking use of the construction to develop local economy in the long term. The public suggest the government should establish the construction plans matching with the project for infrastructure (road and communication) and relevant welfare facilities. And also make plans to accelerate local economic development to improve people’s living standards and then rise funding for construction.

(4) The issue of flood discharging and drainage in time and the ability of preventing flood in the operation period as well as the issue of soil erosion and water loss. The

public hopes the government can pay attention to these issues and check carefully the measures and strategies dealing with these issues in design and environment assessment.

9.3 Conclusion of Public Participation and Suggestions

In sum, the survey shows that the majority of the respondents have some basic idea of the project support the construction of the project. Most of them believe the construction will improve the living standard and stimulate the local economic development and create jobs. The main problem they are worried about is land compensation, environmental pollution and ecological destruction.

According to the suggestions in the investigation, they suggest the owners should strictly implement various measures for treating pollutions in the construction to reduce the air pollution, surface water pollution, noise pollution and solid waste pollution. Meanwhile, it will lessen soil erosion and water loss and ease the destruction on environment.

10. Conclusions and Suggestions

10.1 Conclusion of the Major Environment Element Assessment

(1) Regional climate

After the completion and the water storage of the reservoir, the original land is turned to water surface, which leads to the increase of the water area and the increment of evaporation in the reservoir than that before the construction. With the increase of the vapor in the air, the radiant heat of the sun is regulated and thus the humidity and temperature in the reservoir and the places nearby are changed, which results in the change in the regional climate. After the storage of the water, the temperature change may be gentle, the diurnal and annual temperature range may diminish and the highest temperature within a year may fall while the lowest temperate may rise. As the increase of the water surface area, the toughness of the underlying surface may be reduced and thus the surface wind speed in the reservoir may be increased. However, as the reservoir area is not that large, the influenced area is limited to the places near the reservoir with small change range.

(2) Hydrology and Sediment

The basin of Wangjiahe is in the mountain area and thus the flood is influenced by the intension of the rainstorm and the landscape. With intense rainstorm in the area and steep slope in the riverbed, it is short for the water to conflux and the speed is rather quick, which makes the flood have the feature of sudden rising and falling. The construction will change the natural watercourse in the reach of the reservoir and as the storage of water, the mud and sand in the reservoir will silt up gradually and hydrological conditions like the water level, runoff and flow speed will change correspondently. The change is multi-year average water level in the reaches in the reservoir will be larger and the average flow speed will be slower than in the natural

condition.

The water in the Wangjiahe Powerstation mainly comes to the dam through karst caves with little concentration of mud and sand, which will not cause silting up in the reservoir area.

(3) Geological Environment

The Wangjiahe Hydroelectric Power Station has slim possibility of karst cave leakage and faultage leakage. After the storage of water, collapse and small-scale landslide may occur in some places with no large-scale landslide, which will not bring serious safety threats after the storage of water. There are no mineral resources or cultural relics worth exploiting in the submerged areas and the submerged area is small. The geological structure in the area is relatively stable, which belongs to the microseismic zone and the possibility of earthquakes of high magnitude induced by the construction is rather slim. However, we still have to take anti-quake into consideration in the construction design.

(4) Water Quality and Water Temperature

After the storage of water and the operation of Wangjiahe Hydroelectric Power Station, the change of the hydrological conditions will not exert obvious negative influences on the water quality in the reservoir in the whole and the water quality can maintain its original condition. Small amount of discharged domestic sewage in the upstream will not influence the water quality in the whole and the reservoir, after the completion of the power station, is still nutrition-poor.

According to analysis, the reservoir of Wangjiahe Hydroelectric Power Station is a mixed one. Large-scale spawning sites for economic fishes and rare fishes have not been found in the downstream and there is no demand for water in production, domestic life and irrigation in the reservoir. Thus, the low temperature water in the summer in the reservoir of Wangjiahe Hydroelectric Power Station will have little

influence on the downstream.

(5) Ecological Environment on the Land

After the operation of the powerstation, part of the forestland with high productivity will be submerged and the functions of the land will be correspondently changed, which will reduce the productivity in the regional natural system but still maintain to have relatively high productivity. Thus, the construction of the project will not have great influences on the regional ecological environment.

The construction and the submerging will bring about negative influences on the plants. Except for the main plants, shrubbery, in the submerged areas, the submerging will not cover original vegetation, large areas of economic forests and rare plants. The project also will not exert great influences on the wildlife, not to mention the obvious influences on the species groups and the species diversity of the wildlife in the reservoir.

(6) Aquatic Organism

After the storage of water, due to the submerging in the reaches of the reservoir, the nutritive salts will be increased, primary productivity be improved and the baits will be better which is beneficial to the inhabiting and reproduction for the fishes in the slow flowing water or still water.

After the storage of water, the dam will form into an obstruction and the continuity of the original jet stream ecological system will be damaged. Meanwhile, the construction of the dam will pose as an obstruction for the fish to go upstream, which will lead to the decrease of the fish resources in the dam area.

Seven dumping sites will be set up along the construction line, respectively in the main dam site, near the open channels and all the branch tunnels. Three sides of the dumping sites are designed to be set with barrel-drains, which will be lined with

mortar laid stones and will be connected with the nearby rivers. A sedimentation site will be built at the exit. Before piling up the garbage, get rid of the surface mellow soil and gather it to be piled up at a corner of the dumping site. After the dumping in the end of the construction, the dumping site will be recovered to farmland and forests. The adoption of the mentioned measures will not only ease the influence on ecological environment, but also will reduce its influences.

