Annex 4

COUNTRY POLICY SUPPORT PROGRAMME (CPSP)

WATER ASSESSMENT IN QIANTANGJIANG RIVER BASIN

(draft)

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CONTENTS

Preface

The catchmetn area of Qiantang River, the largest river in Zhejiang Province, is 55558 Km^2 and the catchment area in the upstream of Hangzhou Gate is 41945 Km^2, including 6200 Km^2 in Anhui Province, 109 Km^2 in Jiangxi Province and 136 Km^2 in Fujian Province. The catchment area involved in this report is 3550 Km^2 in the upstream of Hangzhou Gate within the boundaries of Zhejiang Province that are under the jurisdiction of Hangzhou, Quzhou, Jinhua, Shaocing and Lishui five municipalities/prefectures totally 27 counties/cities/districts. Its total population in year 2000 is 10.67 million and cultivated area 0.4240 Mha, including 0.3604 Mha of paddy field. It's one of the areas in Zhejiang Province with great potentialities in economic development.

Special and comprehensive investigation and planning for the main stream and tributaries of Qiantang River had been carried out and a lot of water and hydropower projects, such as Xin'an, Fuchun, Hunanzhen, Huangtankou, Wanyao, Hengjin, Nanjiang, Tongshanyuan, Jinlan, Xiakou, Shanban, Chencai, Shibi and Anhua etc., large and medium reservoirs and hydropower stations, and lots of pumping stations, canal systems and thousand kilometers of dykes have been constructed since the foundation of China in 1949. These projects have played an important role in increasing the flood control capacity, improving the industrial and agricultural production and domestic water use conditions, relieving the flood and drought disasters and promoting local economic and social development.

1. Introduction

1.1 Basin Features

Qiantang River Basin, which lies between Longitude 118°'East to 121°East and Latitude 28° North to 31° North, extends across Zhejiang, Anhui, Jiangxi, Fujian and Shanghai five provinces/municipalities with a total catchment area of 55558 Km^2, including 41945 Km^2 in the upstream of Hangzhou Gate (6200 Km^2 in Anhui Province, 109 Km^2 in Jiangxi Province and 136 Km^2 in Fujian Province). The catchment involved in this report is 3550 Km^2 in the upstream of Hangzhou Gate within the boundaries of Zhejiang Province that are under the jurisdiction of Hangzhou, Quzhou, Jinhua, Shaoxing and Lishui five municipalities/prefectures totally 27 counties/cities/districts (hereinafter the scope of Qiantang River Basin). It borders on Xianxia Mountain and spreads into Min River of Fujian Province in the south, Huaiyu Mountain and Le'an River and Xin River, water system of Poyang Lake of Jiangxi Province in the southwest, Huang Mountain and Tianmu Mountain and Qingyi River of Anhui Province and Taihu Lake of Zhejiang Province in the north, Hangzhou Gulf in the northeast, Siming Mountain and Yong River and Tiantai Mountain and Jiao River in the east, and Xianxia Mountain and Ou River in the southeast. Qiantang River Basin is separated by mountain ranges in a trend of northeast that become divides of the main stream and tributaries. It's high in southwest and low in northeast with more hills, less plains, and scattered valleys and basins, including the largest one Jinqu Basin whose catchment area is 2980 Km^2.

Except running into the sea in the northeast, the entire basin is surrounded by divides that are composed of medium and low hills and separated by intermontane basins. There are over ten mountains in this river basin whose absolute elevations are between 1500 m and 1800 m, such as the highest peak of Liugujian Mountain (1629.8 m) in the source of Xin'an River, Longwang Mountain (1587 m) of Tianmu Mountain Range and Jiulong Mountain (1924 m) of Xianxia Mountain Range etc. The absolute elevations of other divides are between 1000 m and 1400 m. In topography, this river basin can be divided into mountainous area and plain basin two types.

Mountainous Area

There are Yellow Mountain, Baiji Mountain, Tianmu Mountain, Wulong Mountain, Qianligang Mountain, Longmen Mountain and Xianxialing Mountain from northwest to southeast in the river basin, and Dapan Mountain, Kuiji Mountain and Tiantai Mountain from west to east in the east of the river basin that become the divides of other river basins or tributaries of other river basins.

Basin

There are numerous basins in the river basin that are the watersheds of surrounding mountains and linked up by rivers running through the mountainous areas. There are Changshan Basin, Jiangshan Basin, Jinqu Basin, Wuyi Basin, Yongkang Basin, Nanma Basin, Pujiang Basin and Zhuji Basin etc., large basins in Zhejiang Province. Jinqu Basin is the largest corridor-type basin in this river basin with 190 km of long, 15 km to 30 km of wide, and 3000 Km^2 of area where the absolute elevation is

between 40m□100m and the absolute elevation of the boundaries is between 100m□200m. There are various types of topography, including valley plains in the bottom and hilly lands in the edge.

The soil type in this river basin can be divided into red soil, yellow soil, brown soil, meadow soil, purple soil, limestone soil, skeletal soil, tidal soil, saline soil and paddy soil etc., 10 types. Red soil is mainly distributed in low hilly lands and high terraces whose absolute elevation is between 600 m and 650 m. It's the main soil type in the horizontal zones and the base soil type in the longitudinal zones. Yellow soil is mainly distributed in the medium and low lands whose absolute elevation is between 600 m and 1100 m. Meadow soil is mainly distributed in the upper part, horizontal crests and gentle and wide slopes of medium and high mountains. Purple soil is distributed in valley basins and low hills formed by purple sandy shales, particularly in Jinqu Basin. Limestone soil is distributed in the low hilly lands formed by limestone. Skeletal soil is distributed in the peak, ridge and steep parts of mountains. Tidal soil is distributed in the valley plains, low terraces and flood plains and has become the important base for agricultural production. Paddy soil is mainly distributed in estuary plains, valley basins, valleys and gentle slopes of low hills.

Influenced by the favorable water and heat conditions and complicated topography, there are abundant and diversified plant varieties in Qiantang River Basin, predominated in evergreen broadleaf forests of subtropical zones. Most of the primeval forests have been destroyed due to human being's activities and interference and a few second natural evergreen broadleaf forests are still left alive in some steep slopes. There are large areas of coniferous forests planted by mankind, such as mason pine, China fir, and cryptomeria whose coverage area is over 90% of the total forest reserves. Bamboo forest predominated in mao bamboos are scattered in areas with deep pelagic zones and favorable water and heat conditions.

The coverage rate of forest is over 50% in this river basin, except over 30% in populated low hills and valleys, and Kaihua, Suichang, Jiangshan, Wuyi and Pan'an counties that have poor transport facilities. Generally speaking, the soil and water in this river basin are well conserved.

1.2 River System

Qiantang River is the largest river in Zhejiang Province. Its catchment area in the upstream of Hangzhou Gate is 41945 Km^2 and its length of main stream is 477 km. There are Lan River and Xin'an River two source rivers in the upper stream that join together in Meicheng of Jiande City, spreads across Hangzhou Municipality and runs into Hangzhou Gulf in Kanpu of Haiyan City. The catchmetn area in the upstream of Kanpu is 49876 Km^2 and length of main stream is 583 km. Lan River, originating from Qingzhilijian Mountain (1144 m of absolute elevation), Xiuning County of Anhui Province, runs into Zhejiang Province in the southeast at Qixi, and is called Majin River in the downstream of Majin, Kaihua County; Changshan River after joining with Chihuai River at Huabu; Qujiang River after running from west to east, admitting Fangcun River in the left bank and reaching Jiangshan River, south suburb of Quzhou City; Lanjiang River after running to northeast, admitting many tributaries, including Wuxi River and Lingshan River in the right bank and Tongshanyuan River and Lanxi River in the left bank, reaching Shanghua of Lanxi City, and admitting

Jinhua River in the right bank. It runs to north and joins with Xin'an River in Meicheng, Jiande City. Its catchment area is 19468 Km^2 and length is 302.5 km.

Originating from Liugujian Mountain (1629.8 m of absolute elevation), Xiuning County of Anhui Province, the catchment area of Xin'an River is 11674 Km^2 and length is 358.5 Km. Tributaries running into Xin'an River include Heng River, Changyuan River, Yunyuan River, Wuqiang River and Shouchang River.

The river reach between Meicheng and Dongjiangzui (1 km upper reach of Wenjia Weir) in the main stream of Qiantang River is called Fuchun River and the lower reaches of Dongjiangzui is called Qiantang River. Tributaries running into Fuchunjiang River include Fenshui River, Luzhu River and Huyuan River and tributaries running into Qiantang River include Puyang River and Cao'e River.

Table 1-1 Features of the Main Stream and Major Tributaries of Qiantang River

Name of River		Length (km)	Catchment Area (km^2)	Average Gradient (‰)
Main Stream (south)	Majin River	102.2	1011	7.1
	Changchan River	175.9	3385	4.4
	Qu River	257.9	11477	3.1
	Lan River	302.5	19468	2.6
	Fuchun River (upstream of Wenjia Weir)	460.7	38318	2.9
	Qiantang River (upstream of Hangzhou Gate)	476.6	41945	2.8
Main Stream (north)	Xin'an River	358.9	11674	3.7
Tributaries	Longshan River	45.7	332	13.9
	Chihuai River	53.8	418	12.1
	Mawang River	57.4	275	15.3
	Fangcun River	50.6	357	15.5
	Jiangshan River	137.4	1946	7.3
	Wuxi River	155.9	2577	7.5
	Lingshan River	90.6	727	12.6
	Tongshanyuan River	45.4	247	14.3
	Zhi River	63.8	350	15.1
	Dongyang River	165.5	3378	3.6
	Wuyi River	129.2	2520	5.6
	Jinhua River	194.5	6782	3.1
	Fenshui River	164.2	3444	5.9
	Huyuan River	102.8	761	6.6
	Puyang River	149.7	3452	3.0
	Shouchang River	65.8	692	11.0

Note: all of the data are calculated from the source of river.

The upper reach of Fuchunjiang Pumping Station is mountain river and the lower reach is tidal river with huge tidal range and high tidal flow. Both banks of the lower reaches of Qiantang River are the river systems of Binhai Plain. South bank is Xiaoshaoning Plain and north bank is Hangjiahu Plain whose catchment area are not involved in this report. The total catchment area involving in this report is 35500 Km^2, accounting for 35% of the land area in Zhejiang Province.

The map of river systems in Qiantang River Basin is shown in Figure 1-1 and features of some main rivers are given in Table 1-1.

1.3 Climate

Qiantang River Basin comes under subtropical monsoon humid climate zone where there are four well marked seasons, moderate temperature, plentiful rainfall and sunshine, long period of winter and summer and short period of spring and autumn.

