People's Republic of China

FY 2016 Ex-Post Evaluation of Japanese ODA Loan

"Shaanxi Water Environment Improvement Project (Xi'an City)"

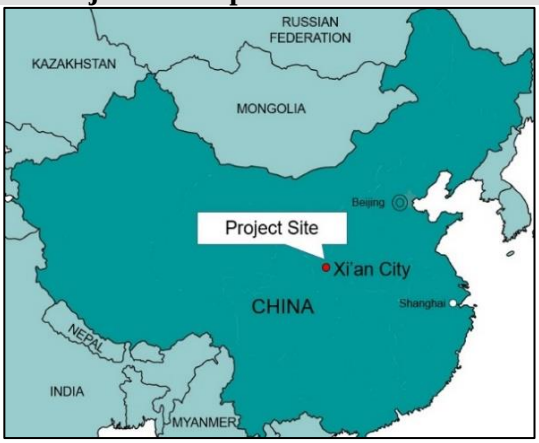
External Evaluator: Kenji Momota, IC Net Limited

0. Summary

This project was implemented in order to contribute to water environment improvement in Xi'an City, Shaanxi Province, including reduction in intracity river water pollution, clean water supply, and flood disaster reduction by constructing and improving sewage treatment plants, water pipe networks, and drainage canals in the city. The relevance of the project is high because of its consistency with the development policies and needs of China at the national, provincial, and municipal levels from the appraisal to the present time. The equipment improved in this project has been steadily operated, and main indicators have generally reached the planned targets, including the volume of water distributed and sewage treatment, reduction in pollutants, and the capacity of the drainage system. Judging from these facts, it can be evaluated that this project plays an effective role in reinforcing the functions of urban water supply and sewer services and flood control. As a result, this project has contributed to clean water supply, improvement on water pollution, and flood disaster reduction in Xi'an City. Thus, effectiveness and impact of the project are high. However, the efficiency of the project is fair because of its period and cost that exceeded the plan. With regard to the sustainability of this project, no significant problem is seen in institutional aspects and technical capability. Xi'an City has been able to stably cover financial expenditure on water, sewer, and drainage systems. This project is managed well as a public service with stable financial assistance and such assistance is expected to continue in the future. Thus, the sustainability of this project is high.

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

1. Project Description



Project Location

Biological Reaction Reservoirs at the Sewage Treatment Plant in the Southwestern Suburb of Xi'an City

1.1 Background

In China, environmental pollution was accelerated by its industrialization and increasing population, while rapid economic growth was achieved after the 1980s. Although the country reinforced its environmental protection policies and produced a certain result after the middle of the 1990s, its effort for infrastructure improvement, including sewage treatment, could not catch up with industrialization and the population which increased even more than had been expected. Therefore, pollution remained at a serious level.

Xi'an City as an old capital of China and the capital of Shaanxi Province had a population of about seven million people as of 2002 and has rapidly grown owing to commercial and industrial development and urbanization. However, the city was left behind in improving water and sewer services: water supply service coverage ratio was 84% and the rate of sewage treated was no more than 37%. In the rainy season from July to September during which rainfalls were concentrated, sewage often overflowed from sewer pipes because of insufficient drainage system, and the urban area was flooded and damaged by the overflow of sewage. Under these circumstances, it was necessary to improve water environment, including sewage treatment plants, water pipe networks, and drainage canals, and this project was planned.

1.2 Project Outline

This project is intended to contribute to water environment improvement in Xi'an City, Shaanxi Province, including reduction in intracity river water pollution, clean water supply, and flood disaster reduction by improving sewage treatment plants, water pipe networks, and drainage canals.

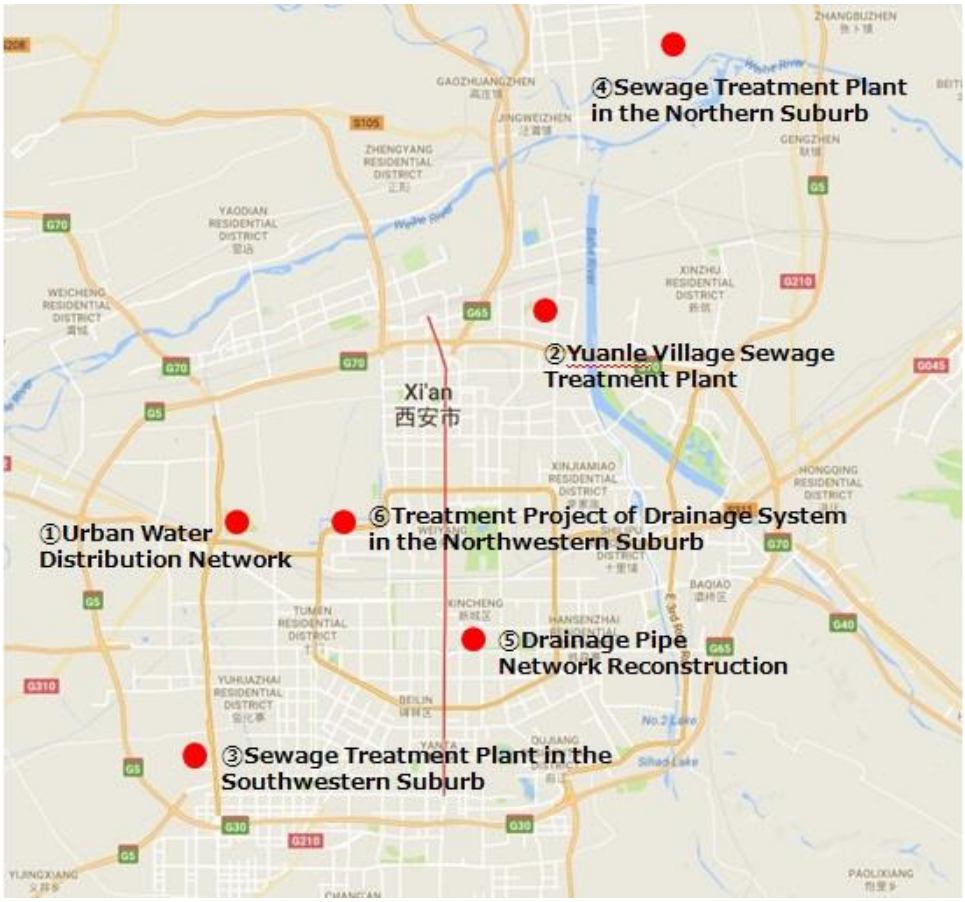


Figure 1: A Location Map of Xi'an City and Sub-projects under This Project

Loan Approved Amount/ Disbursed Amount	19,564 million yen / 18,444 million yen	
Exchange of Notes Date/ Loan Agreement Signing Date	March 2005 /March 2005	
Terms and Conditions	Interest Rate Repayment Period (Grace Period Procurement	1.5% 30 years 10 years) General untied
Borrower/ Executing Agencies	Shaanxi Provincial People's Government/ Xi'an Municipal People's Government	
Project Completion	October 2013	
Main Contractors (Over 1 billion yen)	・ China National General Machinery Engineering Corporation (China) ・ China Potevio Co. Ltd. (China) ・ Merit Technologies Inc. (China) ・ China National Machinery & Equipment Import & Export Corp. (China) ・ China National Precision Machinery Import & Export Corp. (China)	

	・ Hubei International Trade Investment & Development Co., Ltd. (China)/Xinxing Ductile Iron Pipes (Group) Co. (China) (JV)
Main Consultant	-
Feasibility Studies, etc.	F/S (Xi'an Municipal Design Research Institute, China Municipal Process Northwestern Design Research Institute, Xi'an Water Conservancy Construction & Observation Design Institute, Shaanxi Process Consultancy Bureau in August, 2003)
Related Projects	Xi'an Waterworks Improvement (1993) Xi'an City Environmental Improvement (2001) Shaanxi Water Environment Improvement (Shaanxi Province) (2005)

2. Outline of the Evaluation Study

2.1 External Evaluator

Kenji Momota, IC Net Limited

2.2 Duration of the Evaluation Study

This ex-post evaluation study was conducted according to the following schedule.

Duration of the Study: July 2016 - October 2017

Duration of the Field Survey: October 16 - November 6, 2016; April 19 - 28, 2017

2.3 Constraints during the Evaluation Study

At the time of the appraisal, the planned effects of this project were to reduce intracity river water pollution, supply clean water, and reduce flood disasters. However, the direct effects of this project seem to have been the enhancement of the capacities for water supply, sewage treatment, and flood control. Reduction in intracity river water pollution, clean water supply, and flood disaster reduction were rated as impacts rippled by these effects. Because the quality of river water depends on factors other than sewerage improvement, it is difficult to evaluate the contribution of this project. Therefore, in this project evaluation, "enhancing the capacity for water supply," "enhancing the capacity for sewage treatment," and "enhancing the capacity for flood control" are evaluated as the effectiveness of this project, while "clean water supply," "contribution to reduction in intracity river water pollution," and "flood disaster reduction" are rated as impacts. However, grasping the present situation of the city on the whole was limited for lack of data on the quality of river water, which were not obtained from the Xi'an Municipal Environmental Protection Bureau.