(7) Influence on the Environment in Construction Site

Located in the mountains, the construction site has relatively good air quality and sound environment. As the dusts from the construction, waste gas from the operation of machines, the exhaust gas from the vehicles and the flying ashes on the roads will not bring about obvious influences on the regional air quality, the influence is mainly felt by the workers and thus, the protection of the workers should be enhanced. The source of the pollution on the water in the construction mainly comes from the waste water for washing the aggregate processing system, the discharged water from digging the foundation pit, the water for washing and maintaining machines, waste water for mixing concrete and domestic sewage of the workers. The waste water and the domestic sewage will pollute part of the reaches in the constructed area. The gather of a large number of workers will produce a lot of rubbish. Waste water, waste gas, noise and domestic garbage will influence the environment in the construction site to a certain extent but not serious and the influence will disappear as soon as the construction ends.

(8) Soil Erosion and Water Loss

The construction of the road inside the site, excavation of earth and rocks will all cause a certain amount of spoils of the project. If no proper measures being taken concerning water and soil conservation, the water and soil loss will be increased and lead to various degrees of impact on the productivity of the land, the flowing of the river, and the ecological environmental changes in the region, etc.

(9) People's Health

The high intensity of physical labor of the workers will lower their immunity. Thus, if the domestic sewage, production waste water and domestic garbage are not treated effectively, it is very easy for the flies and mosquitoes to reproduce, which will be a vector of infection for arbo infectious diseases and water borne diseases. At the early stage of water storage, the possibility of the occurrence of water borne diseases and natural source diseases may be increased and thus the prevention should be enhanced. The construction will not exert obvious influences on the local epidemics.

10.2 Conclusion of Environmental Protection Measures

(1) Environmental Protection Measures in the Construction Sites

The water pollution in the construction is mainly from the processing and production of sand-gravel aggregate and domestic sewage. The measure for treating waste water in producing sand-gravel aggregate is building sedimentation sites. As for the domestic sewage, treatment equipment like dry toilet plus septic tank should be used. In terms of the air pollution like dusts in the construction and flying ashes on the roads and noise pollution, measures like the individual protection for the field workers, spraying water on the road and limiting speed have been put forward. The adoption of the mentioned measures will surely reduce the influences from the construction on the air quality and sound environment, to a certain extent.

(2) Ecological Environment

As the construction of Wangjiahe Hydroelectric Power Station may bring negative influences on the aquatic organisms, measures like setting fish free for reproduction, monitoring aquatic organisms and guaranteeing the water for ecological use downstream in the operation period of the reservoir. In terms of the influence from the

submerging of reservoir and the construction on the ecological environment on the land, measures like recovering vegetation and enhancing publicity and management are put forward.

(3) Soil and Water Conservation

As for the newly emerged soil erosion and water loss in the construction site, treatment plans for maintaining water and soil for both plants and project are put forward in various fields including project construction, transportation road, dumping sites, material sites and factories.

(4) People's Health

The main protected object of people's health in this project is the workers. The measures for protecting people's health in the construction is mainly cleaning the site, controlling nocuous vector organisms, inspecting epidemics, vaccinating and publicizing hygienic knowledge.

(5) Inspecting Ecological Environment

In order to know the environmental changes in the construction and the change of water, air, noise and aquatic organisms in the influenced areas of the construction as well as the fulfillment of the environmental protection measures, ecological and environmental inspection plans in Wangjiahe Hydroelectric Power Station are put forward.

10.3 Conclusion of Comprehensive Assessment

The construction will meet the demand for electricity in the grid of Wufeng Tujia Autonomy County and ease the tense for electricity in some parts, which will promote the regional economic development. At the same tine, the profits from generating electricity will bring direct income like tax to Wufeng County and investment on

construction will be a force for pushing forward local economic development. Also, the entry of the construction and the workers in large number will stimulate the local consumption greatly.

The negative influences of the construction is: the loss from submerging the terrestrial vegetation after the water storage, potential negative influence on the water for ecological use in the downstream after the operation of reservoir, the pollution of waste water, waste gas and garbage in the construction and the soil erosion and water loss in the construction and so on. The negative influences from the construction can be eased or avoided by taking measures.

In conclusion, there are both advantages and disadvantages from the Wangjiahe Hydroelectric Power Station on the environment and the construction may degrade the natural environment in part of the influenced areas. However, in the long run, the construction will bring massive economic profits, great environmental benefits and obvious social benefits with small changes in the general regional environment quality. Thus, in terms of the environment, the construction of Wangjiahe Hydroelectric Power Station by TianRMB Hydroelectric Power Development Ltd. is feasible.

10.4 Suggestions

In order to minimize the negative influences of the construction to the lowest and give full play to its social, economical and environmental profits, following work is suggested:

(1) Reinforce the environment management in the construction period and protect the environment in the construction sites.

(2) Conduct the work for maintaining water and soil in the construction site and implement the plans for maintaining water and soil.

(3) Set up environment management organs to establish corresponding environment

management systems and put them into practice.

