

People's Republic of China

Ex-Post Evaluation of Japanese ODA Loan
Yichang Water Environmental Improvement Project

External Evaluator: Hiromi Suzuki S., IC Net Limited

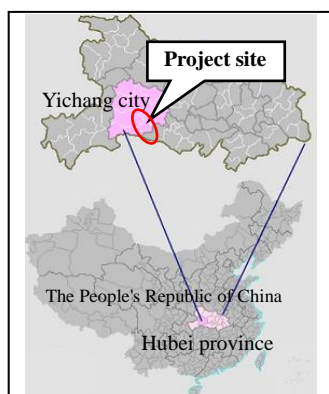
0. Summary

The project aimed to improve the water environment (the quality of river water and the quality of water supplied) in Yichang City, by developing and upgrading water supply and sewerage facilities.

The project was in line with Chinese development policies at the national, provincial and municipal levels, their development needs and the Japanese assistance policy for China, both at the time of the appraisal and at the time of the ex-post evaluation. Therefore, its relevance is high. With regard to the development of sewerage facilities, the targets were achieved or exceeded for all the main project effect indicators, including the amount of wastewater treated and the quality of the water treated. This enabled the Yichang Municipal People's Government to achieve the National Environment Quality Standards for Surface Water Class II. Regarding the improvement of water supply facilities, at the time of the Ex-Post Evaluation, the targets were achieved or the values were improving for the main project effect indicators, including the quantity of the water supplied, the population served and the turbidity of the water supplied. In particular, the target for the improvement of the quality of the water supplied, which is one of the project purposes, was met. Therefore, the project effectiveness is evaluated to be satisfactory. In addition, significant positive impacts were observed with regard to pollution control measures, sludge recycling, residents' living environment and their quality of life. Therefore, the project successfully achieved its intended effects and impacts. The efficiency of the project is evaluated to be fair, because the project period significantly exceeded the plan, although the project cost was within the plan. With regard to the sustainability of the effects of the project, no major problems have been observed in the organization, technical level and financial status of the entities in charge of the operation and maintenance of the water supply and sewerage facilities, therefore sustainability of the project effect is high.

In light of the above, this project is evaluated to be highly satisfactory.

1. Project Description



Project Location



Sedimentation Tank of the
Linjiangxi Sewage Treatment Plant

1.1 Background

Since the 1980s, China has achieved a rapid economic growth but at the same time experienced an increased environmental pollution due to industrialization and population growth. The Government of China has thus strengthened its environmental policy particularly since the latter half of the 1990s, which yielded results to some extent, but the state of environmental pollution remained serious. At the same time, urban areas suffered from serious water shortages for which the government improved water supply facilities mainly in large cities but was still unable to bridge the supply-and-demand gap in many cities.

Yichang City, located in the western Hubei, one of the six provinces that comprise Central China, is the political, economic and cultural center of the mid-and-higher streams of the Yangtze River. It is also an important river port city for collection, distribution and transportation of commodities, and used to be a center of the Yangtze Coastal Railway (Shanghai–Chongqing) and the Hulong Expressway (Shanghai–Chengdu Expressway) which was to become an important transportation as well as logistical facilities in the great western development region. However, the urban infrastructure as a whole was underdeveloped, and the city's water supply and sewage infrastructure was especially lagging behind. As of 2001, the city had no sewage treatment facility, and all wastewater from the urban districts were discharged to other rivers in the city without treatment. On the other hand, although Yichang City had already attained 100% in terms of water supply rate, two out of the three existing water purification plants of Yichang City Water Supply Company were built in 1959 and 1987, respectively, and they had low technical levels and failed constantly to satisfy the turbidity standards. As for the water distribution network, it was built over 40 years ago and many parts were decrepit, resulting in over 100 water pipe breaks occurring every year. Thus urgent improvements were needed.

1.2 Project Outline

The objective of this project is to improve the water quality of the rivers that flow through Yichang City as well as the quality of the water supplied, by developing sewage facilities and improving water supply facilities, thereby contributing to the promotion of a sustainable development of the city.

Loan Approved Amount/ Disbursed Amount	8,460 million yen / 8,459 million yen
Exchange of Notes Date/ Loan Agreement Signing Date	March 2003 / March 2003
Terms and Conditions	[Interest rate] Development of sewage facilities: 0.75% Improvement of water supply facilities: 2.2% [Repayment period] Development of sewage facilities: 40 years (Grace period: 10 years)

	Improvement of water supply facilities: 30 years (Grace period: 10 years) General untied
Borrower / Executing Agency	The Government of the People's Republic of China / Yichang Municipal People's Government (Yichang City Construction Investment Development Co., Ltd.)
Final Disbursement Date	July 2010
Main Contractors	Hubei Ruitian International Trading Co., Ltd (China) / China Tiesiju Civil Engineering Group Co., Ltd. (China) (JV) China First Metallurgical Construction Corporation (China) / Wuhan Evestar Trading Co., Ltd. (China) (JV) Hubei Provincial Minmetals International Trading Corp., Ltd (China) / Xinxing Ductile Iron Pipes Co., Ltd. (China) / China First Metallurgical Construction Corp. (China) (JV)
Main Consultant	Zhongyi International Tendering Company (China)
Feasibility Studies, etc.	Central and Southern China Municipal Engineering Design & Research Institute (2001)
Related Projects	Technical Cooperation: “Country Focused Training Course on Operation and Maintenance of Sewage Facilities under Japan's ODA Loan to China” (2005) Others: Kobe City Exchange Program: Dispatch of an environmental expert (for the improvement of Yichang City's water environment) under the “Changjiang-Shanghai Trade Promotion Project” (2002)

2. Outline of the Evaluation Study

2.1 External Evaluator

Hiromi SUZUKI S. (IC Net Limited)

2.2 Duration of Evaluation Study

Duration of the Study: August 2012 - December 2013

Duration of the Field Study: April 9-13, 2013 and July 23-26, 2013

3. Results of the Evaluation (Overall Rating: A¹)

3.1 Relevance (Rating: ③²)

3.1.1 Relevance to the Development Plan of China

1) Relevance with Development Plan at the Time of Appraisal

China's national development plan at the time of the project appraisal was the "10th Five-Year Plan for National Economy and Social Development", based on which it formulated the "10th Five Year Environmental Protection Plan". Especially with respect to water environment, which was already one of the priority areas of the "9th Five Year Environment Protection Plan" between 2001 and 2005, the 10th Plan aimed to reduce the total emissions of major contaminants by around 10% compared to the emission levels of 2000 in order to achieve further improvements. As for water quality, it set out independent targets, such as to achieve 45% ratio of wastewater treated in urban areas (60% in cities with 500,000 or more population) and start putting into place comprehensive measures towards improving water quality of major rivers and lakes including the Yangtze River. As for water resources management, mainly of those related to water supply services, the said Plan set out targets of increasing the amount of urban water supply to 45 million m³ per day, stabilizing the water supply in large and medium-sized cities by developing new water resources.

In light of the above policies at the national level, the Government of Hubei Province formulated the "10th Five Year Plan for the Economy and Social Development of Hubei Province", and the Yichang Municipal People's Government formulated the "10th Five Year Plan for the Economy and Social Development of Yichang City", both of which aimed to improve the water supply and sewage facilities. In particular, the Yichang Municipal People's Government aimed to improve the quality of river waters that run through the city by constructing five sewage treatment plants including the Linjiangxi Sewage Treatment Plant (200,000 m³/day) subject to this project. In addition, as for the improvement in quality of water, the Government of Hubei Province formulated the "10th Five Year Environment Protection Plan for Hubei Province" and the Yichang Municipal People's Government formulated the "10th Five Year Environment Protection Plan for Yichang City", setting out targets for the improvement of the quality of surface water and launching programs and projects to reach such targets.

2) Relevance with Development Plan at the Time of Ex-Post Evaluation

The national development plan at the time of the ex-post evaluation was the "12th Five-Year Plan for National Economy and Social Development (2011-2015)", in which the government set the goal of "emphasizing resource conservation and management: enhancing water resource conservation" under which it will set up stricter protection of water resources through the introduction and implementation of a water resource management scheme and by promoting the creation of a water-saving society. The Plan also aims to raise the percentage of wastewater

¹ A: Highly satisfactory, B: Satisfactory, C: Partially satisfactory, D: Unsatisfactory

² ③: High, ②: Fair, ①: Low

treatment in urban areas to 85% and improve the overall basic infrastructure including water supply and drainage facilities as well as sewage treatment facilities. Based on this national policy, the “12th Five-Year State Environment Protection Plan (2011-2015)” launched eight environmental protection programs, of which three concerned water environment, aiming to ensure the safety of the environment of drinking water reservoirs both in urban and rural areas, and to substantially improve the water quality by 2015. These national policies indicate that China considers the improvement of water supply and sewage facilities as well as the improvement of water environment as areas with significant importance.

Based on the above-mentioned national policies, the Government of Hubei Province formulated the “12th Five-Year Plan for National Economy and Social Development in Hubei Province”, and likewise, the Yichang Municipal People's Government formulated the “12th Five-Year Plan for National Economy and Social Development in Yichang City”, both of which launched policies and targets to be achieved during the period of 2011–2015 in regard to strengthening water supply and sewage infrastructure and to improve the water quality even further. As shown in Table 1, the Yichang Municipal People's Government specifically set the goals of “strengthening water supply and sewage infrastructure” and “building a water ecosystem where human beings and water resources harmonize with each other.”

