People's Republic of China

Ex-Post Evaluation of Japanese ODA Loan Project

"Water Supply and Quality Environment Project in Changsha City"

External Evaluator: Hiromi Suzuki S., IC Net Limited

0. Summary

The purpose of this project is to address water contamination problems in the Xiangjiang River and to improve the living environment of citizens by constructing water and sewage facilities in Changsha City, Hunan Province.

The project is highly relevant, because at the time of the appraisal and the ex-post evaluation, it meets the development policies and needs indicated by the governments of China, Hunan Province, and Changsha City as well as the Japanese aid policies. Concerning the operation and effect indicators of the resulting waterworks, the goal achievement ratio is about half the plan. However, the effect is sufficient in consideration of the project role in the citywide water supply system confirmed during the ex-post evaluation. In the resultant sewage works, all the indicators have reached their goals defined at the time of the appraisal—both the effectiveness and impact of the project are recognized as high because of the improvement of contaminated rivers including the Xiangjiang River, which run through the City, and of the living environment of residents. Both the project cost and the project period exceed the planned ones significantly, resulting in low efficiency. The systems, technologies, and financial condition of operation and maintenance are good, so the effect resulting from the project is highly sustainable.

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

1. Project Description

Project Location

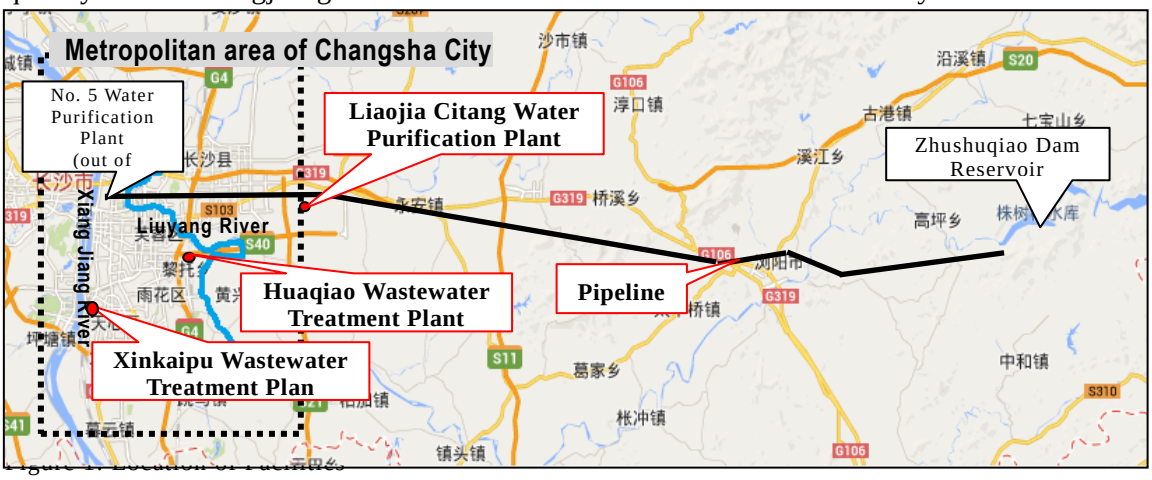
Photo 1: Pipeline from Zhushuqiao Dam Reservoir

1.1 Background[1]

Changsha City, the capital of Hunan Province, is located in central China. It has about 1.96 million people in the urban area as of 2003, and has grown rapidly as the center of the provincial politics, economy, and finance. However, compared with the development of the economy and population, the construction of water and sewage facilities is lagging—the water supply and sewerage treatment coverage ratios are 70% and 37%, respectively. The City receives 100% of its water from the Xiangjiang River, while domestic and industrial wastewater flows in the large river. In about five successive years from the 1990s, the Xiangjiang River, the City's only water source, encountered an extreme drought for about three months in winter, so it was very difficult to supply high-quality drinking water to the citizens. In the meantime, raw domestic and industrial wastewater discharged into the city rivers, branches of the Xiangjiang River, contaminated the main river seriously and degraded the living environment of citizens as the flow rate decreased, which also caused water pollution in Dongting Lake and the Yangtze in the downstream part.

1.2 Project Outline

The objective of this project is to improve Changsha City's ability to supply drinking water and to treat wastewater by constructing water intake and conveyance facilities, water purification plants, and sewage works, thereby contributing to the improvement of the water quality of the Xiangjiang River and the sanitation condition of the City.



[1] This is based on documents created at the time of the appraisal and provided by the executing agency.

Loan Approved Amount/ Disbursed Amount	19,964 million yen / 19,803 million yen
Exchange of Notes Date/ Loan Agreement Signing Date	March 29, 2005 / March 30, 2005
Terms and Conditions	Interest rate: 1.5% for waterworks; 0.75% for sewage works and training Repayment period (grace period): 30 years (10) for waterworks; 40 years (10) for sewage works and training Conditions for procurement: General untied
Borrower/ Executing Agency(ies)	Government of the People's Republic of China / Government of Changsha City
Final Disbursement Date	July 26, 2012
Main Contractors	Hubei International Trade Investment & Development Co. Ltd. (China) and China Textile Industrial Corporation for Foreign Economic and Technical Cooperation (China) / Hunan Technical Import & Export Corporation (China) (JV)
Contract with Consultant(s)	None
Feasibility Studies, etc.	F/S: North China Municipal Engineering Design & Research Institute (conducted the study in March 2003)
Related Projects	Japanese ODA loan: Changsha City Waterworks Construction Project (L/A signed in March 2001) World Bank: Hunan Urban Development Project (from September 2004 to October 2012)

2. Outline of the Evaluation Study

2.1 External Evaluator

Hiromi Suzuki S., IC Net Limited

2.2 Duration of the Evaluation Study

The following shows the studies conducted during ex-post evaluation.

Duration of the study: August 2014–November 2015

Duration of the field study: November 18–26, 2014 and March 30–April 5, 2015

2.3 Constraints during the Evaluation Study

The impact of this project is to improve the water environment quality of the Xiangjiang River and the sanitation condition of Changsha City. The former goal was expected to be attained by (1) reducing the amount of water taken from the Xiangjiang River and (2) promoting the treatment of wastewater discharged directly or indirectly into the Xiangjiang River. The intake reduction shown in (1) decreases the contaminant concentration but does not result in the fundamental improvement of water quality. Moreover, the extent to which the intake should be reduced to realize the impact was not shown clearly at the time of the appraisal. Accordingly, it seems that there was a limit in setting the intake reduction amount as

a way to improve the water quality of the Xiangjiang River. In the wastewater treatment indicated in (2), the main cause of contaminating the Xiangjiang River having more than 2,000 branches is the discharge of raw wastewater from industrial companies (heavy metal industry) in the upstream part. That is to say, the industrial wastewater degrades the water quality of the downstream part of the Xiangjiang River, and external factors have a significant effect on the evaluation of the extent to which wastewater treatment plants constructed in the project contribute to the improvement of the Xiangjiang River's water quality. The effect of the wastewater treatment plant and data on the water quality of the Xiangjiang River were used to evaluate the impact of the project during ex-post evaluation, but the constraints above made precise measurement difficult.

3. Results of the Evaluation (Overall Rating: B[2])

3.1 Relevance (Rating: ③[3])

3.1.1 Relevance to the Development Plan

At the time of the appraisal, the "10th Five-Year Plan (2001–2005)" based on the Chinese development policy aimed to build waterworks and sewage works to improve the efficiency of water source development in all the cities and use as well as to promote measures against contaminated water sources. As a concrete action for achieving both goals, the "10th Five-Year National Environmental Protection Plan (2001–2005)" was drawn up. The key objectives of the plan were to keep water sources in middle- to large-scale cities suffering from serious water shortage and to construct water supply infrastructures in local cities. In addition, to improve the quality of contaminated water, the plan aimed to reduce the total emission of key contaminants, to strengthen sewage works projects, and to promote the introduction of market mechanisms, such as building up a system for collecting contamination costs, modifying the sewage charge, and putting private investments into the environment industry. To keep water sources in the cities, the Chinese government issued a notice[4] in 2000 in order to let them have multiple water sources, rather than a single one, and to optimize the distribution of water sources. In response, Changsha City drew up the "Changsha City Mid-to-Long-Term Development Plan (2002–2020)" as a mid- to long-term policy to develop the Liuyang Zhushuqiao Dam meeting Type II[5] of the national water

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[2] A: Highly satisfactory, B: Satisfactory, C: Partially satisfactory, D: Unsatisfactory

[3] ③: High, ②: Fair, ①: Low

[4] The national government issued the document initiated by the State Council as Notice No. 36 on November 7, 2000.

