People's Republic of China

Ex-Post Evaluation of Japanese ODA Loan Project

Xi'an Environmental Improvement Project

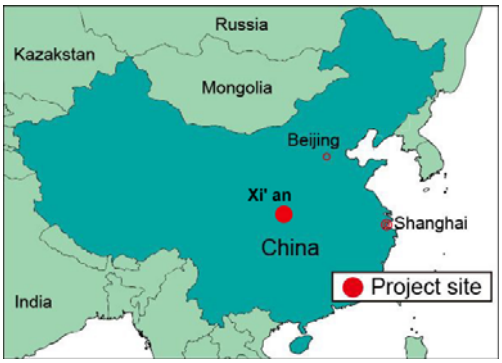
External Evaluator: Akemi Serizawa, Global Link Management, Inc.

0. Summary

The objective of this project was to contribute to the enhancement of wastewater treatment capacity in Xi'an by constructing No.3 and No.4 Wastewater Treatment Plants and developing drainage pipeline networks, and then to the water quality improvement of the rivers and better living conditions. This project was highly relevant with China's development plans, development needs, as well as Japan's ODA policy; therefore its relevance is high. It has contributed to the enhancement of the wastewater treatment capacity in Xi'an as planned and also to the water quality improvement of the rivers to a certain extent; therefore its effectiveness and impact are high. The project cost was higher than planned and the project period was significantly longer than planned; therefore the efficiency is low. Sustainability of the project effect is high as no major problems have been observed in structural, technical and financial aspects of the operation and maintenance system.

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

1. Project Description



Project Location

Xi'an No.3 Wastewater Treatment Plant

1.1 Background

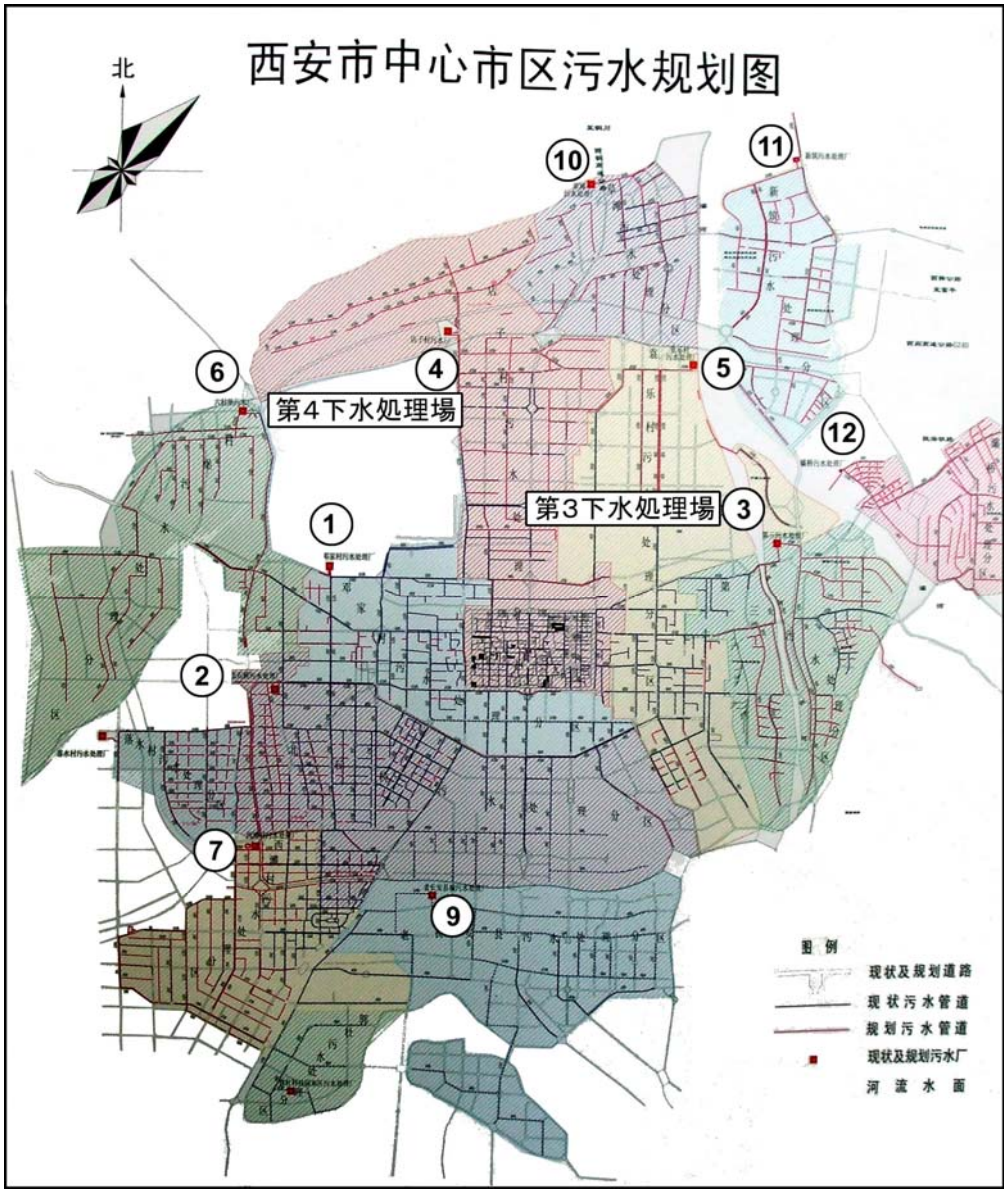
Environmental pollution in China was serious since the 1980s due to the rapid industrialization and increase of population as consequences of rapid economic growth. The Chinese government strengthened its environmental protection policy in the late 1990s, but it had limitations to solve the problem. The domestic sewage had increased by the urbanization and improved standard of living, and became more than the half of the total volume of sewage

in the country in 2000, while the industrial sewage, which had been the main source of water pollution before, had decreased by various efforts. In 2000, the percentage of wastewater treated in large cities in China was only 34%, and the rivers were heavily polluted. Also in Xi'an, the capital of Shaanxi Province and one of the oldest cities in China that attracts many tourists, anti-water pollution measures had not cached up the development of the city and the water pollution of the rivers was serious. The percentage of wastewater treated of Xi'an was only 23% in 2002. Xi'an was urged to enhance its wastewater treatment capacity.