3. Results of the Evaluation (Overall Rating: A[1])

3.1 Relevance (Rating: ③[2])

3.1.1 Consistency with the Development Plan of China

(1) Consistency with the Development Plan at the Time of the Appraisal

1) Positioning of Water and Sewer Service Improvement in the Development Plan

In the *Tenth Five-Year Plan* (2001-2005), the Chinese government took it as a challenge to raise the capacity for urban water supply, increase the volume of water supply, and improve the quality of water by rehabilitating obsolete water facilities. As for sewage treatment, it was determined to aim at a treatment rate[3] of 45% in urban areas (60% in cities with 500,000 people and over). In addition, it is described that the specified value should be achieved in the quality of "three rivers and three lakes" and comprehensive measures to improve water quality should be taken in the upper course of the Yangtze River, the middle course of the Huang He, and the basin of the Songhua River. Thus, enhancing the capacity for sewage treatment covered by this project was identified as a development issue. With regard to water supply, objectives to be attained also included reinforcing the capacity for water supply and securing safe drinking water through the construction of new water facilities and the renewal of obsolete facilities in local cities, and saving water resources by reducing the rate of leakage.

In response to this, Shaanxi Province planned to increase sewage treatment plants in major cities, including Xi'an, in the *Tenth Five-Year Plan* (2001-2005) and set a target of 50% or more to be achieved in Xi'an City by 2005. For tap water, the province aimed at securing safe water as well as increasing water supply by promoting more use of surface water.

2) Positioning of Flood Control in the Development Plan

In the *Tenth Five-Year Plan* (2001-2005), priority in the development of flood control was given to the objectives of safety and security against floods and water disasters in major cities and regions and improvement in the system of flood prevention and disaster reduction. It was determined that the standard of protection against floods specified by the central government should be achieved in the middle and lower main streams of seven great rivers including the Yangtze River within the period of the plan. Thus, the enhancement of the flood control capacity covered by this project was identified as a development issue. Under the above-mentioned development policy of the central government, Shaanxi Province formulated the *Tenth Five-Year Plan* (2001-2005) and aimed to promote measures for preventing flooding of rivers and enhance the capacity for preventing flooding of important

[1] A: Highly satisfactory, B: Satisfactory, C: Partially satisfactory, D: Unsatisfactory
[2] (3): High, (2): Fair, (1): Low
[3] Sewage treatment rate = Treated amount/ Total amount of sewage generated

rivers and cities by implementing dam repair and reinforcement projects.

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

1) Positioning of Water and Sewer Service Improvement in the Development Plan

In the *Twelfth Five-Year Plan* (2011-2015), "*The General Action Plan for Energy-saving and Emissions Reduction under the Twelfth Five-Year Plan* (2011-2015)" was formulated as a policy on environmental protection. In this action plan, a target of 85% was set for sewage treatment to be achieved by 2015. Efforts for environmental protection are also continuously strengthened by encouraging the use of recycled water.

In response to this, Shaanxi Province aimed at much more improvement in sewage treatment in the *Twelfth Five-Year Plan* (2011-2015). As objectives, it is described that the province will construct sewage treatment plants and aim at a treatment rate of 85% in middle-scale cities and a rate of 80% in prefectures by 2015.

2) Positioning of Flood Control in the Development Plan

In the *Eleventh Five-Year Plan* (2006-2010) of the national development plan, stated objectives were to secure safety against floods and water disasters in major cities and regions and reduce flood disasters. Subsequently, in the *Twelfth Five-Year Plan* (2011-2015), the country aimed to reinforce its flood prevention capability even more. To specify this objective, the *Nationwide Water Conservancy Development Plan* (2011-2015) was formulated. In this plan, three objectives were determined for large rivers and lakes, including the Huang He: 1. To improve large rivers and lakes and construct and reinforce regulating reservoirs; 2. To construct breakwaters and make general estuary improvement; and 3. To repair and reinforce dams and sluices which have a possibility of danger.

In response to this, Shaanxi Province announced the *Twelfth Five-Year Plan* (2011-2015) and showed more efforts to promote water security by improving waterworks prevalence and feed capacity and enhance the flood control capacity by implementing the river improvement plan for the whole of the Wei River on the full scale.

3.1.2 Consistency with the Development Needs of China

(1) Consistency with the Development Needs at the Time of the Appraisal

1) Needs for Water and Sewer Services

In those days, water supply service coverage ratio reached a credible level of 85% in Xi'an City. Nevertheless, underground water that did not meet the national standard for the quality of drinking water was used as a source of water in some regions, and there was a concern about an adverse effect of such water. Moreover, the city was late in securing safe

drinking water by improving water supply in its suburbs, which prevented urbanization and caused damage to health at the same time.

On the other hand, the sewage treatment rate[4] remained at a level of about 37% in Xi'an City at the time of the appraisal (2003) and much sewage was discharged without treatment. As a result, the quality of the Wei River flowing from east to west in Xi'an City was substantially below the national standard and exceeded Class V[5] of the national water quality environment standards in 2001. Subsequently, serious water pollution continued.

Thus, it was urgently needed to improve the capacities for water supply and sewage treatment, and this project was consistent with the imminent development needs.

2) Needs for Flood Control

In Xi'an City, roads were often flooded owing to the insufficiency of the drainage system in the rainy season (from July to September) during which rainfalls concentrated and often caused traffic suspension. This brought serious damage to both economic development and health/sanitation. In three waterways (Taiping River, Open Canal, and Xingfu Ditch), among others, which were constructed in the 1950s, the low capacity for flowing down and obsolescence raised a serious problem. They did not work well for urban drainage and flood discharge and caused a water disaster whenever there was a downpour. Thus, there were very strong needs for flood control measures.

(2) Consistency with the Development Needs at the Time of the Ex-Post Evaluation

1) Needs for Water and Sewer Services

The population of water distribution of Xi'an City in 2015 exceeded 4.5 million, which is a 1.9-fold increase compared with that at the time of the appraisal. As the increase is expected to continue following the development of the city in the future, it is necessary to continuously improve water infrastructure. Table 1 summarizes the situation of improvement in water and sewer infrastructure. One can see figures increasing year by year in every item. In this situation, Xi'an City plans to urbanize the suburbs and needs to improve the capacities for both water supply and sewage treatment even more. Although the quality of the above-

[4] Sewage treatment rate = Treated amount/ Total amount of sewage generated

[5] The water quality of rivers and lakes is classified into Classes I to V according to the surface water environment quality and quantity standards (GB3838-2002) as follows:
Class I: This is mainly applicable to water from the source of the river and national prior reserves. Class II: This is mainly applicable to a source of water for intensive drinking in the first-class reserves, valuable reserves for fish and egg-laying sites for fish and shrimps. Class III: This is mainly applicable to a source of water for intensive drinking in the second-class reserves and ordinary reserves for fish and swimming sites. Class IV: This is mainly applicable to industrial water districts, and recreational water districts which do not directly get in touch with human beings. Class V: This is mainly applicable to agricultural water and water areas necessary for general scenery.

mentioned Wei River improved from the level of Inferior Class V at the time of the appraisal, it remains in Class IV and still needs an appropriate measure for improvement.

Table 1: General Situation of Water and Sewer Services in Xi'an City

	2011	2013	2015
1. Tap Water			
Water Supply Capacity (10,000 m^3/day)	197.40	195.52	211.50
Water Supply Volume (10,000 m^3/year)	38,934	51,372	56,055
Population Served (10,000 people)	394.10	444.35	463.05
Distribution Pipe Network Length (km)	2,721.00	3,385.33	4,371.05
Water Supply Service Coverage Ratio (%)	100	100	100
2. Sewage			
Sewage Treatment Capacity (10,000 m^3/day)	111.60	153.10	200.60
Sewage Treatment Volume (10,000 m^3/year)	31,512	41,898	57,034
Sewage Pipe Network Length (km)	4,043.00	4,629.70	4,984.94
Sewage Treatment Rate (%)	85.90	90.72	91.85

Source: Statistical Almanac of Xi'an City

2) Needs for Flood Control

At the time of the ex-post evaluation, urban flood discharge and drainage have been facilitated more smoothly, damage by flooding has been mitigated, and urban safety against water disasters has been secured as a result of improving the drainage system. Meanwhile, improvement in the drainpipe network has recently advanced in Xi'an City, whereas drain is still merged with rainwater as conventional in the old urban area. There is also such a problem that the flowing-down capacity of the network is low because the diameter of drainpipe is narrow. The low prevalence and density of the drainpipe network causes overload for some areas. In the future, the city will need to continuously carry out an appropriate measure for flood control.