Table 1: The 12th Five-Year Plan for the Economy and Social Development of Yichang City:
Policies on Water Resources

Strengthening water supply and sewage infrastructure	<ul style="list-style-type: none"> • Speeding up the upgrading of water pipe networks, developing reasonable water supply networks that ensure sufficient supply of water with sound quality, and building a water supply system that can be automatically managed. • Improving gradually the supply capacity of major water production companies in urban areas and constructing backup purification plants. • Securing 100% of population served and achieving water supply capacity of 650,000t/day in urban districts. • Emphasizing the protection of the living environment and ecosystem and strengthening both drainage work and construction of sewage treatment facilities. • Speeding up the upgrading of drainage pipe networks in the old district area and building drainage facilities in newly urbanized areas. • Speeding up the construction of sewage treatment plants to improve the treatment capacity and raise the percentage of wastewater treatment in urban districts to 90% by 2015.
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Building a water ecosystem where human beings and water resources harmonize with each other	<ul style="list-style-type: none"> • Improve the quality of drinking water so as to reach a 100% compliance with the water quality standards through the protection of reservoirs for drinking water; active promotion of safe drinking water projects; strengthen the construction of backup reservoirs for urban districts; and securing safe drinking water for urban and rural residents. • Reduce emissions of chemical oxygen demand by 3.7% and ammonia nitrogen by 4.1% by 2015 compared to the levels of 2010.
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Source: The 12th Five-Year Plan for the Economy and Social Development of Yichang City.

The Yichang Municipal People's Government also formulated the “Overall Urban Environment Planning of Yichang City (2011–2020)” in 2010 which increases the urban planning area from 1,950km² to 4,741km². In the same year, it also launched the “Yichang City Water Supply Plan”, which specifically aimed to optimize the urban district water supply network and facilities in the First Water Supply District (hereinafter referred to as the “urban districts”, covering Xiling, Wujiagang and Xiaoxita Districts that are residential areas) which includes the purification plant upgraded under this project, and linking this network with the Second Water Supply District (Dianjun District, a new living and residential area) and the Third Water Supply District (Xiaoting and Baiyang Districts where industrial parks are being constructed) to raise the safety level of water supplied to the entire Yichang City and reduce the related cost.

As stated above, in its development policies at the national, provincial and municipal levels, both at the time of appraisal and the ex-post evaluation, China has aimed to further develop the water supply and sewage infrastructure and improve the water quality (of both drinking and discharged water) keeping a balance with economic growth. In this sense, the project is highly relevant to China's development policies.

3.1.2 Relevance to the Development Needs of China

3.1.2.1. Needs for Sewage Facilities

Despite the status as an important river port city, as of 2001, Yichang City had no sewage treatment plant. About 60% of wastewater from the urban districts was being discharged to the Yangtze River and the remaining 40% to other rivers that flow through the city. Because of this, the water quality of the Yangtze River in the urban districts was below the level of Class II required by the National Environment Quality Standards for Surface Water³. Based on the Five-Year State Environment Protection Plan and the standards stipulated by the State Council, Yichang City was required to achieve a ratio of 60% or more of wastewater treated by 2005 and 70% or more by 2010. In addition, as of 2001, the city promoted the construction of five sewage

³ The Environmental Quality Standards for Surface Water (GB 3838-83) that were amended on April 28, 2002 by the State Environmental Protection Administration established 24 indicators for the quality of water. The surface water environmental quality is classified into the following five categories. Type I: water of mainly water resources in national state reserves / Type II: mainly collective drinking water from surface water of water resources in Class I protection zones, habitats of rare water creatures, spawning sites of fish and crustacean, feeding sites of juvenile fish, etc. / Type III: mainly collective drinking water from surface water of water resources in Class II protection zones, overwintering sites of fish and crustacean, migration routes, fishery zones such as cultivation areas and bathing areas / Type IV: mainly water areas for industrial use and water areas for leisure where water does not directly contact human bodies / Type V: mainly water areas for agricultural use and water areas as landscape.

treatment plants (plants 1-5 in Table 2) to improve the water quality of the rivers that flow through the city. This project accounted for 63% of the total treatment capacity of 318,000 m³ per day.

Table 2: Construction Plan for Yichang City Sewage Treatment Plants: 2012-2020

Sewage Treatment Plant Name	Treatment capacity (m ³ /day)		
	2001 Planned value at the time of project appraisal	2012 Actual value at the time of ex-post evaluation	2020 Long-term plan
1. Linjiangxi Sewage Treatment Plant (developed by this project)	200,000	200,000	300,000
2. Shahe Sewage Treatment Plant	50,000	30,000	50,000
3. Xiyan Sewage Treatment Plant	35,000	Plan revised to construct sewage pipe network and pump stations	
4. Dianjun Sewage Treatment Plant* ¹ (To be completed in June 2013)	15,000	10,000	20,000
5. Jiangnan No. 2 Sewage Treatment Plant	18,000	Under consideration* ²	
6. Huayan Sewage Treatment Plant	—	25,000	102,000
7. Xiaoting Sewage Treatment Plant	—	41,000	102,000
Total* ³	318,000	306,000	574,000
Contribution of this project* ⁴	63%	65%	52%

Source: Yichang City Construction Investment Development Co., Ltd.

*1: The plant was called “Jiangnan No. 1 Sewage Treatment Plant” at the time of the project appraisal.

*2: The planned treatment capacity is 30,000 m³/day.

*3: The total values for 2012 and 2020 exclude the figures of Jiangnan No. 2 Sewage Treatment Plant.

*4: The ratio of the Linjiangxi Sewage Treatment Plant (developed by the project) to the total capacity of all the sewage treatment plants.

At the time of the ex-post evaluation, several revisions were made according to the aforementioned Overall Planning (see Section 3.4.1 Project Outputs for details), and the sewage treatment plants 6 and 7 in Table 2 were additionally constructed. The treatment capacity as of 2012 totaled 306,000m³ per day, of which the plant constructed under the project accounted for 65%, playing an important role as was expected at the time of the appraisal. To meet the needs that will increase as a result of urbanization in future, Yichang City is preparing for an expansion of the capacity of the treatment plants currently in operation. As shown in Table 2, the city plans to reach a long-term total treatment capacity of 574,000m³ per day by 2020, in which case, the contribution of this project is expected to be 52%. Even in the long-term plan, the plant constructed under the project is expected to continue to play an important role.

Accordingly, the water environment in Yichang City has improved considerably when the

ex-post evaluation was conducted compared to the situation that existed in at the time of project appraisal. Water quality has also achieved Class II of the National Environment Quality Standards since 2007, and the percentage of wastewater treated reached 91% in 2012. However, the city has been experiencing a continuous economic growth of an average rate of 20% in the past five years as an important river port city, and the amount of wastewater is expected to increase continuously as the economy continues to grow. In addition, as the aforementioned Overall Urban Planning also promotes industrialization, there is a plan to build eight industrial parks in the near future, which will further increase the need for industrial sewage treatment. In conclusion, the development needs to strengthen the city's sewage treatment capacity will continue to remain high.

3.1.2.2 Needs for Water Supply Facilities

At the time of the project appraisal, the urban districts of Yichang City had a water supply capacity of 340,000m³ per day, the population served was 420,000 people, and the water supply rate was 100%. Two of the three purification plants that existed at the time of project appraisal upgraded with the project (Purification Plants No. 1 and No. 3 in Table 3, with a total water supply capacity of 260,000 m³) were built in 1959 and 1987 respectively, and had low technical levels and failed constantly to satisfy the turbidity standards. Both plants needed inspection and repair works several times a year during which the plants had to be stopped, resulting in frequent suspensions of water supply. As for the water distribution network, it was built over 40 years ago and many parts were decrepit, resulting in a leakage rate of 22% in the year 2000, and over 100 water pipe line breaks occur every year. Improvements were needed urgently.

At the time of the ex-post evaluation, the urban districts of Yichang City had a water supply capacity of 500,000m³ per day, the population served was 613,000 (in 2012) and the water supply rate remained at 100%. The project partially upgraded the water distribution network which improved the leakage rate to 17% and the turbidity level met the required standards (see Section 3.2.1. “Quantitative Effects (Operation and Effect Indicators)” for details).

Table 3: Water Purification Plants for Yichang City Urban Districts:
Current Status and Short and Long-term Plans

Name of Water Purification Plant	Current water supply capacity in 2012 (m ³ /day)	Planned water supply capacity in 2015 (m ³ /day)	Planned water supply capacity in 2030 (m ³ /day)
No. 1 (Improved by the project)	160,000	160,000	160,000
No. 3 (Improved by the project)	100,000	100,000	200,000
No. 4	100,000	100,000	200,000
Xiba	80,000	80,000	100,000
Yiling No. 3	60,000	60,000	150,000
Total	500,000	500,000	810,000
Contribution of the project*	52%	52%	44%

Source: Water Supply Plan for the Urban Districts of Yichang City.

*: The ratio of Purification Plants Nos. 1 and 3 (the project) to the total capacity of all the water purification plants

On the other hand, the aforementioned Yichang City Water Supply Plan forecasts that the economic growth and urbanization in the future will increase the water demand of the entire city. Therefore, the strengthening of the water supply capacity will continue to be an important issue for the city. As shown in Table 3, the purification plants improved by the project greatly contribute to Yichang City's urban districts water supply, accounting for 52% of the total water supply capacity. They are expected to account for 44% of the water supply capacity in 2030, continuing to play an important role in the long term.

As stated above, the development needs for strengthening the capacity of sewage treatment and water supply capacities existed not only at the time of the appraisal but also at the time of the ex-post evaluation resulting from Yichang City's future economic growth forecasts. Thus, the project was found to be consistent with the development needs both at the time of project appraisal as well as at the time of ex-post evaluation.