1.2 Project Outline

The objective of the project was to enhance the wastewater treatment capacity in Xi'an by the construction of No.3 and No.4 Wastewater Treatment Plants and the development of drainage pipeline networks, thereby contributing to the water quality improvement of the rivers and to better living conditions in Xi'an.

Loan Approved Amount / Disbursed Amount	9,764 million yen / 8,917 million yen
Exchange of Notes Date / Loan Agreement Signing Date	March 2002 / March 2002
Terms and Conditions	Wastewater treatment plants Interest rate: 0.75%, Repayment Period: 40 years (Grace period: 10 years), Bilateral-tied Drainage pipelines Interest rate: 1.70%, Repayment Period: 30years (Grace period: 10 years), General untied
Borrower / Executing Agency	Government of the People's Republic of China / People's Government of Xi'an City
Final Disbursement Date	January 2010
Main Contractor (Over 1 billion yen)	China Xi'an International Economic Technical Trade Group (China) / China National Chemical Construction Corporation (China) / Beijing High Standard Environmental Equipment Co., Ltd. (China)
Main Consultant (Over 100 million yen)	None
Feasibility Studies, etc.	Feasibility Study by Xi'an Municipal Engineering Design and Research Institute, Co., Ltd. (August 2001)
Related Projects	JICA: Xi'an Water Supply Project I,II (1993,1995), Shaanxi Province Water Environmental Improvement Project (2005) Denmark: Xi'an No. 1 Wastewater Treatment Plant Nordic Development Fund: Xi'an No. 2 Wastewater Treatment Plant



Source: Xi'an Sewage Treatment Co., Ltd.
Note: Numbers in circles indicate the locations of the wastewater treatment plants (1st Wastewater Treatment Plant, etc.)

Figure 1. Project sites

2. Outline of the Evaluation Study

2.1 External Evaluator

Akemi Serizawa (Global Link Management, Inc.)

2.2 Duration of Evaluation Study

Duration of the Study: July 2011 - September 2012

Duration of the Field Study: 9 October - 22 October 2011, 21 February - 2 March 2012

2.3 Constraints during the Evaluation Study

The water quality improvement of the rivers was one of the intended impacts of the project. However, the contribution of the project did not clearly appear in the water quality data of the rivers because of the geographical conditions of the inspection points and the effects of polluted water from other sources that were not covered by the wastewater treatment plants constructed by this project. This limitation is commonly experienced in other wastewater treatment projects in large cities. The details are discussed in the section of Impact.

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

3.1 Relevance (Rating: ③[2])

3.1.1 Relevance with the Development Plan of China

The 10th Five-Year Environmental Conservation Plan of China (2001-2005) aimed to reduce the total pollutant emissions by 10% from the year 2000, to increase the percentage of wastewater treated[3] to 45% in the urban areas and to improve the water quality of the large rivers. The 10th Five-Year Plan of Shaanxi Province aimed to establish more wastewater treatment plants in large cities including Xi'an and raise the percentage of wastewater treated in Xi'an to more than 50% by 2005.

The objectives of the 11th Five-Year Plan of China (2006-2010) included the prevention of water pollution and the improvement of percentage of wastewater treated in large cities to 70% by construction of wastewater treatment plants. The 11th Five-Year Plan of Shaanxi Province also intended to increase the percentage of wastewater treated in the province to 60% by construction of wastewater treatment plants. The 11th Five-Year Plan of Xi'an aimed to prevent water pollution, construct wastewater treatment plants including No.3 and No.4 plants by this project as well as raise the percentage of wastewater treated to 70%. It also planned to develop drainage pipeline networks and to increase the percentage of population served by sewage pipelines to 85% and that by rainwater pipelines to 70%.

The ongoing 12th Five-Year Plans at all levels retain the same direction. The national plan aims to increase the percentage of wastewater treated in the urban areas to 85%. The provincial plan of Shaanxi Province promotes water saving and recycling of water. The municipal plan of Xi'an aims to increase wastewater treatment plants. The Strategic General Plan of Xi'an Municipality (2004-2020) aims to increase the percentage of wastewater treated to 70% by 2010 and to 90% by 2020.

The project was in line with the development plans of the national, provincial, and municipal levels both at the appraisal and ex-post evaluation as the prevention of water

[1] A: Highly satisfactory, B: Satisfactory, C: Partially satisfactory, D: Unsatisfactory
[2] ③: High, ② Fair, ① Low
[3] Percentage of wastewater treated = Amount of wastewater treated / Amount of wastewater

pollution and construction of wastewater treatment plants were among the priorities.