The following table shows the average annual rainfall and the maximum rainfall in Xi'an City. There is no large fluctuation in the average annual rainfall records after the start of this project in 2005. Since 2011, the maximum annual rainfall that may lead to a flood disaster has often been recorded in excess of the volume before the implementation of this project. Therefore, there is still a high possibility of flood occurrence, which requires the city to take an appropriate measure.

Table 2: Average and Maximum Annual Rainfalls in Xi'an City

Unit: mm

	2005	2006	2007	2008	2009	2010
Average Annual Rainfall	541.4	561.6	698.5	525.1	660.3	504.4
Maximum Annual Rainfall	722.8	600.9	734.9	626.4	846.9	735.4
	2011	2012	2013	2014	2015	
Average Annual Rainfall	423.6	426.7	423.9	660.3	551.6	
Maximum Annual Rainfall	948.0	532.2	535.2	792.4	810.0	
Reference: Usual Volume in Beijing					534.3	

Source: Responses to the questionnaire of the implementing agency

Under these circumstances, Xi'an City is now preparing[6] a policy to enhance the flood control capacity on the whole as a new effort and there is still a high need for flood control.

3.1.3 Consistency with Japan's ODA Policy

In the *Economic Cooperation Program for China* (2001) as an assistance policy of Japan toward China at the time of the appraisal, it is stated that emphasis will be placed on environmental and ecological conservation in China where environmental pollution and deterioration are serious. *The Medium-Term Strategy for Overseas Economic Cooperation Operations* (2002-2005) of JICA states clearly that there is the necessity for improving water supply and sewer services and tackling the problems of water resources among other priorities which include the reinforcement of the effort to reduce poverty, improvement in infrastructure for economic growth, the promotion of environmental conservation, and the prevention of pollution.

Moreover, in the *Country Assistance Strategy for China of JICA* formulated in 2002, support for the water environment and resources is stated. In particular, improving water and sewer services was emphasized as economic and social infrastructure for the activities of the private sector. As mentioned above, this project is highly consistent with Japan's ODA policy.

The implementation of this project is fully consistent with the development policy and needs of China and the ODA policy of Japan at the time of both the appraisal and the ex-post evaluation. Therefore, its relevance is high.

[6] According to the implementing agency of this project, they consider an idea of creating an infrastructure called "sponge city" which may enhance the flood control capacity. Specifically, it is a general infrastructure improvement plan which consists of a system whereby rainwater will be once reserved and then absorbed under the ground like a sponge and drained into a pipeline buried underground.

3.2 Efficiency (Rating: ②)

3.2.1 Project Outputs

The planned and actual outputs in this project are as follows. Although the scope was partially changed and added, it can be evaluated that the planned outputs required for achieving the purpose of this project were generally realized as originally planned.

Table 3: Output: Plan and Actual Results

Sub-project	Plan (2005)	Actual (2016)
Urban Water Distribution Network	(1) Water pipe construction 260 km (2) Reservoirs, distribution plants, water quality measuring equipment, central control system improvement	**Partially changed** (1) Water pipe construction 215 km (2) Reservoirs, distribution plants, water quality measuring equipment, central control system improvement
Yuanle Village Sewage Treatment Plant	Treatment capacity 200,000 m^3/day	**As planned**
Sewage Treatment Plant Project (Southwest)	(1) Treatment capacity 80,000 m^3/day (2) Sewer pipe construction 60 km	**Almost as planned** (1) Treatment capacity 80,000 m^3/day (2) Sewer pipe construction[7] 58.6 km
Sewage Treatment Plant Project (North)	(1) Treatment capacity 100,000 m^3/day (2) Sewer pipe construction 160 km	**Almost as planned** (1) Treatment capacity 100,000 m^3/day (2) Sewer pipe construction 159.1 km
Drainage Pipe Network Reconstruction	Sewer pipe construction 231 km	**Almost as planned** Sewer pipe construction 230 km
Treatment Project of Drainage System	(1) Drainage system improvement 43 km (2) Tuanjie Reservoir waterway[8] improvement 12.675 km	**Partially changed and added** (1) Drainage system improvement 31.95 km (74% compared with the plan) (2) Tuanjie Reservoir waterway improvement 12.676 km (3) Addition: 3 bridges, 2 footbridges, retaining wall for bank protection, pump, sluice
Training	Training the employees of the implementing agency in Japan 70 people	**Almost as planned** Participating personnel: those of the implementing agency of this project and all the implementing agencies of the sub-projects Phase I: 20 people Phase II: 12 people Phase III: 25 people Phase IV: 20 people Total: 77 people (63 men and 14 women)

Source: The planned figures are data from JICA and the actual figures are responses to the questionnaire of the implementing agency.

[7] The Fourth Wastewater Treatment Plant deals with wastewater mainly in the urban area; and the Second Wastewater Treatment Plant, in the southern part. Except in a few areas, all the constructed sewage pipes are of a type that sends rainwater and wastewater to the treatment plant through separate pipes.

[8] This is based on the reference material provided by JICA

In improving the urban water system, the pipe network in the southwestern part of the city, being beyond the jurisdiction of the implementing agency of this project, was excluded from the target of improvement. Afterward, the change of the construction site following the change to urban development planning slightly prolonged the total length of the water pipe network within the jurisdiction compared with the plan. However, the total length of the constructed pipe network finally decreased in the whole of urban water system improvement. On the other hand, sewage treatment plants and sewer pipe networks were improved almost as planned.

In the Treatment Project of Drainage System (Northwest), the total length of the drainage system remained at 74% of the planned length. This is because some parts of the planned drainage system were integrated into the existing drainpipe network following the progress of urbanization and excluded from the coverage of this project. In addition, bridges and footbridges were also constructed for the sake of convenience of the local people and in order to secure the top width of the bank and resolve the problem of drainage in the local communities.

3.2.2 Project Inputs

3.2.2.1 Project Cost

The project cost was planned to be 38,396 million yen (19,564 million yen in foreign currency and 18,832 million yen in local currency) at the time of the appraisal but was actually 45,073 million yen (18,324 million yen in foreign currency and 26,749 million yen in local currency), which is 117% of the plan.

The main reason for the increase in the project cost is an increase in the local currency due to soaring personnel and material costs. In particular, there were an increase of 173% in the cost of constructing the Yuanle Village sewage treatment plant and an increase of 150% in the cost of constructing the sewage treatment plant in the southwestern suburb of Xi'an City. According to the implementing agency of this project, the cost of obtaining sites also increased in addition to the increases in personnel and material costs. The increase was covered by the agency's own funds. On the other hand, with regard to the Comprehensive Treatment Project of Drainage System in the Northwestern Suburb of Xi'an City, the project cost was reduced to 65% of the plan by the cancellation of some outputs in this project.

3.2.2.2 Project Period

The project period planned at the time of the appraisal was from April 2005 to October 2011 (79 months)[9] but actually ran from April 2005 to October 2013 (103 months), which

[9] The completion of this project is defined as the completion of inspection in all sub-projects.

exceeded the planned period by 30%. This delay was mainly due to the delayed procedures for government approval and the change of the sites for constructing sewage treatment plants. The reason for a delay in each sub-project is as follows:

Table 4: Reasons for Delays in the Project Period

Sub-project	Reason for Delay
Urban Water Distribution Network	A delay of two years. It took much time to follow procedures for the approval of related agencies. Also, the construction of water pipes was delayed by a delay in the construction of urban roads carried out in parallel with this project.
Yuanle Village Sewage Treatment Plant	A delay of four years and ten months. Because of the change of the construction site forced by locational constraints, such as high-tension wires passing over the planned site for a treatment plant, the construction of the plant was delayed by two years and one month. In addition, technical problems occurred in the installation of a sludge disposal tank that was set up after the construction of the plant. It took more time than expected to complete the installation.
Sewage Treatment Plant Project (Southwest)	A delay of four years. The delay is due to the following two causes: (1) delay in the work to install pipes because of a delay in road construction by Xi'an Municipal People's Government outside this project; (2) This project had expected that it would need to follow only the procedures for approval by Xi'an City. However, it turned out to be necessary to follow the procedures for the approval of related agencies for procurement, as well as for inspection upon the completion of construction, at the municipal, provincial, and national levels. All of these procedures took more time than initially anticipated.
Sewage Treatment Plant Project (North)	A delay of one year and nine months. This was because the rapid progress of urbanization in suburbs required the change of the planned site for a treatment plant.
Drainage Pipe Network Reconstruction	A delay of one year. Although the construction of a pipe network was completed according to plan, completion inspection was delayed until the completion of roads constructed in parallel with this project.
Treatment Project of Drainage System	A delay of ten months. This was because the addition of such outputs as bridges, foot bridges, and sluices required additional coordination and field surveys.

Source: Responses to the questionnaire of the implementing agency.