(4) Implement the investment on environmental protection and set up corresponding monitoring system to make sure the special use of special fund.

Water Resource Department

of Hubei Province

Hubei Bureau of Water Conservancy and Hydroelectric Power

No.173 Document/2007

Official Reply on the FS report of Wangjiehe Reservoir Hydroelectric Power Station and Chinan Hydroelectric Power Station of Wufeng County

Yichang Bureau of Water Conservancy & Hydroelectric Power:

Your ***Transit Report on the FS Report of Wangjiahe Reservoir Hydroelectric Power Station and the FS Report of Chinan Hydroelectric Power Station (Yichang Bureau of Water Conservancy & Hydroelectric Power No.132 Document/2007)*** has been received. The Official Reply upon deliberation is as follows:

1. Wufeng County enjoys abundant hydroelectric resource, and the hydroelectric infrastructure is of certain scale. However, with increasing electricity demand from economic development, the problem of insufficient electrical power, and especially the inadequate peak regulation capacity, is becoming particularly salient, which calls on us to build new electricity resources with peak regulating capacity. Wangjiahe Reservoir Hydroelectric Power Station and Chinan Hydroelectric Power Station are on the upstream reach of Zhisuohe River, first tributary of Qingjia River, and are developed with diversion type and overflow type respectively, with total installed capacity of 12630 kW and average annual power production of 48.423million kWh, and their investment per unit kW are both below 10,000RMB, which lead to favorable economic returns. Upon completion, their significant roles are to be shown on the alleviation of power shortage, decrease of electricity price in mountainous areas, the

development of “electricity for fuel” and the Grain for Green, forest closure, ecological environment protection, as well as on the economic and social sustainable development of the county. Therefore, it is necessary to build the two stations as soon as possible.

2. It is agreed to use Yukou Station as a reference station, and employ hydrological analogy method to analyze the runoffs of the dam sites of Wangjiahe Reservoir Hydroelectric Power Station and Chinan Hydroelectric Power Station, and the adoption of the results.

The method and design of flood analysis are agreed. And further rechecks should be done on the spillway water level and discharge volume relation curve of Wangjiahe Reservoir in the next stage.

The calculation and analysis results of coming sediments are seemingly small, and further recheck is requested.

Basic approval on the analysis result of reservoir characteristic water level. And it is suggested to make further study on the dead water level.

Basic approval on the calculation results of hydroenergy. Basic approval on the installed capacity of Wangjiehe I Hydroelectric Power Station as 630 kW, Wangjiehe II as 10,000 kW, Chinan Hydroelectric Power Station as 2,000 kW.

3. Wangjiehe River Basin is at the mid and lower reach of the Yangtze River, the compound part of the East-to-South Changyang-Wufeng Fold Belt and North-to-East Xinhuaxia System Sichuan-Hubei-Hunan-Guizhou Fold Belt, with a practically stable crust. According to ***The Zonation Map of Earthquake Ground Motion Parameters in China (GB18306-2001)***; within the region, earthquake peak acceleration is 0.05g, the Eigen period of earthquake motion response spectrum is 0.35S, and the corresponding basic earthquake intensity is 6 degree.

Wangjiahe Reservoir features a long and narrow reservoir area of approximately East-South direction. Left bank sees mostly reverse slope, with relatively steep gradient; left bank features cataclinal slope, but strata gradient is more steep than that of landform. Both banks have loose deposits of less thickness. And the assessment that reservoir banks have relatively stable structure in general is approved. The reservoir area is a vertical river valley, with clastic aquiclude petrofabric interlaid in strata of both banks, and the conclusion that there is no problem of leakage to lower valley of both sides is approved.

Wangjiahe Reservoir features a narrow landform of it dam site, steep on both sides, bedrock exposed. And the project geological assessment that it possesses the condition of building a dam of about 50m with local material is basically approved, and the upper dam site plan recommended in design is approved. However, when building impervious body on deep overburden layer on riverbed, following issues should be took into full consideration: the intensity and distortion of toe-boards and the sand gravel in main rock-filling area, and the leakage proof treatment of the percolation zone in K10 karst cave of Maokou formation limestone on the right bank, and feasible and effective engineering measures should be taken. During the construction process, the side slope of the right bank may induces bedding glide; and the sluice tunnel and diversion tunnel on the left bank go through fairly soft rock mass, which leads to relatively bad cave formation condition, and construction techniques should be paid attention to, and monitoring be improved, necessary protective measures taken, so as to ensure the security in construction and operation.

The left bank diversion line plan of Wangjiehe Reservoir II Hydroelectric Power Station is approved. Although the plan features a relatively long route, which goes through more strata, most of them are limestone stratum, the strata directions in general form a large angle with the direction of the tunnels, and the tunnel formation condition is relatively good. In the weak rock section in part of the area, the condition of rock formation is unfavorable, which requires certain protective measures to secure

the project. Ridge at fore bay is thin, weathering is deep on rock mass, therefore in-tunnel fore bay is suggested. The assessment of favorable geological condition at the powerhouse project is approved.