The average annual rainfall in Qiantang River Basin is between 1200 mm and 2200 mm. It decreases progressively from southwest to northeast and is remarkably influenced by topography. It's higher in mountainous area than that in rolling area, and rolling area than that in plain area. It unevenly distributes interannuallly and the ratio between the maximum and the minimum is high to 2 to 3. The rainfall features in this basin are shown in Table 1-2.

Table 1-2 Rainfall Features in Qiantang River Basin

Unit: mm

Name of River	Name of Station	Maximum Rainfall		Minimum Rainfall		Ratio between the Max and the Min
		Precipitation	Year	Precipitation	Year	
Qu River	Quzhou	2335.6	1954	1109.3	1979	2.1
Jinhua Riiver	Jinhua	1944.1	1954	916.7	1978	2.12
Lan River	Lanxi	2150.6	1954	856.5	1978	2.50
Xin'an River	Tunxi	2810.8	1954	926.2	1978	3.03
Fuchun River	Fuyang	2208.2	1954	992.3	1978	2.23
Puyang River	Zhuji	2171.3	1937	903.8	1978	2.40
Qiantang River	Hangzhou Gate	2374.4	1954	941.1	1967	2.52

The rainfall is unevenly distributed annually. The maximum in four consecutive months, usually between March and June or April and July, accounts for 50%□60% of the whole year and the maximum monthly rainfall is in May or June. Influenced by stationary front, unbroken spell of wet weather together with storm frequently occur from the middle and late of June to the early of July and result in flood disaster, such as the flood in 1954, 1955, 1992, 1993, 1994, 1997 and 1998. The tributary Jinhua River and another tributary in the downstream Puyang River are located in the

southeast of this river basin and influenced greatly by tropical storm, predominantly in flood resulted from typhoon storm.

The average annual evaporation is this river basin, which is higher in coastal areas than that in inlands, and higher in plains and basins than that in mountainous areas, is between 800 mm and 1000 mm. The maximum in this river basin is in Jinqu Basin, which is over 1000 mm, and 800mm□900mm in mountainous area. The annual maximum is usually in July and August and the minimum in January and February. It varies not much interannually and the ratio between the maximum and the minimum is 1.3□1.4.

The average annual sunshine duration in this river basin is between 1200□1900 hours, frost-free period between 230□250 days, and temperature between 16.2□□17.7□, which is higher in the south than that in the north, and higher in basins than that in rolling areas.

The relative humidity in this river basin is between 70%□80% and high to 80% in elevated areas of hills. It doesn't differ much in seasons, usually high in spring and summer around 80% and low in autumn and winter around 75%.

1.4 Social Economy

Qiantang River Basin is under the jurisdiction of Hangzhou, Quzhou, Jinhua, Shaoxing and Lishui fiver municipalities/prefectures totally 27 counties/cities/districts in Zhejiang Province. According to the statistical data in 2000, the total population is 10.67 million (accounting for 24% of the total of Zhejiang Province) and cultivated area 0.4240 Mha (accounting for 31% of the total of Zhejiang Province), including 0.3604 Mha of paddy field. Details are shown in Table 1-3.

Table 1-3 Population and Cultivated Area in Qiantang River Basin

Municipa	Area (km^2)	Popula (million)	Cultiva Area (million ha)	Paddy Field (million ha)	County/city/district
Quzhou	8303	2.378	0.0987	0.0871	Kecheng, Jiangshan, Quxian, Kaihua, Changshan, Longyou
Jinhua	9198	4.102	0.1546	0.1358	Wucheng, Lanxi, Jinhua, Yongkang, Wuyi, Dongyang, Yiwu, Pujiang, Pan'an
Hangzhou	13224	2.879	0.1169	0.0897	Xiihu, Binjiang, Xiaoshan, Ting'an, Tonglu, Jiiande, Fuyang, Lin'an
Shaoxing	2329	1.062	0.0436	0.0389	Zhuji
Lishui	2446	0.249	0.0103	0.0090	Suichang, Longquan, Jinyun
Total	35500	10.67	0.4240	0.3604	

Paddy rice, wheat, barley, maize, soybean and potato are the staple crops in this river basin as well as tea, rape, cotton, sugarcane and medical materials etc., cash crops and tea-oil tree, orange, bayberry, grape, persimmon and loquat etc., cash trees. Jinqu Basin is the second commodity grain base where the production of cotton occupies a pivotal position in Zhejiang Province. With the development of town/township enterprises in recent years, the economy develops rapidly. In 2000, the gross value of

agricultural and industrial output is RMB 258 billion (US$31.1 billion), accounting for 17% of the total and it has become one of the area in Zhejiang Province with much potentialities in economic development.

1.5 Land Use

Qiantang River Basin has favorable natural conditions and rich agricultural resources. Intensive cultivation and combination between agriculture and husbandry etc., traditional agriculture have been formed in its long history of development. It also has great potentialities in the development of forestry and fishery and is always an important area for the all-round development in agriculture, forestry, sideline and fishery in Zhejiang Province and Anhui Province. Its cultivated area in 2000 is 0.4240 Mha, accounting for 11.9% of the total land area and the per capita cultivated area 0.04 ha, garden plot 0.1309 Mha, accounting for 3.7% of the total land area.

1.6 Irrigation

The hydraulic facilities in this river basin have been improved continuously since the foundation of China. The effective irrigated area is 0.3933 Mha and area where stable yields can be ensured despite drought and excessive rain is 0.2933 Mha, accounting for 93% and 69% respectively of the cultivated area. There are many varieties of crops, the cropping system has been changed and cropping intensity has been increased since the foundation of China. The seeding area of cereals in 2000 is 0.6120 Mha and the yield is 4.75 million tons, oil-bearing crops 0.0733 Mha and the yield 0.156 million tons.

1.7 Urban Centers

Many cities and towns in this river basin have one thousand and even over two thousand years of history. There are totally 29 cities and towns whose population is over one thousand by 2000 and most of them are distributed along the Qiantang River, including the urban center of Jinhua Municipality whose population is between 200□500 thousand, Quzhou Municipality whose population is between 100□200 thousand, Zhuji City, Fuyang City, Jiande City, Dongyang City, Yiwu City, Lanxi City and Jiangshan City whose population is between 50□100 thousand, and other cities and towns whose population is between 10□50 thousand. The population density in cities and towns decreases obviously from the lower reaches to the upper reaches.

1.8 Industry

Qiantang River Basin is located in the well developed coastal area of Zhejiang Province and the intermediate zone of the sub-developed area of Anhui and Jiangxi provinces where the industrial production is in the middle level. The gross value of industrial output in 2000 is RMB 239 billion (US$28.8 billion). The basic characteristics of industrial production in Qiantang River Baasin is as follows:

- Light industries occupy an important position;
- High water consumption industries are predominant;

- The development level between the upper reaches and the lower reaches differ much;
- There are more medium and small industries and enterprises;
- Machine building, hydro-power generation, chemical industry, metallurgical industry and building material are predominant in heavy industries;
- Papermaking, food processing, textile and arts and crafts are predominant in light industries.

1.9 Flood Control and Drainage

Water disaster that had been recorded in historical data since Jin Dynasty (A.D. 265□240) frequently occur in Qiantang River Basin. According to the statistical data from Jin Dynasty to the foundation of China (A.D. 1949) totally 1684 years, there are 615 years of flood disasters, about 2.7 years one time. From 1949 to 2000 totally 50 years, the years when the peak flow at Lanxi Station, the middle reach of Qiantang River is over 10000 m^3/s include 1952, 1954, 1955, 1961, 1969, 1971, 1989, 1992, 1993, 1994,1997, 1998, 1999, 2000 totally 14 years. Of which, the flood disaster occurred in June 1955 is the most serious. From June 17 to June 22 six consecutive days of rainfall, the precipitation at Changshan Station was 466.6 mm and Jiangshan Station 502 mm. The peak flow at Quxian, Lanxi, Jinhua and Luucibu stations reached 7620 m^3/s, 20400 m^3/s, 6380 m^3/s and 29000 m^3/s and the highest water table reached 65.74m, 33.53m, 37.57m and 20.75m. 0.1333 Mha of lands were inundated by floodwaters and 124 people in Longyou City and Qu County were dead. Jiangshan, Longyou, Qu, Tangxi, Jinhua, Yiwu, Jiande, Sui'an, Tonglu and Fuyang etc., cities/counties/districts had been inundated for 2 to 3 days and 3000 meters long of railway in Jiangshan, Longyou and Suxi cities/counties/districts had been destroyed.

The present flood control capacity in Qiantang River Basin is very low. There were nearly no flood control works in Changshangang before 1997 when the flood control capacity was less than 5 year, Changshan County 3 year and the urban centers of Jiangshan City less than 5 year. A more complete flood control system had not been established yet before 1992 in Qu River, Dongyang River, Wuyi River, Jinhua River and the main stream of Lan River and the flood control standard ,which could only withstand 3□5 year of flood, was very low. Some dykes of Qu River, Jinhua River and Lan River have been repaired and reconstructed since 1993. Currently, the flood plains and low farmlands along the main stream will be inundated by floodwaters in Fenshui River Basin when 2 year flood occur and cities and towns along the river will be inundated in varying degrees when 10 year flood occur. The flood control standard is less than 5 year in Funchun River and is only 5 year in Tonglu and Fuyang etc., counties. The flood control standard in the downstream of Anhua in Puyang River has reached 10 year after improvement. At present, the flood control works in each city/county are being improved with 50 year of flood control standard under the overall planning of the provincial commission and government.

1.10 Fishery

Qiantang River Basin has rich fish resources, including silver carp, black carp, grass carp, bream, carp, crucian carp and eel etc., bred fish, silver crucian carp, golden crucian carp and herring etc., introduced abroad, and perch, eel, crab and shrimp etc., natural fish totally 203 varieties. There are 0.0717 Mha of fish ponds in this river

basin where the amount of aquatic product is 66 thousand tons and the gross value of fishery is RMB 1.4 billion (US$ 0.17 billion).

1.11 Water Pollution

The average annual ionic amount in the main stream and tributaries of Qiantang River is less than 200 mg/l, around 50 mg/l in Wuyi River, upstream of Dongyang River, Xin'an Reservoir, Jinhua River, downstream of Fenshui River and upstream of Puyang River, 100 mg/l in Changshan River, Jiangshan Riiver, Fuchun River, upstream of Fenshui River and middle and lower reaches of Puyang River. The mineral content at the estuaries of Qiantang River is very high due to the influence from chlorine ion.

The average annual hardness in the main stream and tributaries of Qiantang River is less than 10 degree (German degree), 1□2 degree in the middle and upper reaches of Wuxi River, Lingshan River, Dongyang River and upstream of Wuyi River, 2□4 degree in other rivers, and 4□10 degree between Weijia Weir and Yanguan County in Qiantang River.