3.2.3 Results of Calculations for Internal Rates of Return (Reference only)

The financial internal rate of return (FIRR) of water and sewer services was calculated on the assumption that benefit would be income from water rates, cost would include the project cost and management, maintenance, and administration costs, and the project life would be 20 years.

The FIRR assumed at the time of the appraisal of the urban water service improvement project was 9.5% but became negative at the time of the ex-post evaluation. Water service is

managed as a public utility with financial investment from the municipal government and pricing of the service is kept at a low level. However, water supply cost has been increasing since the appraisal, and conceivably lowered profitability. Therefore, the service as a unit is managed in the red and compensated by a subsidy from the municipal government and non-operating income[10].

On the other hand, the FIRR of sewer service was estimated at 4.5% in the Yuanle Village Sewage Treatment Plant Project, 4.8% in the Sewage Treatment Plant Project in the Southwestern Suburb, and 4.1% in the Sewage Treatment Plant Project of Jinghe and Weibe Rivers Area in the Northern Suburb. In the field survey, however, the FIRR could not be calculated because financial data from each agency were not disclosed.

In the Drainage Pipe Network Reconstruction of Xi'an City and the Comprehensive Treatment Project of Drainage System in the Northwestern Suburb of Xi'an City, the economic internal rate of return (EIRR) was estimated at 14.7% (the former) and 14.4% (the latter) on the assumption that benefit would be a decrease in flood disasters, cost would include the project cost and management, maintenance, and administration costs, and the project life would be from 22 years to 50 years. However, the EIRR was not actually calculated because it was difficult to confirm detailed data required for benefit calculation after the completion of this project.

Both the cost and period of this project slightly exceeded the plan. Therefore, efficiency of the project is fair.

3.3 Effectiveness[11] (Rating: ③)

At the time of the appraisal, reduction in intracity river water pollution, clean water supply, and flood disaster reduction were expected as project effects. In this evaluation, first of all, as direct effects of the project, effects will be measured on the basis of direct outputs such as "enhancing the capacity for water supply," enhancing the capacity for sewage treatment," and "enhancing the capacity for flood control"; then, as a ripple effect, reduction in intracity river water pollution, clean water supply, and flood disaster reduction will be assessed.

3.3.1 Quantitative Effects (Operation and Effect Indicators)

(1) Improvement of water supply capacity

Table 5 shows the target value and actual performance of volume of water supply in the area targeted by this project, population served, and water supply service coverage ratio which have been set as operation and effect indicators. The target value set at the time of the

[10] This includes income from the connection of water pipes from the main pipe network to households and the construction of the main pipe network and commission fees for the relocation of the pipe network owing to underground railway and road construction and similar work.

[11] Rating is carried out by assessing not only the effectiveness but also the impact.

appraisal was achieved in terms of volume of water supply and population served; and, the rate of achievement against the target value is 120% for volume of water supply and 133% for population served. The rate of increase of volume of water supply was slightly lower than that of population served because of the improvement on water use efficiency as a result of such factors as recycling of industrial water, popularization of water-saving devices, and enhanced water-saving awareness among the population.

As, in parallel with this project, water pipe networks were also installed by domestic urban development projects, the installation of water pipe networks was completed in all areas under the jurisdiction of this implementing agency. Thus, the water supply service coverage ratio as of 2015, two years after the completion of the project, is 95.4%, which is very high; therefore, it can be said that the initial target, improvement of Xi'an City's water supply capacity, was achieved.

Table 5: Volume of Water Supply in the Area Targeted by This Project (Urban Area of Xi'an City), Population Served, and the Water Supply Service Coverage Ratio

		Baseline	Target	Actual		
		2003	2013	2013	2014	2015
		Appraisal year	2 years after completion	Completion year	1 year after completion	2 years after completion
Operation	Water Supply Volume (m^3/day)	696,000	1,323,000	1,492,159	1,493,589	1,591,000
	Population Served (person)	2,210,000	3,380,000	4,300,000	4,300,000	4,500,000
Effect	Water Supply Service Coverage Ratio (%) (Note 1)	84	92	91.2	91.2	95.4

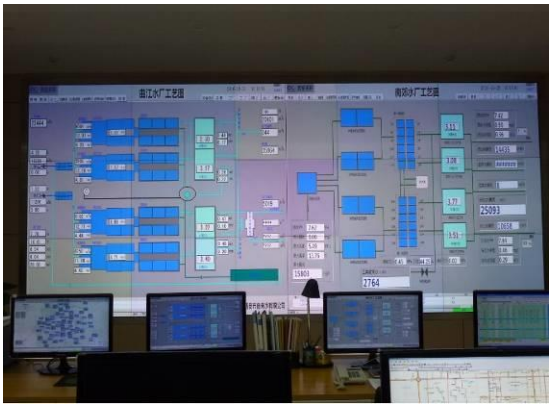
Source: The standard value and target value are based on the reference material provided by JICA; Actual performance is based on the answer of Xi'an Municipal Facility Administration Bureau to the questionnaire.
Note 1: Service coverage ratio = Population of water distribution / Total population of urban area of Xi'an City

The stability of water supply, including water pressure and water quality, is also improved. According to the interview conducted with the implementing agency of this project, the water pressure in the area targeted by this project is stable, as the average water pressure at the output of the water treatment plant is 0.5 MPa (Mega Pascal) and the water pressure in the area targeted by this project is 0.36 MPa.[12]. In addition, before this project was implemented, the water supply capacity was insufficient; for example, they had water rationing in summer time. After the completion of this project, there has been no such water rationing and water is supplied 24/7.

[12] The water pressure for general tap water in Japan is, depending on geological conditions, within the range of 0.05-1.0 MPa

With respect to water quality, as all major measurement values related to water quality meet national standards for drinking water[13], safe supply of water has been achieved.

Water Quality Measurement Equipment



Central Control Room

(2) Improvement of Sewage Treatment Capacity

The target set for improvement of sewage treatment facilities at the time of the appraisal was the one assumed for the treatment system of the city as a whole. For that reason, in the ex-post evaluation of this project, evaluation was carried out on the basis of the percentage this project accounts for in the indicators for the city as a whole. However, as no statistical data for the population served by sewer, which was set as an operational indicator, have been disclosed and the implementing agency has not been able to get hold of them either, we assessed the achievement of overall goal by amount of sewage being treated. In addition, with respect to conditions of water quality improvement of the discharge destination (Wei River), which was set as an effect indicator, it will be analyzed, as mentioned above, in the "Impact" section as reduction in intracity river water pollution.

The table below shows the target and actual performance of operational indicators. In this sewage improvement project, a total treatment capacity of 380,000 m^3/day was developed at three sewage treatment plants. This accounts for about 25% of Xi'an's total sewage treatment capacity at the time of completion of this project and approximately 20% of the actual amount of sewage being treated in the whole city, indicating that this is playing an important role in the sewage treatment system of Xi'an City which has a population of over 8 million. As the sewage treatment rate, together with various sewage treatment projects implemented in

[13] The reliability of water quality testing system of Xi'an City is high. Thanks to the introduction of water quality measurement equipment by this project, water quality measurement capability was also improved; for example, it became possible to measure all 106 test items specified by the National Drinking Water Standards. As 40 online automatic monitoring spots are up and running in the city currently, the measured data are transmitted to the central control room of the implementing agency in real-time, and they are checking the water quality to see if there is a problem as needed. In addition, the employees collect water samples from 120 measurement spots in the city to carry out a water quality test.

parallel with this project, has also improved by a large margin from 76% to 92%, it can be evaluated that this project has made an important contribution to the improvement of the sewage treatment capacity of Xi'an City.

Table 6: Xi'an City's Sewage Treatment Capacity

	Indicator (unit)	Baseline	Target	Actual		
		2003	2010	2013	2014	2015
		Appraisal year	2 years after completion	Completion year	1 year after completion	2 years after completion
Operation	Sewage treatment capacity (10,000 m^3/day)	/	/	153.1	153.1	200.6
	Ratio this project accounts for	/	/	24.8%	24.8%	18.9%
	Sewage treatment volume (10,000 m^3/year)	/	/	41,898	47,907	57,034
	Ratio this project accounts for	/	/	19.8%	19.0%	17.2%
	Sewage treatment rate (%) (Note 1)	37	76	90.72	92.71	91.85

Source: The standard value and target value are based on the reference material provided by JICA. Actual performance is based on Xi'an City's Statistical Yearbook and answers to the questionnaire by the implementing agency
Note 1: Sewage treatment rate = Treated amount / Total amount of sewage generated (Total amount of sewage generated in Xi'an City as a whole)

1) Operational status of respective sewage treatment plants developed by this project

To clarify the effects of this project, amount of sewage treated and the facility utilization rate for Xi'an Yuanle Village Sewage Treatment Plant, Sewage Treatment Plant in Southwestern Suburb of Xi'an City, and the Sewage Treatment Plant in Northern Suburb of Xi'an City are shown in the table below. The facility utilization rate after the completion of this project has increased steadily; and, the facility utilization rate as of 2015 has achieved 87.2% for Xi'an Yuanle Village Sewage Treatment Plant and 84.7% for the Sewage Treatment Plant in Southwestern Suburb of Xi'an City.