Basic approval on the description and appraisal of the geological condition of Chinan Hydroelectric Power Station, however, because of coarse granules of the colluvial deposits covering layer in Moshigou dam site, and the permeability of water, low dam that builds on it will suffer serious leakage which in long term will jeopardize the dam body. Proper adjustment of the dam site is suggested; it should sit on bedrocks. The powerhouse is on a covering layer of fair thickness, part of the anchor blocks and buttresses on covering layer prone to be instable. And appropriate movement of the powerhouse is recommended.

4. Wangjiehe Reservoir Hydroelectric Power Station is a Grade IV Type Minor I Project, its main buildings are of Grade IV, secondary buildings are of Grade V. Chinan Hydroelectric Power Station is a Grade V Type Minor I Project, its main buildings are of Grade V. It is agreed that the flood standards of the water retaining, diversion and intake structure, and the powerhouse of the I Station will be designed for flood of “50 years return period”, checked for floor of “300 years return period”. The flood standard of II Station will be designed for floor of “30 years return period”, checked for floor of “100 years return period”. The flood standards of the water diversion works of the Chinan Hydroelectric Power Station will be designed for floor of “10 years return period”, checked for floor of “30 years return period”.

It is agreed to employ the upper dam site plan and earth and rockfill dam type for Wangjiahe Hydroelectric Power Station, and to adopt the general works layout of integrate left bank diversion tunnel with sluice tunnel, to utilize the right bank tunnel for diversion. And it is suggested to cancel the release tunnel construction, and to integrate the release, diversion and sluice tunnel, and a release tunnel section of certain length, whose exit will adopt the form of blasting control bulkhead, and connects with the diversion tunnel with the other end.

Basic approval on adopting the impervious wall plan and curtain grouting scheme to treat the dam base on deep overburden layer. However, on the prerequisite of operation security, further comparison between the geomembrane rock-fill dam plan and concrete slab rock-fill dam plan in terms of construction, management, material, operational duration, and investment, etc. Because of the relatively low project grade, optimization is required on the dam slope and detailed structure and dimension of the slab rock-fill dam.

In the next stage, prospecting conclusion should be integrated to adopt corresponding engineering measures for karst duct leakage on the right abutment of the Wangjiahe Reservoir.

Approval on the Kanglinxi, Yanzigou, Hanchiwan Dam Sites, and the dam types of gravity dam and bottom trash rack dam. And since the diversion structure in Moshigou is on colluvial deposit which may jeopardize the stable operation, reconsideration on dam sites and types is recommended.

The electricity generation and water diversion systems of the Wangjiehe Reservoir I Hydroelectric Power Station are built on landslide mass, which may cause stability problem hidden dangers, that is unfavorable to the security of construction and operational management. Suggestion is to further study on the necessity and possibility of the station construction. If the station is necessary, pressure tunnel is suggested to bypass the hemline of the landslide mass, on the basis of which, proper site will be selected out.

The diversion line and scheme of the Wangjiahe II Hydroelectric Power Station is agreed. And the pressure pipeline layout is under basic approval. Study on the possibility of setting up in-tunnel fore bay should be carried out, as well as the further checking of the fore bay capacity.

The diversion line and powerhouse layout plan of the Chinan Hydroelectric Power Station is principally agreed. The fore bay layout is basically approved, and the next

step should be studying on the necessity of increasing fore bay capacity and further deliberating on the pros and cons of the siphoning type and hydraulic type hoisting system. Suggestion is when changing the site, pipeline layout should be adjusted too, and reasonable coordination and connection between the tail water and the reservoir water level should be paid attention to, and flood prevention measures should be taken on the powerhouse according to standard.

5. That the dam construction of Wangjiahe Reservoir to use complete interception cofferdam and tunnel diversion is agreed. And the flood standard of cofferdam design is agreed to be for flood of "5 years return period" in low flow period. The temporary flood withstanding design standard during construction period is for flood of "20 years return period". Since in later period, the diversion tunnel will be used for permanent sluice end, its sluicing capacity should meet the due demand. The sluice curve should be supplemented to determine the water retention elevation after flood regulative calculation.

Principle approval is given on the construction plan and method of the main works. However, the entrance and exit of the diversion tunnel are too close to both upstream and downstream cofferdam, which is unfavorable to the anti-seepage treatment, therefore appropriate adjustment of the entrance and exit position of the diversion tunnel is recommended.

Principle approval is granted on the general construction layout and the arrangement of 2-year construction period.

6. That Chinan Hydroelectric Power Station to choose CJA237-W-100/1×10.5 Hydro-turbine and SFW1000-/1430 Generator is basically approved, and it is suggested to have a recheck on the ventilation height of the units. Basic approval is granted on Wangjiahe Reservoir to choose HL260/D74-WJ-88 Hydro-turbine and SFW630-16/1730 Generator. Approval on the selection of HL100-WJ-73 Hydro-turbine and SFW5000-5/1430 Generator, but the calculation result of H_s value

is relatively large, and suggestion has it to follow the two methods of simplified calculation and model curve value calculation for rechecking, and reach a value reasonably with units condition integrated.

That Chinan Hydroelectric Power Station's adoption of Φ400 , 30kg/cm^2 Ball Valve, YWT-600 Speed Governor and 10-ton Electrical Beam Crane. Wangjiahe Reservoir I Hydroelectric Power Station is authorized to use LD-10 Electrical Beam Crane, YWT-600 Speed Governor, in the next stage and on the basis of recheck; the main valve diameter of the speed governor should be defined. Wangjiahe Reservoir II Hydroelectric Power Station is approved to employ DN800, 40kg/cm^2 Electrical Gate, YWT-1000 Speed Governor.