1.11.1 Water Environment Zone

To protect the water quality in Qiantang River Basin, a plan for the division of water zone had been worked out by relevant departments. The water quality in rivers of Qiantang River Basin is divided into five classes according to their functions. Class I water source protection zone, class II multifunctional water zone and first level central domestic drinking water source protection zone, class III multifunctional water zone and second level central domestic drinking water source protection zone, class IV water use for normal landscape and industrial water supply zone, and class V water use for normal landscape and agricultural water supply zone. Class IV and class V water quality is only dispersed in some partial reaches of the tributaries and the entire main stream is class II and class III water zone.

1.11.2 Water Quality

In the light of the *Water Resources Bulletin in Zhejiang Province* issued by Zhejiang Provincial Water Conservancy Department in 2000, in 27 totally 870 kilometers long of rivers for water assessment, the water quality in 405 kilometers long of river is better than class IIII surface water quality standard in drought period, accounting for 46.6% of the total assessment river length, 264 kilometers long of river in high-water period, accounting for 30.3%, and 249 kilometers long of river in the whole year, accounting for 28.6%. The water quality is class I and Class II in Majin River, Fuchun River and Xin'an River, class III and class IV in Changshan River and Lan River, class II and class III in the upstream of Dongyang River, class V or poorer than class V in the downstream of Fotang, class III in the upstream and poorer than class V in the downstream of Nan River, class IV in Qu River, class IV and class V in Jiangshan River and Jinhua River. The river reaches in Yiwu, Yongkang, Wuyi cities/counties/districts and urban centers of Quzhou City are seriously polluted in ammonia nitrogen, permanganate, COD, flourate and mercury etc., indexes.

According to the monitoring data, the water quality in Xin'an, Wanyao, Hunanzhen and Tongshanyuan four large reservoirs is good and all meet the standard of class I.

The conditions of water quality in Qiantang River Basin are shown in Table 1-4.

Table 1-4 Water Quality of Rivers in Qiantang River Basin in 2000

Time / Class River length (Km)	Class□	Class □	Class □	Class □	Class □	Poorer than class □
Drought Period	870	49	66	350	133	99	173
High-water Period	870	4	241	361	217	0	47
Whole year	870	49	124	448	114	22	113

1.12 Miscellaneous

1.12.1 Status Quo of Hydro Projects

Hydro projects in this river basin mainly include reservoirs, dykes, weirs, water diversion works and electric irrigation stations.

Reservoir

A lot of medium and large reservoirs, such as Xin'an, Fuchun, Hunanzhen, Huangtankou, Wanyao, Hengjin, Nanjiang, Tongshanyuan, Jinlan, Xiakou, Shanban, Chencai, Shibi and Anhua etc., reservoirs have been constructed in Qiantang River Basin since the foundation of China in 1949. Presently there are totally 48 medium and large reservoirs, including Fuchun Reservoir whose catchment area is 31645 Km^2 and other 47 reservoirs whose catchment area is 20148 Km^2, accounting for 48% of the catchment area in the upstream of Hangzhou Gate, and 200 small reservoirs whose catchment area is 1500 Km^2. These reservoirs played an important role in improving the industrial, agricultural and domestic water uses and relieving flood disasters.

Special and comprehensive investigation and planning for the main stream and tributaries of Qiantang River had been carried out, and a lot of water and hydropower projects, large and medium reservoirs and hydropower stations, and lots of pumping stations, canal systems and thousand kilometers of dykes had been constructed since the foundation of China in 1949. These projects played an important role in increasing the flood control capacity, improving the industrial and agricultural production and domestic water use conditions, relieving the flood and drought disasters and promoting local economic and social development.

Dyke

To withstand floodwaters, dykes have been constructed on both banks of some main stream and tributaries of this river basin. However, except the complete dykes on both banks of Fuchun River, those of other rivers are usually broken or the dyke bodies are

usually very thin and many dangers such as piping are hidden behind. At present, the flood control works in each city /county are being reconstructed in a 50 year standard under the overall planning of the provincial commission and government. The dykes along Qiantang River are being constructed according to the planning for the river basin.

Weir

Weirs had ever been used as the main facilities for farmland irrigation and scattered everywhere. The most famous old weirs include Luxi Weir in Jiangshang City, Shishi Weir in Qu County, Jiming Weir in Longyou City, and Taofan Weir in Zhuji City.

Water Diversion Works

There are many water diversion works in Qiantang River Basin, including the largest one Wuxi River Water Diversion Works with 82.7 kilometers long of main canal. It runs through Kecheng, Qu and Longyou cities/counties/disricts of Quzhou Municipality, Jinhua Municipality and until it reaches Lan River. Its design annual water diversion is 560 m^3. It can irrigate 29.3 thousand hectare of land in the south of Qu River and also supply water to 210 thousand people and industries of villages and towns along the canal.

Electric Irrigation Station

There are many electric irrigation stations in Qiantang River Basin with 132 thousand kilowatts of total installed capacity that can irrigate 0.06933 Mha of farmlands, including the largest one is Lazhutai Electric Irrigation Station. Meanwhile, many pumping stations with the main purpose of irrigation together with power generation have been constructed in Jinhua River Basin, including the three largest, Taxia Pumping Station and Yangzhai Pumping Stationin Yiwu City and Yangbaoshan Pumping Station in Jinhua County.

1.12.2 Existing Problems

At present the main problems in water resources utilization are:

- Water shortage and water quality deterioration exist in many regions. About 0.0267 Mha of dry lands and 0.0667 Mha of loess hills need the increase of irrigation water supply. However, with the socio-economic development and improvement of people's life, industrial and domestic water consumption increase remarkably and many rivers are polluted, contradictions between water supply and demand are becoming more and more serious. Difficulties in quality drinking water supply often occur in cities and towns and influenced the industrial and agricultural production and the people's life.

- Irrigation water consumption is very high. Because the hydraulic facilities in some irrigation districts are ageing and out-of-repair and many corollary works have not been completed, the water use efficiency can't meet the design standard and the irrigation water consumption is very high.

- The development and utilization of water resources are to be improved. There are abundant water resources in this river basin and the mean annual runoff is high to 38.64 billion m^3. However, only 20% of the water resources have been exploited and further utilization is needed.

- Much forest vegetation was destroyed due to some historical reasons and many problems such as soil and water loss, and sedimentation and decrease of flood control capacity of rivers arose. The soil and water loss was much serious from the late of 1950's to the early of 1960's and decreased remarkably after 1980's with the improvement of forest vegetation owning to the attention from governments at various levels. However, the lift of river bed caused by soil and water loss is still producing adverse impact on flood control.
- With the development of economy, sewage water discharge from industrial and domestic uses are increased, the natural water bodies are seriously polluted, and the water quality in the river reaches of Quzhou, Longyou, Jinhua and Yiwu cities/counties/districts is deteriorated, which not only influenced quality water supply, but also reduced the environmental quality of this river basin.

- The conditions of water transportation need further improvement. At present, the river in the downstream of Tonglu City has a well-developed navigation system and 50□100 tons of ships can pass through Lan River. But the navigation conditions in Changshangang River, Qu River, Dongyang River, Wuyi River and Jinhua River are very poor and nearly at a standstill due to river sedimentation.

2. Water Resources

The water resources involved in this report include surface water and shallow ground water. Because the water resources come from rainfall, which varies greatly interannually, the water resources represent the average annual value. The water resources in rolling area are the sum of surface water and shallow ground water, usually called river runoff. Because the embedded depth of groundwater in plain area is very shallow, the evaporation from shallow groundwater can be used and is involved in this report.

Qiantang River Basin comes under subtropical monsoon climate with well-marked four seasons. The average annual precipitation is between 1200 mm and 2200 mm and evaporation between 800 mm and 1000 mm.

2.1 Surface Water

The total water resources in Qiantang River Basin (upstream of Hangzhou Gate) is 38.64 billion m^3 and shallow groundwater resources 7.71 billion m^3, accounting for 20% of the total amount. The water resources in the main stream and tributaries of Qiantang River is shown in Table 2-1.

The water resources in Qiantang River basin are unevenly distributed annually. Influenced by mold rain, the high-water period in the upstream of Mei City, including Qu River, Lan River and Xin'an River is usually between March and June or April and July when the water resources account for 60%□65% of that of the whole year. July to February of the next year or August to March of the next year is drought

period when the water resources account for 35%□40% of that of the whole year. Influenced by mold rain and typhoon rain, there are usually two high-water periods in the downstream of Mei City, including the main stream of Fuchun River, Fenshui River and Puyang River. The first period is between March and June or April and July when the water resources account for 40%□50% of that of the whole year. The second is usually in August or September when the water resources account for 15%□20% of that of the whole year. The water resources in the downstream of Mei City are the same as that in the upstream if there is no influence from typhoon. There is usually only one high-water period that is usually between March and June when the water resources account for 60%□70% of the total.

The river runoff also varies much interannually and the proportion between the maximum and the minimum is about 3 to 4 times. The river runoff in drought year with 95% of assurance coefficient is only about 50% of the annual average. Consecutive high-water years and consecutive drought years frequently occur in this river basin.

Table 2-1 Water Resources in Qiantang River Basin

River	Tributary	Catchment Area (km^2)	Total Water Resources (billion m^3)	Shallow Groundwater	
				Groundwater Resources (billion m^3)	Recharge Modulus of Groundwater (thousand m^3/km^2)
Qiantang		41945	38.64	7.71	185
	Xin'an	11674	11.0.0	2.10	180
	Changshan	3385	4.33	0.84	243
	Jiangshan	1946	2.26	0.48	244
	Wuxi	2577	2.94	0.63	243
	Jinhua	6782	5.20	1.12	164
	Fenshui	3444	3.18	0.62	181
	Puyang	3452	2.46	0.62	181

2.2 Groundwater

The groundwater resources in the rolling areas of Qiantang River Basin are very rich. However, influenced by geology and topography, it's unevenly distributed and the conditions for water storage are very poor. The annual distribution of groundwater resources is usually the same as that of surface water. There is usually only one peak groundwater runoff usually between April and June in a year in inland mountainous area and the lowest is between July and September, which is not good to agricultural production.

2.3 Water Resources Development and Utilization

To rationally exploit and use the water resources in Qiantang River Basin, many large, medium and small reservoirs and other hydro projects have been constructed.

There are totally 48 large and medium reservoirs with 20148 Km^2 of catchment area (excluding Fuchun Reservoir) and over 200 small reservoirs with 1500 Km^2 of catchment area.