3.1.2 Relevance with the Development Needs of China

At the time of the appraisal, the percentage of wastewater treated in Xi'an central districts was only 23%. The pollution of river water was serious because of the insufficient wastewater treatment capacity. In 2001, the water quality of Wei River, which runs from west to east through the northern part of the central districts, was worse than Class V (the worst category) of the national water quality standards. At that time, Xi'an central districts had only two wastewater treatment plants (No.1 and No.2) of 270,000 m^3/day capacity in total while other three plants were to be constructed. This project aimed to enhance the wastewater treatment capacity by construction of No. 3 and No.4 Wastewater Treatment Plants (100,000 m^3/day and 250,000 m^3/day capacity respectively) as well as to develop the drainage pipeline networks.

At the time of the ex-post evaluation, the percentage of wastewater treated in Xi'an central districts had increased to 86% by 2010 and the wastewater treatment capacity had reached to 1,180,000 m^3/day by 2011. The municipality plans to enhance its wastewater treatment capacity to 1,910,000 m^3/day by 2020 by construction of new plants. As discussed in the section of Impact later, the water quality in 2010 at the inspection points of downstream of No.3 and No.4 Wastewater Treatment Plants was still Class V (the worst category) of the national Environmental Quality Standards for Surface Water (GB3838-2002) or worse than that. The contribution of the project to the water quality improvement of the rivers did not clearly appear on the data because the effect of polluted water from other sources that were not covered by the wastewater treatment plants constructed by this project, while the citizens and the project executing agencies recognized the positive change in water quality. The municipality is intended to continue efforts for the water quality improvement of the rivers.

From the above, the needs to enhance the wastewater treatment capacity in Xi'an were high both at appraisal and ex-post evaluation.

3.1.3 Relevance with Japan's ODA Policy

Japan's Economic Cooperation Program for China (October 2001), Overseas Economic Cooperation Implementation Policy of JICA (JBIC at that time) and JICA country program implementation policy 2001 all prioritized environmental conservation. The country program implementation policy gave priorities to water infrastructure projects such as construction of wastewater treatment plants and promotion of water saving and water recycling. This project was in line with the Japan's ODA policies as it aimed to enhance the wastewater treatment capacity of Xi'an.

The project has been highly relevant with the country's development plan, development needs, as well as Japan's ODA policy; therefore its relevance is high.

3.2 Effectiveness[4] (Rating: ③)

3.2.1 Quantitative Effects (Operation and Effect Indicators)

(1) Enhancement of wastewater treatment capacity

Table 1 shows the change in the wastewater treatment capacity of Xi'an central districts. This project constructed No.3 and No.4 Wastewater Treatment Plants (100,000 and 250,000 m^3/day respectively), which have 30% of the total wastewater treatment capacity in Xi'an central districts (1,180,000 m^3/day) in 2011. The total extension of the drainage pipelines laid by the project was 117.6 km, which composed 10% of that in Xi'an central districts. The share of the project in the increase of the wastewater treatment capacity since 2001 (at appraisal) is 38% (350,000 m^3/day out of 910,000 m^3/day) and that in the total extension of the drainage pipelines is 16% (117.6 km out of 710 km). It shows that the project had contributed to the increase of capacity to a certain extent.

Table 1. Wastewater treatment capacity in Xi' an central districts

Year	2001	*(2006 Target)*	2006 Actual	2007 Actual	2008 Actual	2009 Actual	2010 Actual	2011 Actual
Percentage of wastewater treated	23%	*(65%)*	60%	62%	65%	81%	86%	No data
Wastewater treatment capacity (10,000 m^3/day)	27	*(62)*	37	37	62	62	87	118
Total extension of drainage pipelines (km)	484.12	*(No data)*	951	1,033	1,033	1,145	1,145	1,194
Output of this project			Drainage pipelines 117.6 km (Dec. 2005) No.3 Plant (100,000 m^3/day) (Dec. 2006)		No.4 Plant (250,000 m^3/day) (Oct. 2008)			

Source: Appraisal documents, Project Completion Report (PCR), Questionnaire responses

The wastewater treatment plants in Xi'an central districts are shown in Table 2 and Figure 1.

[4] Sub rating for Effectiveness is to be put with consideration of Impact.

Table 2. Wastewater treatment plants in Xi'an central districts

(Unit: 10,000 m^3/day)

Plant	Location	Operating company	2001	2006	2008	2010	2011	Expansion plan
No.1	Dengjia Village	Xi'an Venture Water Co., Ltd.	12	12	12	12	12	+6
No.2	Beishiqiao		15	15	15	15	15	+10
No.3	Textile City	Xi'an City Sewage Treatment Co., Ltd.	-	**10 (*1)**	10	15 (+5)	15	+12.5 To be completed in June 2012
No.4	Dianzi Village		-	-	**25 (*1)**	25	25	
No.5	Yuanle Village		-	-	-	**20 (*2)**	20	
No.6	Liucunbao							+10 To be completed in July 2012
No.7	Southwest suburb, High-Tech Zone	Xi'an High-Tech Zone Sewage Treatment Co., Ltd.					**8 (*2)**	
No.8	Cunhuang Town in Gaoling County	Xi'an Economic Development Zone Sewage Treatment Co., Ltd.					**10 (*2)**	
No.9	Chang'an District	Beijing Sound Group					5	
No.10	Caotan	Xi'an City Sewage Treatment Co., Ltd.						+4 Completed in Dec. 2011. Under test-run.
No.11	Xingzhu Street	Xi'an International Trade and Logistics Park Administrative Committee					5	
No.12	Ba Bridge	Chanba Ecological District Administrative Committee					2.5	
Total			27	37	62	87	117.5	(*3)

(Note) (*1) No.3 Plant (100,000 m^3/day) and No.4 Plant (250,000 m^3/day) were constructed by this project.
(*2) No.5 Plant (200,000 m^3/day), No.7 Plant (80,000 m^3/day) and No.8 Plant (100,000 m^3/day) were constructed by another JICA loan project.
(*3) Constructions of several other wastewater treatment plants are being planned.