Basic approval is granted on the system design on oil, water supply, drainage, measurement, ventilation, etc. of all the power stations.

Basic approval is granted on the layout style of the main unit, auxiliary equipments, supporting equipments of all the power stations.

Approval is granted on the layout style hydraulic machinery and equipments.

7. The access system plan that Wangjiahe I and II Hydroelectric Power Station use the voltage of 6,300V and 35,000V respectively to connect with Chinan Hydroelectric Power Station, and transmit by 35,000V line of 6 km to Niuzhuang Transformer Station for Grid entry is approved.

The main connection plan that Chinan Hydroelectric Power Station uses two generators and one transformer connected as extended unit, Wangjiahe I Hydroelectric Power Station employs one generators and one transformer connected as extended unit, and Wangjiehe II Hydroelectric Power Station applies one generators and one transformer connected as extended unit is approved.

Because Chinan Hydroelectric Power Station assumes the responsibility of voltage

boosting for the Wangjiehe I Hydroelectric Power Station, its main transformer capacity is lower than what is required, therefore certain adjustment is recommended. And because the Wangjiehe I connects to the bus bar of the Chinan station with terminal voltage, both require lightening protection.

The Wangjiahe I must be designed a protective scheme for strictly according to the regulation requirement.

It is suggested to improve the lightning protection and earthing design of the three stations.

It is suggested to optimize the electrical installation of the three stations, and according to the requirement of “unattended operation and less on-duty personnel”, the computer control and protection scheme should be optimized, with full consideration on the possibility of cascade optimized regulation.

8. Approval is granted on the principle, foundation and service fee norm of the budge estimate making, as well as on the identification of labor-budged unit price and basic price. The budget prices of water, electricity and main materials for construction are basically approved.

After check and adjustment, the total investment of the Wangjiahe Reservoir Hydroelectric Power Station (including the I and the II) is estimated at 104.7724 million RMB, and Chinan Hydroelectric Power Station at 15.6087 million RMB.

9. Basic approval on the methods and results in the project National Economic Evaluation and Financial Evaluation. All numbers meet the requirement of prior norms, and are economically feasible.

It is expected that relevant departments, project proprietors should follow the national regulations, set up special work group, implement construction capital and loan, to start the project as soon as possible.

October 24th, 2007

Theme: Hydroelectric Power Station, Initial Design, Official Reply

CC: Wufeng Bureau of Water Conservancy and Hydroelectric Power,

Yichang Design Institute of Water Conservancy and Hydroelectric Power,
Yichang Engineering Regiment of Water Conservancy and Hydroelectric Power

General Office of Hubei Water Conservancy Department

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No.986 Document/2007

Official Reply on the FS report of Wangjiehe Reservoir Hydroelectric Power Station and Chinan Hydroelectric Power Station of Wufeng County

Yichang Bureau of Water Conservancy & Hydroelectric Power:

Your ***Transit Report on the FS Report of Wangjiahe Reservoir Hydroelectric Power Station and the FS Report of Chinan Hydroelectric Power Station (Yichang Bureau of Water Conservancy & Hydroelectric Power No.132 Document/2007)*** has been received. The Official Reply upon deliberation is as follows:

1. Wangjiahe Reservoir Hydroelectric Power Station and Chi'nan Hydroelectric Power Station are on the upstream reach of Zhisuohe River, first tributary of Qingjia River, and are developed with diversion type and overflow type respectively, with total installed capacity of 12630 kW and average annual power production of 48.423million kWh, and their investment per unit kW are both below 10,000RMB, which lead to favorable economic returns. Upon completion, their significant roles are to be shown on the alleviation of power shortage, decrease of electricity price in mountainous areas, the development of “electricity for fuel” and the Grain for Green, forest closure, ecological environment protection, as well as on the economic and social sustainable development of the county. Therefore, it is necessary to build the two stations as soon as possible.

2. It is agreed to use Yukou Station as a reference station, and employ hydrological analogy method to analyze the runoffs of the dam sites of Wangjiahe Reservoir Hydroelectric Power Station and Chinan Hydroelectric Power Station, and the adoption of the results. The method and design of flood analysis are agreed. And further rechecks should be done on the history of flood and feasibility analysis on the design of the geographical distribution of flood should be added in the next stage.

Basic approval is granted on the dam site, power plant water levels and flow analysis methods and results. The rationality of results verified by measured data should be supplemented. That the adoption of 80% to ensure power plant design and water calculation using a typical representative of the average annual flow is basically approved. Basically approval is granted on the installed capacity of 12630km.

3. Approval is granted on the regional geological assessment. The geological conditions in the project areas are basically clear. The dam site and water lines are practicable. The selection of rockfill dam is feasible in accordance with the characteristics of local materials.

Approval on the regional tectonic environment is relatively stable. According to the Seismic Zoning Map of China 2001, the seismic basic intensity of this project area is

6 degree.

Basic approve on the report's natural construction material assessment in terms of quality and reserves. For the next stage it comes to the study of rockfill dam material site and its development scheme.

Geotechnical physical mechanical index should be added.