Large reservoirs in this river basin mainly include Hunanzhen Reservoir, Tongshanyuan Reservoir, Hengjin Reservoir, Xin'an Reservoir, Fuchun Reservoir and Wanyao Reservoir. Particularly, as the largest reservoir in Zhejiang Province, the storage capacity of Xin'an Reservoir is 21.63 billion m^3 for the main purposes of flood control, power generation, irrigation, aquiculture and tourism etc. Through the conjunctive use with Fuchun Reservoir in the downstream, the discharged water amount is effectively regulated and the water resources are fully used. It provides abundant fresh water not only to agricultural production but also to Tonglu County, Fuyang City, urban centers of Hangzhou Municipality and Xiaoshan Municipality. Details about the constructed large reservoirs in this river basin are shown in Table 2-2.

Qiantang River Basin is an area with rich water resources. The water resources in Puyang River Basin, Wuyi River Basin and Dongyang River Basin is the lest and Jiangshan River Basin and Changshan River Basin is the most where the per capita and per hectare of water resources are all one time higher than the average value of the whole province.

Table 2-2 Basic Data of Constructed Large Reservoirs

Reservoir Features	Xin'anjiang	Fuchunjiang	Hunanzhen	Huangtankou	Hengjin	Nanjiang	Tongshanyuan	Wanyao
River located	Xin'an	Fuchun	Wuxi	Wuxi	North stretch of Dongyang	South stretch of Dongyang	Tongshanyuan	Jiangshanda
Catchment area (km^2)	10442	31645	2151	2388	378	210	180	212.5
Type of dam	gravity	gravity	gravity	gravity	Core wall	gravity	Core wall	gravity
Check flood level (m)	114.0	28.2	240.25	119.4	173.97	210.08	143.9	197.41
Total storage capacity (10^8m^3)	216.26	8.74	20.6	1.04	2.81	1.17	1.71	2..23
Design flood level (m)	111.0	24.7	238.0	115.0	167.5	207.05	142.13	197.24
Corresponding storage capacity (10^8m^2)	198.0	5.55	19.47	0.795	2.13	0.98	1.57	2.21
Normal water level (m)	108.0	23.0	230.0	115.0	1.59	206	137.1.2	196
Corresponding storage capacity	178.6	4.41	15.82	0.795	1.427	0.92	1.21	2..08

(10^8m^3)								
Flood level limit (m)	106.5	23.0	230.0	115.0	158.5	202	137.12	196
Corresponding storage capacity (10^8m^3)	168.94	4.41	15.82	0.795	1.39	0.71	1.21	2.08

3. Water for Agricultural Use

3.1 Irrigation Zone

Qiantang River Basin is divided into 16 irrigation zones on the basis of the geological conditions, administrative areas and current hydraulic facilities. Details are as follows:

- Changshan Zone: Changshan River Basin;
- Jiangshan Zone: Jiangshan River Basin;
- Qubei Zone: north bank of the main stream of Qu River;
- Qunan Zone: south bank of the main stream of Qu River;
- Dongpan Zone: Pan'an County and Dongyang City in Dongyang River Basin;
- Yiwu Zone: Yiwu City in Dongyang River Basin;
- Yongkang Zone: Yongkang City and Jinyun County in Wuyi River Basin;
- Wuyi Zone: Wuyi County in Wuyi River Basin;
- Jinwulan Zone: Wucheng District, Jinhua County and some areas of Lanxi City in Jinhua River Basin;
- Shouchang Zone: Shouchang River Basin;
- Funchun Reservoir Zone: downstream of Lanxi City in Lan River Basin, Xin'an River Basin, and upstream of Fuchun Dam in Fuchun River Basin;
- Fenshui Zone: Fenshui River Basin;
- Luzhu Zone: Luzhu River Basin;
- Huyuan Zone: Huyuan River Basin;
- Mainstream Zone of Fuchun River: river basins between Fuchun Dam and Hangzhou Gate (excluding Fenshui River, Luzhu River, Huyuan River and Puyang River);
- Puyang Zone: Puyang River Basin.

There are totally 10.67 million populations in these 16 irrigation zones in year 2000 including 3.557 million of urban populations, 0.4240 Mha of cultivated area including 0.3604 Mha of paddy field, and 0.1309 Mha of garden plot.

The socio-economic conditions in each zone in year 2000 are shown in Table 3-1.

3.2 Irrigated Area

It's predicted that the cultivated land will be decreased at a rate of 2.0‰ before 2010 and 1.5‰ between 2010 and 2020 due to the occupation of some cultivated land by industries, communication and house building and also some will be moved back to forest plantation for the purpose of soil and water conservation. However, the loess

hills in Jinhua and Quzhou municipalities have huge potentials for further exploitation. It's projected that the garden plot will be increased from 0.1307 Mha in 2000 to 0.1673 Mha in 2010 and 0.1993 Mha in 2020.

Table 3-1 Basic Data on Irrigation Zones in 2000

Zone	Population (million)			Cultivated Area (Mha)			Garden Plot □Mha□	Livestock converting into standard sheep (million)
	Urban	Rural	Subtotal	Paddy	Dry Land	Subtotal		
Changshan	0.1672	0.4102	0.5773	0.0218	0.0046	0.0264	0.0216	0.8595
Jiangshan	0.0748	0.4525	0.5273	0.0235	0.0026	0.0260	0.0101	1.7034
Qubei	0.3746	0.4366	0.8111	0.0226	0.0020	0.0246	0.0078	1.0263
Qunan	0.3354	0.5372	0.8726	0.0282	0.0037	0.0319	0.0057	0.6943
Dongpan	0.229	0.3044	0.5334	0.0192	0.0046	0.0238	0.0035	0.3913
Yiwu	0.1702	0.3669	0.5371	0.0172	0.0034	0.0206	0.0043	0.4434
Yongkang	0.0751	0.1691	0.2442	0.0171	0.0018	0.0189	0.0033	0.3186
Wuyi	0.4415	0.6963	1.1378	0.0123	0.0007	0.0130	0.0035	0.3101
Jinwulan	0.0338	0.1394	0.1732	0.0378	0.0190	0.0568	0.0118	1.5959
Shouchang	0.3217	0.8869	1.2086	0.0064	0.0008	0.0073	0.0025	0.2133
Fuchun Reser	0.1493	0.3992	0.5485	0.0343	0.0052	0.0396	0.0312	1.4394
Fenshui	0.0421	0.1263	0.1685	0.0202	0.0027	0.0229	0.0044	0.6336
Luzhu	0.0466	0.1201	0.1667	0.0066	0.0008	0.0074	0.0008	0.1882
Huyuan	0.2491	0.3934	0.6426	0.0052	0.0008	0.0060	0.0023	0.1305
Main stream of Fuchun River	0.6613	1.1483	1.8096	0.0238	0.0025	0.0263	0.0043	0.4302
Puyang	3.557	7.113	10.67	0.0643	0.0083	0.0726	0.0138	1.4406
Total	0.1672	0.4102	0.5773	0.3604	0.0636	0.4240	0.1309	11.819

1.3 Statistics and Projection of Population

The population in 2010 and 2020 two scenario years are projected on the basis of the statistical data in 2000 and the *Plan for the Economic and Social Development in the Tenth Fiver-Year Period and Outline for the Long-term Objective in Year 2010*. The projected populations in each scenario year are detailed in Table 3-2 and Table 3-3.

1.4 Irrigation Duty

Continuous paddy cropping is predominant is the cropping system of Qiantang River Basin. The net irrigation duty with 90% of assurance coefficient is 72000m^3/ha□102000 m^3/ha for paddy field, 1950 m^3/ha□3150 m^3/ha for dry land, and 1500 m^3/ha□2400 m^3/ha for garden plot. The net irrigation duty in each irrigation zone with 90% assurance coefficient is given in Table 3-4.

1.5 Water Duty in Rural Areas

The water uses in rural areas include water for domestic uses, village industries and livestock. The per capita water duty, which is get from investigation and relevant data, multiply the population is the total water consumption. The water duty and water consumption in rural areas are given in Table 3-5.

Table 3-2 Projection of Some Basic Data in Each Irrigation Zone in 2010

Zone	Population (million)			Cultivated Area (Mha)			Garden Plot □Mha□	Livestock Converting into sheep (million)
	Urban	Rural	Subtotal	Paddy	Dry Land	Subtotal		
Changshan	0.2633	0.4722	0.7355	0.0214	0.0045	0.0259	0.0276	0.9494
Jiangshan	0.2378	0.3589	0.5967	0.0230	0.0025	0.0255	0.0129	1.8816
Qubei	0.1063	0.4387	0.545	0.0222	0.0020	0.0241	0.0100	1.1337
Qunan	0.503	0.3353	0.8383	0.0276	0.0036	0.0312	0.0073	0.7669
Dongpan	0.478	0.4239	0.9019	0.0189	0.0045	0.0234	0.0044	0.4322
Yiwu	0.3258	0.2255	0.5512	0.0169	0.0034	0.0202	0.0055	0.4898
Yongkang	0.2398	0.3153	0.5551	0.0167	0.0018	0.0185	0.0042	0.3519
Wuyi	0.1105	0.1418	0.2524	0.0120	0.0007	0.0127	0.0045	0.3425
Jinwulan	0.6279	0.548	1.1759	0.0370	0.0186	0.0556	0.0151	1.7629
Shouchang	0.0482	0.1309	0.179	0.0063	0.0008	0.0071	0.0032	0.2356
Fuchun Reser	0.4871	0.7619	1.2491	0.0336	0.0051	0.0388	0.0400	1.5900
Fenshui	0.2123	0.3546	0.5669	0.0198	0.0026	0.0225	0.0057	0.6999
Luzhu	0.0601	0.114	0.1741	0.0064	0.0008	0.0072	0.0010	0.2079
Huyuan	0.0663	0.1059	0.1722	0.0051	0.0008	0.0058	0.0029	0.1442
Main stream of Fuchun River	0.354	0.3101	0.6641	0.0233	0.0025	0.0257	0.0055	0.4752
Puyang	0.9407	0.9295	1.8702	0.0630	0.0082	0.0712	0.0177	1.5913
Total	5.061	5.966	11.027	0.3533	0.0623	0.4156	0.1675	13.055