Source: Executing agency

Table 3 shows the actual volume of treated wastewater of No.3 and No.4 Wastewater Treatment Plants. The rates of facility utilization were around 85% as of 2011.

Table 3. Actual volume of treated wastewater of No.3 and No.4 Plants

(Unit: 10,000 m^3/day)

Year	2007	2008	2009	2010	2011
No.3 Plant	6.83	8.52	8.59	8.86	12.53 (rate of facility utilization: 84%)
No.4 Plant	N/A	N/A	16.59	21.34	21.55 (rate of facility utilization: 86%)

Source: Questionnaire responses

Table 4 and Table 5 below show that in 2011 both plants achieved the targets of the annual emissions and those of the quality of treated water at the completion of construction (it was planned to be in 2006) which had been set up at appraisal. The actual wastewater treatment capacity, emissions of COD and other pollutants and quality of treated water indicate that the two plants have been functioning as expected in view of the quality and quantity. Although the water quality at the entrance of the wastewater treatment plants in 2011 (see data at the entrance in Table 5) was worse than that of 2001, the emissions (see Table 4) and the water quality (see Table 5) at the exit were much better than the targets. While data of annual emissions and quality of treated water at the construction completion of the plants (December 2006 for No.3 Plant and October 2008 for No.4 Plant) were not available, the water quality at the entrance at that time was likely to be better than that of present, and therefore the two plants were likely to have achieved the targets of emissions and quality of treated water when they started operation.

Table 4. Annual Emissions of No.3 and No.4 Wastewater Treatment Plants

(Unit: ton/year)

Year	2001 (baseline)	*2006 (target)*	2011 (actual)
No.3 Plant COD (*1)	14,235	*(2,190)*	1,638
No.3 Plant BOD (*2)	7,300	*(730)*	540
No.3 Plant SS (*3)	9,125	*(730)*	526
No.4 Plant COD	37,413	*(5,475)*	2,540
No.4 Plant BOD	20,988	*(1,825)*	560
No.4 Plant SS	22,813	*(1,825)*	827

(Note) (*1) COD (chemical oxygen demand)
(*2) BOD (biochemical oxygen demand)
(*3) SS (suspended solids)

Source: Appraisal documents, PCR, Questionnaire responses

Table 5. Water quality of treated wastewater

(Unit: mg/L. MPN/100mL for total coliform)

Year	2001 (baseline)		*2006 (target) (*5)*		2011 (actual)	
Plant	No.3	No.4	No.3	No.4	No.3	No.4
COD cr (*1) Entrance	390	410	*N/A*	*N/A*	666.67	615.92
COD cr Exit	N/A	N/A	*<60*	*<60*	38.07	33.22
BOD5 (*2) Entrance	200	230	*N/A*	*N/A*	240.67	346.11
Exit BOD5	N/A	N/A	*<20*	*<20*	12.56	7.33
SS Entrance	250	250	*N/A*	*N/A*	565.67	477.89
SS Exit	N/A	N/A	*<20*	*<20*	12.22	10.82
TP (*3) Entrance	4	5	*N/A*	*N/A*	7.37	4.37
TP Exit	N/A	N/A	*<0.5*	*<1.0*	0.37	0.72
NH_4^+-N (*4) Entrance	30	40	*N/A*	*N/A*	42.81	32.45
NH_4^+-N Exit	N/A	N/A	*<15*	*<15*	4.70	1.83
Total coliform Entrance			*<1000 thousand*	*<1000 thousand*	-	-
Total coliform Exit	N/A	N/A	*<300 thousand*	*<300 thousand*	*<10 thousand*	*<10 thousand*

(Note) (*1) COD cr: Chromium chemical oxygen demand

(*2) BOD5: Biochemical oxygen demand of wastewater during decomposition occurring over a 5-day period.

(*3) TP: Total phosphorus

(*4) NH_4+-N: Ammonia nitrogen

(*5) The targets of 2006 are the same as Class 1-B of the national Discharge standard of pollutants for municipal wastewater treatment plant (GB18918-2002).

No. 3 Wastewater Treatment Plant

No. 3 Wastewater Treatment Plant

3.2.2 Qualitative Effects

(1) Recycling

Recycling of treated water and sludge was expected in this project. No.3 Wastewater Treatment Plant has a water recycling capacity of 50,000 m^3/day as planned and the recycled water is used for cooling of industrial plants, street cleaning, utility water in construction sites, watering plants, car washing and toilets. The actual volume of recycled water in 2011 was 14,000 m^3/day. According to Xi'an City Sewage Treatment Co., Ltd. that

manages the plant, there has been no profit from recycling of treated water so far because the cost and sales price are same (1.25 yuan/ m^3), but the profit is expected in the near future as the cost of water recycling would be reduced after the upgrading of the plant from Class 1-B to 1-A of the "Discharge standard of pollutants for municipal wastewater treatment plant" (GB18918-2002) and the quality of treated water would be improved.

The original plan of the project was to dispose most of the sludge to a landfill and recycle some as fertilizer for urban greening if they meet the quality standard. Currently, all sludge is disposed to a landfill after biological treatment because the technology of drying sludge has not been fully developed and the recycling cost is high.

3.3 Impact

3.3.1 Intended Impacts

(1) Water quality improvement of the rivers

There are eight large rivers in Xi'an. Wei River is the largest and runs from west to east in the northern part of Xi'an central districts. Chan River runs from south to north in the eastern part of the central districts, and Ba River runs east of Chan River. No.3 Wastewater Treatment Plant is located in the eastern part of the central districts along Chan River at 4.9km upstream of the junction of Chan River and Ba River. No.4 Plant is located in the northern part of the central districts along Wei River at 6.8km upstream of the junction of Wei River and Zao River.