4. Wangjiehe Reservoir Hydroelectric Power Station is a Grade IV Type Minor I Project, its main buildings are of Grade IV, secondary buildings are of Grade V. Chinan Hydroelectric Power Station is a Grade V Type Minor I Project, its main buildings are of Grade V. It is agreed that the flood standards of the water retaining, diversion and intake structure, and the powerhouse of the I Station will be designed for flood of "50 years return period", checked for floor of "300 years return period". The flood standard of II Station will be designed for floor of "30 years return period", checked for floor of "100 years return period". The flood standards of the water diversion works of the Chinan Hydroelectric Power Station will be designed for floor of "10 years return period", checked for floor of "30 years return period".

It is agreed to employ the upper dam site plan and earth and rockfill dam type for Wangjiahe Hydroelectric Power Station, and to adopt the general works layout of integrate left bank diversion tunnel with sluice tunnel, to utilize the right bank tunnel for diversion.

5. Chi'nan Hydroelectric Power Station: Basic approval is granted on the general designing plan. The adoption of Φ400 , 30kg/cm2 Ball Valve, YWT-600 Speed Governor and 10-ton Electrical Beam Crane is approved. Approval is granted on the system design on oil, water supply, drainage, measurement, ventilation as well as the layout style of the main unit, auxiliary equipments, supporting equipments. Further research is required on the adoption of Φ400 , 30kg/cm2 Ball Valve and SFW1000-/1430 Generator suggested by experts.

Wangjiahe Reservoir I Hydroelectric Power Station:asic approval is granted on the general designing plan. The adoption of SFW630-16/1730 Generator, YWT-600 Speed Governor and LD-10 Electrical Beam Crane is approved. Approval is granted on the system design on oil, water supply, drainage, measurement, ventilation as well as the layout style of the main unit, auxiliary equipments, supporting equipments. Further research is required on the definition of the main valve diameter of the speed governor.

Wangjiahe Reservoir II Hydroelectric Power Station: Approval is granted on the adoption of HL100-WJ-73 Hydro-turbine, SFW5000-5/1430 Generator, DN800, 40kg/cm2 Electrical Gate and YWT-1000 Speed Governor as well as the system design on oil, water supply, drainage, measurement, ventilation.

The access system plan that Wangjiahe I and II Hydroelectric Power Station use the voltage of 6,300V and 35,000V respectively to connect with Chinan Hydroelectric Power Station, and transmit by 35,000V line of 6 km to Niuzhuang Transformer Station for Grid entry is approved.

The main connection plan that Chi'nan Hydroelectric Power Station uses two generators and one transformer connected as extended unit, Wangjiahe I Hydroelectric Power Station employs one generators and one transformer connected as extended unit, and Wangjiehe II Hydroelectric Power Station applies one generators and one transformer connected as extended unit is approved.

Because Chi'nan Hydroelectric Power Station assumes the responsibility of voltage boosting for the Wangjiehe I Hydroelectric Power Station, its main transformer capacity is lower than what is required, therefore certain adjustment is recommended. And because the Wangjiehe I connect to the bus bar of the Chinan station with terminal voltage, both require lightening protection.

6. That the dam construction of Wangjiahe Reservoir to use complete interception cofferdam and tunnel diversion is agreed. And the flood standard of cofferdam design

is agreed to be for flood of “5 years return period” in low flow period. The temporary flood withstanding design standard during construction period is for flood of “20 years return period”.

Approval is granted on the general construction layout and the arrangement of 2-year construction period.

7. Approval is granted on the environmental impact assessment and ecological protection plan.

8. Approval is granted on the principle, foundation and service fee norm of the budge estimate making, as well as on the identification of labor-budged unit price and basic price. The budget prices of water, electricity and main materials for construction are basically approved.

After check and adjustment, the total static investment of the Wangjiahe Reservoir Hydroelectric Power Station is estimated at 104.7724 million RMB, and Chi'nan Hydroelectric Power Station at 15.6087 million RMB.

9. Basic approval on the methods and results in the project National Economic Evaluation and Financial Evaluation. All numbers meet the requirement of prior norms, and are economically feasible.

It is expected to refer to experts' accreditation and the above requirements and regulations, to fulfill all the tasks and to get in place construction capital and loan for the early start of the project.

December 23th, 2007

Theme: Energy, Hydroelectric Power Station, Feasibility Research,

Official Reply

Hubei Development and Reform Commission

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Environmental Protection Agency of

Wufeng Tujia Autonomous County

Reply on the Implementation Standard for Assessing the Environmental Influence of Wangjia River Hydropower Project contracted by Yichang TaiRMB Hydropower Development Limited Liability Company

December 9, 2007

Yichang TaiRMB Hydropower Development Limited Liability Company,

During your environmental influence assessment of Wangjia River Hydropower Project construction in the Wangjia River basin, you are required to follow the following assessment standards.