Table 7: Amount of Sewage Treated and the Facility Utilization Rate for Sewage Plants

		Actual (Note 1, 2)					
		2010	2011	2012	2013	2014	2015
Yuanle Village Sewage Treatment Plant (treatment capacity: 200,000 m^3/day)	Amount of sewage treated* (10,000 m^3/day)	n/a	13.34	13.77	15.76	17.20	17.44
	Facility utilization rate** (%)	n/a	66.70	68.85	78.80	86.00	87.20
Sewage Treatment Plant Project (Southwest) (treatment capacity: 80,000 m^3/day) (Note 3)	Amount of sewage treated (10,000 m^3/day)	3.30	3.90	4.60	4.70	5.60	6.80
	Facility utilization rate (%)	41.30	49.20	57.60	59.10	69.40	84.70
Sewage Treatment Plant Project (North) (treatment capacity: 100,000 m^3/day)	Amount of sewage treated (10,000 m^3/day)	0.50	0.70	0.95	2.25	2.17	2.61
	Facility utilization rate (%)	5.00	7.00	9.50	22.50	21.70	26.10

Source: Answer to the questionnaire by the implementing agency
*Average daily amount of sewage that a sewage treatment plant accepts and treats
** Average daily amount of sewage treated / treatment capacity
Note 1: The frame in bold line indicates the year of completion of the project
Note 2: Although the formal commencement of operation of Xi'an Yuanle Village Sewage Treatment Plant was in January 2011, as the commencement of operation of the sludge digestion tank was 2013, the year of completion for the project as a whole was 2013.
Note 3: Although the formal commencement of operation for the Sewage Treatment Plant in the Southwestern Suburb of Xi'an City was May 2009, the completion year of the project as a whole including development of piping network is 2012.

On the other hand, although the amount of sewage treated by the Sewage Treatment Plant in the Northern Suburb of Xi'an City is on an upward trend after the completion of the project, the actual performance in 2015 stays at a low level being less than 30% of the design capacity. The reason for this, according to the implementing agency, is the fact that relocation of plants from urban areas to the area targeted for development was delayed owing to the delay of urban development. The Xi'an Municipal Government plans to complete relocation of plants by 2025[14]; it is estimated that the amount of sewage treated by the Sewage Treatment Plant of the Northern Suburb of Xi'an City will be approximately 98,000 m^3/day at that point. As the relocation of these plants has been decided in the development plan of the city and the probability of realization of relocation is high, it is expected that the amount of sewage treated by the sewage plant will also achieve the initial target over a medium term.

As discussed above, the utilization rate of the two treatment plants is over 80% and at a satisfactory level and the average utilization rate was 70% including the Sewage Treatment Plant of the Northern Suburb of Xi'an City, for which the amount of received sewage has not reached the planned value. It is highly likely that the utilization rate of the Sewage Treatment

[14] According to the Xi'an Weibei Industrial Zone Industrial Development Plan, all factories in the urban areas are to be relocated to industrial park zone in the future; and, it is anticipated that 23 companies will be relocated by 2020 and factories of 34 companies by 2025.

Plant of the Northern Suburb of Xi'an City will improve in the near future; therefore, it can be evaluated that the operational status is satisfactory as a whole.

2) Quality of water discharged from respective sewage treatment plants developed by this project

The table below shows the water quality at the discharge outlet of respective sewage treatment plants. With respect to the quality standard of discharged water, criteria for the National Standard Class 1A has been applied to the Xi'an Yuanle Village Sewage Teratment Plant and the Sewage Treatment Plant in the Southwestern Suburb of Xi'an City since 2013 and to the Sewage Plant in the Northern Suburb of Xi'an City since 2015. With regard to main contaminants, the water quality after treatment has achieved all reduction results, exceeding National Standard Class 1A.

Table 8: Quality of Water Discharged from Respective Sewage Treatment Plants

Unit: mg/l

Sewage plant	Quality of discharged water (Note 1)	National Standard (Note 2)	Actual (Note 3)					
			2010	2011	2012	2013	2014	2015
Xi'an Yuanle Village Sewage Treatment Plant	COD concentration	50	-	27.7	24.1	22	21	19
	BOD concentration	10	-	10	9	7	7	7
	NH3-N concentration	5	-	1.63	0.91	0.93	0.973	1.054
Sewage Treatment Plant in the Southwestern Suburb	COD concentration	50	27	23	33	25	20	21
	BOD concentration	10	5	2	2	3	2	2
	NH3-N concentration	5	1.17	1.01	0.77	0.52	1.218	0.854
Sewage Treatment Plant in the Northern Suburb	COD concentration	50	-	-	47.6	33.9	29.0	35.2
	BOD concentration	10	-	-	14.6	15.5	13.9	8.6
	NH3-N concentration	5	-	-	4.40	1.21	0.79	0.70

Source: Answer to the questionnaire by the implementing agency
Note 1: COD means chemical oxygen demand; BOD, biochemical oxygen demand; and NH_3-N, ammonia nitrogen.
Note 2: The value of environmental standard set by the National Standard Class 1A
Note 3: The year marked by the bold line is the year the National Standard Class 1A was applied. Actual performance values show the values of respective sewage treatment plants since the official year of operation. The values for the National Standard and actual performance indicate the average values of respective concentration categories.

(3) Improvement of Flood Control Capacity

At the time of the appraisal, hours of flood damage occurrence per year due to levee crevasse or overflow were set as an operation and effect indicator. According to the Office of Flood Prevention and Management of the Xi'an Municipal People's Government, there has

been no flood damage since the completion of the project in Xi'an City. We can estimate the effects of this project based on the fact that the drainage canals developed by this project account for 80% of the drainage canals of Xi'an City as a whole and there has been no major flood damages so far although they had the same level of rainfalls as those that caused flood damages before the project. To analyze the effects in a more precise manner, with respect to the evaluation of improvement of flood control capacity, we carried out the evaluation on the basis of the assumed effects after verifying the developmental status of direct functions such as disposal capacity of the drainage canals. In concrete terms, we decided to use as the criteria whether the maximum rate of flow for the year over past years is within the flow capacity[15] and whether an appropriate manner of maintenance is being carried out.

The table below shows the flow capacity at the time of appraisal and that at the time of the ex-post evaluation. Before the implementation of the project, the flow capacity of the drainage canals by this project were 30 m^3/second for Taiping River, 30 m^3/second for Open Canal, and 15 m^3/second for Xingfu Ditch. It has been significant improvement, as these flow capacities have increased by as much as 3.2-fold on average.

Table 9: Flow Capacity and Rate of Flow of Respective Drainage Canals

Unit: m^3/second

Drainage	Flow capacity		Rate of flow					
	At the time of appraisal	At the time of evaluation	2010 Completion year	2011	2012	2013	2014	2015
Taiping River	30	92						
Maximum rate of flow for the year	-	-	61	83	54	66	51	69
Flow capacity - maximum rate of flow for the year	-	-	31	9	38	26	41	23
Open Canal	30	66						
Maximum rate of flow for the year	-	-	43	64	39	41	38	51
Flow capacity - maximum rate of flow for the year	-	-	23	2	27	25	28	15
Xingfu Ditch	15	69.7						
Maximum rate of flow for the year	-	-	36	65	37	43	35	54
Flow capacity - maximum rate of flow for the year	-	-	33.7	4.7	32.7	26.7	34.7	15.7

Source: Answer to the questionnaire by the implementing agency

[15] This means the maximum flow that can discharge the flood water safely.

In addition, the difference between the maximum rate of flow and flow capacity[16] of respective drainage canals is shown in the table above. According to the implementing agency, although they said that they were not able to get hold of the figures concerning the rate of flow before 2010, the year the three canals were completed, there had been flood damages such as levee crevasse, overflow, and flooding in the urban area before the implementation of the project every time they had heavy rain of 20-30 mm in a short span of time. As there has been no year in which the maximum rate of flow of the year exceeded the flow capacity after the completion of this project, we can see that discharged water is safely flowing down. In addition, as mentioned in "Relevance," considering that the precipitation in Xi'an City does not show any major change from the time of planning to the present, we were able to confirm that the risk of overflow and levee crevasse at the current standard weather conditions has been significantly reduced.

Those drainage canals developed by this project have been regularly maintained; as a result, it can be evaluated that they are maintaining the planned capability, such as capacity of flow. (See "3.5 Sustainability" for details)

On the basis of the above, although there is limitation in carrying out quantitative analysis of reduction of flood damage, as drainage canals with expected flood control capacities have been developed, it can be evaluated that the effect of drainage canal development is high.