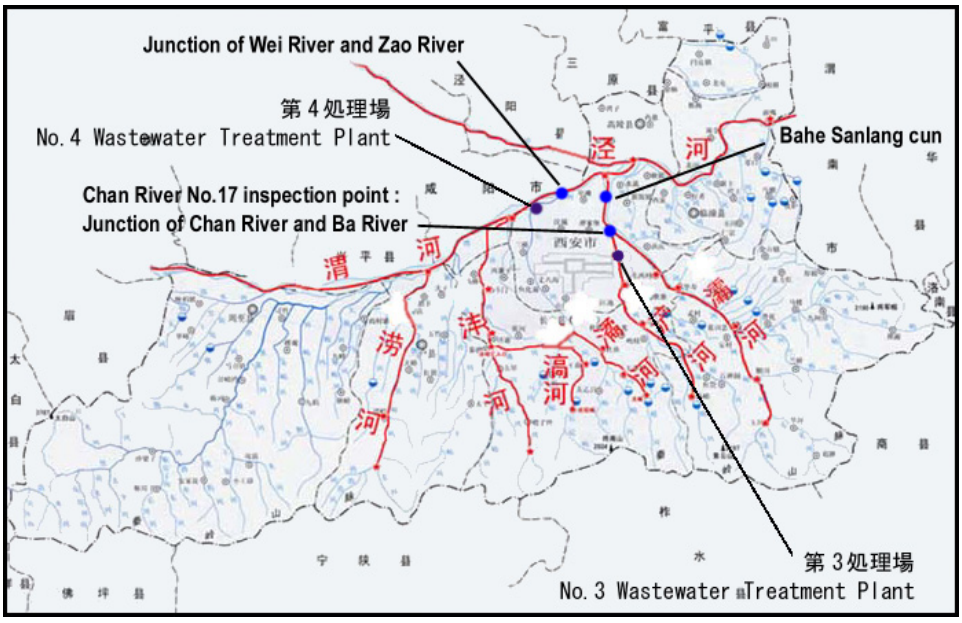


Figure 2. Rivers in Xi'an

At appraisal, JICA and the executing agencies agreed to measure COD, BOD5, SS, TP, and NH_4^+-N of Chan River, although they did not specify the inspection points, baseline or target. Regarding Wei River, they agreed on the baseline and target of the water quality as shown in Table 6 below, although the inspection points were not identified.

Table 6. Target of water quality of Wei River (at appraisal)

(Unit: mg/L)

Year	2001 (baseline)	2005 (target)	2010 (target)
COD	40	33	20
BOD5	12	10.1	4
NH_3^+-N (*1)	0.15	0.12	0.02

Note: (*1) NH_3^+-N: Ammonia nitrogen
Source: appraisal documents

Table 7 shows the national Environmental Quality Standards for Surface Water.

Table 7. Environmental Quality Standards for Surface Water, China (GB3838-2002)

(Unit: mg/L)

	Class I	Class II	Class III	Class IV	Class V
COD	15	15	20	30	40
BOD	3	3	4	6	10
NH_3^+-N	0.15	0.5	1.0	1.5	2.0

Water quality data from three inspection points were obtained from executing agencies as shown in Table 8, 9, 10 below.

Table 8. Chan River No.17 inspection point
(Junction of Chan River and Ba River:
4.9km downstream of No.3 Wastewater Treatment Plant)

(Unit: mg/L)

Year	2006	2007	2008	2009	2010
COD	77	50	62	103	56
BOD	20	9	19	31	13
NH_3^+-N	9.908	9.274	4.966	3.110	3.508

Note: No.3 Wastewater Treatment Plant was constructed in December 2006.
Source: Executing agencies

At this inspection point, the water quality data of 2007 and 2008 were better than those of 2006 before No.3 Plant was constructed. The water quality at this inspection point is affected more by Ba River, which is not covered by No.3 Plant, than Chan River, as the former has a flow of 552 million m^3/year and the latter has 132 million m^3/year. Therefore, the effect of No.3 Plant on this inspection point is limited. Because wastewater from the upstream of Ba River had increased due to the rapid development since 2008, the data did

not show a clear trend of improvement of water quality since then. The water quality of this inspection point in 2010 was worse than Class V (the worst category) of the national Environmental Quality Standards for Surface Water.

Table 9. Ba River Sanlang cun

(13.6km downstream of No.3 Plant. 8.7km downstream of No.17 inspection point)

(Unit: mg/L)

Year	2006	2007	2008	2009	2010
COD	45	44	14	49	38
BOD	8	7	4	13	9
NH_3^+-N	9.568	17.17	5.084	5.169	0.936

Note: No.3 Wastewater Treatment Plant was constructed in December 2006.
Source: Executing agencies

The water quality of Sanlang cun was better than that of No.17 inspection point despite the fact that the former is downstream of the latter. The reasons are that Chanba Ecological Zone is located between these two inspection points and Xi'an Municipal Government had made efforts for environmental conservation in this area, and that the pollution materials tend to sink to the bottom of the river due to the slow flow of water at this point. The water quality in 2010 was Class V of the national Environmental Quality Standards for Surface Water.

Table 10. Junction of Wei River and Zao River

(6.8km downstream of No.4 Plant)

(Unit: mg/L)

Year	2006	2007	2008	2009	2010
COD	685	512	274	161	127
BOD	220	198	84	49	41
NH_3^+-N	22.64	13.5	25.12	33.16	19.71

Note: No.4 Plant was constructed in October 2008.
Source: Executing agencies

At this inspection point, the water quality has improved since the construction of No.4 Plant. In 2010, however, it was still worse than Class V of the national Environmental Quality Standards for Surface Water.