Table 3-3 Projection of Some Basic Data in Each Irrigation Zone in 2020

Zone	Population (million)			Cultivated Area (Mha)			Garden Plot □Mha□	Livestock Converting into sheep (million)
	Urban	Rural	Subtotal	Paddy	Dry Land	Subtotal		
Changshan	0.3297	0.4282	0.7578	0.0211	0.0044	0.0255	0.0329	1.0488
Jiangshan	0.2976	0.3172	0.6148	0.0226	0.0025	0.0251	0.0153	2.0785
Qubei	0.1331	0.4285	0.5615	0.0218	0.0019	0.0238	0.0119	1.2523
Qunan	0.5183	0.3455	0.8638	0.0272	0.0036	0.0308	0.0087	0.8472
Dongpan	0.5966	0.3327	0.9293	0.0186	0.0044	0.0230	0.0053	0.4775
Yiwu	0.4072	0.1607	0.568	0.0166	0.0033	0.0199	0.0065	0.5410
Yongkang	0.2997	0.2723	0.572	0.0165	0.0018	0.0182	0.0050	0.3888
Wuyi	0.1386	0.1214	0.2601	0.0119	0.0007	0.0126	0.0054	0.3784
Jinwulan	0.7852	0.4265	1.2117	0.0365	0.0183	0.0548	0.0179	1.9473
Shouchang	0.06	0.1245	0.1845	0.0062	0.0008	0.0070	0.0038	0.2603
Fuchun Reser	0.6307	0.6564	1.2871	0.0331	0.0051	0.0382	0.0476	1.7563
Fenshui	0.2655	0.3186	0.5841	0.0195	0.0026	0.0221	0.0067	0.7731
Luzhu	0.075	0.1044	0.1794	0.0063	0.0008	0.0071	0.0012	0.2296
Huyuan	0.0829	0.0946	0.1775	0.0050	0.0007	0.0058	0.0035	0.1592
Main stream of Fuchun River	0.4431	0.2411	0.6843	0.0229	0.0024	0.0254	0.0066	0.5249
Puyang	1.1765	0.7506	1.9271	0.0621	0.0080	0.0701	0.0210	1.7578
Total	6.24	5.123	11.363	0.3480	0.0614	0.4094	0.1993	14.421

Table 3-4 Net Irrigation Duty in Irrigation Zone (90% of assurance coefficient)

Unit: m^3/ha

Zone	Paddy	Dry Crop	Gardens
Changshan	9495	2835	2130
Jiangshan	9795	3000	2250
Qubei	10110	3165	2370
Qunan	10110	3165	2370
Dongpan	9390	2715	2040
Yiwu	9435	2895	2175
Yongkang	9240	2595	1950
Wuyi	8955	2565	1920
Jinwulan	9825	3060	2295
Shouchang	8070	2550	1920
Fuchun Reser	7575	2535	1905
Fenshui	7260	2460	1845
Luzhu	8985	2055	1545
Huyuan	8700	2010	1515
Main stream of Fuchun River	9300	2145	1605
Puyang	9840	2445	1830

1.6 Water Consumption in Agriculture

The net irrigation water duty multiply the area of paddy field, dry land and garden plot is the net irrigation water demand. According to the data provided by each county/city, the present irrigation water use efficiency is 0.50□0.65. With the improvement of management level and corollary facilities of canal system, the irrigation water use efficiency will be increased to 0.60□0.70 by year 2010 and 0.70□0.80 by year 2020.

The irrigation water demand in each irrigation zone is shown in Table 3-6.

Table 3-5 Water Consumption of Domestics, Industries and Livestock in Rural Areas

Zone	2000		2010		2020	
	Water duty (t/cap day)	Water consumption (10^4m^3)	Water duty (t/cap day)	Water consumption (10^4m^3)	Water duty (t/cap day)	Water consumption (10^4m^3)
Changshan	0.13~0.23	3364	0.23~0.33	5170	0.28~0.38	5079
Jiangshan	0.15~0.28	3181	0.25~0.35	3602	0.28~0.40	3908
Qubei	0.13~0.23	2890	0.23~0.33	4404	0.28~0.38	5083
Qunan	0.13~0.23	3585	0.23~0.33	4590	0.28~0.38	5045
Dongpan	0.20~0.30	4902	0.28~0.38	5028	0.35~0.45	4857
Yiwu	0.23~0.30	2916	0.28~0.38	2674	0.35~0.45	2347
Yongkang	0.13~0.18	2009	0.23~0.35	3309	0.25~0.40	3230
Wuyi	0.13~0.21	1034	0.25~0.35	1553	0.28~0.43	1551
Jinwulan	0.23~0.30	6671	0.28~0.40	6750	0.35~0.48	6422
Shouchang	0.13~0.25	954	0.23~0.33	1314	0.28~0.38	1477

Fuchun Reser	0.18~0.30	7688	0.25~0.38	8691	0.30~0.45	8984
Fenshui	0.18~0.28	3278	0.25~0.38	4044	0.28~0.43	4070
Luzhu	0.18~0.25	980	0.23~0.35	1197	0.28~0.40	1286
Huyuan	0.18~0.25	931	0.23~0.35	1112	0.28~0.40	1165
Main stream of Fuchun River	0.18~0.30	3410	0.25~0.38	3537	0.30~0.45	3301
Puyang	0.18~0.30	9954	0.25~0.38	10602	0.30~0.45	10274
Total		57749		67577		68079

Table 3-6 Irrigation Water Demand in Irrigation Zone (90% assurance coefficient)

Unit: billion m^3

Zone	Year 2000	Year 2010	Year 2020
Changshan	0.56038	0.53554	0.51403
Jiangshan	0.45438	0.43424	0.41680
Qubei	0.52599	0.50267	0.48249
Qunan	0.63801	0.60973	0.58524
Dongpan	0.34795	0.33253	0.31917
Yiwu	0.31440	0.30046	0.28839
Yongkang	0.29065	0.27777	0.26661
Wuyi	0.22382	0.21390	0.20531
Jinwulan	0.80729	0.77150	0.74052
Shouchang	0.12256	0.11712	0.11242
Fuchun Reser	0.59119	0.56498	0.54229
Fenshui	0.27572	0.26350	0.25292
Luzhu	0.11697	0.11178	0.10729
Huyuan	0.09902	0.09463	0.09083
Main stream of Fuchun River	0.48732	0.46572	0.44702
Puyang	1.18474	1.13222	1.08675
Total	7.04037	6.72830	6.45810

Note: the irrigation water use efficiency has been considered in the data.

4. Water for Domestic and Industrial Use

4.1 Projection of Population

The population Qiantang River Basinin 2010 and 2020 two scenario years are projected on the basis of the statistical data in the base year 2000 and the *Plan for the Economic and Social Development in the Tenth Fiver-Year Period and Outline for the Long-term Objective in Year 2010* and *Planning for Cities and Towns* The projected populations in the base year and each scenario year are detailed in Table 4-1.

Table 4-1 Statistical Data and Projection of Populations in Qiantang River Basin

Year	Population (million)		
	Urban Centers	Rural Areas	Total
2000	3.557	7.113	10.670
2010	5.061	5.966	11.027
2020	6.240	5.123	11.363

4.2 Projection of Water Demand

The water uses in urban centers mainly include domestic water use, industrial water use and public water use. According to the investigated data, the water duty in urban centers in the irrigation zones in year 2000 is between 0.25m^3/capita.day□0.60 m^3/capita.day. The per capita water duty in each irrigation zone are projected taking into account of the extension of urban centers, adjustment of industrial structure, economic development level and conditions of water sources etc. It's projected that the water duty in 2010 and 2020 two scenario years are 0.45m^3/capita.day□0.75 m^3/capita.day and 0.55m^3/capita.day□0.95 m^3/capita.day respectively. The water duty and water demand in each irrigation zone are detailed in Table 4-2.

Table 4-2 Water Duty and Water Demand in Urban Centers

Zone	2000		2010		2020	
	Water duty (t/cap day)	Water consumption (10^4m^3)	Water duty (t/cap day)	Water consumption (10^4m^3)	Water duty (t/cap day)	Water consumption (10^4m^3)
Changshan	0.25~0.45	2364	0.45~0.65	5766	0.55~0.75	7821
Jiangshan	0.30~0.55	2593	0.50~0.70	4773	0.55~0.80	7331
Qubei	0.25~0.45	956	0.45~0.65	2133	0.55~0.75	3157
Qunan		29652		32679		38634
Dongpan	0.40~0.60	6122	0.55~0.75	11340	0.70~0.90	17421
Yiwu	0.45~0.60	4388	0.55~0.75	7729	0.70~0.90	11892
Yongkang	0.25~0.35	1864	0.45~0.70	5033	0.50~0.80	7111
Wuyi	0.25~0.42	918	0.50~0.70	2421	0.55~0.85	3541
Jinwulan	0.45~0.60	8460	0.55~0.80	15471	0.70~0.95	23643
Shouchang	0.25~0.50	462	0.45~0.65	967	0.55~0.75	1422
Fuchun Reser	0.35~0.60	5578	0.50~0.75	11113	0.60~0.90	17264
Fenshui	0.35~0.55	2453	0.50~0.75	4843	0.55~0.85	6783

Luzhu	0.35~0.50	654	0.45~0.70	1261	0.55~0.80	1848
Huyuan	0.35~0.50	723	0.45~0.70	1392	0.55~0.80	2042
Main stream of Fuchun River	0.35~0.60	4319	0.50~0.75	8075	0.60~0.90	12131
Puyang	0.35~0.60	11465	0.50~0.75	21460	0.60~0.90	32206
Total		82971		136456		194248

1.3 Current Water Demand and Sewage Water Discharge

It's indicated from Table 4-2 that the total water demand in urban centers of Qiantang River Basin in year 2000 is 830 million m^3.

In the light of the *Water Resources Bulletin* issued by Zhejiang Provincial Water Conservancy Department in year 2000, the domestic sewage water discharge in urban centers of Qiantang River Basin is 0.6277 million tons per day and 229 million tons per year, accounting for 24.2% of the total sewage water discharge. The sewage water discharge from industries is 1.9685 million tons per day and 719 million tons per year, accounting for 75.8% of the total.

5. Water Use by Eco-System

The water use by eco-system represents the minimum water amount used to maintain the function and implement the development of the ecological environment, including the minimum runoff for sand sluicing, sedimentation flushing, dilution and rejuvenation of polluted water and protection of rivers, lakes and swamps etc., and the minimum sea inflow.

The water use by eco-system can be projected on a in-channel and out-channel two types basis according to the main problems confronted by the eco-environment and the target for ecological protection and environmental development.

The in-channel water use by eco-system represent the water used to maintain the basic functions and river channels and the eco-environment of estuaries. The out-channel water use by eco-system represent the water used to beautify the eco-environment of cities and towns and construct other eco-environmental works.