[5] Environmental Quality Standards for Surface Water issued by the National General Bureau of Environmental Protection on April 28, 2002: Type I: Water source and national wildlife sanctuary; Type II: Class 1 sanctuary having centralized surface water source for drinking, rare aquatic life zone, fish/shellfish spawning ground, and fry feeding ground; Type III: Class 2 sanctuary having centralized surface water source for drinking, fish/shellfish wintering area, migration route, fisheries waters (e.g. fish farm), and bathing area; Type IV: General industrial waters and entertaining waters without direct contact with humans; Type V: Irrigation and landscape waters

standards as the second source for drinking water. The dam would reduce the amount of water taken from the Xiangjiang River, resulting in a reduction in contaminant concentration and making the water quality at least Type III, which is suitable for drinking water. Moreover, the City aimed at a water supply ratio of 100% by enlarging the existing water purification plants and constructing new plants to increase the water supply scale of the six plants in total. Concerning the sewage works, this project aimed to construct two new wastewater treatment plants to attain a sewerage treatment coverage ratio of 80% by 2015. Another purpose was to improve the City's water environment, particularly the water quality of the Xiangjiang River into which wastewater and treated water flowed, by constructing a sewer network.

At the time of the ex-post evaluation, the Chinese government drew up two kinds of plans: one was the "12th Five-Year National Environmental Protection Plan (2011–2015)" and the other was the "12th Five-Year Overall Action Plan for Energy Saving and Emission Reduction (2011–2015)." The purpose of the former was to strive to improve the water quality by 2015 by ensuring the environmental safety of drinking water sources in urban and rural areas, while that of the latter was to attain a sewerage treatment coverage ratio of 85% in urban areas by 2015. According to the national plans, Hunan Province and Changsha City separately made the "12th Five-Year Plan for Developing the Nation's Economy and Society (2011–2015)." The city plan for waterworks shows the rational development and use of water sources and the strict protection of drinking water sources. In addition, the City plans to increase the water supply capacity per day to 2.2 million m^3 in the urban area by 2015 by constructing new water purification plants, enlarging the existing ones, and establishing a city water supply network. Concerning sewage works, the municipal government aims to increase the city sewerage treatment coverage ratio to 95% by constructing new wastewater treatment plants (8 in total), expanding the existing ones, and installing a new 4 km-long sewer network. The plan also includes the promotion of fast sludge treatment and recycled water use programs.

In addition to the plans above, the State Council announced the "Action Plan for Water Contamination Prevention (Ten Water Articles) (No. 17 State Affair [2015])" on April 16, 2015. The plan shows that measures against water pollution will be taken from ten aspects; for example, suppressing the emission of all contaminants, strengthening water saving and water source protection, making legal enforcement and supervision stricter, enhancing water environment control, and strengthening the local government's responsibility. It also sets up concrete goals by 2020 for the seven river basins including the Yangtze and the Huang, such as the achievement of at least Type III of the national water standards and a sewerage treatment coverage ratio of 95% in the urban area.

The above shows that at the time of both the appraisal and the ex-post evaluation, the national, provincial, and municipal governments draw up their own development plans separately in order to establish the infrastructures of waterworks and sewage works as well as

to improve the water quality (drinking water and treated wastewater)—the water supply and wastewater treatment fields are kept important. This project is highly relevant to the development policy shown by the Chinese government. Therefore, its relevance is high.

3.1.2 Relevance to the Development Needs

a. Waterworks: Changsha City had 1.96 million people in the urban area at the time of the appraisal (2003). As the population increased and the economy grew, the maximum demand would reach 1.73 million m^3/day in 2010, while the supply capacity was up to 1.43 million m^3/day, so the shortage was expected to be 0.3 million m^3/day. At that time, the Xiangjiang River was the single water source for the City and encountered an extreme drought for about three months in winter in about five successive years, which accelerated water pollution in the basin and made it difficult to maintain high-quality drinking water. To overcome such conditions, the municipal government drew up some plans, including this project, to increase the water supply capacity to 2.2 million m^3/day by 2015 by giving priority to the construction of pipelines, water purification plants, and a water supply network all over the City.

At the time of the ex-post evaluation (2014), the City had 3.71 million people, which was about 89% higher than that at the time of the appraisal. It planned to achieve a water supply coverage ratio of 100% and a water supply capacity of 2.2 million m^3/day by 2015, and the latter was already 2.31 million m^3/day at the time of the ex-post evaluation. However, the latest mid-to-long-term plan of Changsha City shows that continuous and rapid city development will increase the population of the urban area to 6.29 million people by 2020. According to the plan, the City will increase the water supply capacity to 4.0 million m^3/day by 2020 by constructing the Liuyang Zhushuqiao and Dahu Dams as water sources other than the Xiangjiang River as well as preparing 13 water supply facilities in the urban area. Note that the Liaojia Citang Water Purification Plant constructed in this project connects with No. 1, No. 3, No. 5, No. 8, and Shongyahe Water Purification Plants via pipelines, so even if the demand increases or a certain plant pauses for maintenance, water can be inter-exchanged between from the service areas. This system plays a key role as part of the water supply system in the urban area of Changsha City.[6]

[6] For example, when the City suddenly faced a difficulty in keeping the drinking water quality in 2014 because of a problem in the facilities of the Shongyahe Water Purification Plant, the Liaojia Citang Water Purification Plant constructed in this project supplied high-quality drinking water to the residents in the service area in question.

Table 1: Changsha City's Water Purification Capacity (10,000 m^3/day)

Plant name	Water source	At the time of the appraisal	At the time of the ex-post evaluation
No. 1 WPP	Xiangjiang River and Dahu Dam	20	20
No. 2 WPP	Xiangjiang River	5	10
No. 3 WPP	Xiangjiang River	30	30
No. 4 WPP	Xiangjiang River	20	40
No. 5 WPP	Xiangjiang River and Zhushuqiao Dam	30	30
No. 8 WPP	Xiangjiang River	50	50
Wangcheng WPP	Xiangjiang River	5	15
Shongyahe WPP	Laodao River (branch of Xiangjiang River)	6	6
Liaojia Citang WPP (this project)	Zhushuqiao Dam	—	**30**
	Total	166	231

Source: Documents provided by the executing agency
WPP: Water Purification Plant

b. Sewage works: In 2003, the sewerage treatment coverage ratio of Changsha City was as low as about 37%, because the City could not catch up a rapid population rise and economic development. Such a low ratio contaminated the Xiangjiang River and its branches in the City seriously and degraded the water quality of Dongting Lake and the Yangtze in the downstream basin. The City's mid- to long-term plan showed the construction of two new wastewater treatment plants in this project to aim at a sewerage treatment coverage ratio of 70% by 2010, so needs for developing sewage works were high. At the time of the ex-post evaluation, as mentioned before, a further population rise and city development would increase the treatment demand to 2.83 million m^3/day in 2020. To meet it, the municipal government plans to increase the number of wastewater treatment plants to 14 and the treatment capacity from 1.28 million m^3/day during ex-post evaluation to 3.53 million. Therefore, needs for developing sewage works are continuously high.[7]

Table 2: Changsha City's Wastewater Treatment Capacity (10,000 m^3/day)

Facility name	At the time of the appraisal	At the time of the ex-post evaluation
No. 1 WTP	18	18
No. 2 WTP	14	14
Yuelu WTP	—	30
Xinkaipu WTP (this project)	—	**10**
Huaqiao WTP (this project)	—	**16**
Changshan Yuan WTP	—	16
Kaifu WTP	—	20
Pingtang WTP	—	4
Total	32	128

Source: Documents provided by the executing agency
WTP: Wastewater Treatment Plant

[7] A drought problem in the Xiangjiang River was addressed by constructing a dam (completed in 2011) in the upstream part. Although the flow rate was stable, the Xiang Jiang's flow ability reduced, resulting in a fall in the Xiangjiang River's self-purification function. In addition, a rise in the number of cargo ships running along the Xiangjiang River increases the need for improving the water quality of the river.

3.1.3 Relevance to Japan's ODA Policy

At the time of the appraisal, Japan's assistance policies for China included the "Economic Cooperation Plan for China (made in 2001)," the "Policy for Conducting Overseas Economic Cooperation Activities (2005–2008)," and the "Country-Specific Action Policy (2002–2005)," all of which focused on environmental preservation. The third one gives priority to public projects requiring a government's role, such as support to the construction of water and sewage facilities, and promotes efforts to improve the environment administration ability by strengthening cooperation with local governments and transferring Japanese know-how to provide software aid. Accordingly, this project is highly consistent with Japan's support policy.

In light of the above, this project has been highly relevant to China's development plan and development needs, as well as Japan's ODA policy. Therefore, its relevance is high.

3.2 Efficiency[8] (Rating:①)

3.2.1 Project Outputs

This project consists of three pillars: waterworks, sewage works, and training (for more information, see the table titled "Comparison of the Original and Actual Scope of the Project"). This subsection describes differences between the plans and results as well as their reasons.