3.1.3 Relevance to Japan's ODA Policy

The Government of Japan formulated the Economic Cooperation Program for China in 2001, where it shifted from focusing on traditional infrastructure development in the coastal areas to six priority areas: conservation of environment and ecosystems whose pollution and degradation have become serious problems; improvement of public welfare and social development in the inland regions; human resource development; institution building, and technology transfer. The purpose of this project is particularly in line with the priority area concerned with the "cooperation towards resolving environmental and other global issues" that aims to assist conservation of the ecosystem including measures against water and other pollutions, conservation and creation of forests and sustainable use of water resources. It is also in line with another priority area, namely "improvement of public welfare and social development in the inland regions" that aims to assist

economic and social development to bridge the gap between the coastal and inland regions. In addition, the necessity for the development of water supply and sewage facilities, as well as commitments to water resource issues is also highlighted in the context of one of the priority areas of the Medium-Term Strategy for Overseas Economic Cooperation Operations (2002–2005) of the former Japan Bank for International Cooperation, namely, strengthening responses to poverty reduction, infrastructure development for economic growth, environmental conservation and pollution control. Moreover, Japan’s assistance policies on water environment and resources are also reflected in the Country Assistance Strategy for China formulated in 2002 by the Japan International Cooperation Agency (JICA), which stated that Japan will focus on sewage services and other public services where the governments are required to play key roles; strengthen partnerships with local municipalities in order to provide assistance for non-infrastructure areas including the improvement of environmental administrative capacities; and strive to transfer know-how.

In light of the above, the project is consistent with the assistance policies of the Japanese Government (“Economic Cooperation Program for China”, “Medium-Term Strategy for Overseas Economic Cooperation Operations” and “Country Assistance Strategy for China”).

This project has been highly relevant to the development plans and development needs of Yichang City in Hubei Province of China, as well as Japan’s ODA policy. Therefore its relevance is high.

3.2 Effectiveness⁴ (Rating: ③)

3.2.1 Quantitative Effects (Operation and Effect Indicators)

3.2.1.1 Development of Sewage Facilities

The effects of the development of sewage facilities have been assessed mainly by comparing the planned and actual values of indicators such as amount of wastewater treated as well as the quality of water discharged from the sewage treatment plant, rate of wastewater treated in the urban districts of Yichang City, sewer coverage rate among others.

a. Operation and effect indicators of sewage facilities

As shown in Table 4, all the six major indicators including the amount of wastewater treated set out at the time of the project appraisal achieved the planned values by 2010. In addition to these, indicators on the amount of sludge treated, sludge recycling rate and rate of service charge recovery were also collected. The amount of sludge treated fluctuated between 6,000 and 6,500 tons per year since the plant started operations and 100% of the sludge is recycled. The rate of service charge recovery is also fairly high at around 94–96%. In sum, it was found that the sewage facilities are operated appropriately in general and that the effects of the project have been

⁴ Sub-rating for Effectiveness is to be put with consideration to impact.

produced.

Table 4: Operation and Effect Indicators of Sewage Facilities

Indicator	Base line 2002	Planned value after completion	Actual value (achievement rate)				
			2008 Starting of operations	2009	2010	2011	2012
Amount of wastewater treated at Linjiangxi Sewage Treatment Plant (10,000m ³ /day)	0	12 * ¹	16.9 (141%)	16.0 (133%)	14.5 (121%)	15.6 (130%)	16.0 (133%)
Rate of facility utilization (%) * ²	0	60	84.3 (141%)	80.0 (133%)	72.5 (121%)	78.0 (130%)	79.0 (132%)
Wastewater treated in the urban districts of Yichang City (%)	0	84	86 (102%)	88 (105%)	88 (105%)	90 (107%)	91 (108%)
Population served by sewage treatment (10,000 people)	0	57	55.4 (97%)	56.3 (99%)	57.2 (100%)	58.1 (102%)	59.2 (104%)
Coverage ratio of sewer main (%) * ³	60	100	100 (100%)	100 (100%)	100 (100%)	100 (100%)	100 (100%)
Sewer coverage rate (%) * ⁴	0	60	60 (100%)	62 (103%)	64 (107%)	68 (113%)	69 (115%)
Amount of sludge treated (ton/year)	—	n.a.	6,444.5	6,265.3	6,326.5	6,023.1	6,478.7
Sludge recycling rate (%)	—	n.a.	100	100	100	100	100
Rate of service charge recovery (%) * ⁵	—	n.a.	96	94	95	95	95

Source: Target values are based on JICA's documents at the project appraisal. Actual values are based on Yichang City Construction Investment Development Co., Ltd.

*1: China adopts 60% of the maximum treatment capacity under normal design (200,000m³ /day in this project) as the planned value.

*2: Rate of facility utilization = Average daily amount of wastewater treated / Plant capacity.

*3: Sewer mains are sewage pipes directly connected with sewage treatment plants and pumping stations. Coverage ratio of sewer main = Length of main sewage pipes already laid / Total length of sewage pipes planned to be laid.

*4: Sewer coverage rate = Population treated / Population to be treated.

*5: Rate of service charge recovery = Amount of service charge collected / Amount of service charge.

b. Quality of water discharged from the Linjiangxi Sewage Treatment Plant



Figure 1: Pre-treatment water (left) and treated water (right) at the Linjiangxi Sewage Treatment Plant

As shown in Table 5, all the water quality indicators have achieved or surpassed the planned values, having achieved Class II of the National Environment Quality Standards for Surface Water. The Biochemical Oxygen Demand (BOD) fell from 8,766 tons per year in 2002 to 548.9 tons per year in 2012, and the amount of Suspended Solids (SS) reduced from 13,140 tons per year to 815.3 tons per year over the same period. BOD concentration and SS concentration

prior to treatment remain under the standard values, though the decreasing trends are somewhat stagnant. The BOD reduction rate has been fluctuating around the 90% level since the plant started operations and the SS reduction rate has increased over the years, and both indicators achieved 94% in 2012. Considerable improvements can also be seen in other turbidity indicators such as chemical oxygen consumption and ammonia nitrogen. Moreover, coliform bacteria count substantially fell from 4,000 MPN/100ml in 2002 to 940 MPN/100ml in 2012, and the reduction rate has been remained constant at 77% since the plant started operations. In short, the quality of water discharged from the sewage treatment plant developed by the project has remarkably improved.

Table 5: Quality of Water Discharged from the Linjiangxi Sewage Treatment Plant

Quality of Water Discharged		Baseline 2002	Planned value Class II of the National Environment Quality Standards for Surface Water (after completion)	Evaluation standard: Sound if the value is above / below National Environment Quality Standards for Surface Water	Actual value				
					2008 Starting of operations	2009	2010	2011	2012
BOD emissions (ton/year)		8,766	1,460	Below standard	815.9	850.3	729.7	769.9	548.9
BOD reduction rate (%)		—	83%	Above standard	91%	90%	92%	91%	94%
BOD concentration mg/l	In	120	120	—	65.1	78.2	106.0	87.5	103.6
	Out	≤20	—	Below standard	13.2	14.6	13.8	13.5	10.5
SS emissions (ton/year)		13,140	1,460	Below standard	1,102.9	994.9	874.2	897.2	815.3
SS reduction rate (%)		—	89%	Above standard	92%	92%	93%	93%	94%
SS concentration mg/l	In	180	180	—	171.6	144.9	145.9	126.6	146.3
	Out	≤20	—	Below standard	13.2	17.1	16.5	15.7	15.6
COD _{Cr} mg/l		250	≤60	Below standard	40.4	26.4	34.3	31.8	27.1
NH ₃ -N mg/l		25	≤15	Below standard	4.4	4.5	4.6	4.0	4.8
T-N	In	35.7	35.7	—	18.9	15.8	39.5	33.5	28.9

mg/l	Out	≤15	—	Below standard	10.7	9.7	7.8	7.3	6.7
T-P mg/l	In	3	3	—	1.9	1.1	1.1	1.0	0.9
	Out	≤0.5	—	Below standard	0.7	0.5	0.2	0.3	0.4
pH (range)		7.3~7.9	7.3~7.9	Within standard	7.3~7.9	7.3~7.9	7.3~7.9	7.3~7.9	7.3~7.9
Coliform bacteria count (MPN/100ml)*		4,000	1,000	Below standard	920	930	920	930	940
Reduction rate of coliform bacteria count		—	75%	Above standard	77%	77%	77%	77%	77%

Source: Target values are from JICA's documents at the project appraisal and F/S. Actual values are from and Yichang City Construction Investment Development Co., Ltd.

* MPN: Most Probable Number

3.2.1.2 Development of Water Supply Facilities

Table 6 shows the operation and effect indicators of water supply facilities.

Table 6 Operation and Effect Indicators of Water Supply Facilities
for the Urban Districts of Yichang City

	Present (2000)	Target Value (2010)	Actual value (Achievement rate)				
			2008	2009	2010	2011	2012
Amount of water supply (10,000m ³ /day)	25	35	22.62	22.89	23.70 (68%)	25.16 (72%)	26.88 (77%)
Rate of facility utilization (%) ^{*1}	—	—	76	77	78	79	80
Population served (10,000 people)	42	52	60.1	60.2	60.3 (116%)	60.6 (117%)	61.3 (118%)
Percentage of population served (%) ^{*2}	100	100	100	100	100	100	100
Water supply for domestic use per capita (l/per person day)	252	300	255	260	265 (88%)	270 (90%)	280 (93%)
Leakage rate (%)	22	7	18	18	18	18	17
Water quality (turbidity) annual maximum NTU ^{*3}	17	≤1.0	≤1.0	≤1.0	≤1.0	≤1.0	≤1.0
Revenue on water supply (10,000 yuan)	4,118	7,980	5,800	5,730	5,822 (73%)	6,008 (75%)	6,663 (83%)

Source: Target values are from JICA's documents at the project appraisal and F/S. Actual values are from and Yichang City Construction Investment Development Co., Ltd.