The contribution of the project did not clearly appear in the above water quality data of the rivers because of the geographical conditions of the inspection points and of the polluted water from other sources that were not covered by the wastewater treatment plants constructed by this project.

Comparison between the baseline, the target and the actual figures was not possible because of the following reasons. At appraisal, the inspection points of Wei River were not specified while there were baseline data and target. Regarding Chan River, there were no

baseline or target, and inspection points were not specified.

Although the water quality data did not clearly show the improvement of the water quality at these inspection points, 97% of the respondents of the beneficiary survey (Table 11) felt that the water quality (turbidity and smell) had improved mostly between 2007 and 2009 after the construction of No.3 and No.4 Wastewater Treatment Plants. This project has contributed to the water quality improvement of rivers at least to a certain extent as most respondents thought that it happened after the construction of these plants.

(2) Improvement of living conditions in Xi'an

According to the beneficiary survey results, 76% of the respondents consider that the sanitary conditions at home have improved and 95% consider that that of Xi'an have improved thanks to the enhanced wastewater treatment capacity. They pointed out that there were fewer stenches of the rivers and that sewage water no longer overflew in heavy rain thanks to the drainage pipelines. They think that the living environment along the rivers has been improved as well as at home and in the community.

Table 11. Result of the beneficiary survey

(100 respondents living in the catchment areas either of No.3 or No.4 Plant. 53 men and 47 women)

Effects of No.3 and No.4 Wastewater Treatment Plants	Percentage of respondents who agree with the statement in the left column
Wastewater treatment capacity of Xi'an has been enhanced.	100%
Wastewater is managed appropriately	100%
Water quality of the rivers has been improved.	97% (Turbidity 97%, smell 95%) 84% think that it improved between 2007 and 2009.
Sanitary conditions at home have improved thanks to the enhanced wastewater treatment capacity.	76%
Sanitary conditions in Xi'an have improved thanks to the enhanced wastewater treatment capacity.	95%
Wastewater treatment fees are appropriate.	88%
There are no negative impacts.	97%

The respondents pointed out following impacts of this project.

- Birds have returned to the rivers.
- We can enjoy walking along the rivers and playing on the riverbanks as the stenches from the rivers reduced.
- We can see the water plants and stones in the bottom of the rivers through the clearer water.
- Water from Wei River is used for irrigation.
- The 3rd stage of the Formula 1 Powerboat Racing 2007 (held in Xi'an in October 2007) and the World Horticultural Expo 2011 (held in Chanba area from April to October 2011) were possible because the water quality of the rivers had been improved.

- Hanchen Lake (downstream of No.4 Plant) became a popular tourist destination thanks to the improved water quality and fewer stenches.
- Thanks to the improved drainage pipeline networks, there is no overflow of the sewage in heavy rain and the pipelines are no longer blocked. There are no more stenches in the community after heavy rains. There are fewer mosquitos.

3.3.2 Other impacts

(1) Impacts on the natural environment

Both No.3 and No.4 Wastewater Treatment Plants were designed to meet Class 1-B of the national "Discharge standard of pollutants for municipal wastewater treatment plant." They always operate automated measurement system of the quality of treated water at the exit regarding 12 items including COD, BOD5 and SS (please refer to Table 5 as well)[5] according to the standard, and they report the results monthly to the municipal Environmental Protection Bureau.

No negative impacts of this project have been observed on the natural environment because the wastewater treatment plants take measures to prevent environmental pollution. In order to prevent odors from the wastewater treatment plants, the related facilities are sealed and the green belts were built around the plants for insulation. The pomp stations have noise insulation systems. The reservoirs in the plants have large capacity to prevent the wastewater from overflowing into the rivers in case of emergency.

(2) Land Acquisition and Resettlement

Table 12. Land acquisition

Wastewater treatment plant	Land acquired	Cost of land acquisition	Resettlement	Compensation
No.3	22.52ha	46.08 million yuan	None	None
No.4	58.77ha	61.92 million yuan	None	None

Source: Questionnaire responses

Land acquisition process was carried out by the Bureau of Land and Resources of Xi'an. Its Baquao Branch and Weiyang Branch were responsible for No.3 and No.4 Wastewater Treatment Plants respectively. They observed the land acquisition plans and obtained the consent from the land owners. As explained in the section of Efficiency (project period), the decision of land acquisition for No.4 plant was delayed because of the lengthy discussions with the organizations around the project site. However, the executing agency explained that there were no problems in the negotiation process with the land owners. There was no resettlement.

[5] The twelve items are COD, BOD5, SS, oil extracted from animals and plants, petroleum, anionic surfactant, nitrogen, ammonia nitrogen, total phosphorus, color, pH, and total coliform.

(3) Unintended Positive/Negative Impacts

As reported in the beneficiary survey results, the improved water quality of the rivers made it possible to hold the 3rd stage of the Formula 1 Powerboat Racing 2007 (held in October 2007) and the World Horticultural Expo 2011 (held in Chanba District from April to October 2011) in Xi'an. In the expo site, good quality water was available in the ponds, streams and water facilities.

This project has largely achieved its objectives; therefore its effectiveness and impact are high.