3.2.1.1 Waterworks

a. Water intake and conveyance

- The capacity of the intake facility from the Liuyang Zhushuqiao Dam was changed from 0.95 million m^3/day to 0.65 million (68% of the planned). The reason was that the city government made a decision to divide the facility construction plan into two phases (by 2015 and 2020) according to the development plan by 2020. Therefore, this project would attain 0.65 million m^3/day and the Chinese side would complete the remainder with its own expenses. The output change has been reasonable from an efficiency point of view, because it was based on the City government's plan for running the first-phase project to meet the needs by 2015 and completing the second-phase project by 2020.
- Installation of pipelines: The planned pipeline was 76 km long, but the resulting length was 98 km (129% of the planned one) because after the project started, the City government made a request for laying an additional pipeline 22 km long to the No. 5 Water Purification Plant, an existing facility, in order to supply water meeting Type II from the Liuyang Zhushuqiao Dam to the plant and to improve the living environment

[8] The efficiency is evaluated with the impact in mind.

of citizens. The output change has been reasonable because it improves the living environment of more citizens in the City.

・Construction of the Liaojia Citang Water Purification Plant: As planned, the facility having a capacity of 0.3 million m^3/day has been completed.

b. Construction of a water distribution network: The plan showed that the resulting length would be 553 km in total (new: 412 km and repair: 141 km). This project has completed a new network 23.23 km long, and the remainder has been constructed in different projects out of the scope.[9] Of the new distribution network, a section 1.37 km long was under construction during ex-post evaluation but the remainder (387.40 km) and the pipeline (141 km) to be repaired were completed in the different project (for more information about the water distribution network, see "3.2.2.2 Project Period"). The output change and its reason have been proper, because it is reasonable to lay not only distribution pipes but also sewers and electric wires simultaneously with road construction to increase efficiency, including project cost reduction, from a city infrastructure building point of view.

3.2.1.2 Sewage works

a. Construction of the Xinkaipu Wastewater Treatment Plant: Almost as planned, a facility having a capacity of 107 thousand m^3/day (107% of the planned capacity) and featuring the A2O process[10] has been completed.

b. Construction of the Huaqiao Wastewater Treatment Plant: Almost as planned, a facility having a capacity of 168.6 thousand m^3/day (105% of the planned capacity) and featuring the A2O process has been completed.

c. Construction of a sewer network: Almost as planned, the network has been completed (plan: 116.60 km and result: 119.51 km).

d. Construction of pump stations: The plan showed the construction of nine pump stations, but rationalizing the city and sewer network plans cancelled three sites. As a result, six pump stations have been completed.[11] The output change has been proper, because it has no effect on the operation and effectiveness of the resulting sewage works.

e. Training: The plan showed that about 57 trainees would learn the operation and maintenance of a wastewater treatment plant, water purification plant, sewer network, and pump station as well as the chemical analysis and monitoring of the water quality.

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[9] The water distribution network has been completed with expenses paid by Xingsha Water Supply Corporation and ward-by-ward water supply companies, both buying purified water from Changsha Water Diversion and Water Quality Company Co. Ltd.

[10] The A2O method (anaerobic, anoxia, and aerobic processes) is an advanced wastewater treatment type. Reaction tanks consist of anaerobic, anoxia, and aerobic ones to get rid of nitrogen and phosphorus together.

[11] The cancelled facilities were the Mayang Qiao Wastewater, Caijia Submerged, and Guitang Xiang Jiang Pump Stations. The planned wastewater tank of the third station was integrated into that of the Laodonglu Wastewater Pump Station—the latter capacity increased.

The resulting number of trainees has been 54, which is almost as planned.[12]

3.2.2 Project Inputs

3.2.2.1 Project Cost

The planned project cost was 46,963 million yen consisting of 19,964 million yen (paid in foreign currency) and 26,999 million yen (paid in local currency). The former was the Japanese ODA loan portion. The actual cost was 71,547 million yen (including the Japanese ODA loan portion of 19,803 million yen), which was significantly higher than planned (152% of the planned).

Table 3: Planned and Actual Project Costs (Unit: million yen)

Item	Planned costs			Actual costs			Ratio to the plan
	Japanese ODA loan	Amount paid in local currency	Total	Japanese ODA loan	Amount paid in local currency	Total	
Construction of pipelines and water purification plants (incl. distribution network)	10,185	13,367	23,552	12,918	26,595	39,513	168%
Construction of Xinkaipu Wastewater Treatment Plant (incl. related sewer network and pump stations)	3,024	3,365	6,389	3,225	8,194	11,418	179%
Construction of Huaqiao Wastewater Treatment Plant (incl. related sewer network and pump stations)	6,068	6,663	12,731	3,648	10,904	14,553	114%
Training	30	0	30	12	0	12	40%
Price escalation	657	199	856	0	0	0	0%
Reserve	0	2,181	2,181	0	80	80	4%
Interest during project	0	1,224	1,224	0	5,971	5,971	488%
Total	19,964	26,999	46,963	19,803	51,744	71,547	152%

Source: The planned and actual costs are provided by JICA and the executing agency, respectively.
Planned cost: Calculated at 1 dollar = 110 yen, 1 dollar =8.28 yuan, 1 yuan = 13.3 yen, Annual price escalation rate =1.4% for foreign currency and 0.4% for local currency, and Physical reserve rate = 5.0% for foreign and local currencies in September 2004.
Actual cost: Found at the average exchange rate (1 yen = 0.0732 yuan) from 2005 to 2012 because no annual cost in yuan was available.

There were three major reasons why the actual project cost was significantly higher than planned despite the output reductions in the water supply works, that is, the capacity of the water intake facility and the total length of the water supply pipeline network of the water supply, as well as in the sewage works, that is the number of pump stations: (1) the existence of topographical features and faults that were not identified in the geological survey of the

[12] The Kagoshima and Fukuoka City Waterworks Bureaus received the trainees. The training period was January 5–19, 2011 in the first phase and February 13–27, 2012 in the second phase.

feasibility study (F/S)[13] increased the costs for constructing pipelines, the water distribution network, wastewater treatment plants, and the sewer network; (2) the material and equipment prices increased; and (3) the project cost consisted of a Japanese ODA loan and financial aid from domestic commercial banks, and a rise in the latter and the associated interest and the prolonged project period raised the interest during the project tremendously. Particularly in reason (1), geological problems were found in all components, so large-scale foundation works were added as a result.

3.2.2.2 Project Period

The planned period was from March 2005 to December 2008 (3 years and 10 months = 46 months in total), while the actual period was from March 2005 to August 2012 (7 years and 6 months = 90 months in total). The latter was significantly longer than the former (196% of the planned).[14]

[13] Based on the interviews to the Executing Agency, the standard procedure in China is that, the level of accuracy in which geological surveys are conducted during the F/S are in line with what is established in the national standards, and more detailed surveys are conducted at the time of the detailed design if deemed necessary. The F/S of this project was approved by the National Development and Reform Commission in March 2004, thus it is possible to say that the geological survey at the time of the F/S was in line with the national standards, and from the point of view that it was approved at the national level, no additional surveys with a higher level of accuracy were conducted at the moment of the detailed design. However, if the fact that several problems related to the lack of accuracy in the geological survey appeared once the project started is taken into consideration, it is possible to infer that a higher level of accuracy of the geological survey at the time of the F/S and the detailed design could have resulted in a more efficient execution of the project. The Executing Agency commented that "the F/S geological survey should have been conducted more meticulously".

[14] The project is regarded as complete when all the operations are inspected and a test run is completed.

Table 4: Planned and Actual Project Periods

Process		Planned date/period	Actual date/period	Ratio to the plan*
L/A signing date		March 31, 2005	March 31, 2005	—
Preparation for bidding		Mar. 2005 to Dec. 2006 22 months	Mar. 2005 to Dec. 2006 22 months	On schedule
Bidding for earthwork		May 2005 to Dec. 2006 20 months	May 2005 to Mar. 2009 47 months	235%
Bidding for equipment and material		Aug. 2005 to Dec. 2006 17 months	Aug. 2005 to Aug. 2010 61 months	359%
Preparation for earthwork		Apr. 2005 to May 2006 14 months	Apr. 2005 to May 2006 14 months	On schedule
Earthwork and construction	Intake and conveyance facilities	Jan. 2006 to Dec. 2007 24 months	Feb. 2006 to Aug. 2010 55 months	229% Delay in start: 1 mo.
	Liaojia Citang Water Purification Plant	Jan. 2006 to Sept. 2007 21 months	Oct. 2005 to Oct. 2009 49 months	233%
	Water distribution network	Jan. 2006 to Dec. 2007 24 months	Nov. 2010 to Apr. 2012 18 months	75% Delay in start: 58 mos.
	Xinkaipu Wastewater Treatment Plant	Jan. 2006 to Sept. 2007 21 months	Sept. 2006 to June 2009 34 months	162% Delay in start: 8 mos.
	Huaqiao Wastewater Treatment Plant	Jan. 2006 to Sept. 2007 21 months	Nov. 2005 to Mar. 2009 41 months	195%
	Sewer network	Jan. 2006 to Dec. 2007 24 months	Sept. 2005 to May 2011 69 months	287%
Procurement, installation, test, and operation of equipment		Jan. 2006 to Dec. 2008 36 months	Jan. 2006 to Aug. 2012 80 months	222%
Training		Jan. 2006 to Dec. 2008	Jan. 2011 to Feb. 2012	—

Source: The planned and actual data are provided by JICA and the executing agency, respectively.
The project is regarded as complete when all the operations are inspected and a test run is completed.