□Environmental Quality Standards

A Standard Ⅱ of Surface Water Environment Quality Standard (GB3838-2002)

B Secondary Standard of Ambient Air Quality Standard (GB3095-1996)

C Standard □ of Urban Region Environment Noise Standard (GB3096-93)

ⅡPollution Discharge Standard

A Primary Standard of Comprehensive Waste Water Discharging Standard (GB8978-1996)

B Secondary Standard of Comprehensive Air Pollution Discharge Standard (GB6297-96)

C Limit for Construction Site Noise (GB12523-90)

Letter of Authorization

March 2, 2007

To Whom It May Concern,

Yichang TaiRMB Hydropower Development Limited Liability Company, hereby authorize the Environmental Protection Institute of Yichang City, to assess the environmental influence exerted by our planed Wufeng Wangjia River Hydropower Project and the Chinian Power Station Project according to the Management Regulations of Environmental Protection of Construction Project. The environment influence report must be in line with related guidance of environmental assessment technology and meet the requirements and standards issued by environmental protection apartments in charge. More details will be specified in the contract signed.

Sincerely,

Tan Denxing

Legal Representative

Yichang TaiRMB Hydropower Development Limited Liability Company

For more please contact Luo Xuhong at 13032745076

Grant of Permission to Forest Land Requisition

December 8, 2007

Yichang TaiRMB Hydropower Development Limited Liability Company:

You may have our permission to requisition 15.943 hectares forest land for the construction of Wangjia River Hydropower Project after the assessment according to Forest Law and the Implementation Regulation of the Forest Law.

We require, however, you go through the permitting procedures for construction land requisition abiding by related regulations and pay for the forest land requisition compensation in accordance with law. After the permission, a legal procedure has to be followed when it is necessary to cut down trees.

Sincerely,

Verification Department

Yichang TianRMB Hydroelectricity Development Limited Company Wangjia River Reservoir Electricity Plant and Chinan Electricity Plant Project Environmental Effect Report Paper Expert Evaluation

On 15th September, 2008, Yichang City Environmental Protection Bureau organized and held the "*Yichang TianRMB Hydroelectricity Development Limited Company Wangjia River Reservoir Electricity Plant and Chinan Electricity Plant Project Environmental Effect Report Paper*" (*Report Paper*) evaluation meeting in Wufeng Tujia Autonomous County. Participants of the meeting include 12 representatives from the Wufeng Tujia Autonomous County Environmental Protection Bureau, China Geology University (Wuhan) Environment Evaluation Research Centre (environment evaluation organisation), Yichang City Environmental Protection Research Centre (environment evaluation co-working organisation), and Yichang TianRMB Hydroelectricity Development Limited Company (construction organization). Invited to the meeting were a panel of 4 experts (for list, see attached table), who are responsible for the technical evaluation work of the Report Paper.

During the meeting, the construction organization and the environmental evaluation organization respectively introduced the relative information of the planned project and the main contents of the Report Paper, and thoroughly discussed and carefully evaluated the Report Paper with the experts and representatives. The experts' views are as follows:

Project Briefing

The Wangjia River Reservoir Electricity Plant and Chinan Electricity Plant is located in the upper reaches of Chisuo River in Niuzhuang Town of Wufeng Tujia Autonomous County and include three plants and one reservoir. The project controls a total catchment area of 105 sq km and possesses a total capacity of 12630 kW. The Wangjia River reservoir's normal water level is 875m and the normal water surface area is 0.14 sq km. The Chinan Plant is a dam plant. The Wangjia River Primary Plant is a reservoir regulative plant. The Wangjia River Secondary Plant is a regulated water diversion plant.

The Chinan Electricity Plant Project's main structures consist of a dam, water channels, front basin, pressure pipes, plant building, transformer station and distribution power lines. Water catching dam is made up of one main dam and three collateral dams. The main dam is masonry gravity dam with a maxim height of 10.31 m. The length of the water diversion channels is 2660m with the main channel 2170 m in length. The front basin is 3m by 8m. The pressure pipes are 409.8m long with the main pipe's diameter being 0.7m. The plant building is 23×13m. The transformer station has a 3150kVA transformer. The grid line is 6km long with a voltage of 35kV.

The main hydraulic structures of Wangjiahe I Hydroelectric Power Station include the water intake works, diversion project and powerhouse construction. And the water intake works consist of retention structure and discharge building, the detention structure is a concrete slab rock fill dam with dam crest elevation of 878.95m, and top dam height of 50.95m, top length 136m, width of crest 6m, maximum width of dam bottom 189.51m; discharge building is of side-channel flip trajectory bucket type, with weir crest height of 875.00m, length of weir crest overflow section 40.00m, width of side-channel head end bottom 5.00m and that of tail end bottom 15.00m. Diversion structure comprises intake port, in take tower, hoisting device and diversion tunnel, etc., the total length of the diversion channel is 253.61m, diameter 1.5m. The

powerhouse section incorporates main hall, service room and booster station, etc.

The main hydraulic structures of Wangjiahe I Hydroelectric Power Station include the diversion structure, fore bay, pressure pipeline and powerhouse. And the diversion works are composed of open diversion channel, non-pressure tunnel and connective structure; the open diversion channel is as long as 400m, and the height and width of the water-carrying section are 1.85m and 2m, the length of the diversion tunnel is 4610m, the height and width of the water-carrying section are 2.1m and 2.18m, the length, width and depth of the pressure fore bay are 23.5m, 7.1m and 10.48m; and the length of the pressure pipeline is 392.83m, and the pipe inside diameter is 1.5m. The total length of the branch pipes is 29.31m, and the pipe inside diameter is 0.8m; the project of the factory district is composed of major factory building and switching stations so forth.