3.3.2 Qualitative Effects (Other Effects)

As effects of recycling, the reuse of treated water and reuse of sludge were expected. Respective statuses are discussed as follows:

(1) Reuse of Treated Water

As the use of treated water is still at the discussion stage, reuse of treated water has not yet been put into practice. They say that the Sewage Treatment Plant in the Northern Suburb of Xi'an City uses the treated water for watering roadside trees, etc.; and, at this stage, they are considering the future use of treated water in the sewage plant by preparing a concrete technical plan.

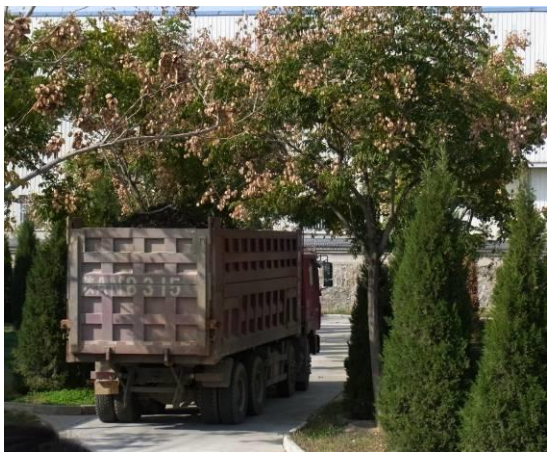
(2) Reuse of Sludge

The sludge generated after the treatment of sewage goes through primary treatment[17] at the treatment plant and then all of it is outsourced to go through regeneration process as

[16] If the maximum rate of flow for the year is less than flow capacity, it means that river water is flowing safely without overflow.

[17] This treatment decreases the water content rate of sludge to 75 to 80% by using a centrifugal separator.

planned; it is mainly reused as tiles, bricks, or compost. In addition, with regard to the Sewage Treatment Plant Project in Yuanle Village, as a sludge digestion tank was installed by this project, the environment to use sludge to generate methane gas as a source of heat supply in the treatment plant has been developed. However, at the time of study, operation of the digestion tank had been suspended since the end of 2015 and we were told that the cause of trouble was still under investigation.



A Truck Carrying Sludge

Sludge Digestion Tank at the Xi'an Yuanle Village Sewage Treatment Plant

3.4 Impacts

3.4.1 Intended Impacts

The expected impact of this project is improvement of Xi'an City's water environment as a whole through supply of clean water, reduction of water pollution, and reduction of flood disaster. We will now analyze the role this project played in relation to this impact.

(1) Supply of Clean Water

1) Water quality

As mentioned in "Effectiveness and Impact," after development of a water pipe network was carried out through this project, the water supply service coverage ratio has achieved almost 100%. As the water quality satisfies national drinking water quality standards with respect to all test items, it has been proven appropriate as tap water. In addition, as the range of water supply was expanded as a result of development of the water pipe network, all wells were closed in Xi'an City after the implementation of this project.

2) Reduction of waterborne diseases

Although it is difficult to prove direct causal relationship between reduction of

waterborne diseases and effects of this project, cases of water related diseases are on a downward trend up until now in Xi'an City. If one compares the number of hepatitis patients and that of diarrhea patients between 2015 and 2005, it has been confirmed that, despite increased population, the number of hepatitis patients was reduced by 9,519 cases and that of diarrhea patients by 5,890 cases. Although it is not possible to prove the causal relationship in a clear-cut manner, there is a possibility that realization of supply of clean water led to the reduction of waterborne diseases such as diarrhea.

(2) Reduction of water pollution

As this project is positioned as a part of the city planning of Xi'an City and the treatment capacity of those sewage treatment plants that were developed by this project accounts for approximately 25% that of Xi'an's total urban areas, it can be evaluated that the project played an important role in controlling the sources of water contamination of the rivers in the City. Before the implementation of this project, as there were no sewage treatment plants in suburban areas, most sewage had been discharged into the river untreated. It can be said that this project has contributed to the reduction in intracity river water pollution in both urban areas and suburbs of Xi'an City by developing an independent sewage treatment system in the suburban area; i.e., the construction of a sewage treatment plant in the southwestern suburb as well as the one in the northern suburb.

The table below shows an estimated amount of contaminants removed by the implementation of this project and the ratio of the removed contaminants in comparison to the total in Xi'an City as a whole. The ratio of contaminants reduced by this project is as much as 29.1% for COD and 22.4% for NH_3-N on average between 2010 and 2015. As the treatment capacity of the sewage treatment plants developed by this project accounts for 20% of the total in Xi'an City as a whole, it can be said that this project showed more than expected results in reducing the contaminants in the city as a whole.

Table 10: Amount of Contaminants Reduced

	2010	2011	Actual 2012	(Note) 2013 The year this project was completed	2014	2015
COD reduction amount by this project (tons/year)	4,964	32,941	39,013	42,049	41,882	44,993
NH_3-N reduction amount by this project (tons/year)	462	2,421	2,654	2,954	3,065	3,397
Ratio this project accounts for in Xi'an City's COD reduction amount	4.4%	38.9%	48.0%	44.8%	29.3%	23.4%
Ratio this project accounts for in Xi'an City's NH_3-N reduction amount	5.4%	26.6%	33.5%	31.4%	22.9%	18.4%

Source: The reduction amount by this project is based on the answer to the questionnaire by the implementing agency; and, the reduction amount of Xi'an City is based on Xi'an Statistical Yearbook.
Note: The year all three sewage treatment projects were completed is 2013.

Sewage to be treated by this project had been discharged into the tributaries of the Wei River untreated. According to Shaanxi Provincial People's Government Environmental Protection Bureau, the water quality of Wei River, which had been class "V minus" in 2006, was improved to be assessed as class "IV" in 2015. As factors other than this project can have significant impact on the water quality of the river, it is difficult to prove causal relationship with this project; however, considering that the share of the sewage treatment capacity of this project accounts for a high percentage of the total sewage capacity of the city, it is conceivable that this project is making a certain contribution to the improvement of water quality of the Wei River.

(3) Reduction of flood disaster

There are, roughly speaking, five drainage systems in Xi'an City; and, as the rain water and sewage coming from most of the urban areas of the Xi'an City except for the eastern area are collected by the Zao River, Open Canal, and Xingfu Ditch, these three drainage systems accounts for more than 80% of the drainage systems of Xi'an City's urban area.[18] As the Taiping River (a tributary of the Zao River), Open Canal, and Xingfu Ditch play an extremely important role in the flood control system of the city as a whole, it can be said that the development of drainage systems implemented by this project has also made a significant

[18] The rain water and sewage of southern area, western area, and northwestern area are all discharged into the Zao River and Taiping River, and then into the Wei River; and, the rain water and sewage of old urban areas are mainly discharged into the Tuanjie Dam and then through Open Canal to the Wei River; and, the rain water and sewage of northeastern area are discharged into the Wei River through Xingfu Ditch.

impact in terms of reduction of flood disaster in the city as a whole.

In addition, as flooding risk in the urban area was significantly reduced thanks to the development of the drainage pipe network implemented in the urban area, the flood defense standard (recurrence cycle) of the drainage pipe network in Xi'an's urban area was improved from once in one and half years (once in three years for certain areas) at the time of the appraisal in 2005 to once in five years by the time of the ex-post evaluation.

As stated in "Relevance," there has been no significant change with respect to the precipitation in Xi'an City since the time of planning; and, the current risk of occurrence of flood disaster is the same as at the time of planning. On the other hand, as drainage capacity has improved significantly after the development of drainage systems and drainage pipe network and there has been no flood disaster such as overflow, it can be evaluated that this project made a certain impact on reduction of flood disaster in Xi'an City as a whole.

With respect to the reduction of flood disaster, partly because there has been no serious damage since the completion of the project, we were unable to confirm a direct impact as actual performance. For that reason, with the cooperation of the implementing agency, we conducted a beneficiary survey[19] with 120 residents who were randomly selected from households' lists in areas that reportedly had been affected by frequent flood disaster, to confirm the effects of Treatment Project of Drainage System.

According to the beneficiary survey, all 70 respondents who said that they had experienced flood disaster in the past answered that they had experienced flood disaster on their farmland. On the other hand, with respect to flood disasters after 2010, all 120 respondents targeted for the survey answered that there had been significant improvement in relation to flooding of farmland; and 98% of them answered that it had been significant improvement in relation to other damages such as mudslide or landslide as well as flooding over/under the floor level. Further, 94% of them answered that fear of flood disaster was mitigated.

In addition, out of the 120 respondents targeted for the survey, 116 or 97% of them answered that environmental conditions of nearby rivers have improved; and, the other four respondents answered that they have generally improved. In fact, with respect to environmental improvement of rivers, the implementing agency also expressed a view that, although considerable foul odor was generated before the treatment project of drainage system, at present, odor has been mitigated and water quality has also been improved so much so that even fish came to live there.