Here are the three reasons for a long delay in the project period.

a. Bidding procedures: As will be mentioned in "c. Water distribution network," the main cause of a long delay was that it took a long time for the City government to define the policy for laying distribution pipes. Moreover, passing the pipeline through many prefectures required time to have talks with the prefectural governments, which caused a further delay in bidding procedures for earthwork. The delay also let bidding for equipment and material be behind the plan. Another reason for the delay was that the executing agency was not familiar with bidding and approving procedures for the Japanese ODA loan project.

b. Accuracy of geological survey: The existence of topographical features and faults that could not be foreseen in the geological survey of the F/S became apparent, which led to a landslide during the underground laying work of intake and conveyance facilities. As a result, it was necessary to change the whole work and to conduct recovery work after the laying process. The construction of the Liaojia Citang Water Purification Plant, the Xinkaipu Wastewater Treatment Plant, and the Huaqiao Wastewater Treatment Plant faced similar problems; for example, unexpected geographical features were found and the geological conditions were worse than expected. Therefore, an increase in foundation improvement work made the project period

longer.

c. Water distribution network: The plan showed that the network construction would start in January 2006, but the actual start date was November 2010. That was because the internal organizations of Changsha City did not agree to the water distribution network design of the city's urban area[15] and made a decision to lay pipes with road work in the section (1.37 km) where the pipeline would run along the road from an efficiency point of view. During the ex-post evaluation, the section was under construction because of a delay in the road work.[16] In the remaining network, sections measuring 23.23 and 387.40 km long were completed in this and different projects, respectively.

3.2.3 Results of Calculation of Internal Rates of Return (Reference only)

At the time of the appraisal, only the financial internal rate of return (FIRR) was calculated, so during ex-post evaluation, the FIRR was recalculated under the same condition as at the time of the appraisal to a possible extent. The resulting return was negative in the construction of the intake and conveyance facilities and the Liaojia Citang Water Purification Plant, because the cost was significantly higher than planned. Concerning the Xinkaipu and Huaqiao Wastewater Treatment Plants, the rates of return were 1.16% and 3.21%, respectively, because of a rise in income thanks to change in charge in 2014.

Table 5: Internal Rates of Return at Appraisal and Ex-Post Evaluation

At the time of the appraisal	At the time of the ex-post evaluation
• Intake and conveyance facilities and Liaojia Citang WPP: 6.22% • Xinkaipu WTP: 4.30% • Huaqiao WTP: 4.23%	• Intake and conveyance facilities and Liaojia Citang WPP: -3.98% • Xinkaipu WTP: 1.16% • Huaqiao WTP: 3.21%
Expenses: Project, operation, and maintenance costs Profit: Charges Project life: 20 years	Expenses: Project, operation, and maintenance costs Profit: Charges Project life: 20 years

Source: The rates at the time of the appraisal are given by JICA, while the evaluator finds the rates during ex-post evaluation according to information from the executing agency.

In light of the above, both the project cost and project period significantly exceeded the plan. Therefore, the efficiency of the project is low.

[15] Experts discussed whether the pipeline should be single or double and made no decision until July 2010. Some experts recommended the double type because two types of water could be supplied: one was quality water that would be supplied from the Liuyang Zhushuqiao Dam to residents as drinking water, while the other was water taken from the Xiang Jiang, which would be used for industrial purposes. The opponents stated that the double pipeline was not efficient from a long-term point of view, so the single type should be adopted as planned. In the end, the single type was employed in consideration of costs and long-term maintenance.

[16] The pipeline, which runs along Hongqilu under construction, will be completed in 2015. This area is a developing zone near the station of a rapid transit railroad, so the population is expected to increase.

3.3 Effectiveness (Rating:③)

3.3.1 Quantitative Effects (Operation and Effect Indicators)

a. Waterworks: Assessing the quantitative effects of constructing the waterworks during the ex-post evaluation required that three points be taken into consideration. The first point is that the water supply ratio is nearly 100% in the areas (Xingsha, Xinshijidiqu, and north of Wuyilu) that receive water from the Liaojia Citang Water Purification Plant—the effect is very good. The second point is that the Liaojia Citang Water Purification Plant belongs to the whole water supply system of Changsha City and has a sufficient capacity to fulfill the role of complimenting other plants when the demand increases, an emergency event occurs, or maintenance is necessary in a certain area—the plant contributes to the stable and safe water supply system. The third point is that although the development of the area receiving water from the Liaojia Citang Water Purification Plant is delayed, its progress is firm, so the demand is expected to increase as the population rises in the future.

Photo 2: Liaojia Citang Water Purification Plant

Table 6 shows the operation and effect indicators of the Liaojia Citang Water Purification Plant defined at the time of the appraisal. Concerning the former, the basic indicators[17] were evaluated, while the latter was assessed according to the achievement degree of the water supply ratio because of only one indicator.The basic operation indicators were evaluated in consideration of two points. The first point is that the population of the area receiving water from the Liaojia Citang Water Purification Plant does not increase as expected because the city development is lagging behind the plan. The second point is that it is not clear whether the goal is set up at the time of the appraisal in consideration of the whole water supply system of Changsha City after this project's role is clarified in the system.[18] As shown in Table 6, none of the indicator has reached its goal after two years of the project completion, but the rating should not be so low if both points are taken into consideration. The first reason is that a delay in the city plan is an external factor to this project, so if the water supply population is 37% (258,000 people) of the goal (700,000 people) in 2012, it is natural to fail to attain the

[17] The basic indicators consist of the water supply population, daily maximum water supply, daily average water supply, peak facility usage ratio, average facility usage ratio, and unaccounted-for water rate.

[18] At the time of the appraisal, the goals of the peak and average facility usage ratios were set at 100% and 80% respectively, but ensuring stable water supply to the whole City requires letting the whole system have a certain reserve capacity. As mentioned in the text, at the time of the appraisal, there was no in-depth description of what role the Liaojia Citang Water Purification Plant should play in the whole system of Changsha City. Therefore, the goal might be specified solely for the plant rather than from the viewpoint of the plant belonging to the water supply system.

flow rate and facility usage ratio as planned at the time of the appraisal. Accordingly, failure to achieve the goal at 100% does not reduce the effect of this project. Note that the goal achievement ratio of the basic operation indicators was 100% for the unaccounted-for water rate and ranged from 37 to 52% for the other indicators two years after the completion of the project. As the population increases three years after the completion, all the achievement ratios are beyond 50%, which shows a tendency of improvement. After progress in the development of the service area in question and completion of the water distribution network 1.37 km long constructed with Hongqilu by the end of 2015, the daily water supply of the plant will increase to about 200,000 m^3 and the average facility usage ratio will rise to 81%, so the latter will reach the goal in the near future.[19] The second reason is that the average facility usage ratio of the water purification plants belonging to the system excepting the Liaojia Citang Water Purification Plant is 75% as of 2014, which is enough to supply water to the whole City stably and meets area-by-area demands. For example, the average facility usage ratios of No. 3 and No. 8 Water Purification Plants having densely populated areas are 100 and 89% respectively, while that of No. 5 Plant is 66% although it has almost the same population and purification capacity as this project. This example suggests that the average facility usage ratio (about 60%) of the Liaojia Citang Water Purification Plant is reasonable because it has a service area where city development will progress in the future. In addition, as mentioned in "3.1.2 Relevance to the Development Needs," this project also plays the role of complementing other plants as part of the water supply system of Changsha City, so it is indispensable to operate the plant with a certain margin for the safe and stable supply of the whole system.

The effect indicator, which is the water supply ratio, is nearly 100% at the time of the ex-post evaluation because the water distribution network of the supply area of Liaojia Citang Water Purification Plant has been completed with the exception of a 1.37 km long section mentioned before.[20] Moreover, the field survey shows that the quality of water treated in the Liaojia Citang Water Purification Plant, although not an indicator, meets the "National Sanitation Standards for Drinking Water." Therefore, the plant is recognized as effective.

[19] This is a forecast presented by Changsha Water Group Co. Ltd., the parent company of the executing agency. The company may think that the service area in question will be developed firmly because Changsha City plans to start the second-phase plant construction work by 2020 to increase the purification capacity.
[20] Changsha Water Supply Co. Ltd. buys water from the (Liaojia Citang Water Purification Plant) and supplies it. The water supply to the area in question (given by this project) accounts for 10% of the whole City.