3.4 Efficiency (Rating：①)

3.4.1 Project Outputs

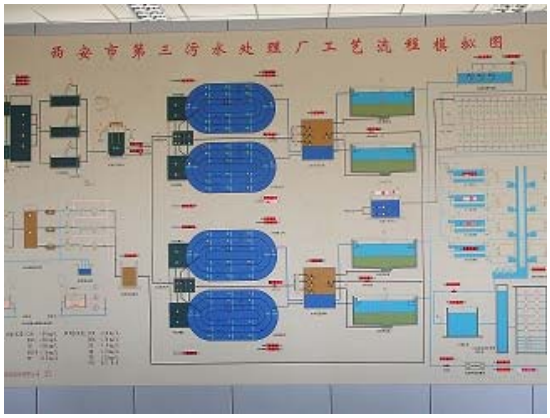
The actual project outputs were as planned, as summarized in Table 13.

Table 13. Outputs

Item	Plan and actual
A. No.3 Wastewater Treatment Plant: 10,000 m^3/day Oxidation ditch system (Orbal system[6]) + Recycled water 50,000 m^3/day	Pomp rooms, first sedimentation tank, biological reaction tank, final sedimentation tank, filtering tank, sludge treatment plant, etc.
B. No.4 Wastewater Treatment Plant 250,000 m^3/day A2O system[7]	Pomp rooms, first sedimentation tank, aeration tank ,final sedimentation tank, etc.
C. Drainage pipeline networks	Total extension: 117.6km (17 sections)

Source: PCR

No.3 Wastewater Treatment Plant
(Orbal oxidation ditch)



No.3 Wastewater Treatment Plant
Monitoring room

[6] Orbal system is one of the oxidation ditch systems. The Orbal oxidation ditch has three concentric channels. The outer channel is an aerated anoxic reactor. The second channel is a mixer. The last channel removes remaining BOD and ammonia.

[7] A2O (Anaerobic-Anoxic-Oxic System): One of the cyclic activated sludge technologies.

3.4.2 Project Inputs

3.4.2.1 Project Cost

The project cost was higher than planned. The estimated project cost at appraisal was 14,990 million yen, of which the Japanese loan was to be used only for the foreign currency portion amounting to 9,764 million yen and the rest was to be financed by the Xi'an Municipal Government and loan from China Development Bank. The actual project cost was 18,156 million yen, of which the Japanese loan covered the foreign currency portion in full amounting to 8,917 million yen and the rest was financed by the Xi'an Municipal Government and loan from China Development Bank. It was 121% of the estimated cost in Japanese yen and 136% of it in Chinese yuan. The increase in the project cost was due to the escalation of the price of raw materials during the extended project period, which is explained in the next section. The maximum average increase in price per year was 62% for steel and 19% for cement between 2006 and 2008. The increase in price of raw materials raised the cost of civil engineering work of No.3 and No.4 Wastewater Treatment Plants (completed in December 2006 and October 2008 respectively), which was financed by local currency.

Table 14. Project cost

	Plan					Actual				
	FC*	LC**		Total		FC	LC		Total	
	Mill. yen	Mill. yuan	Mill. yen	Mill. yuan	Mill. yen	Mill. yen	Mill. yuan	Mill. yen	Mill. yuan	Mill. yen
No.3 Plant	1,965	33	500	164	2,465	1,427	119	1,591	226	3,018
No.4 Plant	3,222	44	653	258	3,875	3,626	226	3,021	497	6,648
Drainage pipeline networks	3,775	252	3,775	503	7,550	3,864	346	4,626	635	8,490
Sub total	8,962	329	4,928	925	13,890	-	-	-	-	-
Price escalation	337	3	49	26	386	-	-	-	-	-
Contingency	465	17	249	48	714	-	-	-	-	-
Total	9,764	348	5,226	999	14,990	8,917	691	9,239	1,358	18,156

Source: Appraisal documents, PCR, questionnaire responses
Exchange rate: 1yuan=JPY15 at appraisal. 1yuan=JPY13.37at ex-post evaluation (average of during the loan period)
Note: FC*: Foreign currency, LC**: Local currency

No.4 Wastewater Treatment Plant

No.4 Wastewater Treatment Plant

3.4.2.2 Project Period

The actual project period was significantly longer than planned. The project period planned at appraisal was 50 months from March 2002 (signing of the Loan Agreement) to April 2006 (completion of inspection). The actual project period was from March 2002 (signing of Loan Agreement) to October 2008 (completion of inspection) with a total of 80 months, which is 160% of the plan.

The delay was due to the postponement of the construction commencement of both No.3 and No.4 wastewater treatment plants. The construction was to be commenced in June 2003, but it was postponed to 2004 due to the SARS pandemic in 2003. The construction of No.3 Plant started in October 2004 and completed in December 2006. The construction of No.4 Plant started in December 2006 and completed in October 2008. The reason for the substantial delay in construction commencement of No.4 Plant was that, after the request for the preliminary review of the land acquisition plan for No.4 Plant was submitted to the Ministry of Land and Resources in March 2004, the new urban master plan of Xi'an was launched, and educational institutions and economic development zones were constructed rapidly around the planned project site of No.4 Plant, and discussions took time to obtain the consent of these neighboring institutions on the construction of No.4 Plant as they had biased views on these plants. Xi'an Municipal Government and the Ministry of Land and Resources repeated discussions, and the land acquisition plan was finally approved in September 2005. They were prepared to find an alternate project site for No.4 Plant at the same time in case that the neighbors did not give consent. They finally agreed with the original project site, and the land acquisition process was complete in November 2006. The new urban master plan of Xi'an assumed co-existence of No.4 Plant and other new institutions surrounding it as the plan of No.4 Plant had existed earlier, and the Municipal Government did not seem to have anticipated the resistance of the neighbors. The rapid development around the planned project site and the resistance caused the delay of the construction of No.4 Plant, which was unexpected by the executing agencies, and they would not be able to avoid the delay. The prolonged discussions with the neighboring institutions to obtain their consent have contributed to, as a result, the smooth operation of the plant.