[19] The survey was conducted on 120 residents of Sha He Tan Village, located in the basin of the Zao River and Taiping River, in the urban area of the city, and Ba Xing Tan Village, located in the lower basin, where flood disasters frequently occur, (60 residents in Sha He Tan Village and another 60 in Ba Xing Tan Village) by the door-to-door survey method. Respondents were: 77% of male and 23% of female; 20-29 of age (3%), 30-39 of age (23%), 40-49 of age (38%), 50-59 of age (33%), and 60-69 of age (1%).

3.4.2 Other Positive and Negative Impacts

(1) Impacts on the Natural Environment

In the environmental assessment carried out before the implementation of the project, there was no report of serious negative impact on or risk to the natural environment or ecological system in relation to any sub-projects. Moreover, with regard to the outputs that were added in a few sub-projects, it was confirmed that they had no particular impact on the environment.

At the time of the implementation of the project, as a measure against the odor from sewage treatment plants, such measures as installation of deodorizing facilities in the building were taken.

In addition, at the Sewage Treatment Plant in the Southwestern Suburb of Xi'an City, observation points were established at the boundary of the plant premises, and odor index has been monitored to confirm that it is less than the index specified by the national standard. In addition, with respect to all sewage treatment plants, a strict monitoring system has been developed where the Xi'an Municipal Environmental Protection Bureau is constantly monitoring the quality of the discharged water online and carrying out regular on-site inspections. As they have not heard of complaints from local residents either, no particular impact on the natural environment has been recognized.

(2) Land Acquisition and Resettlement

1) Resettlement

As had been planned, there has been no relocation of residents in relation to all sub-projects.

2) Land Acquisition

The actual area of land acquired is 223.8 ha, which is 118% of the plan. Looking at the area of acquired land for respective sub-projects, it increased to 136% of the plan for Yuanle Village Sewage Treatment Plant and 143% for Sewage Treatment Plant Project of Jinghe and Weihe Rivers Area in the Northern Suburb of Xi'an City. This is because, in Yuanle Village, on top of the land for the plant, acquisition of extra lands for roads and green spaces became necessary. In addition, the area of land to be acquired increased because there was a case where it was necessary to acquire a whole village[20]; the location for the construction of the sewage treatment plant in the Northern Suburb was changed and the new location included a part of the village. With respect to the urban water distribution network, the area of acquired land increased significantly by 700% compared to the plan because the installation routes of

[20] The land to acquire was someone's property but not a place of residence. No one lived there.

water supply pipe were revised in consideration of city planning. With respect to all sub-projects for which acquisition of land was required, the acquisition was carried out smoothly, as required procedures such as briefing in advance and compensation were followed according to the domestic law.

(3) Other Positive and Negative Impacts

With regard to the Tuanjie Reservoir water way developed by this project, before the implementation of the project, it was in an unsanitary environment with piled up rubbish and overflowing sewage; however, thanks to this project, a drainage system was developed, water environment became clean, and landscape was improved. As a result, the water way became a place of recreation and is now designated as one of the national waterside scenic spots. In addition, thanks to the efforts of the municipal government, Xi'an Water Conservation Museum was established, as an auxiliary facility for the purpose of enhancing ecological protection awareness, which is open to the residents in the vicinity free of charge. With respect to this, the implementing agency says that this is resulting in improvement of awareness of the nearby residents concerning protection of the environment.

Further, after the training course in Japan in this project, Xi'an City and Kyoto City have reached an agreement to continually engage in exchange and collaboration in the area of protection of water environment with improvement of combined-type sewage pipe as a theme of future cooperation. Based on this, grass-root technical cooperation projects were implemented in Xi'an City in 2010 and 2011 taking advantage of support from Kyoto City, and cooperation between the two cities has been strengthened.

As stated above, since its objectives were generally achieved in accordance with the plan by implementation of this project, its effectiveness and impact are high.

3.5 Sustainability (Rating: ③)

3.5.1 Institutional Aspects of Operation and Maintenance

According to the plan at the time of the appraisal, Xi'an Municipal Infrastructure Construction Investment & Management Co., Ltd. (hereafter "Management Co., Ltd.") is to carry out, commissioned by the Xi'an Municipal Government, overall supervision of procurement and construction of this project in an integrated fashion. For managing the sub-projects, implementing agencies such as Municipal Facility Administration Bureau and Sewage Treatment Co., Ltd. were assigned. Although at the time of project evaluation, the name Management Co., Ltd. was changed to Xi'an Urban Infrastructure Investment Group Co., Ltd., as the main personnel in charge of this project have not been replaced since the time of appraisal and are continually engaging in communication and coordination with

implementing agencies, etc., and supervision of subordinate organizations which carry out operation and maintenance of the operation, there have been no major changes to the substantive operation of this project. With respect to the implementing agencies of sub-projects, although there have been partial changes from the time of planning in terms of organizational framework, names, and so on, there have been no changes to the substance as a state enterprise in relation to respective agencies. In addition, as respective agencies responded that they have no privatization plan, it is likely that there will be no major changes to the current framework in the medium and long terms.

3.5.2 Technical Aspects of Operation and Maintenance

(1) Technical Level Concerning Management and Maintenance

With respect to both water and sewage systems, the implementing agencies responsible for sub-projects have previously been involved in the operation of respective facilities; and while doing that, they have employed human resources who have certain skills and experience on a preferential basis. As the water and sewage facilities including ODA loan projects are, both in terms of employed technologies and facilities, standard ones that have been used in China before, it is considered that the engineers who have been working for Xi'an's water and sewage program have accumulated a certain degree of operational knowhow and experience and have ability required for operation and maintenance. In addition, an education and training system for engineers and other employees has also been developed; and, after taking the course or practical training concerning operation and management or machine operations, etc., they are required to sit for a written examination or technical test, and they are obliged to acquire a qualification in machine operation and so on. As a framework to maintain technical capability has been developed, for example, they proactively engage in transfer of skills among engineers, we cannot see any problem in regard to their technical capability in general.

(2) Status of the Development of an Operation and Maintenance Manual

In the field study, we conducted a survey with sub-project implementing agencies from such perspectives as follows: Protocol of operation and management, the manner in which troubles are dealt with, and whether the report and communication system has been established as a rule, commonly accepted, and practiced as an organization. As a result, we were able to confirm that operational and maintenance manuals have been developed in all sub-projects, and common perception among employees regarding their work and level of understanding of the manual are also generally high.

On the basis of above, as technical capability of the employees required for operation and

maintenance has been ensured and the operational and maintenance environment for maintenance has also been established, it is considered that technical aspects for the sustainability of project effects are high.

3.5.3 Financial Aspects of Operation and Maintenance

The table below shows the annual budget of the Xi'an Municipal Government and expenditure for water-related sectors as well as its percentage of the whole budget. As indicated in "Relevance," we can see that development of water and sewage infrastructure has been carried out in a continual manner even after the commencement of the project and investment has continued to be put into the sector as a priority area in municipal development. The water and sewage program, being a public utility service, assumes financial management to be supported by subsidies and assistance from the government; and, considering the growth and scale of Xi'an Municipal Government's spending and stable expenditure for water related areas, it can be judged that a major problem is unlikely to emerge at this point.

Table 11: Fiscal Budget of the Xi'an Municipal Government

Unit: 10,000 yuan

	2011	2012	2013	2014	2015
General account	4,945,750	5,974,937	7,298,119	8,195,366	9,172,400
Agriculture, forestry, and water related expenditure (Note 1)	387,899	451,053	499,357	487,646	566,231
Percentage	7.8%	7.5%	6.8%	6.0%	6.2%

Source: Xi'an Statistical Yearbook
Note 1: As we could not confirm any financial data specific to the water sector, we used the data above as a substitute.

The financial statuses of respective programs are shown below.

(1) Water Supply System Development Program

Although water rate income alone cannot cover operation and maintenance costs, resulting in a slight deficit, the fee collection rate is high at 99.5%-99.8% as shown in Table 12. In addition, with regard to the income and expenditure of the most recent two years, the total turnover including water and sewage rate income and non-operating income exceeds the total expenditure, indicating that income and expenditure are well balanced.

Table 12: Income and Rate Collection Rate

Unit: 10,000 yuan

	2014	2015
Total income	94,951	99,110
Water supply fee income	80,460	88,831
Non-operating income	14,491	10,279
Total expenditure (Note 1)	82,958	91,978
Rate collection	99.65%	99.68%

Source: Answer to the questionnaire by the implementing agency
Note 1: Including operation and maintenance costs, labor costs, etc.

As the water supply program is implemented as a public utility service, if operation and maintenance budget is not sufficient, it would be supplemented by a subsidy from the municipal government; however, at the time of the ex-post evaluation, we did not see any need for that. When one also takes into account the stable financial status of the municipal government, there is no problem in financial aspects for the sustainability in this area.