Table 6: Liaojia Citang Water Purification Plant: Operation and Effect Indicators

		Goal*	Actual				
			2010 Project completion	2011 1 year after completion	2012 (target) 2 years after completion	2013	2014
[Operation indicators]					Goal achievement ratio (%)		
Basic indicators	1. Water supply population (10,000 people, at year end)	70	2.2	10.2	25.8 (37%)	39.2 (56%)	39.2 (56%)
	2. Daily maximum water supply (10,000 m^3/day)	30	0.82	3.81	15.5 (52%)	18.2 (61%)	16.95 (57%)
	3. Daily average water supply (10,000 m^3/day)	24.6	0.79	3.6	9.1 (37%)	13.8 (56%)	13.97 (57%)
	4. Peak facility usage ratio (%)	100	2.7	12.7	51.7 (52%)	60.7 (61%)	56.5 (57%)
	5. Average facility usage ratio (%)	82	2.6	12	30.3 (37%)	46 (56%)	46.56 (57%)
	6. Unaccounted-for water rate (annual average in %)	18	16.32	15.31	14.86 Achieved	13.69 Achieved	13.88 Achieved
Auxiliary indicators	7. Accounted-for water rate (annual average in %)	82	83.68	84.69	85.14 Achieved	86.31 Achieved	86.12 Achieved
	8. Leakage rate (annual average in %)	13	16.32	15.31	14.86 (87%)	13.69 (95%)	8.28 Achieved
	9. Maximum intake (m^3/s)	3.76	0.1	0.45	1.84 (49%)	2.15 (57%)	1.99 (53%)
	10. Average intake (m^3/s)	3.08	0.1	0.42	1.08 (35%)	1.63 (53%)	1.64 (53%)
[Effect indicators]							
	11. Water supply ratio (%)	Nearly 100%	Nearly 100%	Nearly 100%	Nearly 100% Achieved	Nearly 100% Achieved	Nearly 100% Achieved

Source: The goals and results are provided by JICA and the executing agency, respectively.
*: The goal is a value two years after the completion of the project.

b. Sewage works: Table 7 shows the operation and effect indicators of the Xinkaipu and Huaqiao Wastewater Treatment Plants constructed newly in this project. In the former plant, all the water-related indicators reached or exceeded their goals in 2011 which is two years after project completion. The wastewater treatment rate, wastewater treatment population, and facility usage ratio reduced a little in 2012, but they improved in 2013 and reached 100% in 2014. All the indicators exceed 100% in 2014, which means that the Xinkaipu Wastewater Treatment Plant is effective in improving the living environment of the neighborhood residents and the water quality of the Guitang River into which the said plant directly discharges its treated water. The Huaqiao Wastewater Treatment Plant also achieved the goals of all the water-related indicators except the inlet SS concentration in 2011. The wastewater treatment rate, wastewater treatment population, and facility usage ratio were nearly 100%. After 2013, all the indicators reach or exceed 100%, which means that like the Xinkaipu Wastewater Treatment Plant, the Huaqiao Wastewater Treatment Plant is effective in improving the living environment of the neighborhood residents and the water quality of Liuyang River into which the said plant directly discharges its treated water. The reason for a reduction in inlet SS concentration after 2011 is increasing wastewater from the continuous construction of infrastructures through city development. The wastewater treatment rate of the plant is a little beyond the design load range, so expanding work for an additional 200,000 tons/day is carried on during the ex-post evaluation and will be completed in 2015.

Photo 3: Guitang River into which the Xinkaipu Wastewater Treatment Plant discharges its treated water

Table 7: Operation and Effect Indicators of the Wastewater Treatment Plants

	2002	Goal[1]	Actual (Achievement ratios)					
			2009 Project completion	2010 1 year after completion	2011 (target) 2 years after completion	2012	2013	2014
Xinkaipu Wastewater Treatment Plant								
Operation indicators								
1. Wastewater treatment rate (m^3/day)	0	10	5.81	6.87	8.16 (82%)	7.2 (72%)	9.33 (93%)	10.7 Achieved
2. Wastewater treatment population (10,000 people, at year end)	0	16.28	9.52	11.26	13.37 (82%)	11.8 (72%)	15.29 (94%)	17.41 Achieved
3. Facility usage ratio (annual average in %)	0	100	58.1	68.7	81.6 (82%)	72 (72%)	93.3 (93%)	100 Achieved
4. Inlet BOD concentration[2] (monthly average in mg/L)	100	100	85.11	88.36	81.45	86.47	84.29	88.79
5. Outlet BOD concentration (monthly average in mg/L)	100	20	8.25	8.34	8.78 Achieved	9.02 Achieved	8.51 Achieved	8.92 Achieved
6. BOD reduction ratio (%)	0	80	91	91	90 Achieved	90 Achieved	90 Achieved	90 Achieved
7. BOD emission rate (tons/year)	3,650	730	91.1	209.1	261.5 Achieved	237 Achieved	289.8 Achieved	344.1 Achieved
Inlet SS concentration[2] (monthly average in mg/L)	90-110	150	104.4	109.5	113.5	114.3	106.7	119.1
9. Outlet SS concentration (monthly average in mg/L)	90-110	20	11	10	11 Achieved	11 Achieved	10 Achieved	11 Achieved
10. SS emission rate (tons/year)	3,285-4,015	730	121.4	250.7	327.6 Achieved	289.1 Achieved	340.5 Achieved	424.3 Achieved
Effect indicators								
11. Ward sewerage treatment coverage ratio (annual average in %)	0	100	65	77	92 (92%)	81 (81%)	100 Achieved	100 Achieved
Huaqiao Wastewater Treatment Plant								
Operation indicators								
1. Wastewater treatment rate (m3/day)	0	16	6.59	10.07	15.87 (99%)	15.67 (98%)	16.11 Achieved	16.86 Achieved
2. Wastewater treatment population (10,000 people, at year end)	0	47.47	19.5	29.8	46.97 (99%)	46.38 (98%)	47.68 Achieved	49.98 Achieved
3. Facility usage ratio (annual average in %)	0	100	41.2	62.9	99.2 (99%)	97.9 (98%)	100 Achieved	100 Achieved
4. Inlet BOD concentration[2] (monthly average in mg/L)	100	100	95.63	93.92	82.99	78.33	88.25	86.67
5. Outlet BOD concentration (monthly average in mg/L)	100	20	12.21	10.88	10.44 Achieved	9.77 Achieved	10.25 Achieved	12.00 Achieved
6. BOD reduction ratio (%)	0	80	87	89	87 Achieved	88 Achieved	88 Achieved	90 Achieved
7. BOD emission rate (tons/year)	5,840	1,168	293.7	388.8	764.7 Achieved	710.5 Achieved	602.7 Achieved	739.5 Achieved
8. Inlet SS concentration[2] (monthly average in mg/L)	90-110	150	97	132	153	153	272	252
9. Outlet SS concentration (monthly average in mg/L)	90-110	20	12	11	11 Achieved	11 Achieved	13 Achieved	14 Achieved
10. SS emission rate (tons/year)	5,256-6,424	1,168	305.2	404.3	637.2 Achieved	629.1 Achieved	764.4 Achieved	852.5 Achieved
Effect indicators								
11. Ward sewerage treatment coverage ratio (annual average in %)	0	61.5	25	39	62 Achieved	61 (99%)	62 Achieved	62 Achieved

Source: The goals and results are provided by JICA and the executing agency, respectively.
1: The goal is a value two years after the completion of the project.
2: BOD (Biochemical Oxygen Demand) refers to the amount of oxygen required for microorganisms to decompose organic contaminants in water. The larger the value, the greater the water pollution (Source: Website of the Ministry of the Environment (MOE) of Japan).
SS (Suspended Solids) refers to insoluble substances which are suspended in water and whose diameter is not more than 2 mm. They make water turbid, cut sunlight, and sometimes kill fishes by clogging their gills if the concentration is high (Source: Website of MOE).

In summary, concerning the effect indicators of the waterworks constructed, the water supply ratio is nearly 100% in the area receiving water from the Liaojia Citang Water Purification Plant, and the drinking water quality meets the "National Sanitation Standards for Drinking Water." Therefore, this project is highly effective. Regarding the operation indicators, the goal achievement ratio does not reach 100%, because the development of the area in question is delayed and the population growth is sluggish, but the results are not so bad in consideration of the purification plant's role in the whole water supply system of Changsha City—they are recognized as reasonable from the viewpoint of ensuring stable water supply to the City. Moreover, the ongoing development of the area in question is confirmed during the ex-post evaluation, and, simultaneously, the population is increasing, so there is the high possibility of raising the operation indicators in the future. The waterworks constructed run properly during the ex-post evaluation, so the effect is satisfactory as a whole. In the same manner, as for the sewage works, the operation and effect indicators of the two wastewater treatment plants reach 100%, and the water quality meets Class I-B set forth in the "Standard for Waste from City Wastewater Treatment Plants." Wastewater, which was not processed before this project, is treated properly in this project, and the effect of this is very high. Therefore, this project for constructing water and sewage facilities is highly effective in improving the living environment of citizens in Changsha City and the quality of water flowing into the Xiangjiang River and its branches.

3.3.2 Qualitative Effects (Others)

The qualitative effects expected in this project were "Improving the sanitary environment of residents in the Xiangjiang River basin" and "Preserving the ecosystem environment of the basin by reducing the flow rate of water taken from the Xiangjiang River." The evaluation of them was integrated into "3.4 Impact," because the resulting effect was equivalent to the impact of this project.