Qiantang River Basin has rich water resources. The average annual inflow at Quzhou Station, Jinhua Station and Lanxi Station (whose catchment area is 5424 Km^2, 5953 Km^2 and 18233 Km^2) is 5.44 billion m^3, 3.87 billion m^3 and 11.30 billion m^3 respectively. The inflow at Hangzhou Gate with 99%, 90%, 75% and 50% of assurance coefficient is 16.57 billion m^3, 20.83 billion m^3, 23.38 billion m^3 and 34.08 billion m^3. There are 48 large and medium reservoirs in Qiantang River Basin whose total catchment area is 20148 Km^2 (excluding Fuchun Reservoir). Particularly, the storage capacity of Xin'an Reservoir, the largest reservoir in Zhejiang Province, is 21.63 billion m^3. Through the conjunctive use with Fuchun Reservoir in the downstream, the discharged water amount from Xin'an Reservoir is effectively

regulated and the water resources are fully used. Consequently, the plentiful water resources in Qiantang River Basin can meet the demand for eco-system.

6. Water Balance

6.1 Calculating Method and Principle

The long-series day-by-day water balance calculating method is adopted. 1961 to 2000 forty years of data are selected as the hydrologic series.

The principles for water balance are using river water first and then reservoir water, using water in small reservoirs first and then in large reservoirs. The detailed principles are:

- The water with fixed water source should be used first if possible;
- River runoff, including the natural runoff formed by rainfall, treated water from domestics and industries in the upper reaches, and return water from irrigation should be used first. In the calculation, 50%□60% of the domestic and industrial water is taken as treated water, 20% of the irrigation water supply is taken as the return water;
- The water in scattered ponds and small reservoirs should be used firstly when the river runoff can't meet the water demand;
- The medium and large reservoirs take the responsibilities of irrigation and hump modulation;
- The tidal fresh water from the main stream of Qiantang River should be used first if possible and then reservoir water;
- The order for water supply is that the water demand for some key water consumers, i.e. the domestics and some important industries with 95% of assurance coefficient should be met first, the water consumption for important industries can be calculated as 50%□90% of the total water consumption in urban centers in accordance with the industrialization level; and the water demand for normal industries with 90% of assurance coefficient and irrigation with 75%□90% of assurance coefficient should be met afterwards;
- Three times of the natural daily flow in the calculated section with 95% of assurance coefficient can be taken as the water consumption for eco-system.

1.2 Water Balance Analysis

With the above-mentioned methods and principles, the day-by-day water balance is calculated on the basis of the forty-year series of inflow and current water consumption and hydraulic facilities. The water balance in the typical year with 90% of assurance coefficient is given in Table 6-1. It's indicated from the table that water is short in most of the irrigation zones, including the serious water shortage in Changshan, Yiwu and Shouchang, and more serious water shortage in Qunan, Yongkang and Wuyi, except Jiangshan, Dongpan, Fuchun Reservoir and main stream of Fuchun River when 10 year of flood occur (P=90%). The water shortage rate in the whole basin is 9.1%. The irrigation water consumption in this river basin accounts for 83.4% of the total water demand and the domestic and industrial water demand in most areas can be met.

Table 6-1 Water Balance with 90% of Assurance Coefficient in 2000

Unit: million m^3

Zone	Water Demand				Water Supply	Water Shortage		
	Rural	Urban Center	Irrigation	Total		Normal	Guaranteed	Total
Changshan	33.64	23.64	560.38	617.66	516.10	101.56	0	101.56
Jiangshan	31.81	25.93	454.38	512.12	512.12	0	0	0
Qubei	28.90	9.56	525.99	564.45	489.24	75.21	0	75.21
Qunan	35.85	296.52	638.01	970.38	947.41	22.97	0	22.97
Dongpan	49.02	61.22	347.95	458.19	458.19	0	0	0
Yiwu	29.16	43.88	314.40	387.44	338.60	48.84	0	48.84
Yongkang	20.09	18.64	290.65	329.38	165.89	160.39	3.10	163.49
Wuyi	10.34	9.18	223.82	243.34	171.59	71.75	0	71.75
Jinwulan	66.71	84.60	807.29	958.60	867.81	90.79	0	90.79
Shouchang	9.54	4.62	122.56	136.72	99.74	36.98	0	36.98
Fuchun Reser	76.88	55.78	591.19	723.85	723.85	0	0	0
Fenshui	32.78	24.53	275.72	333.03	331.45	1.58	0	1.58
Luzhu	9.80	6.54	116.97	133.31	124.68	8.63	0	8.63
Huyuan	9.31	7.23	99.02	115.56	93.22	22.34	0	22.34
Main stream of Fuchun River	34.10	43.19	487.32	564.61	564.61	0	0	0
Puyang	99.54	114.65	1184.74	1398.93	1341.45	57.48	0	57.48
Total	577.47	829.71	7040.37	8447.55	7745.93	698.52	3.10	701.62

With the socio-economic development, land use for capital construction will be increased and result in the decrease of cultivated area. Moreover, with the adjustment of cropping pattern, the cultivated area of double cropping of rice will be decreased while the single cropping of rice will be increased. Therefore, the irrigation water consumption will be decreased correspondingly, to 76.7% (P=90%) of the total in 2010. With the development of industry and improvement of people's life, the water consumption for domestics, industries and others will be increased from 16.7% of the total in 2000 to 23.3% in 2010 (P=90%). The total water consumption will be increased correspondingly. However, the water shortage rate in 2010 will not differ much comparing with that in 2000 due to the even distribution of water for domestics, industries and others. The water balance in 2010 is given in Table 6-2.

In 2020, water consumption for irrigation will be decreased and water for domestics, industries and others will be increased continuously. The total water consumption and water shortage will be increased, but the water shortage rate won't change much due to the reduction of water consumption in irrigation peak. The water balance in 2020 is shown in Table 6-3.

Table 6-2 Water Balance with 90% of Assurance Coefficient in 2010

Unit: million m^3

Zone	Water Demand				Water Supply	Water Shortage		
	Rural	Urban Center	Irrigation	Total		Normal	Guaranteed	Total
Changshan	51.70	57.66	535.54	644.90	543.84	101.06	0	101.06
Jiangshan	36.02	47.73	434.24	517.99	517.99	0	0	0

Qubei	44.04	21.33	502.67	568.04	495.00	73.04	0	73.04
Qunan	45.90	326.79	609.73	982.42	956.74	25.68	0	25.68
Dongpan	50.28	113.40	332.53	496.21	496.21	0	0	0
Yiwu	26.74	77.29	300.46	404.49	299.11	105.38	0	105.38
Yongkang	33.09	50.33	277.77	361.19	203.01	149.48	8.70	158.18
Wuyi	15.53	24.21	213.90	253.64	181.80	70.61	1.23	71.84
Jinwulan	67.50	154.71	771.50	993.71	919.94	73.77	0	73.77
Shouchang	13.14	9.67	117.12	139.93	103.65	36.28	0	36.28
Fuchun Reser	86.91	111.13	564.98	763.02	763.02	0	0	0
Fenshui	40.44	48.43	263.50	352.37	350.05	2.32	0	2.32
Luzhu	11.97	12.61	111.78	136.36	127.51	8.85	0	8.85
Huyuan	11.12	13.92	94.63	119.67	96.86	22.81	0	22.81
Main stream of Fuchun River	35.37	80.75	465.72	581.84	581.84	0	0	0
Puyang	106.02	214.60	1132.22	1452.84	1393.39	59.45	0	59.45
Total	675.77	1364.56	6728.30	8768.63	8029.97	728.73	9.93	738.66

Table 6-3 Water Balance with 90% of Assurance Coefficient in 2020

Unit: million m^3

Zone	Water Demand				Water Supply	Water Shortage		
	Rural	Urban Center	Irrigation	Total		Normal	Guaranteed	Total
Changshan	50.79	78.21	514.03	643.03	542.49	100.54	0	100.54
Jiangshan	39.08	73.31	416.80	529.19	529.19	0	0	0
Qubei	50.83	31.57	482.49	564.89	492.23	72.66	0	72.66
Qunan	50.45	386.34	585.24	1022.03	995.30	26.73	0	26.73
Dongpan	48.57	174.21	319.17	541.95	541.95	0	0	0
Yiwu	23.47	118.92	288.39	430.78	335.51	79.77	15.50	95.27
Yongkang	32.30	71.11	266.61	370.02	197.74	155.18	17.10	172.28
Wuyi	15.51	35.41	205.31	256.23	184.68	69.45	2.10	71.55
Jinwulan	64.22	236.43	740.52	1041.17	956.37	84.80	0	84.80
Shouchang	14.77	14.22	112.42	141.41	105.69	35.72	0	35.72
Fuchun Reser	89.84	172.64	542.29	804.77	804.77	0	0	0
Fenshui	40.70	67.83	252.92	361.45	358.27	3.18	0	3.18
Luzhu	12.86	18.48	107.29	138.63	129.32	9.31	0	9.31
Huyuan	11.65	20.42	90.83	122.90	99.99	22.91	0	22.91
Main stream of Fuchun River	33.01	121.31	447.02	601.34	601.34	0	0	0
Puyang	102.74	322.06	1086.75	1511.55	1445.34	64.11	2.10	66.21
Total	680.79	1942.47	6458.10	9081.36	8320.20	724.36	36.80	761.16

1.3 Principle for Water Resources Development and Utilization and Approaches for Water Shortage Relief

Qiantang River Basin has rich water resources, but the current river runoff has not been fully used and water shortage in varying degrees still exists. It's a structural

water shortage area. The water resources can be further developed and utilized through the following principles and measures.

1.3.1 Principles for Water Resources Development and Utilization

- Structural measures and non-structural measures should be combined. In areas where the water resources have been full developed and used while the water resources are short, water-saving measures should be taken to increase the water use efficiency. The dispatching plan for current hydro projects should be optimized for the rational development and comprehensive utilization of water resources.

- Water resources development and utilization should be coordinated with other development tasks, such as flood control and power generation to meet the demand of comprehensive utilization.

- The water shortage relief should firstly base on water resources development and utilization in this river basin, then water diversion from other river basins can be taken into account when the water resources in this river basin can't meet the water demand and water saving measures have been taken.

- Reservoir water should be firstly used for domestics. To guarantee the water demand for domestics and some important industries, some storage capacity in the large and medium reservoirs should be reserved.

- Water resources development and utilization should be coordinated with environmental protection for the sustainable development. Protecting the water quality is an important measure to increase the water resources development and utilization level.

1.3.2 Approaches and Measures for Water Shortage Relief

Qiantang River Basin has plentiful water resources, but it unevenly distributes spatially and temporally and the water balance among each irrigation zone differs much. Therefore, some feasible measures should be taken to relieve the water shortage. The main approaches and measures are as follows:

- Reducing water loss and extending water saving measures. Presently, the water loss from percolation of canal system is very huge, the water use efficiency is only about 0.50□0.65. Therefore, the canals are planned to be lined up and water saving technology are to be extended, particularly in Yongkang, Yiwu and Wuyi etc.., zones. The circulation use of industrial water should be increased. Particularly the water consumption by huge water consumers should be reduced.