*1: Rate of facility utilization = Daily average water supply amount / Plant capacity

*2: Percentage of population served = Population served / Urban population

*3: NTU (Nephelometric Turbidity Unit) is the density of suspended particles in the water

Among the eight indicators, population served, percentage of population served, and water quality achieved the target values that were set for 2010. As for amount of water supply, water supply for domestic use per capita, and rate of facility utilization, although they failed to achieve the target values they were on a steady upward trend from 2008 to 2012. One of the reasons for the amount of water supply not being able to achieve the target set is the fact that all factories that used to be large consumers were relocated outside the urban district according to the aforementioned Overall Urban Environment Planning of Yichang City, resulting in a change in the water demand structure. Since the percentage of population served is 100%, it can be said that water demand is well satisfied. On the other hand, the leakage rate failed to achieve the target value of 7% because replacement of decrepit water pipes was still behind schedule, but managed to meet the standard value of 18% that is stipulated by the Government of Hubei Province. From the point of view of “improvement of the quality of water supply” which is one of the project objectives, the turbidity was ≤1.0NTU, much lower than the ≤3.0 stipulated by the national government, indicating that the project effects have been produced. In short, the operation and

effect indicators of the water supply facilities developed by the project have either achieved their targets in general or are on a steady upward trend.

It can thus be concluded that the development of water supply and sewage facilities have yielded significant effects quantitatively.

3.2.2 Qualitative Effects

The qualitative effects of the project expected at the time of appraisal were “effects that contribute to pollution control measures” and “recycling effects (recycling of sludge after treatment)”. For the ex-post evaluation, these were considered as effects at the project impact level, and thus were analyzed in the under “Section 3.3 Impact”.

3.3 Impact

3.3.1 Intended Impacts

Since the project impact intended at the time of appraisal, namely “sustainable development” was not clearly defined, the “effects that contribute to pollution control measures” and the “improvement on the quality of local citizens’ living environment and their quality of life” were considered to be the project impacts⁵.

3.3.1.1 Effects that Contribute to Pollution Control Measures

At the time of the appraisal, the project was expected to alleviate water pollution of the Yangtze River as well as other rivers that flow through the city and improve the quality of tap water by constructing a sewage treatment plant, developing a sewage pipe network, improving purification plants and developing a water pipe network. The Government of Yichang City had been making efforts to achieve a balance between economic growth and environment conservation even before the project appraisal. This project has certainly assisted such efforts and measures, and contributed to further improve water environment and pollution control, as well as the conservation of the natural environment as a whole.

Water quality indicators (COD, BOD, SS and ammonia nitrogen) from three water monitoring points (Zhenchuanmen, Changjiang Wanshou Temple and the lower part of the Linjiangxi river) closest to the places where sewage water was discharged before the project started were collected to check their trends. As shown in Table 7, water quality has improved at all the three monitoring points: water that was classified as Class III of the National Environmental Quality Standards for Surface Water in 2002 is classified as Class II ever since 2008 when the sewage treatment plant built by the project started operations. This project was clearly an important one that contributed

⁵ As a possible impact of the project, the ex-post evaluation assessed the “effects contributing to the investment environment and economic development in Yichang City”. Although development of infrastructure including water supply and sewage facilities is essential for economic growth as well as to attract direct investment, it was difficult to measure the direct causal relationship between them, that is, how much the project actually contributed to Yichang City’s economic growth and promotion of both domestic and foreign direct investment.

to improve the water environment of Yichang City where there was no sewage treatment facility at all.

Table 7: Trends in the Quality of Water at Monitoring Points

Monitoring point	Water quality indicators monitored	2002 (Appraisal)	2008 (Starting of operations)	2009	2010	2011	2012
Zhenchuanmen	COD concentration	19.6	13.9	13.5	13.4	13.8	13.9
	BOD concentration	3.8	2.4	2.5	2.3	2.4	2.8
	SS concentration	18	15	14	15	13	12
	Ammonia nitrogen	0.84	0.49	0.38	0.39	0.38	0.38
	National Standard Class	III	II	II	II	II	II
Changjiang Wanshou Temple	COD concentration	19.5	11.9	12.1	11.6	11.9	11.7
	BOD concentration	3.7	2.7	2.9	2.8	2.6	2.5
	SS concentration	16	15	17	19	17	15
	Ammonia nitrogen	0.86	0.41	0.49	0.4	0.39	0.38
	National Standard Class	III	II	II	II	II	II
Lower course of Linjiangxi	COD concentration	19.5	13.1	12.7	12.8	12.5	12.4
	BOD concentration	3.4	2.8	2.7	2.8	2.9	2.6
	SS concentration	19	18	14	12	11	12
	Ammonia nitrogen	0.79	0.43	0.48	0.38	0.4	0.41
	National Standard Class	III	II	II	II	II	II

Source: Based on documents provided by the Executing Agency

Since 2008, Yichang City has won various environmental and sanitation awards at the national level as shown in Table 8. These awards are granted only after passing a screening process that is conducted under strict standards, and re-screenings are conducted every two to three years. Among these awards, the “National Environmental Protection Model Cities” is considered to be a prestigious award because out of 285 prefecture-level cities, it was given to eight cities in 2010 and seven cities in 2011 (data as of June 2012)⁶. It was found that one of the important reasons for Yichang City being designated as a Model City was not only because of the improvement in its water environment but also because of the recycling of sludge at a cement plant where the training program conducted in Japan under the framework of the project was applied. (For JICA Training Course in Japan and recycling of sludge, see the “Column” given

⁶ Similarly, the award on “National Civilized Cities” were given for the first time in 2005, the second time in 2009 and the third time in 2011. Only 12-14 prefecture-level cities were awarded each time. Yichang City was among 14 prefecture-level cities winning the titles in the third award.

below.)

Table 8: Awards for Environment and Sanitation at the National Level Given to Yichang City

Award	Date	Granting organization
National Sanitary City	November 17, 2008	National Committee for Patriotic Health Campaign
National Environmental Protection Model City	February 9, 2010	Ministry of Environmental Protection
3rd National Civilized City	December 20, 2011	Central Guidance Committee on Ethical and Cultural Construction

Source: Executing Agency and the Environmental Protection Department

3.3.1.2 Improvement on the Quality of Local Citizens' Living Environment and Quality of Life

In order to grasp the qualitative effects on the quality of local citizens' living environment and their quality of life, a beneficiary survey was conducted to 50 residents in the area subject to the project⁷. The questionnaire mainly covered four items: "Quality of water supply, river water, and natural environment", "improvement of citizens' awareness on water for domestic use and sewage water", "degree of satisfaction with respect to water supply and sewage service providers (services, etc.)" and "opinions about the degree of achievement of the project purposes". The questionnaire was designed to compare the present situation with the situation existing five years ago (i.e. prior to the completion of the project) for each of the four items and changes were identified (Table 9).

Table 9: Results of the Beneficiary Survey

Item	Results
Quality of water supply, river water, and natural environment	<p><u>Quality of water supply</u></p> <ul style="list-style-type: none"> As for the quality and safety of tap water, 88% of the respondents answered that they found it "safe", proving that the project had an important effect on one of its purposes, namely "improvement of the quality of water supply". From the remaining 12% who answered that they were "concerned" about the quality and safety of tap water, the majority cited "because chemicals (chlorine, etc.) are used in the process of producing tap water" as the main reason for concern⁸. <p><u>Quality of river water and of the surrounding natural environment</u></p> <ul style="list-style-type: none"> The survey asked the respondents to assess the present situation as compared to five years ago concerning five items: turbidity, odor, suspended solids such as garbage, habitat around the river for plants and other living creatures. For all the items, 85-90% of the respondents replied "improved to some extent" or "improved significantly". Only on the item "habitat around the river for living creatures" the majority of the respondents answered that it "did not improve very much" or "did not improved at all" (15%). It became clear that in general terms, the quality of river water and surrounding natural environment has improved compared to the situation prior to the implementation of the

⁷ Total sample size: 50 people (male: 35, female: 15) / Age groups: 20-29 (54%), 30-39 (36%), and 40-49 (10%) / Monthly average income: 9,280 yuan / Regional distribution: Wujiagang (32%), Xiling (42%), Others (26%) / Type of residence: housing complex (76%), single-family house (18%), others (6%).