3.4 Impact

3.4.1 Intended Impacts

The intended impacts of this project were "Improving the water quality of the Xiangjiang River" and "Improving the sanitation condition of Changsha City." The results are shown below.

a. Improving the water quality of the Xiangjiang River: This impact was expected to be attained by taking two measures: (1) Reducing water taken from the Xiangjiang River to suppress the contaminant concentration and (2) Treating wastewater discharged directly or indirectly into the Xiangjiang River. Note that as mentioned in "2.3 Constraints during the Evaluation Study," there were many external factors having an effect on the measurement of the impact. Therefore, this ex-post evaluation was made according to data on the water quality of the Xiangjiang River announced by the

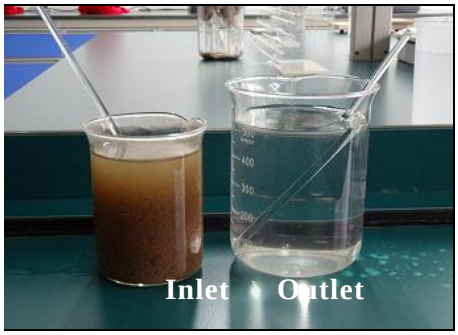

Photo 4: Huaqiao Wastewater Treatment Plant: Water before and after treatment

government of Hunan Province and the contaminant concentration reduced by the wastewater treatment plants constructed in this project. According to the "Environmental Condition Report" and environment-related press releases issued by Hunan Province, the water quality of the Xiangjiang River was improved in 2005, 2011, and 2012 as shown in Table 8. In 2011, the water quality was at least Type IV of the quality standards for surface water environment at all monitoring points, and in 2012, it met Class III at 88% of the monitoring points. However, it is impossible to precisely identify the extent to which the project has contributed to the water quality improvement indicated in Table 8. As mentioned in "3.3 Effectiveness," the quality of water flowing from the two treatment plants in question to the Guitang and Liuyang Rivers is improved, because the BOD, SS, and main contaminant concentration are significantly lower than the national standards, and both plants treat wastewater properly and discharge it at about 280,000 m^3/day, which means that the amount of contaminants flowing into the rivers reduces compared with when no wastewater was treated. Both the Guitang and Liuyang Rivers are branches of the Xiangjiang River, so the wastewater treatment plants in question have a certain effect on stopping degradation in the water quality of the main river.[21]

Table 8: Changes in the Water Quality of the Xiangjiang River

National water standards	Ratio of monitoring points		
	2005	2011	2012
Types I to III	84.8%	87.5%	88.0%
Type IV	3.2%	12.5%	12.0%
Type V	3.2%	—	—
Type VI or over	9.6%	—	—
Number of points	31	40	42

Source: The data in 2005 and 2011 are given by the "Environmental Condition Report" issued by the government of Hunan Province, while that in 2012 are shown in the "Press Release on the 2013 World Environment Day in Hunan Province."
Note: The contaminants measured include colon bacilli, ammonia, COD, total phosphorus, arsenic, and cadmium, but no concrete values are shown.

b. Improving the sanitation condition of Changsha City: This impact was assessed according to the results of taking a survey of people receiving benefit (for more information about the survey, see the appendix). Most of the answerers think that the

[21] A survey of people receiving benefit shows that many people say, "The water quality of rivers is improved," while the number of people stating, "The water pollution of rivers is still serious" is not so small. Some of the latter emphasize the necessity of strictly controlling wastewater from companies and waste disposal.

project goal has been achieved, and 80% of them are satisfied with the resulting water and sewage facilities. Therefore, it is obvious for the citizens to actually recognize the improvement of river water and sanitary environment thanks to the ability to use tap water with ease and the treatment of wastewater.

As mentioned before, The Chinese State Council announced the "Action Plan for Water Pollution Prevention" in April 2015 to show water improvement goals to be achieved by 2020, and to enforce new laws to give a penalty to companies committing a violation, such as a production stop or shutdown. Such measures are expected to be taken thoroughly (for more information, see "3.1.1 Relevance to the Development Plan").

3.4.2 Other Impacts

(1) Impacts on the natural environment

This project issued an environmental impact assessment (EIA) report to the National General Bureau of Environmental Protection, which approved it in September 2003. At the time of the ex-post evaluation, it was confirmed that the area in question and its surrounding place included neither sanctuaries nor valuable species living zones. Good measures were taken against environmental pollution during project operation, including the construction of a water purification plant and two wastewater treatment plants.[22] At the time of the ex-post evaluation, turbid water generated in the treatment plant was processed or reused in it, and noise was reduced by a noise suppressor, so their impacts on the residents were kept low. The wastewater treatment plant generated a loud noise, but it was not problematic during the field survey, by virtue of noise insulation measures. It was also confirmed that sludge generated in both wastewater treatment plants was properly combusted and landfilled at an existing final waste disposal site (Hunan Province legally bans the reuse of sludge).

The impact of the Liuyang Zhushuqiao Dam constructed in this project on the natural environment and ecosystem, which was a matter of concern at the time of the appraisal, was not negative. The annual average water level has been 164 meters since 2010 during which this project started an intake, so it was kept higher than 161 meters from 2005 to 2009 before the project. To maintain the water quality of the dam, Liuyang Zhushuqiao Dam Management Authority conducts real-time monitoring of eight indicators around the clock. As a result, the water quality has conformed to Type II of the national water standards from 2005 to ex-post evaluation. Therefore, this project has no negative impact.

(2) Land acquisition and resettlement

This project planned to move 81 residents (20 households). Actually, 80 people (21

[22] The following shows the concrete measures. Exhaust gas: Introduction of machines meeting the national standards. Waste: Delivering it to a waste treatment center by special truck. Dust: Suppressing it by sprinkling water over the construction site. Turbid water: Discharging turbid water generated at the site in question into the sewer network under city control. Noise: Introducing a noise suppressor to minimize its level. Vibration: Avoiding blasting to a possible extent and employing methods involving little vibration.

households) moved, almost as planned. The plan showed that the area of land to be acquired would be 32.44 km^2, and the resulting area was 34.07 km^2. The executing agency constructed temporary dwellings and then permanent houses in the final place, and paid movement expenses in accordance with the "Changsha City Law of Land Acquisition and Resettlement." All the residents in question moved before the construction started, and no problem has arisen.[23]

In summary, concerning the waterworks, the water supply ratio is nearly 100%, drinking water meets the national standards, and the water purification plant plays a role expected as part of the water supply system of Changsha City, so this project contributes to stable water supply to the City. Regarding the sewage works, almost all the operation and effect indicators have reached their goals, and the quality of treated water meets the national standards. The people receiving benefit express a deep satisfaction to both the water and sewage facilities, and the evaluation results, which had some constraints, show that the plants contribute to improving the water quality of the Xiangjiang River and the sanitation condition of the City. Therefore, the effectiveness and impact of this project are high, because the effect appears almost as planned.

3.5 Sustainability (Rating:③)

3.5.1 Institutional Aspects of Operation and Maintenance

Changsha Water Diversion and Water Quality Company Co. Ltd, the facility operator of this project is a subsidiary company of Changsha Water Group Co. Ltd., together with Changsha Water Supply Co. Ltd. and Changsha Municipal Drainage Co. Ltd. The operator started in November 2003 as an organization that should fulfill the project goal and that was 100%-owned by the City government. Its duties include taking water from the Liuyang Zhushuqiao Dam constructed in this project, operating and maintaining the water purification plant and part of the distribution pipeline, and operating and maintaining the wastewater treatment plants and sewer network. Figure 2 shows the organization as well as operating and maintaining members. All the facilities employ a shift system consisting of four groups and three shifts.

[23] The detailed compensations include money proportional to the site area (land compensation), money depending on farm product income gained at the site (resettlement compensation), money for buildings at the site (ground attachment compensation), and money for farm products cultivated and not harvested at the site (seedling compensation). According to interviews to three residents who moved to permanent houses, they were highly satisfied with it because the city government held a meeting to describe the project, the compensations were reasonable, and the new living and sanitary environments were better than those before movement.

Changsha Water Diversion and Water Quality Company Co. Ltd.			
Water Pipeline Management Center (taking water from Zhushuqiao Dam and supplying it) Engineers: 29 Office workers: 7	Liaojia Citang Water Purification Plant Engineers: 50 Office workers: 9	Xinkaipu Wastewater Treatment Plant Engineers: 48 Office workers: 9	Huaqiao Wastewater Treatment Plant Engineers: 49 Office workers: 9
		Sewer network: Engineers: 49; Office workers: 9 Pump station: Engineers: 22	

Source: Information provided by the executing agency
Figure2: Organization as well as operation and maintenance system of the facility operator

The Liuyang Zhushuqiao Dam Management Authority, which is owned by the electric power company that operates hydraulic power stations in the area, operates and maintains the Liuyang Zhushuqiao Dam. To ensure safety and protect the natural environment, the Authority makes strict control and commissions the parent company to maintain the crane used to open and close the intake gate, while the Water Pipeline Management Center always monitors the pipeline with cameras. Moreover, the operator forms an inspection team having six to seven members to maintain the sewer network with the City government. The organization and system are sufficient for sustainable operation and maintenance, and cooperation with the Authority is suitable from the viewpoint of maintaining the water source quality. In addition, for efficient operation and maintenance, the operator makes efforts to commission external companies to clean and guard the facilities. Therefore, the system is kept in a good condition as a whole.