- Increasing the water supply through seepage control, extension of storage capacity and increase of water diversion works. For instance, rubber dams can be constructed in Dongyang Zone to increase the storage capacity of reservoirs; Yangxi Reservoir in Yongkang Zone can be extended to increase its storage capacity; Yuankou Reservoir in Wuyi Zone can be heightened and reinforced;

water diversion works can be constructed in the current medium reservoirs in Yiwu Zone to increase the storage capacity of reservoirs.

- Functions of the current hydro projects should be adjusted for the purpose of rational water resources development and utilization. Hunanzhen Reservoir is the largest reservoir in the upstream of Qu River. Therefore, the power flow in Hunanzhen Reservoir and Huangtankou Reservoir can be rationally dispatched to increase the water supply to the lower reaches. Meanwhile, to rationally develop and fully use the water resources in Qiantang River, the largest hydro project in this river basin, Xin'an Reservoir should be fully used to meet power generation, water supply and environmental protection etc., various demands. An optimal plan for the comprehensive utilization of the water in Xin'an Reservoir should be worked out so as to provide preferential conditions in water supply to the urban centers of Hangzhou and Xiaoshan municipalities and both banks at the estuary.

- Constructing water storage works. Reservoirs planned to be constructed in this river basin include Misai Reservoir, Furong Reservoir, Baishuikeng Reservoir, Xiachuan Reservoir, Muchen Reservoir, Shuangfeng Reservoir, Huaxi Reservoir, Llixu Reservoir and Wuliting Reservoir.

- Constructing inter-region or inter-basin water diversion works. In areas where the water resources are short and the water resources have been fully used, but the water resources can't meet the water demand, water diversion works from nearby river basins can be constructed to increase the water supply in this river basin. For example, Yiwu Zone plans to construct Badu Reservoir in Dachen River, the tributary of Puyang River and divert water from Hengjin Reservoir in Dongyang River to increase water supply to urban centers; Yongkang Zone plans construct an inter-basin water transfer project, Haoxi Water Diversion Project to increase the water supply.

1.4 Planned Water Supply Projects

Changshan Zone

- Misai Reservoir will be constructed to supply water for irrigation and towns/townships along Changshan River. Misai Reservoir is located in Majin River (the main stream of Changshan River) and 6 kilometers away from Kaihua County. Its catchment area is 797 Km^2 and live storage 146 million m^3. It can also be used as the water source for Kaihua County in a long-term view.
- Furong Reservoir will be constructed for water resources development and flood control in Facun River, tributary of Changshan River. Its catchment area is 126 Km^2 and live storage 72 million m^3. There are no large water storage works in Fangcun River Basin, only many small reservoirs with 9.98 million m^3 of storage capacity that can irrigate 667 ha of land, and some ponds and weirs. After the complete of Furong Reservoir, the tail water from power generation can irrigate over 1330 ha of farmlands in the downstream.
- Longtan Reservoir will be constructed in Longtan River for the main purpose of water supply to domestics, public works and some industries in Tianma Town of Changshan County, together with flood control, power generation and irrigation ect. It's also used as the irrigation water source of Qiankou Township and

Erduqiao Township. Its catchment area is 44.38 Km^2 and live storage 12 million m^3.

- The water diversion works of Changfeng Irrigation District for the purpose of power generation and irrigation will be further improved. Changfeng Hydro Project (had been completed) is located near Jujia Village, Hejia Township of Changshan County. Its catchment area is 2082 Km^2 and normal storage 4.98 million m^3. Changgeng Irrigation District will irrigate 1200 ha of farmlands in the first stage and 6000 ha of farmlands after the completion of canal systems. The canal systems of Dongkeng Reservoir and Bijiahe Reservoir will be further improved to increase the water use efficiency.

Jiangshan Zone

- Wanyao Reservoir is a large water storage works for the main purpose of irrigation together with water supply, flood control and power generation. It can irrigate 21400 ha of farmlands and supply 100000 tons of water per day to Jiangshan City. Construction of canal systems of this reservoir should be accelerated to give full play to its water supply benefits. The total length of canals in the irrigation district of this reservoir is 86.5 kilometers, including 6.6 kilometers long of main canal, and 19.8 km, 14.6 km and 45.7 km long of east canal, south canal and north canal.
- Baishuikeng Reservoir will be constructed for the main purpose of flood control and power generation, together with water supply and irrigation. It's located in the upstream of Xiakou Reservoir. Its catchment area is 330 Km^2, storage capacity 226 million m^3 and live storage 176 million m^3. The irrigation conditions of nearly ten thousand ha of farmlands in Xiakou Irrigation District will be improved after the completion of this reservoir. It can also supply water to Jiangshan Zone joined with Wanyao Reservoir.

Qubei Zone

- Currently there is one large reservoir, Tongshanyuan Reservoir. However, the irrigation water use efficiency is only 0.31. Therefore, rehabilitation of the irrigation district should be strengthened to increase the irrigation water use efficiency and give full play to its benefits. Xiachuan Reservoir, which is located in Zhi River, the tributary of Qu River, will be constructed. Its catchment area is 221.4 Km^2 and live storage 106 million m^3. The irrigation assurance coefficient in this river basin will be further increased with its joint dispatching with Zhougongfan etc., medium reservoirs and rehabilitation of Tongshanyuan Irrigation District.
- Siqiao Reservoir will be constructed with the purpose of flood control, irrigation and power generation. It's located in Siqiao Village, Shiliang Town of Qu County. Its catchment area is 57 Km^2 and live storage 20 million m^3.

Qunan Zone

- Juhua Groups and the urban centers of Quzhou Municipality are the huge water consumers. The water demand for domestics and industries of the urban centers of Qu Municipality can be met after the rational dispatching of the power flow from Hunanzhen and Huangtankou power plants. In principle, there will be no

increase in the water supply to Juhua Groups. They should exploit the water saving potentialities to improve the water use conditions.

- Reservoirs and ponds should be constructed to relieve the irrigation water shortage in the rolling areas of south Wuxi River Water Diversion Works. The largest one is Luozhangyuan Reservoir that supplies water for domestics, industries and irrigation to Dazhou Town and Henglu Town of Qu County. It's located in Yuankou Village, Dazhou Town of Qu County. Its catchment area is 76 Km^2 and live storage 13 million m^3.
- Muchen Reservoir will be constructed with the main purpose of flood control together with irrigation and power generation. It's located in Lingshan River, the tributary of Qu River. Its catchment area is 397 Km^2, storage capacity 120 million m^3 and live storage 48 million m^3.
- Gaopingqiao Reservoir will be constructed for the purpose of flood control jointed with Sheyang Reservoir in the downstream and supplying clean water to Longyou Town. Its catchment area is 64 Km^2 and live storage 21 million m^3.

Dongpan Zone (Dongyang River)

There are many large and medium reservoirs in this zone, which have laid a good foundation for irrigation water supply. To make full use of the water resources and create conditions for water supply to Yiwu Zone, the following works can be constructed

- To increase the irrigation benefits and increase the water use efficiency, he canals of Hengjin Reservoir, Nanjiang Reservoir, Dongfang Reservoir, Shenlingkeng Reservoir and Langkengkou Reservoir should be lined up.
- The water supply works to be constructed in Pan'an County, which is located in the upper reaches of Hengjin and Nanjiang two large reservoirs, should be first used to supply water for the county and irrigation of some farmlands. Longtouyan Reservoir with 4.65 million m^3 of storage capacity and 3.6 kilometers long of water diversion tunnel will be constructed to supply 6.0 million m^3 of water per year to Anwen Town of Pan'an County.

Yiwu Zone (Dongyang River)

- Wangdian Reservoir, which is used as the downstream reservoir of Jinguangding Power Station and to supply to Wufotang and Xucun etc., towns/townships, will be constructed before 2010. Its storage capacity is 12.7 million m^3 and normal storage is 5.2 million m^3. Huaxi Reservoir will be constructed with the purpose of irrigation, water supply, flood control and power generation. Its storage capacity is 303 million m^3 and live storage 160 million m^3.
- Water diversion works from Changyan, Bofeng and Yankou etc., reservoirs will be constructed to increase the water storage of existing reservoirs, by 13.9 million m^3. Meanwhile, Qiaoxi Reservoir will be extended and the water storage will be increased by 5.0 million m^3. The construction and extension of Nanshan and Fengshuikeng etc., small reservoirs will increase 9.8 million m^3 of water supply.
- To save irrigation water, the canals of Yankou, Bofeng and Changyan three medium reservoirs will be lined up and water saving technology will be extended.

- Besides the newly constructed and extended water storage works in Yiwu Zone, the water in Hengjin Reservoir will be diverted to Yiwu Zone (0.21 million tons per day and total water diversion 50 million m^3).

Yongkang Zone (Wuyi River)

The present water resources development in this zone can't meet the water demand. A lot of small reservoirs which can increase 4.0 million m^3 of water supply will be constructed and Yangxi Reservoir will be extended. Moreover, an inter-basin water diversion project, Haoxi Water Diversion Project will be constructed in the planning.

- Water saving irrigation is an important measure to relieve the water shortage. The canals of three medium reservoirs will be lined up. Meanwhile, water saving measures, such as low-pressure pipe irrigation will be taken to reduce water loss and water saving technology will be technology.
- Yangxi Reservoir will be extended for water supply to Yongkang City. It can increase 540 million m^3 of storage capacity.
- Implementation of the above measures also can't meet the water demand. Therefore, an inter-basin water diversion project, Haoxi Water Diversion Project will be constructed. The catchment area of Haoxi River Basin in the upstream of Chengguan Town of Jinyun County is 680 Km^2, average annual runoff 540 million m^3 and per capita water resources 4150 m^3. Therefore, the plentiful water in Haoxi River can be diverted to Yongkang to relieve the water shortage there. The diversion flow and total water diversion is 0.8 m^3/s and 25 million m^3 in year 2010 and 1.8 m^3/s and 56 million m^3 in year 2020.
- Two reservoirs, Liu'an Reservoir and Qianming Reservoir will be constructed by two stages. Qianming Reservoir, which is located in 1400 meters downstream of Qianming Village, will be constructed first. Its catchment area is 304 Km^2, storage capacity 98 million m^3 and live storage 59 million m^3. It can supply 0.8 m^3/s of flow to Yongkang when it's completed. Liu'an Reservoir will be constructed in Liu'an Village, Renchuan Township of Pan'an County, upstream of Qianming Reservoir. Its catchment area is 48.5 Km^2, storage capacity 34 million m^3 and live storage 25 million m^3. It can supply 1.0 m^3/s of flow to Yongkang when it's completed.

Wuyi Zone (Wuyi River)

This zone has plentiful water resources. However, it's unevenly distributed spatially and temporally and drought disaster frequently occurs. Extension of water saving measures and construction of hydraulic engineering will be combined to increase water supply to urban centers and irrigation.