⁸ No clear relationship between health and the project could be confirmed. This is perhaps because of changes in drinking water habits: 77% of the respondents "drink boiled water", 8% "drink bottled water" and 8% "drink water purified with a water filter".

	project.
Improvement of citizens' awareness on water for domestic use and sewage water	<ul style="list-style-type: none"> The survey confirmed changes in awareness of the respondents concerning five items "water saving", "not pouring away oil and/or garbage in the drain", "not using unnecessary amounts of soap and detergent", "wipe heavy soil from saucepans and dishes before washing them with water" and "not discharging harmful substances in the drain". A fairly high proportion of the respondents replied "improved significantly" or "improved to some extent" concerning the two items on "water saving" (96%) and "not pouring away oil or garbage in the drain" (88%). For the other items, 60% or more of the respondents gave similar answers. Many of the respondents mentioned that "they would like the authorities to seek more ways to further improve the recycling of domestic sewage and measures for water saving", indicating that the awareness of residents has improved as the sewage facilities have been developed.
Degree of satisfaction with respect to water supply and sewage service providers (services, etc.)	<ul style="list-style-type: none"> For the sewage services as a whole, 86% of the respondents answered that they are "satisfied" and the percentage was 96% for the water supply services. The beneficiaries' degree of satisfaction has improved for both water supply and sewage services.
Opinions about the degree of achievement of the project purposes	<ul style="list-style-type: none"> After explaining again the project objectives, the beneficiaries were asked whether the project had achieved its purposes or not. A high proportion of respondents, 77%, answered that "the objectives have been achieved". As for the reasons for their positive response, they mentioned that "the surrounding environment has improved", that "the natural environment of Yichang City has improved so much as to be awarded the National Sanitary award and the Civilized City awards" and that "respondents are no longer concerned about health problems even if they use tap water at home". On the other hand, 22% of the respondents replied that "the objectives have not been achieved" because "small amounts of domestic sewage are still being discharged directly to the river".

Source: Prepared by the evaluator based on the results of the beneficiary survey

As shown above, the results of the beneficiary survey prove that the project has brought benefits to the quality of river water as well as water supply, which in turn have resulted in improvements of the living environment and awareness of the residents of Yichang City. In addition, the project has also helped improve the degree of local citizens' satisfaction with respect to water supply and sewage companies including the services they offer. In sum, a certain impact of the project can be recognized regarding improvements on the living environment and the quality of life.

3.3.2 Other Impacts

3.3.2.1 Impacts on the Natural Environment⁹

a. Environmental monitoring

At the time of the project appraisal, it was planned that the Environmental Protection

⁹ The Environmental Impact Statement for the project had been already formulated at the time of appraisal, and the approval of the State Environmental Protection Administration was already obtained on September 6, 2001.

Department of Yichang City would monitor the quality of river water (such as COD, BOD, SS and ammonia nitrogen) six times a year in accordance with the criteria established by the State Environmental Protection Administration. In addition, it was also assumed that the sewage treatment plant would monitor the quality of the influent and effluent on a daily-basis by their own. The ex-post evaluation confirmed that these monitoring activities were conducted as planned. As for the water quality of the Yangtze River and other rivers that flow through the city, the Water Quality Monitoring Office (13 officers) of the Environmental Protection Department of Yichang City conducts monitoring six times a year¹⁰. Each sewage treatment plant also inspects the influent and effluent qualities every day on their own. The Environmental Protection Department also outsources monitoring of the water quality of the sewage treatment plants to the environmental monitoring stations of the city on a quarterly basis. If any sewage treatment plant fails to meet the standards, the Department analyzes the causes and conducts an on-site examination. If the company in charge of the operation of the sewage treatment plant is responsible, the Department makes a request for improvement and provides guidance to the company.

Because the environmental monitoring was conducted as planned and even strengthened, the quality of the water of the rivers that flow through Yichang City have improved significantly and a positive impact on the natural environment can be recognized (for details refer to “3.2.1 Qualitative Effects” and “3.3.1.1 Effects that Contribute to Pollution Control Measures”).

b. Environmental pollution measures during construction

The ex-post evaluation considered the anti-pollution measures taken during the construction period of the project as an impact on environment. It was confirmed that requirements established in the environmental assessments were met during construction, and necessary measures based on the National Environmental Standards such as dust control, sewage treatment, noise control and waste disposal were put into place.

In the aforementioned beneficiary survey, questions on six items regarding pollution control measures during construction were included, i.e. gas emissions, waste disposal, dust, turbid water, noise and vibrations. More than 70% of the respondents replied that they were “very bothered” or “slightly bothered” by gas emissions, waste disposal, dust and turbid water, and more than 60% gave the same answers in terms of noise and vibration. 12 respondents (24%) filed a complaint about dust and noise to the city government, for which the executing agency enhanced measures such as frequent water sprinkling and cleaning, enclosure of the construction site with walls and restraint of noise at night. 10 out of the 12 people that filed the complaint replied that these measures had “improved the situation”. Although the anti-pollution measures taken during construction were not thorough enough, it was found that the executing agency did take measures

¹⁰ According to hearing to the Environmental Protection Agency of Yichang City, the monitoring of the water quality had been tentatively conducted once a year until 2007. The monitoring scheme was gradually enhanced afterwards. It was conducted three times in 2008, four times in 2009 and five times in 2010 and 2011, and six time in 2012.

to solve the residents' complaints to the extent possible.

c. Recycling effect (recycling of sewage treatment sludge)

At the time of the project appraisal, it was planned that the Yichang City Institute of Agricultural Sciences would examine the sludge generated from the sewage treatment plant, and the sludge that met the standards would be converted into organic fertilizer for planting, gardening and horticulture. However, an engineer of the executing agency that had participated in JICA Training Course in Japan entitled "Country Focus Training Course on Operation and Maintenance of Sewage Facilities under Japan's ODA Loan to China" in 2005, suggested that the sewage treatment facilities of Yichang City should adopt the recycling of sludge that he saw at a cement plant in Japan. Currently, the entire sludge generated at the Linjiangxi Sewage Treatment Plant (16 tons/day) is recycled in coordination with a dry cement kiln (handling capacity of 150 tons/day) of Huaxin Cement Co., Ltd. (Yichang). In order to treat the sludge, the Yichang Municipal People's Government pays 200 yuan per ton of sludge to the cement company.

[Column] Sludge Recycling Effect: Collaboration of an ODA Loan Project and Technical Cooperation (JICA Training Course in Japan)

On November 13, 2008, Huaxin Cement Co., Ltd. (Yichang), a private cement manufacturer, Yichang City Construction Investment Development Co., Ltd. which was the executing agency of the project, and Yichang Sanxia Water Service Co. Ltd, the company that operates the sewage treatment plant signed the "Memorandum of Agreement on the Cooperation for Sludge Treatment of Yichang City". Since no reasonable sludge treatment method was available in China at the time and people concerned with environmental protection were seriously troubled with this problem, the technology of handling sludge in collaboration with a dry cement kiln was highly valued by the Ministry of Environmental Protection. In 2010, the Ministry introduced it as an important environmental protection technology that medium-sized provincial cities across the country should adopt.

Among the factors contributing to the introduction of the technology that marked a major step for recycling of sludge in China, is the "Country Focus Training Course on Operation and Maintenance of Sewage Facilities under Japan's ODA Loan to China" which was conducted for one month from October 2005. An engineer of the executing agency who participated in JICA Training Course in Japan visited various cities in Japan, brought back the ideas to China, and materialized them through cooperation with the private sector and the city government which had been making strong environmental protection efforts.

When visiting various cities in Japan, the trainee learned that Kitakyushu City had adopted a sludge treatment method which consisted of recycling sludge as a raw material for cement. The trainee also learned that the right choice of a treatment method that is in line with the conditions of each city, would enable to achieve both sludge recycling and environmental protection, and

completed a project research paper entitled “Sludge Treatment Methods at Sewage Treatment Plants in Yichang City”. In 2008, the Linjiangxi Sewage Treatment Plant built under this project started operations, and the Yichang Municipal People's Government launched the “Urban Sewage Water Sludge Treatment Project” in order to make the city a National Environmental Protection Model City, improve the urban environment further and raise the living standards of urban residents. Making full use of the knowledge learned and experience attained through the Training in Japan, and taking into consideration the characteristics of Yichang City, the trainee concluded that the technology of recycling the sludge as a raw material for cement was the most appropriate one. He continued technical research in cooperation with Huaxin Cement Co., Ltd. (Yichang), made a proposal which was then approved by the city government.

During the ex-post evaluation, the trainee who participated in the aforementioned Training Course, wrote a document entitled “Urban Domestic Sewage Treatment Plants in Yichang City: Looking Back on Sludge Treatment” in which the trainee concludes: *“I would like to thank all the lecturers who taught me selflessly in Japan as well as all the other participants from China. I hope that Japan and China will work together to create environment protection projects, yield as many results as possible and make the world happy.”* The trainee is now working actively as Chief Engineer at the executing agency’s Project Technology Management Team.

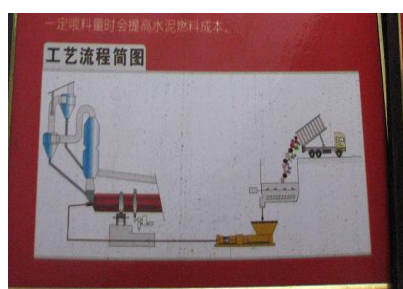


Figure 2: Sludge Recycling Process Chart Displayed at the Plant



Figure 3: Drying and Crushing Sludge (the initial process of sludge recycling)

3.3.2.2 Land Acquisition and Resettlement

At the time of project appraisal, no resettlement of residents was expected, and it was assumed that the project would require only land acquisition for the development of sewage facilities. During the field survey of the ex-post evaluation, it was confirmed that 8.8 ha of land was acquired which involved 92 households who were using this land mainly as farmland. From August to October 2002, the executing agency conducted hearings and coordinated with the households, and agreed to pay a compensation fee of 201.35 million yuan per mu¹¹ based on national standards. On November 22, 2002 the “Agreement on the Transfer of the Right to Use the Land” was signed and the land acquisition process was successfully completed upon the approval of the Land Management Agency of Yichang City. Although according to the beneficiary survey there were some complaints among the residents, such as “the land acquisition

¹¹ Mu is a unit of land area defined as 1/15 hectare.

process was complicated and required a lot of paperwork”, it was also verified generally, the procedures were conducted as planned.