(2) Sewage Treatment Plant/Drainage Pipe Network/Drainage System Development Program

Sewage treatment, flood mitigation, and urban drainage programs are not operated as an individual profit-making business, as they are operated and maintained by a state enterprise under the jurisdiction of the municipal government. For this reason, we were given an answer that there are no detailed financial data at the implementing agency or they cannot be disclosed. From what we know from the interviews with sub-project implementing agencies, the following has been confirmed with regard to the financial management situation.

1) The water service company collects from users a sewage fee in combination with a water charge, and the collection rate is stable.
2) The sewage treatment plant in the Southwest area receives no revenue from a sewage fee. It receives all of its maintenance cost as a subsidy from the high-tech zone.
3) The sewage treatment plants of Yuanle Village and the Northern Suburb use a sewage fee and a subsidy for the maintenance fee.

Based on the above, with regard to the financial status of all the sewage projects, it can be evaluated that a stable financial base is being maintained as, although direct profitability of the sewage projects is low, operation and maintenance are carried out assuming there is financial assistance from the municipal government.

On the basis of the above, revenue source for expenditures required for operation and maintenance of the water, sewage, and drainage program is warranted in the finances of the

Xi'an Municipal Government and, according to the interviews with implementing agencies, it is expected that assistance from the government will continue for the time being; therefore, we see no problems with sustainability of operational and maintenance expenditures.

3.5.4 Current Status of Operation and Maintenance

The status of operation and maintenance of each sub-project after the completion of the project is good and facilities and equipment are operating without a problem. With respect to spare parts and engineers and support for maintenance, we were able to confirm that it is possible to procure or deal with all of them domestically and there have been no particular problems. In field study, we conducted an interview with the employees in charge of the operation and management, and confirmed that the following operation and maintenance are carried out in relation to respective facilities:

Table 13: Status of Operation and Maintenance

Sub-project	Status of Operation and Maintenance
Urban Water Distribution Network	Regular patrolling, monitoring, and routine inspection are carried out in relation to chlorine treatment facilities, hoisting equipment, pumps, electrical facilities, clean water reservoirs, and so on. The Water Quality Management Department was established inside Xi'an Municipal Facility Administration Bureau which is in charge of operation and maintenance; they measure 106 items of water quality as prescribed by the national standard and the results of the test are recorded as water quality measurement report which is reported to supervisory organizations including Xi'an Municipal Environmental Protection Bureau.
Yuanle Village Sewage Treatment Plant	Operation and maintenance are carried out under common perception with respect to daily operation, including maintenance, testing, and monitoring where everyone understands what has been set out to do. At the treatment plant, they take water samples every day to measure the water quality. Part of the operation, the sludge digestion tank installed by this project, has been suspended since the end of 2015; however, that does not cause any problem in relation to the operation of the sewage plant itself.
Sewage Treatment Plant Project (Southwest)	Operation and maintenance are carried out on the basis of patrol inspection and routine maintenance once a month. To verify whether the treatment method is appropriate, they send a sample of treated water to a state-designated organization to measure the water quality.
Sewage Treatment Plant Project (North)	Patrolling monitor is carried out to check operational status of the facilities, measurement of water quality of the meters, etc. on a regular basis. Measurement of the quality of treated water is carried out every day at the laboratory in the sewage plant, and the results of the measurement are cross-checked with the data of online measurement equipment to see if there is any malfunction of equipment.
Drainage Pipe Network Reconstruction	They carry out patrol inspection of each pipe once a month, reinforcement of pipes before flood/snow season, and sampling of rainwater once a month.
Treatment Project of Drainage System	They carry out daily cleaning, replacement of parts by patrol inspection of facilities once a month, and regular water quality checking. At the time of the year when heavy rain tends to occur, they check the weather forecast in advance, increase the frequency of the patrol inspection, and monitor water levels, etc. When they spot abnormalities or overflow while patrolling, they send a rescue team to the site and issue an evacuation order to the residents around the site.

Source: Answer to the questionnaire by the implementing agency and answer to the hearing at the time of local study

On the basis of above, the related policy and institutional aspects of this project in terms of organizational aspects, technical aspects, and financial aspects are all without problems; therefore, the sustainability of project effects is high.

4. Conclusion, Lessons Learned and Recommendations

4.1 Conclusion

This project was implemented in order to contribute to water environment improvement in Xi'an City, Shaanxi Province, including reduction in intracity river water pollution, clean water supply, and flood disaster reduction by improving sewage treatment plants, water pipe networks, and drainage canals in the city. The relevance of the project is high because of its consistency with the development policies and needs of China at the national, provincial, and municipal levels in the period from the appraisal to the present time. The equipment improved in the sub-project has been steadily operated, and main indicators have generally reached the planned targets, including the volume of sewage treatment and reduction in pollutants. Judging from these facts, it can be evaluated that this project plays an effective role in reinforcing the functions of urban water and sewer services and flood control. As a result, this project has contributed to water quality improvement, clean water supply, and flood disaster reduction in Xi'an City. Thus, effectiveness and impact of the project are high. However, the efficiency of the project was fair because of its period and cost that exceeded the plan. With regard to the sustainability of this project, no significant problem is seen in organizational capacity and technical aspect. Xi'an City has stably continued financial expenditure on water, sewer, and drainage systems. This project is managed well as a public service with stable financial assistance. Accordingly, such assistance is expected to continue in the future. Thus, the sustainability of this project 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 respect to the sludge digestion tank at the Xi'an Yuanle Village Sewage Treatment Plant, as it has been some time since the suspension of operation at the end of 2015, it is feared that the equipment could deteriorate. It is necessary to urgently consider measures, in addition to coordination toward functional recovery, to prevent deterioration; for example, request for short-term support of the manufacturer for the purpose of maintaining the condition of the equipment, and a short-to-middle term work plan toward operation.

4.2.2 Recommendations to JICA

None

4.3 Lessons Learned

Improvement of the effects of development by expansion of related policies taking advantage of Japanese ODA loan.

As mentioned in “Effectiveness and Impact,” in the Comprehensive Treatment Project of Drainage System in the Northwestern Suburb of Xi’an City, a sub-project of this project, Xi’an Water Conservation Museum was established, taking advantage of the drainage system constructed by the project (Tuanjie Reservoir Water Way) through the efforts of the municipal government. It is considered that the Xi’an Municipal Government had an intention to enhance the effects of an ODA loan project; for example, realization of continuous introduction of related environmental improvement projects on its own funds, by taking advantage of the output of Japanese ODA loan as a catalyst for related measures toward environmental improvement and demonstrating its effects.

To enhance the effects of implementation of an ODA loan project, it is desirable to ensure that we consider a scenario which would further enhance the effects of development by proposing a project which is highly consistent with the infrastructure, comprehensive urban development plans, and policies, etc., of the implementing agency of the project, positioning the effects of the ODA loan project in such way that it facilitates a subsequent development plan, and letting it lead to further input.

Comparison of the Original and Actual Scope of the Project

Item	Plan	Actual
(1) Project Outputs Urban Water Distribution Network	(1) Installation of water pipe: 260 km (2) Development of water pond, water distribution station, water quality measurement equipment, and central control system	(1) Installation of water pipe: 215 km (2) As planned
Yuanle Village Sewage Treatment Plant	Treatment capacity: 200,000 m^3/day	As planned
Sewage Treatment Plant Project (Southwest)	(1) Treatment capacity: 80,000 m^3/day (2) Installation of sewage pipe: 60 km	(1) As planned (2) Installation of sewage pipe: 58.6 m
Sewage Treatment Plant Project (North)	(1) Treatment capacity: 100,000 m^3/day (2) Installation of sewage pipe: 160 km	(1) As planned (2) Installation of sewage pipe: 159.1 km
Drainage Pipe Network Reconstruction	Installation of sewage pipe: 231 km	Installation of sewage pipe: 230 km
Treatment Project of Drainage System	(1) Development of drainage system: 43 km (2) Development of Tuanjie Reservoir water way: 12.675 km	(1) Development of drainage system: 31.95 km (2) Development of Tuanjie Reservoir water way: 12.676 km (3) Installation of three bridges, two pedestrian overpasses, floodwall, pump, and water gate
Training program	Training program in Japan for the employees of implementing agency: 70 people	Personnel of the implementing agency of this project and all the implementing agencies of the sub-projects:77 people in total (63 men and 14 women)
(2) Project Period	April 2005 - October 2011 (79 months)	April 2005 - October 2013 (103 months)
(3) Project Cost Amount Paid in Foreign Currency	19,564 million yen	18,324 million yen
Amount Paid in Local Currency	18,832 million yen (1,416 million yuan)	26,749 million yen (1,916 million yuan)
Total	38,396 million yen	45,073 million yen
ODA Loan Portion	19,564 million yen	18,324 million yen
Exchange Rate	1 yuan=13.3 yen (As of September 2004)	1 yuan=13.96 yen (Average between 2005 and 2013)
(4) Final Disbursement	July 2014	