- Yuankou Reservoir with 91 Km^2 of catchment area, 23.6 million m^3 of storage capacity and 21.6 million m^3 of normal storage will be constructed.
- Xili Reservoir will be extended from the present small reservoir with 2.0 million m^3 of normal storage to a medium one with 31 Km^2 of catchment area, 13 million m^3 of storage capacity and 10 million m^3 of normal storage to increase water supply to urban centers and irrigation.

- To save irrigation water and increase the irrigation water use efficiency, the canals of Yuankou Reservoir, Qingxikou Reservoir and other small reservoirs will be lined up.

Jinwulan Zone

- Jiufeng Reservoir, which is located in Taosi Vilage of Houdaxi Town, will be constructed with the main purpose of flood control and water supply together with power generation. Its catchment area is 120 Km^2, storage capacity 66 million m^3 and live storage 52 million m^3. It will be mainly used to supply water to the urban centers of Jinhua Municipality at a rate of 100000 tons per day together with irrigation of some farmlands.
- Dongxi Reservoir, which is located in Zhengdian Village of Jinhua County, will be constructed. Its catchment area is 21 Km^2, storage capacity 10.3 million m^3 and live storage 10 million m^3.
- Andi Reservoir will be extended to increase water supply for irrigation of 6667 ha of farmlands, domestics and industries in Wucheng District. The storage level will be lifted by 1.5 m and the normal storage will be increased from 58.75 million m^3 to 63.58 million m^3.
- Rehabilitation of Shafan Reservoir Irrigation District. The total area of Shafan Reservoir Irrigation District is 24300 ha. Firstly, Shjin'an Canal with 28.6 kilometers long and 6 m^3/s of flow will be excavated to irrigate 3640 ha of farmlands and 853 ha of garden plots in Shanxin Irrigation District; secondly, there are 11573 ha of farmlands and 2027 ha of garden plots in Jinlan Reservoir Irrigation District, 5.94 kilometers long of canals will be excavated and 99 kilometers of canals will be lined up to increase the water use efficiency and save irrigation water; thirdly, there are 6667 ha of farmlands and 2340 ha of garden plots in Andi Irrigation District and 68 kilometers long of canals will be lined up.
- To increase irrigation water supply in Lanxi City, Xiliyuan Reservoir that has 17 million m^3 of storage capacity and can increase 13 million m^3 of water, and Yaolang Reservoir that has 10 million m^3 of storage capacity and can increase 13 million m^3 of water will be constructed.

Shouchang Zone

- The water resources development and utilization level in Shouchang River Basin is very low, only around 11%. So the water is serious short. Small reservoirs and ponds are to be constructed to increase irrigation water supply in rolling areas and water saving measures are to be taken to save irrigation water. There is only one medium reservoir, Lixu Reservoir that will be constructed in this zone. Lixu Reservoir is located in Chenjia Village of Shouchang Town, Its catchment area is 33 Km^2, storage capacity 12 million m^3 and live storage 10 million m^3.

Fuchun Zone

- This zone is located in Fuchun Reservoir area where the water resources are abundant and can meet the water demand. To relieve the water shortage in some parts and rationally develop and utilize the water resources, Zhiyan Reservoir will be extended. The water supplied to the urban centers of Jiande City in this zone is diverted from Xin'an Reservoir.

Fenshui Zone

There is no much water shortage in Fenshui River Basin due to its abundant runoff. Water shortage in the sector of irrigation can be relieved through construction and extension of reservoirs and water diversion works, particularly the construction of the key project, Fenshui Hydro Project. It's located in Wuliting, downstream of Fenshui River for the main purpose of flood control and power generation together with irrigation water supply. Its catchment area is 2630 Km^2, mean annual runoff 250 million m^3, storage capacity 184 million m^3 and live storage 60 million m^3.

Lvzhu Zone

It's indicated from the water balance analysis that the water here can't meet the water demand, but the water shortage is not huge. Water saving irrigation, increase of water use efficiency of canal systems, and construction of small reservoirs and ponds etc., measures will be taken to increase the water supply capacity, together with the full use of the main stream of Fuchun River.

Huyuan Zone

As one of the tributaries of Fuchun River, the water shortage in Huyuan River Zone is higher than that in Lvzhu River Zone and the available water supply can be increased through water saving irrigation, increase of water use efficiency of canal systems, and construction of medium and small water storage works. Qianxitan Reservoir, which is located in Qianxitan of Tan River, the tributary of Huyuan River, will be constructed to supply water for domestics and irrigation in Tanxi Town. Its live storage is 12 million m^3. Nanshan Reservoir, which is located in the tributary of Huyuan River in Dafan Township, will be constructed to supply water for domestics and irrigation in north of Puyang River. Its live storage is 25 12 million m^3.

Main Stream of Fuchun River Zone

Due to the abundant water resources in the main stream of Fuchun River, the assurance coefficient of irrigation is very high and the water can meet the demand. To save water resources, water saving irrigation is encouraged. The water supplied to the urban centers of Tonglu County and Fuyang City is diverted from Fuchun River.

Puyang Zone

The water resources in Puyang Zone are fully used. There are totally 10 medium reservoirs in the upper reaches and one tidal water diversion work with 96 million m^3 of tidal water diversion capacity in the lower reaches. It's indicated from the water balance analysis that with the increase of water use efficiency of canal systems, the present and future water can meet the demand. The present source of water supply to Puyang County is Jinkengling Reservoir and Tongjiqiao Reservoir can be used as the water source in the future. The source of water supply to Zhuji City is from Puyang River and Qingshan Reservoir.

Most of the above projects will be completed before 2010, except Xiachuan Reservoir and Huaxi Reservoir before 2020 and by-stage construction of Haoxi Water Diversion Project.

1.5 Future Water Balance

The future water balance is analyzed according to the above-mentioned water shortage relieving approaches and measures and planed water supply projects in this river basin.

The water balance results in each zone in 2010 and 2020 two scenario years are given in Table 6-4 and Table 605.

With 90% of assurance coefficient, water is still short in Qunan, Yongkang, Wuyi, Jinwulan and Shouchang zones in year 2010 and the water shortage in Wuyi, Jinwulan and Qunan zones is mainly concentrated in areas without large and medium reservoirs. With 90% of assurance coefficient, water is still short in Yongkang, Wuyi and Shouchang zones in year 2020. Comparing with that in year 2010, even though the growth of populations in urban centers in year 2020 resulted in increase of water consumption in domestics and industries, the total water shortage is decreased due to the reduction of water consumption in irrigation with the reduction of cultivated area and improvement of hydraulic facilities.

7. Conclusions and Recommendations

There are abundant water resources in Qiantang River Basin. However, the water resources are unevenly distributed spatially and temporally, the present use rate of river runoff is very low and water shortage in varying degrees still exists in some areas. Therefore, structural measures and water saving etc., non-structural measures should be combined to further exploit and utilize the water resources and relieve the water shortage.

It’s recommended that canal system improvement and water saving measures should be strengthened to reduce water loss; potentialities of the current projects should be exploited to increase water supply; functions of the present projects should be adjusted to increase the water supply capacity; reservoirs should be constructed and extended to increase the regulation capacity of water resources and increase water supply; the circulation use rate of industrial water should be increased and water supply should not be increased as far as possible; inter-basin water diversion projects can be constructed in water shortage areas, such as Yongkang and Yiwu etc.

Table 6-3 Water Balance with 90% of Assurance Coefficient in 2010

Unit: million m^3

Zone	Water Demand				Water Supply	Water Shortage		
	Rural	Urban Center	Irrigation	Total		Normal	Guaranteed	Total
Changshan	51.70	57.66	535.54	644.90	644.90	0	0	0
Jiangshan	36.02	47.73	434.24	517.99	517.99	0	0	0
Qubei	44.04	21.33	502.67	568.04	568.04	0	0	0
Qunan	45.90	326.79	609.73	982.42	959.94	22.48	0	22.48
Dongpan	50.28	113.40	332.53	496.21	496.21	0	0	0
Yiwu	26.74	77.29	300.46	404.49	404.49	0	0	0
Yongkang	33.09	50.33	277.77	361.19	318.29	42.90	0	42.90
Wuyi	15.53	24.21	213.90	253.64	236.49	17.15	0	17.15
Jinwulan	67.50	154.71	771.50	993.71	957.22	36.49	0	36.49
Shouchang	13.14	9.67	117.12	139.93	130.05	9.88	0	9.88
Fuchun Reser	86.91	111.13	564.98	763.02	763.02	0	0	0
Fenshui	40.44	48.43	263.50	352.37	352.37	0	0	0
Luzhu	11.97	12.61	111.78	136.36	136.36	0	0	0
Huyuan	11.12	13.92	94.63	119.67	119.67	0	0	0
Main stream of Fuchun River	35.37	80.75	465.72	581.84	581.84	0	0	0
Puyang	106.02	214.60	1132.22	1452.84	1452.84	0	0	0
Total	675.77	1364.56	6728.30	8768.63	8639.72	128.90	0	128.90

Table 6-4 Water Balance with 90% of Assurance Coefficient in 2020

Unit: million m^3

Zone	Water Demand				Water Supply	Water Shortage		
	Rural	Urban Center	Irrigation	Total		Normal	Guaranteed	Total
Changshan	50.79	78.21	514.03	643.03	643.03	0	0	0
Jiangshan	39.08	73.31	416.80	529.19	529.19	0	0	0
Qubei	50.83	31.57	482.49	564.89	535.74	29.15	0	29.15
Qunan	50.45	386.34	585.24	1022.03	1015.09	6.94	0	6.94
Dongpan	48.57	174.21	319.17	541.95	541.95	0	0	0
Yiwu	23.47	118.92	288.39	430.78	430.78	0	0	0
Yongkang	32.30	71.11	266.61	370.02	370.02	0	0	0
Wuyi	15.51	35.41	205.31	256.23	256.23	0	0	0
Jinwulan	64.22	236.43	740.52	1041.17	1041.17	0	0	0
Shouchang	14.77	14.22	112.42	141.41	137.88	3.53	0	3.53
Fuchun Reser	89.84	172.64	542.29	804.77	804.77	0	0	0
Fenshui	40.70	67.83	252.92	361.45	361.45	0	0	0
Luzhu	12.86	18.48	107.29	138.63	138.63	0	0	0
Huyuan	11.65	20.42	90.83	122.90	122.90	0	0	0
Main stream of Fuchun River	33.01	121.31	447.02	601.34	601.34	0	0	0
Puyang	102.74	322.06	1086.75	1511.55	1511.55	0	0	0
Total	680.79	1942.47	6458.10	9081.36	9041.72	39.62	0	39.62