3.3.2.3 Other Impacts

At the time of the appraisal, the following positive and negative impacts were expected.

- a. Impact on the cultural property of Tianran Tower: an actual inspection of the tower at the time of the ex-post evaluation confirmed that there was no damage to this cultural property, due to appropriate preliminary measures taken.
- b. Places around the drain outlet of the sewage treatment plant were processed with concrete, and there is no risk of sediment runoff due to the water discharge effluent.
- c. Fishery operators: it was confirmed that there were no fishery operators along the Yangtze River in the urban districts of the city both at the time of project appraisal and at the time of the ex-post evaluation.

In light of the above, this project has largely achieved its objectives, therefore its effectiveness is high.

3.4 Efficiency (Rating: ②)

3.4.1 Project Outputs

3.4.1.1 Development of Sewerage Facilities

The Linjiangxi Sewage Treatment Plant was constructed as planned (see Table 10). Regarding relay pumping stations, the number was reduced from the planned five down to three. The reason was because the implementing agency streamlined the original design. More specifically, it canceled the construction of two pumping stations in Xiling Yilu and the Development Zone and increased the treatment capacity of the Wanshou Qiao pumping station from 100,000 m³/day to 220,000 m³/day, in order to concentrate the pumping function in three pumping stations. As a result, the total capacity of relay pumping stations was almost the same as the planned capacity, although it was reduced from 820,000m³/day to 800,000m³/day. With regard to the construction of the sewer network, the total planned length of the network to be constructed was 33 km at the time of the appraisal. However, it was decided that the Yichang Municipal People's Government would construct 6 km out of the 33 km using its own funds as part of its road improvement project¹², which was implemented in parallel with the project. As a result, 27.08 km were constructed by the project.

¹² The original plan of the Yichang Municipal People's Government for the project as of 2001 included three components, namely development of sewerage facilities, development of water supply facilities and road development. The Yichang Municipal People's Government explained the connection between the three components as follows: “Both the construction of the drainpipe network and the water pipe network would require digging up the roads. Therefore, it would be more efficient to improve deteriorated roads at the same time as the pipes are laid, in terms of cost reduction and convenience for residents.” However, the purpose of the project was to improve the water quality of the city's rivers and improve the quality of the water supply. Therefore, at the time of the appraisal, JICA excluded the road development component from the project (the Yichang Municipal People's Government implemented the road development using its own funds).

Table 10: Details of the Development of Sewerage Facilities (All Newly Constructed)

Main items	Planned capacity and/or length	Actual capacity and/or length
A. Linjiangxi Sewage Treatment Plant (including grit chambers, biological tank, final sediment tanks and sludge treatment facilities)	A2O method ¹³ 200,000 m ³ /day	As planned
B. Five relay pumping stations		
1. Xiling Yilu	80,000 m ³ /day	Canceled and integrated into the Wanshou Qiao pumping station.
2. Dagong Qiao	180,000 m ³ /day	As planned
3. Development Area	60,000 m ³ /day	Canceled and integrated into the Wanshou Qiao pumping station.
4. Wanshou Qiao	100,000 m ³ /day	Capacity increased to 220,000 m ³ /day
5. Yang Ba	400,000 m ³ /day	As planned
Total capacity	820,000 m ³ /day	800,000 m ³ /day
C. Development of the sewage collection systems (sewer network construction)	33 km	27.08 km

Source: Appraisal documents provided JICA and information provided by the executing agency.

3.4.1.2 Development of Water Supply Facilities

As shown in Table 11, development of water supply facilities was implemented as planned.

Table 11: Details of the Improvement of Water Supply Facilities

Main items	The planned capacity and length	The actual capacity and length
A. Two water purification plants (Improvement of filter beds, changing water pumps and motors, introduction of automatic control systems, etc.)	<ul style="list-style-type: none"> Improvement of Water Purification Plant No. 1 (treatment capacity :160,000 m³/day) Improvement of Water Purification Plant No. 3 (treatment capacity: 100,000 m³/day) 	As planned
B. Upgrading aqueducts	5.3 km	As planned
C. Upgrading and expanding the water mains network	49 km	As planned

Source: Appraisal documents and information provided by the executing agency.

3.4.2 Project Inputs

3.4.2.1 Project Cost

¹³ The A2O (Anaerobic-Anoxic-Oxic) method is an advanced sewerage treatment method. It uses an anaerobic reactor, an anoxic reactor and an oxic reactor, in order to remove nitrogen and phosphorus at the same time.

The planned project cost was 11,727 million yen (foreign currency portion: 8,460 million, domestic currency portion: 3,270 million yen), and the actual project cost was 10,785 million yen (foreign currency portion: 8,460 million, domestic currency portion: 2,325 million yen). Thus the project cost was 92% of the planned cost, which was lower than planned.

One of the reasons why the project cost was lower than planned, was that the number of relay pumping stations was reduced from five to three.

3.4.2.2 Project Period

The planned project period was 41 months from March 2003 to July 2006, while the actual project period was 70 months from March 2003 to December 2008. Thus the actual project period was 171% of the planned period, which was significantly exceeded the plan¹⁴ (Table 12).

Table 12: Planned and Actual Project Periods

Procedures	Planned (P/M)	Actual (PCR)	Actual vs. Planned
Signing of the L/A to bidding process	March 2003 - August 2004 18 months	March 2003 - December 2006 46 months	256%
Civil engineering works	September 2004 - July 2006 23 months	May 2004 - December 2007 44 months	191%
Installation of machinery and equipment	January 2005 - July 2006 19 months	May 2006 - December 2008 32 months	168%
Improvement of water mains network	September 2004 - July 2006 23 months	August 2006 - December 2008 29 months	126%
Entire project	March 2003 - July 2006 41 months	March 2003 - December 2008 70 months	171%

Source: JICA's Appraisal documents and Yichang City Construction Investment Development Co., Ltd.

The main reasons for the delay were as follows. (1) The bidding processes of both the machinery and equipment for the development of sewerage facilities as well as the improvement of water supply facilities required time, and the longest of the bidding process period was 28 months (156% of the planned period). (2) In the development of sewerage facilities, it took time to clear, prepare and compact the land that was to be used for the pumping stations and the sewage treatment plant. It also took time to construct river banks. In addition, adjustments were made to some of the construction procedures due to changes in the water level. As a result, the civil engineering work took 44 months in total (191% of the planned period). (3) Because of the delay in the bidding procedures, there was a delay of a maximum 24 months in the installation of machinery and equipment of both the sewage as well as the water supply facilities. (4) In order to reduce costs, the Yichang Municipal People's Government decided to simultaneously implement the project's improvement of the water mains network with the road improvement project. Since it took time for the municipal government to implement the road improvement work (more

¹⁴ Project completion was defined as the completion of defect inspections for all project components.

specifically the modification of roads tunnels), it took five months longer than planned (122% compared to planned) to complete the improvement of the water mains network which was one component of the project.

3.4.3 Results of Calculations of Internal Rates of Return (IRR)

At the time of the appraisal of the project, only the Financial Internal Rate of Return (FIRR) was calculated. Therefore, in the ex-post evaluation, the FIRR was recalculated using the same method to the extent possible.

Table 13: Comparison of FIRR: At the Time of the Appraisal and Ex-Post Evaluation

Appraisal	Ex-Post Evaluation
Development of Sewerage facilities: 3.5% Development of water supply facilities: 7.2% <ul style="list-style-type: none"> Costs: Construction costs, operation and maintenance costs, equipment upgrade costs, income and sales taxes Benefits: Revenues from service charges of sewerage treatment and water supply Project life: 21 years 	Development of Sewerage facilities: negative Development of water supply facilities: 7.5% <ul style="list-style-type: none"> Costs: Construction costs, operation and maintenance costs, equipment upgrade costs, income and sales taxes Benefits: Revenues from service charges of sewerage treatment and water supply Project life: 21 years

Source: Appraisal data are from JICA's appraisal documents, and Ex-post Evaluation data were recalculated by the evaluator.

In the ex-post evaluation, the FIRR was calculated using the actual costs and benefits listed in Table 13, which were collected from the executing agency. Regarding the development of sewerage facilities, the actual revenue from sewerage treatment fees was lower than the revenue expected at the time of the appraisal and its operation is being partially covered by government subsidies. Therefore, the FIRR resulted in a negative value. On the other hand, the FIRR for the development of water supply facilities was 7.5%, which was almost the same as it was at the time of the appraisal.

In conclusion, although the project cost was within the plan, the project period significantly exceeded the plan. Therefore efficiency of the project is fair.

3.5 Sustainability (Rating: ③)

3.5.1 Institutional Aspects of Operation and Maintenance

At the time of the appraisal, the Yichang Municipal People's Government planned to establish the Yichang City Construction Investment Development Co., Ltd. in October 2002, which was to become the executing agency for the project and the entity responsible for the construction work related to the project. The government also planned to establish the Yichang Sewage Treatment Company as a subsidiary company of the implementing agency and to have it maintain and manage the sewerage facilities development component of the project. With regard to the

development of water supply facilities, the government planned to have the Yichang City Water Supply Company as the responsible entity, as the company had already been in charge of water supply projects since its establishment in 1959. At the time of the Ex-Post Evaluation, the actual entity in charge of the operation and maintenance of the sewerage facilities component (the Linjiangxi Sewage Treatment Plant and pumping stations) was the Yichang Sanxia Water Service Co., Ltd. (a private company) instead of a subsidiary of the implementing agency. Although all the facilities are owned by the Yichang City Construction Investment Development Co., Ltd., their operation and maintenance has been outsourced to a private company. On the other hand, the maintenance of the sewage collection systems and the sewer network is being conducted by the Yichang Municipal Bureau of City Administration. In reference to the water supply component, the Yichang City Water Supply Company is in charge of the operation and maintenance as planned.