3.5.2 Technical Aspects of Operation and Maintenance

a. Staff's technical level of operation and maintenance: The operator sets a high human resource employment level to preferentially adopt those who have certain experience and expertise in the water and sewage fields. Wastewater treatment engineers, water purification workers, pump operators, and chemical inspectors shall pass a technical test given by the Province. The operator employs such authorized people positively or encourages its employees to gain a qualification. In the meantime, those who handle a 10-kW unit, bridge crane, or pressure vessel shall have a certificate of designated work issued by the Province, and electric engineers shall obtain a national qualification. The engineers shown in Figure 5 already have such a qualification. In addition, the operator employs senior experts having plentiful experience as site supervisors and gives importance to the education of young employees. Changsha Water Diversion and Water Quality Company Co. Ltd, which is 100%-owned by the City government, is a very popular company, despite a personnel change in the same corporate group, because the

workplaces are stable and the welfare is very good. Moreover, the low job turnover allows the employees to accumulate knowledge and experience.[24] This is proven by there being no major problem in the operation and maintenance of the facilities.

b. Operation and maintenance manuals as well as records and control of using and maintaining activities: The operator has operation and maintenance manuals for all the facilities and conducts daily inspection and preventive maintenance. Particularly in the operation and maintenance processes, poster-sized panels are put on the wall of each facility to allow the workers to always know what to do. Maintenance records show handover tasks to members working the next shift, and in some facilities, a whiteboard is used in addition to the records.

c. Training system for the people in charge of operation and maintenance as well as investments and training for improving skills: New employees take training in the Changsha City Wastewater Treatment Training Center for three months after joining the Company, then receive OJT for six months, and finally go to the department in charge of operation or maintenance. Those who treat wastewater, analyze the water quality, or operate the pump station shall pass a qualification test given by the, Hunan Province's Department of Labor after having certain experience. The operator draws up and implements a training plan for the personnel after determining needs; for example, what knowledge and skills are insufficient or should be improved. Some training is delivered internally, but most of it is given at the Hunan Province Education and Training School or the Changsha Training School.[25]

In light of the above, no major problems have been observed in the operator's ability to operate and maintain the facilities. The company has and uses manuals, makes a record of operation and maintenance, and draws up and implements a training plan in response to needs. Therefore, no major problems have been observed in the technical aspects of operation and maintenance.

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[24] In many countries, the operator of sewage works faces difficulty in keeping human resources and the job turnover is high, so it has a problem of failing to accumulate knowledge and experience. After a hearing was given to the staff members of the operator of this project, it was proven that they were deeply satisfied with their workplaces. Accordingly, the operator accumulates expertise and skills gained through external training and OJT.

[25] Hunan Province and Changsha City make active contact with Japanese local governments, such as those of Fukuoka City, Kagoshima Prefecture, Shiga Prefecture, and Kobe City; therefore, many training and exchange projects take place every year in Japan. In March 2013, they started to run a 3-year training project with Shiga Prefecture and the facility operator sends five trainees to attend the "Training Course for Controlling Wastewater Treatment Plants" for 15 days every year. After going back to the country, all the trainees still work for the operator and use knowledge and experience in their workplaces. For example, the operator introduces daily maintenance such as 5S (sorting, organizing, keeping clean, cleaning, and discipline) and advanced topics such as energy saving technology for wastewater treatment plants. Concerning the latter, the technology the Associate Director has learned in the training held in Shiga Prefecture will be introduced to the second phase of the Huaqiao Wastewater Treatment Plant under construction. The operator takes full advantage of such continuous training from a mid- to long-term point of view.

3.5.3 Financial Aspects of Operation and Maintenance

No financial statements are disclosed, but the operation is in deficit if its cost includes money for expanding the Huaqiao Wastewater Treatment Plant currently and depreciation expenses. The operation and maintenance costs for the facilities constructed in this project are covered through the water and sewage charges (except for 2010).

Table 9: Water and Sewage Charges versus Operation and Maintenance Costs

(Unit: thousand yuan)

	2009	2010	2011	2012	2013	2014
Total water and sewage charges (A)	13,740	14,474	35,344	104,518	146,463	337,131*
Total operation and maintenance costs (B)	12,235	15,845	28,421	77,813	55,004	68,523
Labor cost included**	2,701	3,143	6,701	10,370	10,548	14,979
Other expenses***	9,534	12,702	21,719	67,443	44,456	53,545
Gross profit = (A) – (B)	1,504	-1,371	6,923	26,704	91,458	268,607

Source: Documents provided by the executing agency

*: In 2014, the income showed a year-on-year rise of 230% thanks to change in water and sewage charges.

**: The labor cost is paid to workers involved in the operation and maintenance of the wastewater treatment and water purification plants.

***: The other expenses include the operation and maintenance costs other than the labor cost.

The reason for deficit operation in 2010 is that no water charge was obtained for about three months because the pipeline broke twice, and required an inspection and repair with water supply stopped.

The operation and maintenance costs are covered through the water and sewage charges. Changsha City's Price Bureau sets up the charge and the facility operator can make a request to the Bureau for changing it if necessary. Because the expansion work of the Huaqiao Wastewater Treatment Plant lagged behind the plan, the labor, material, and equipment costs increased, the governmental funds were not enough, the loan interest rose, and the plan and design had been changed or reviewed. As a result, the operator made a request for revising the water charge for home use, which was approved in 2014 as shown in Table 10.

Table 10: Trends in Water and Sewage Charges

	2005	2011	2014
Water charge	1.02 yuan/m^2	Home: 1.21 yuan/m^2 Industry: 1.38 yuan/m^2	Home: 1.61 yuan/m^2 Industry: 2.47 yuan/m^2
Sewage charge	0.4 yuan/m^2	Home: 0.65 yuan/m^2 Industry: 0.70 yuan/m^2	Home: 0.75 yuan/m^2 Industry: 1.05 yuan/m^2

Source: Documents provided by the executing agency

In summary, no major problems have been observed in financial sustainability, because the operation and maintenance costs for the facilities constructed in this project are covered through the water and sewage charges from 2011, change in charge system in 2014 produces a return on the maintenance cost and investment, and if the funds are short, the Changsha City government is obliged to give financial support to the waterworks and sewage works, the lifelines of citizens.

3.5.4 Current Status of Operation and Maintenance

This subsection describes the status of operation and maintenance confirmed during the ex-post evaluation.

No major problem has arisen in the waterworks including the operation and maintenance of the pipeline and purification plant, and the procurement of spare parts. However, construction of the distribution pipe running along Hongqilu is under way and will be completed by the middle of June 2015. It is desired to keep striving to carry on the work on schedule while strengthening cooperation with the City government.

A problem in the sewage works identified during ex-post evaluation is that an overload is put on the Huaqiao Wastewater Treatment Plant because the flow rate of wastewater exceeds the design value slightly. Notwithstanding quick expansion work, it is hoped that the maintenance of the existing equipment will be reinforced. No major problem has arisen in the plant so far, but strong and thorough maintenance will be necessary in the future because the combined sewer carries lots of garbage, which puts a heavy load on the inlet and wears the screen at a rate higher than expected. The Xinkaipu Wastewater Treatment Plant faces no major problem, but there is a concern: if the blower fails to work, it is necessary to call the supplier from South Korea, which requires a high cost. Therefore, it is recommended that daily maintenance be conducted thoroughly according to the manual. The operator grasps the problems above and understands the necessity of proper and careful operation and maintenance, so the problem may not become serious.

In both the water and sewage facilities, some workers failed to wear helmets for safe operation because of lack of safety instructions. It is hoped that safety measures will be introduced and followed thoroughly in the future.

In light of the above, no problems have been observed in the institutional, technical, and financial aspects of the operation and maintenance system. Therefore, the sustainability of the effects of this project is high.

4. Conclusion, Lessons Learned and Recommendations

4.1 Conclusion

The purpose of this project is to address water contamination problems in the Xiangjiang River and to improve the living environment of citizens by constructing water and sewage facilities in Changsha City, Hunan Province.

The project is highly relevant, because at the time of the appraisal and ex-post evaluation, it meets the development policies and needs indicated by the governments of China, Hunan Province, and Changsha City as well as the Japanese aid policies. Concerning the operation and effect indicators of the resulting waterworks, the goal achievement ratio is about 50% of

the plan. However, the effect is sufficient in consideration of the project role in the citywide water supply system confirmed during ex-post evaluation. In the resultant sewage works, all the indicators have reached their goals defined at the time of the appraisal—both the effectiveness and impact of the project are recognized as high because of the improvement of contaminated rivers including the Xiangjiang River, which run through the City, and of the living environment of residents. Both the project cost and the project period exceeded the planned ones significantly, resulting in low efficiency. The systems, technologies, and financial condition of operation and maintenance are good, so the effects resulting from the project are highly sustainable.