The major project construction covers an area of 13882.5 square meters, including: permanent occupation of land counting for 12422.5 square meters, temporaty occupation of land counting for 1460 square meters. The total sum of investment to the project is 120.3811 million RMB. Chi Nan power station has the designed yearly-using-hour of 4090h, with the average electric energy prodution of 8.18 million km.h; the yearly-using-hour of Wang Jia He first class power station is 4128h, with the average electric energy prodution of 2.6 million km.h; Wang Jia He’s second class power station has the yearly-using-hour of 3767h, with the average electric energy prodution of 37.64 million km.h.

2. General Environment Situation

The project construction area is located in the southwest part of Hubei province where boasts shales, coal series etc. and has rickles and plants growth without rare fauna and

flora. And it enjoys subtropical warm and humid monsoon climate. This place is sparsely populated and there is no industrial enterprises and air pollution. This area enjoys high mountains, precipitous cliffs, large area of containing rain-water. In summer, it is hot and humid with high precipitation; rainstorms and floods frequently happen, which leads to the problem of geological disasters, water loss and soil erosion.

The dam of the power station is designed by the standard of flood prevention-----flooding every other 50 years and inspecting the situation of flood every other 300 years, and it has open-spillway without any worry of flooding. Owing to the stability of the area and relatively small volume of the reservoir, there is also no worry about the earthquake. The water in the reservoir covers the slope farmland (the gradient is commonly more than 25 degree) and the mountain forest with an area of 35 acres and 220 acres respectively. We have finished compensation to the farmland and forest in the water covered area, and the construction of the reservoir will, to some extent, relieve the problem of water loss and soil erosion. Furthermore, the construction and operation of the power station will not affect people's life on the two sides and use of water for irrigation. In view of spring water supplement to the lower reach of river each under 50, 150 and 600m of the dam; it will not lead to water interception because of the water conduction by the tunnel.

The project is in accordance with the plan of river basin, and the current quality of environment of the construction area is preferable (except the water loss and soil erosion). The influence on the ecological environment by the whole project is relatively little. After the implementation of all measures of pollution prevention and ecological environment protection, the construction is feasible from the view of environment protection.

3. The quality of report organization

The <Report> is organized under the requirement of relevent technique guidences and principles, with rich accordance, accuration of the rank of comments and confirmation of scales, and the content of comments with emphasis from almost all aspects. The basic situation of the planned project and the engineering analysis are clear, which at the same time show the features of water electricity industry. The Report has a thorough investigation of the current situation of regional ecological environment and clear record of major pollution sources and exhaustion, also the correct analysis of factors and sensative points of environmental influence, the feasible method of comments, reasonable selection of prediction model, and trustworthy and objective conclusion of comments. The environmental protection measures are all to the points.

The <Report> almost contains the required work by the technique guidences and principles, and it can be applied to admission after further correction.

4. Some advice to further correction and improvement of <Report>

a. We should lay more stress on the water loss and soil erosion prevention during project construction. Due to the already existing water and soil loss problem and pollution of the coal series earth, we initially estimate the amount of waste slag of the project will reach to 56.5 thousand cubic meters. Moreover, with the earth disturbance by construction, the total loss of water and soil in the construction area will increase, so we should carry out further discussion on the environmental rationality of organization of the slag dump, and come up with

relative prevention measures (e.g. slag wall in the dump and slag dam at the end of the reservoir), also examine the calculation of material balance and detail the work of ecological restoration of stock ground, slag dump and temperary land occupation, environmental protection and recycling of waste slag in the use of road and dam construction.

b. We should enhance the practice of environmental protection measures, and confirm the objects of protection, also the scale, craftsmanship, parts of constructing, time and the security system of goal facilities, based on which we further verify the investment of environmental protection.

c. We should set up the questionaire of public participation and add more pictures of the project. What's more, we should correct and proofread the wrong and missed characters and inconsistency of the context appearing in some parts of the Report.

Signature of the leader of expert group

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September 15th, 2008

Public Opinion Questionnaire

on the Wangjia River Hydropower Station Project by Yichang TianRMB Hydropower Development Limited Liability Company

Name Zhu Jianhua

Sex Male

Age 39

Education Background Primary School

ID No.422729196603291811

Former Address Group One, Jingshan Village, Liuzhuang Town, Wufeng County,

Current Address Group Five, Changdong and Baiyan Village, Wufeng County

Please check.☑ Or fill in the blanks.

1 What is your attitude towards hydraulic engineering construction?

☑for □against □ basically for

2 What do you think of site chosen for this hydraulic project?

☑feasible □non-feasible □ basically feasible

3 What do you think of the current local economic status?

□pretty good ☑bad □average

4 How do you think this project will influence the local economic development?

☑big promotion □slight promotion□ no effect

5 How will it affect the local environment after its completion?

□big influence ☑no influence □ normal influence

6 How will this project affect the local environment during its construction?

□big influence □no influence ☑ normal influence

7 What kind of influence do you think it will exert on locals' living standard?

☑improvement □no change □deterioration

8 What do you think are the positive and negative effects the construction will bring about?

(e.g. prevention of natural disasters, flood prevention capacity, economic development, living standard, soil and water loss, forest vegetation, the geological structures of dyke body and foundation)

What is your most concern?

What are your demands and advice for the construction of this project?