- a. Linjiangxi Sewage Treatment Plant and pumping stations: Operation and maintenance is conducted by 102 staff members in total headed by two sewage treatment plant managers (Table 14). Through interviews with the managers of the Linjiangxi Sewage Treatment Plant, and on-site surveys at the treatment plant as well as the three pumping stations, it was verified that the size of the organization and the quality of the personnel is appropriate and the chain of command is clear. All the facilities display information boards on the walls showing the operation and maintenance procedures of the machinery and equipment, as well as safety management precautions. It can be said that the operation and maintenance is being conducted based on an appropriate organizational framework.

Table 14: Institutional Framework for the Operation and Maintenance of the Linjiangxi Sewage Treatment Plant and Pumping Stations

Department and number of personnel	Description of duties
[Linjiangxi Sewage Treatment Plant]	
“Sludge Area” Operation Team: 23 people	Administration of all the sludge management processes, operation and maintenance of machinery, equipment and materials
“Water Area” Operation Team: 24 people	Administration of all the sewage management processes, operation and maintenance of machinery, equipment and materials, management of the quality of water to be discharged
Repair Team: 8 people	Repair and maintenance of machinery, equipment and materials for the entire treatment plant
Chemical Testing Team: 3 people	Environmental monitoring, monitoring and analysis of water quality
Operation Control Office: 4 people	Support the management of operations of the entire treatment plant
Administration Office: 5 people	Maintenance of the warehouse, dining hall and green spaces, management of employees’ working hours
[Pumping stations]	
“Yang Ba” Operation Team: 11 people	Operation and maintenance of each pumping station
“Wanshou Qiao” Operation Team: 11	

people	
“Dagong Qiao”	
Operation Team: 11 people	

Source: Yichang Sanxia Water Service Co., Ltd.

- b. The maintenance of the sewage collection systems and the sewer network is under the responsibility of the Repair Management Department of the Yichang Municipal Bureau of City Administration (hereinafter referred to as “the Repair Management Department”). The department has a total of 114 staff members, of which those who are directly involved in maintenance are five engineers and two office workers for sewage collection systems; and 16 engineers and six office workers for the sewer network. The Repair Management Department conducts cleaning maintenance every year for drainage systems in the areas they are in charge of, in accordance with the condition of the facilities, prioritizing maintenance in urban areas with hollow land and water-bearing areas. Through interview surveys and documents that were provided by the Repair Management Department, it was found that problems are occurring regarding the maintenance of 135 drainpipes that the Repair Management Department is in charge of (a total length of 174.76 km, of which 27.0 km was improved by the project). Since the majority of these pipes are deteriorated and also because the original drainage construction standards when these were first constructed were low, they do not have enough capacity to cope with torrential rain which can cause water to accumulate in hollow areas of the city¹⁵. The current number of staff has not been sufficient to cope with these problems, thus it is necessary to strengthen the operation and maintenance organization as well as upgrading the whole drainpipe network.
- c. Water supply works (Water Purification Plants No. 1 and No. 3, and water mains network): The operation and maintenance of the Water Purification Plants No. 1 and No. 3, which were improved by the project, is conducted by 30 workers and 29 workers respectively. When looking at the number of engineers and office workers, the plants are run and operated by 60 workers in total, including 15 engineers and 45 office workers. Aqueducts are maintained by 23 workers in total, including five engineers and 18 office workers. The water mains network is maintained by a total of 53 workers, including 15 engineers and 38 office workers. Through an interview with the Yichang City Water Supply Company and on-site surveys at Water Purification Plants No. 1 and No. 3, it was confirmed that the size of the organization and the quality of the personnel are appropriate and the chain of command is clear. In general terms, the operation and maintenance is conducted through an appropriate organizational framework.

From the above, it can be concluded that although there is a need to strengthen the

¹⁵ Through interview surveys, it was discovered that most of the drainpipe network in urban districts of Yichang City was built in the 1970s and the 1980s. The construction standards at the time were low, but the network was functioning as the main drainage system for the urban districts. However, due to the development of the city and an increase in the population, the obsolete drainage facilities have become insufficient for fulfilling the role of sewage discharge.

organizational framework for the maintenance of the sewer network, the overall maintenance of both water supply facilities and sewerage facilities developed or improved by the project is generally being conducted by appropriate personnel and based on appropriate chains of commands.

3.5.2 Technical Aspects of Operation and Maintenance

Regarding the qualifications and technical levels of the personnel, there are specific qualification systems and training systems for both water supply facilities and sewerage facilities. Efforts are being made to maintain and improve the technical levels of the personnel. Thus it can be said that the technical levels necessary for the personnel in charge of operation and maintenance are adequate. In addition, through maintenance plans and maintenance manuals, rigorous maintenance records are kept, thus no problems were found regarding their technical levels.

With regard to sewerage facilities, there are certification tests conducted at the provincial level, namely the “Qualifying Examination for Technical Experts” and the “Certification Examination on Technical Skills for Special Occupations”¹⁶. A certain percentage of the personnel working at the companies that operate sewerage facilities are required to have these qualifications. Also, all the personnel are deployed to each workplace after receiving operational training, and further techniques for the operation of machinery and equipment are obtained through on-the-job training (OJT). Training for personnel in charge of maintenance and management is conducted based on national government regulations and/or provincial government regulations. For example, the “pre-job training” is conducted once a year for those who have already received a job offer (in machinery operation). There are other trainings such as the “operational training to obtain licenses for special occupations” which are conducted for special job categories, and the “training for workplaces requiring technical skills” which are conducted for technical experts.

In reference to water supply facilities, these are run by the Yichang City Water Supply Company, which was established in 1959 and has accumulated experience in the operation and maintenance of water supply facilities. Technical experts are allocated to each facility and they receive training and qualifying examinations based on national and provincial government regulations, and no major problems were found with their technical levels.

In the maintenance and management plans for sewerage facilities, there are daily inspections, and periodic inspections which are conducted less frequently but require the participation of larger number of personnel. The pumps, power distribution systems, blowers and sludge thickening facilities are overhauled every five years. Through on-site surveys, it was confirmed that maintenance and management is generally implemented using the process stipulated in the

¹⁶ The “Qualifying Examination for Technical Experts” is designed to mainly check theoretical knowledge and there are no preconditions for taking the test. Even after obtaining the qualification, these persons still need to go through On-the-Job-Training (OJT). On the other hand, the “Certification Examination for Technical Skills for Special Occupations” requires specific qualifications for taking the test. A certain level of work experience is required and the test targets engineers who elaborate the plans for maintenance and management or engineers who have overall responsibility on these activities. Qualifications obtained through provincial-level qualifying examinations and certification examinations are differentiated from national qualifications in the sense that the provincial qualifications are only valid in the respective provinces.

maintenance manuals and that the maintenance records are managed properly. Similarly with regard to the maintenance of water supply facilities, daily inspections and periodic inspections are conducted at the water purification plants. Through on-site surveys, it was confirmed that maintenance is generally implemented by following both the procedures and frequencies stipulated in the respective manuals. It was also confirmed that the maintenance records are kept and managed properly. On the other hand, although the maintenance of the water mains network (leakage investigations and repairs) that include the sections of the network upgraded by the project, is being conducted based on the manuals, leakage control measures are lagging behind. The water mains need to be upgraded rather than just being maintained in their current condition through repeated repairs. Nonetheless, the leakage rate is lower than the provincial government's standard.

3.5.3 Financial Aspects of Operation and Maintenance

Table 15 shows the financial status of the Yichang Sanxia Water Service Co., Ltd., which runs and manages the sewerage facilities. With regard to revenues, the Municipal Bureau of Finance pays the company a rate of 0.45 yuan/ton to cover operation costs based on the quantity of sewerage treated. As of 2012, the corporation also collects 0.8 yuan/m³ as sewerage service charges.

Table 15: Financial Status of the Yichang Sanxia Water Service Co., Ltd.

(Unit: 10,000 yuan)

Item	2008 (Starting of operations)	2009	2010	2011	2012
[Revenues]					
Sewerage treatment fees	4,026	4,068	4,090	4,180	4,240
Government subsidies	2,760	2,760	2,760	2,760	2,760
A. Sub-total	6,786	6,828	6,850	6,940	7,000
[Expenditures]					
Labor costs ^{*1}	380	395	410	430	450
Other costs ^{*2}	2,380	2,365	2,350	2,330	2,310
B. Sub-total	2,760	2,760	2,760	2,760	2,760
A-B	4,026	4,068	4,090	4,180	4,240

Source: Yichang Sanxia Water Service Co., Ltd.

^{*1} Labor costs: Labor costs for the operation and maintenance staff of the sewerage treatment

^{*2} Other costs: Operation and maintenance costs other than labor costs

Although the expenditures are covered by government subsidies, the revenues from sewerage treatment fees are increasing and their business would be in surplus even without the government subsidies. Therefore, financial sustainability is ensured.

On the other hand, as shown in Table 16, the Yichang City Water Supply Company runs and manages water supply facilities without receiving government subsidies or any other assistance

from the government and its main revenue source is water charges¹⁷. According to the table 16, their business is constantly in surplus with the revenue from water charges. Their self-evaluation also concluded that the “company is in a financial situation which enables them to maintain normal operations.”