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

4.2 Recommendations

4.2.1 Recommendations to the Executing Agency

a. The distribution pipe running along Hongqilu will be completed by the middle of June 2015. It is necessary to keep striving to carry on the work on schedule while strengthening cooperation with the city government.

b. "3.5.4 Current Status of Operation and Maintenance" shows the following problems in operation and maintenance, which should be addressed correctly. In the Huaqiao Wastewater Treatment Plant, all the facilities shall be maintained strictly, because an overload is put on them. Because the screen has been worn at a rate faster than expected, the maintenance frequency shall be increased. In the Xinkaipu Wastewater Treatment Plant, it is desired to continue daily and thorough maintenance of the blower that requires a high maintenance cost.

c. The results of surveying people receiving benefit and giving a hearing to residents showed that to improve the water quality of the rivers running through Changsha City, many people demanded stricter control of companies that discharged raw wastewater and garbage into them. To address this problem, the operator is expected to monitor water from the water and sewage facilities continuously, to strengthen cooperation with the city government in protecting the water environment included in the policy "Making Local Government's Responsibility Stronger," and to continue activities for improving the living environment of citizens in accordance with the "Action Plan for Water Contamination Prevention (Ten Water Articles)" mentioned previously.

4.2.2 Recommendations to JICA

None.

4.3 Lessons Learned

Ensuring the range and accuracy of the geological survey

Although the geological survey conducted at the time of the F/S met the national standards, once the project started, problems that were caused by topographical features and faults that were not found in the F/S appeared which resulted in a prolonged project period and an increase in its cost. Each country and/or executing agencies have their own standards when it comes to the level of accuracy of F/S geological surveys. However, as in the case of this project, when a project covers an extensive area, it can more or less be assumed that different topographical features and soils exist. In such cases, once complying with the country and/or executing agency's standards for the level of accuracy of the F/S topographical survey, it is desirable to internalize the possibility that the level of accuracy of the topographical survey during the detailed design will have to be increased, by reflecting this fact beforehand in the project's cost and period, thereby elaborating an efficient project plan.

Establishing the range of the Impact

One of the project's impacts was to improve the water quality of the Xiangjiang River. However, it was difficult to measure its degree, because of too many factors related to the improvement of the Xiangjiang River that has such a huge scale. Therefore, specifying the impacts requires checking the project scale, external factors for presence, and the extent to which each factor affects the project.

END.

Comparison of the Original and Actual Scopes of the Project

Item	Plan	Actual
(1) Project Outputs		
[Waterworks]		
I. Intake and conveyance		
a. Intake facility from Liuyang Zhushuqiao Dam	950,000 m^3/day	650,000 m^3/day
b. Pipeline	76 km	98 km
II. Liaojia Citang Water Purification Plant	300,000 m^3/day	As planned
III. Water distribution network		
a. New	412 km	23.23 km
b. Repair	141 km	0 km
[Sewage works]		
IV. Xinkaipu Wastewater Treatment Plant	100,000 m^3/day	107,000 m^3/day
V. Huaqiao Wastewater Treatment Plant	160,000 m^3/day	168,600 m^3/day
VI. Sewer network		
a. Sewers	116.60 km	119.51 km
b. Pump stations	9 places	6 places
[Training]		
VII. Training	57 trainees	54 trainees
(2) Project Period	Mar. 2005 to Dec. 2008 (46 months)	Mar. 2005 to Aug. 2012 (90 months)
(3) Project Cost		
Amount paid in foreign currency	19,964 million yen	19,803 million yen
Amount paid in local currency	26,999 million yen (2,030 million yuan)	51,744 million yen (3,819 million yuan)
Total	46,963 million yen	71,547 million yen
Japanese ODA loan portion	19,964 million yen	19,803 million yen
Exchange rate	1 yuan = 13.3 yen (as of Sept. 2004)	1 yen =0.0732 yuan (Average from 2005 to 2012)

Appendix: Results of Surveying Persons Receiving Benefit

Survey period	November 24-26, 2014
Area and number of samples	50 residents living around the Liaojia Citang Water Purification Plant, Xinkaipu Wastewater Treatment Plant, or Huaqiao Wastewater Treatment Plant
Sampling method	The facility operator called out to residents for cooperation, and those that gathered filled a survey sheet.
Characteristics of respondents	• 50 people (20 men and 30 women) • Age distribution: 20-29 years (56%); 30-39 years (20%); 40-49 years (18%); 50-59 years (6%) • Jobs: Agriculture (55%); Commerce (38%); Fishing (2%); Other (5%) • Dwellings: Apartment house (72%); detached house (20%); Other (8%) • Living years in Changsha City: 10 years or more (46%): 5 to less than 10 years (32%); Less than 5 years (22%) • Waterworks: Water supply ratio (98%); Home use (94%); Most of the respondents used a purifier. • Residents having flush toilet in house: 47; Joint cesspool toilet: 3 • Monthly average water and sewage charges: 78.75 yuan in total
Survey results	
1. Project goal achievement ratio • "The project goal was achieved," said 32 residents (64%). The main reasons were (1) The quality of both tap and river water was completely improved (neither bad odor nor strange taste) and (2) The environment was better than before because completing the basic part of the urban sewer network made it possible to collect and treat wastewater. • "The project goal was not achieved," said 16 residents (32%). Note that two residents gave no answer. The main reasons were (1) The water quality was better than before, but the pollution problem was still serious and (2) The improvement was not enough, because tap water was sometimes too chloric, stinky (smell like a fish), or awful-tasting.	
2. Waterworks: Checking for the degree of satisfaction in the following items before and after the project • Water quality: Concerning tap water after the project completion, "Safe," said 40 residents (80%) and "Anxious," said the remainder (10). The main reasons for the latter were (1) The water source was contaminated and (2) The purification process used a large amount of chemicals (e.g., chlorine). • Water quality and health: "No change in health before and after the project," answered 20 residents (40%), "I do not know what kind of disease is derived from contaminated water," said 12 residents (22%), "Diseases derived from contaminated water reduced," said 13 residents (26%), and "My health became worse," said four residents (8%). Those who showed the third answer described the reasons as follows: "No dysentery" or "No stomachache." The residents who put the fourth answer said, "Change in water quality increases the number of residents that suffer from a calculus." • Water services: "Satisfactory," said 41 residents (82%) and "Unsatisfactory," said the remainder 9. Of the latter, seven said, "Tap water is not tasty," 1 said, "Anxious about safety," and 1 said, "The water charge is too high." • Improvements residents want in the future: Improving the water pressure, repairing the pipeline, and making the water quality standards stricter.	
3. Sewage works: • Concerning changes in sewage facilities and services before and after the project, "Satisfactory," said 40 residents (80%) and "Unsatisfactory," complained the 10 remaining residents (20%). The latter all said, "The river water is not clear." The other reasons were (1) The sewage works did not spread, (2) Providing information including charges was not enough, and (3) Measures against heavy rain and flood were not enough. • Water quality and surrounding environment of city rivers: Regarding changes, before and after the project, in river water's turbidity, the presence of garbage and suspended matter, odor, and the living environment of animals and plants, "Improved," said 80% of the respondents and "No change," said 20%. The main reasons for the former were (1) Wastewater treatment advanced significantly, (2) Resident's awareness was raised, and (3) The government paid attention to the protection of the water quality environment. The reasons for the latter were (1) Wastewater and garbage were still put into the river and (2) The government did not let the residents know about environmental protection. • Awareness of wastewater: Concerning change in resident's awareness of wastewater after the completion of sewage works, two questions were put to the residents. To one question "Do you know that neither oil nor garbage should flow into the kitchen drain?" 94% of the residents answered, "My awareness of it was raised a little or very much." To the other question "Do you know soap or detergent should not be used too much?" 72% of the answerers said, "My awareness of it was raised a little or very much." Note that the news of water quality problems provided by newspapers and media as well as public relations delivered by water and wastewater treatment companies contributed significantly to a rise in residents' awareness. • Improvements residents want in the future: Strengthening the control of companies who discharge raw wastewater into the Xiangjiang River and making the water quality standards stricter.	
4. Project running process • Land acquisition and resettlement by the project: 40 residents (80%) knew about them. Of them, 30 people said, "The land acquisition process went on relatively smoothly." The main reasons were (1) The compensation was reasonable and satisfactory and (2) A meeting for telling that the purpose of the project was to improve the living environment of residents encouraged the residents to give cooperation and support to the project. On the other hand, 10 people said, "The land acquisition process did not go on smoothly." The main reasons were (1) It took a long time and (2) The moving process was complicated in China. • Environmental impacts during construction: Concerning exhaust gas, disposal of waste, dust, turbid water, noise, and vibration, "I minded them," said 28-44% of the answerers and "I did not mind them," told 44-56% of the residents—the latter was a little more than the former (12-16% shows no answer). The former added, "Exhaust gas and dust were the most mindful." After 13 residents made a request to the city government for taking action, seven received a satisfactory answer.	