Table 16: Financial Situation of the Yichang City Water Supply Company
(Unit: 10,000 yuan)

Item	2008 (Starting of operations)	2009	2010	2011	2012
[Revenues]					
Water charges	5,800	5,730	5,822	6,008	6,663
Government subsidies	0	0	0	0	0
A. Sub-total	5,800	5,730	5,822	6,008	6,663
[Expenditures]					
Labor costs ^{*1}	1,310	1,445	1,547	1,605	1,670
Other costs ^{*2}	3,736	3,197	3,199	3,322	3,492
B. Sub-total	5,046	4,642	4,746	4,927	5,162
A-B	754	1,088	1,076	1,081	1,501

Source: Yichang Gorge Water Service Co., Ltd.

^{*1} Labor costs: Labor costs for the operation and maintenance staff of the water purification plants

^{*2} Other costs: Operation and maintenance costs other than labor costs

Regarding the budget for the maintenance of sewage collection systems and the sewer network, from 2008 to 2012, the Repair Management Department of the Yichang Municipal Bureau of City Administration included in its annual budget 740,000 yuan for maintenance and 500,000 yuan as reserve funds to be used for measures to stop sewage gushing out of deteriorated drainpipes¹⁸.

From the above it can be concluded that the financial situation of each of the entities in charge of the operation and management of both water supply and sewerage facilities is generally stable, and the budget required to keep an appropriate maintenance of the project has been secured.

3.5.4 Current Status of Operation and Maintenance

The Linjiangxi Sewage Treatment Plant, the sewage collection systems and the sewer network developed by the project are generally being maintained in good condition. In the Sewage Treatment Plant, there were some problems in the past including malfunctions and the performance deterioration of blowers, coarse mesh screens, sludge pumps, among others, but sufficient measures were taken every time, such as replacement of parts by suppliers and repair of malfunctioning equipment. However, at the Dagong Qiao relay pumping station, the pumps are not

¹⁷ Water charges as of 2012 were as follows: 1.44 yuan/m³ for households, 1.89 yuan/m³ for industries and 1.89 yuan/m³ for commercial facilities. In China, local governments have the authority to decide water charges and sewerage facilities fees. The charges and fees are revised in response to requests from business operators.

¹⁸ According to materials provided by the Repair Management Department of the Yichang Municipal Bureau of City Administration and the results of interview surveys, although the sewer pipes laid by the project have no problems, the budget for the maintenance and repair of the sewer network constructed in the 1970s and the 1980s is too small considering the degree of deterioration. The lack of budget is making it difficult to achieve the normal level of maintenance for the drainpipe network.

operating efficiently due to relatively large pieces of waste collected in the sewer network. This kind of problem occurs because the “combined method” is used where the same drainpipes are used for both rainwater and sewerage. In order to solve the problem, it is necessary to either construct facilities to temporarily store rainwater, or install additional devices (grids and screens) to remove the waste contained in the sewage to be discharged. In addition, part of the floor in the administrative building of the pumping station has a crack and the floor has sunken because of land subsidence. Immediate action is required to solve this problem. In addition, during on-site surveys, parts of some pumping stations were not sufficiently cleaned and things were not well organized. However, overall, there were no major problems in the maintenance and management of the facilities. It is worth mentioning that in addition to the maintenance of the facilities, both at the sewage treatment plant and pumping stations, efforts are being made to plant vegetation in order not to disturb the landscape. These are efforts that can be valued highly. There have been no particular problems with the supply of spare parts because machinery, equipment and materials are mainly made in China and even the products made in foreign countries come with sufficient after-sale service by suppliers.

With regard to water supply facilities, at the time of the ex-post evaluation, Water Purification Plant No. 3 was in normal operation and there were no significant problems regarding the operation and maintenance of the facility. On the other hand, Water Purification Plant No. 1 was hardly in operation because the plant is considered as a back-up system at this stage of the implementation of the aforementioned city’s Overall Urban Planning. As mentioned earlier, the Yichang Municipal People’s Government is currently constructing several industrial parks in the Development Area, and the plan is for the Water Purification Plant No.1 to start normal operations as soon as the construction to connect the Development Area with the existing water mains network is completed. When the on-site survey was conducted, the plant was going through periodic maintenance and there were no particular maintenance problems observed.

In conclusion, no major problems have been observed in the operation and maintenance system, therefore sustainability of the project is judged to be high.

4. Conclusion, Recommendations and Lessons Learned

4.1 Conclusion

The project aimed to improve the water environment (the quality of river water and the quality of water supplied) in Yichang City, by developing and upgrading water supply and sewerage facilities.

The project was in line with Chinese development policies at the national, provincial and municipal levels, their development needs and the Japanese assistance policy for China, both at the time of the appraisal and at the time of the ex-post evaluation. Therefore, its relevance is high. With regard to the development of sewerage facilities, the targets were achieved or exceeded for all the main project effect indicators, including the amount of wastewater treated and the quality of the water treated. This enabled the Yichang Municipal People’s Government to achieve the National

Environment Quality Standards for Surface Water Class II. Regarding the improvement of water supply facilities, at the time of the Ex-Post Evaluation, the targets were achieved or the values were improving for the main project effect indicators, including the quantity of the water supplied, the population served and the turbidity of the water supplied. In particular, the target for the improvement of the quality of the water supplied, which is one of the project purposes, was met. Therefore, the project is evaluated to be satisfactory. In addition, significant positive impacts were observed with regard to pollution control measures, sludge recycling, residents' living environment and their quality of life. Therefore, the project successfully achieved its intended effects and impacts. The efficiency of the project was evaluated as fair, because the project period significantly exceeded the plan, although the project cost was within the plan. With regard to the sustainability of the effects of the project, no major problems have been observed in the organization, technical level and financial status of the entities in charge of the operation and maintenance of the water supply and sewerage facilities, therefore sustainability of the project effect is high.

In light of the above, this project is evaluated to be highly satisfactory.

4.2 Recommendations

4.2.1 Recommendations to the Executing Agency

With regard to the Dagong Qiao relay pumping station, it is necessary to install additional devices (grids and screens) to remove the waste contained in the sewage to be discharged. In addition, measures need to be taken immediately regarding the floor subsidence in the administrative building of the pumping station. More specifically, it is desirable to conduct a subsurface investigation again and then conduct construction work for ensuring the safety of the building.

Both the water mains network and the drainpipe network have problems caused by aging. Although no problem was observed regarding the maintenance of pipes newly laid or replaced by the project, it will be necessary to upgrade both the overall drainpipe network and the water mains network. Although a new upgrade plan is currently being formulated, this process should be speeded up. It is also necessary to implement measures such as increasing the number of operation and maintenance personnel in order to strengthen the maintenance organization structure.

4.2.2 Recommendations to JICA

None.

4.3 Lessons Learned

At the time of the appraisal, the initial project plan was to recycle the sludge produced through the treatment of the sewerage, into organic fertilizer. However, an engineer from the Yichang City Construction Investment Development Co., Ltd. (the executing agency) participated in a one-month JICA Training Course in Japan in 2005, where he visited a cement factory and learned about the

recycling of sludge into cement. He introduced the method into the project and currently all the sludge generated by the project's sewage treatment plant (16 tons/day) is recycled at a private cement factory. One of the important factors that enabled the application of the example of the Japanese cement factory was that an appropriate person was chosen as the participant for the Training in Japan. It was important that the selected participant had a certain level of decision making power, who could objectively determine whether the knowledge and experience obtained in the training would be technically, financially and institutionally feasible. The timing of the training was also ideal, because it was when the Yichang Municipal People's Government had submitted an application to become a "National Model City for Environmental Protection." Also the fact that the engineer was able to participate in the Training and apply the knowledge during the project period was most appropriate, as it enabled an optimum coordination between an ODA loan project with a technical cooperation program. This is a good example that should be followed when conducting similar projects in the future.

End

Comparison of the Original and Actual Scope of the Project

Item	Original	Actual
1. Project Outputs [Development of Sewerage Facilities]		
a. Linjiangxi Sewage Treatment Plant (including grit chambers, biological tank, final sediment tanks and sludge treatment facilities)	A2O method Treatment capacity: 200,000 m ³ /day	As planned
b. Five relay pumping stations		
1. Xiling Yi Lu	80,000 m ³ /day	Canceled
2. Dagong Qiao	180,000 m ³ /day	As planned
3. Development Area	60,000 m ³ /day	Canceled
4. Wanshou Qiao	100,000 m ³ /day	220,000 m ³ /day
5. Yang Ba	400,000 m ³ /day	As planned
c. Development of the sewage collection systems (sewer network construction)	33 km	27.08 km
[Development of water supply facilities]		
a. Improvement of two water purification plants (improvement of filter beds, changing water pumps and motors, the introduction of automatic control systems, etc.)	[Water Purification Plant No. 1] Treatment capacity: 160,000 m ³ /day [Water Purification Plant No. 3] Treatment capacity: 100,000 m ³ /day	As planned As planned
b. Upgrading aqueducts	5.3 km	As planned
c. Upgrading and expanding the water mains network	49.0 km	As planned
2. Project Period	March 2003 - July 2006 (41 months)	March 2003 - December 2008 (70 months)
3. Project Cost		
Amount paid in Foreign currency	8,460 million yen	8,459 million yen
Amount paid in Domestic currency	3,270 million yen (218 million yuan) 11,727 million yen 8,460 million yen	2,333 million yen (165 million yuan) 10,785 million yen 8,452 million yen
Total	1 yuan = 15 yen	1 yuan = 14.13 yen
Japanese ODA loan portion	(As of September 2002)	(Average end-of-year rates between 2004 and 2008)
Exchange rate		