3.4.3 Results of Calculations of Internal Rates of Return

Financial Internal Rates of Return (FIRR) and Economic Internal Rates of Return (EIRR) at appraisal for each sub-component of this project are shown in Table 15. The Benefits included water charge revenue for the wastewater treatment plants and indirect profit for the calculation of EIRRs. The Costs included construction costs and operation and maintenance costs. The project life was assumed as 23 years for the wastewater treatment plants (which included three years for the construction) and 25 years for the

drainage pipeline networks (which included four years for the construction).

Table 15. Internal Rates of Return at Appraisal

	FIRR	EIRR
No.3 Plant	5.2%	16.12%
No.4 Plant	5.0%	17.17%
Drainage Pipeline Networks	Not calculated	15.67%

Source: Appraisal documents

It was not possible to re-calculate the FIRRs and EIRRs at ex-post evaluation, as the formula used at appraisal were not clear and it was not easy to substitute the values collected at ex-post evaluation in the formula.

The project cost was slightly exceeded the plan, while the project period was significantly exceeded the plan, therefore efficiency of the project is low.

3.5 Sustainability (Rating: ③)

3.5.1 Structural Aspects of Operation and Maintenance

The entities responsible for operation and maintenance of the infrastructures constructed by the project are same as planned. The wastewater treatment plants constructed by the project are operated by Xi'an City Sewage Treatment Co., Ltd., a state-owned company fully financed by Xi'an Municipal Government. The drainage pipeline networks are maintained by the Public Utility Bureau of Xi'an Municipal Government, which is responsible for operation and maintenance of all public infrastructures in Xi'an. In addition to No.3 and No.4 Wastewater Treatment Plants (150,000 m^3/day and 250,000 m^3/day respectively) that were constructed by this project, Xi'an City Sewage Treatment Co., Ltd. also manages No.5 Wastewater Treatment Plant (200,000 m^3/day). It will also operate No. 10 Plant (40,000 m^3/day) that were completed in 2011 and is now under test-run and No.6 Plant (100,000 m^3/day) that is to be completed in July 2012. The total capacity of the wastewater treatment plants managed by this company at present is 600,000 m^3/day, which is more than half of the wastewater treatment capacity of Xi'an central districts (1,180,000 $m^{3/}$day). As indicated in Table 2, there are twelve wastewater treatment plants in Xi'an central districts. All operating companies are state-owned, except for Beijing Sound Group that operates No.9 Plant.

3.5.2 Technical Aspects of Operation and Maintenance

Xi'an City Sewage Treatment Co., Ltd. has 35 senior engineers, 56 engineers and 237 skilled workers. The Public Utility Bureau of Xi'an Municipal Government has 150

engineers specialized in operation and maintenance of infrastructure. In view of good condition of the wastewater treatment plants and the drainage pipelines managed by them, the both units have sufficient number of engineers and technical capacity.

3.5.3 Finance Aspects of Operation and Maintenance

The source of income of the wastewater treatment companies in Xi'an including Xi'an City Sewage Treatment Co., Ltd. is wastewater treatment charges from Xi'an Municipal Government[8]. The user fees paid to the municipal government and the wastewater treatment charges paid from the government to the wastewater treatment companies are not directly related. The wastewater treatment companies in Xi'an do not have their own source of income, and totally depend on the wastewater treatment charges paid by the government. Table 16 shows the water and wastewater treatment rates in Xi'an.

Table 16. Water and wastewater treatment rates of Xi'an (revised in September 2008)

(Unit: yuan/ m^3)

	Water rates		Wastewater treatment rates	Whole price
	Basic water rates	Water resource rates		
Private house	1.95	0.30	0.65	2.90
Industrial	2.25	0.30	0.90	3.45
Administrative	2.65	0.30	0.90	3.85
Commercial	3.10	0.30	0.90	4.30
Special	15.80	0.30	0.90	17.00

Note: "Special" category includes car washing, hair dressing, baths and swimming pools.
Source: Questionnaire responses

As shown in Table 17, the equity ratio of Xi'an City Sewage Treatment Co., Ltd. was 58.2% in 2011 and has never been below 56%. The equity ratio of this level indicates the strong financial status of the company. At the same time, the company has experienced operational loss almost every year. According to them, all state-owned wastewater treatment companies in Xi'an have the same problem, as the wastewater treatment charges paid by the municipal government has been the same (0.8yuan/ m^3) in spite of the increased operational cost including labor cost. Also, the current liabilities accrued during the construction of wastewater treatment plants are recorded under the cost of sales account, which is a factor leading to the operational loss. Supposing that the company covered the operational loss since 2006 (52.5 million yuan in total) by borrowing, the debt to total

[8] The wastewater treatment charges are calculated from the actual amount of treated water (the unit price is 0.8yuan/ m^3), the data of which are automatically sent from the plants to the municipal government. The users pay water and wastewater treatment fees together to the municipal government, and the government pools the portion of the wastewater treatment fees in a specific account for wastewater treatment.

assets ratio[9] would be 47.2% and the equity ratio would be still high at 52.8%. Xi'an Municipal Government plans to raise the unit price of the wastewater treatment 2012[10], by which the company can expect improvement of its financial status from this year[11]. The company also expects the increase in income by the increase of the amount of wastewater treated by the enhanced treatment capacity, and also by the reduction of the cost of recycling water by upgrading of the wastewater treatment plants to Class 1-A of the national Discharge standard of pollutants for municipal wastewater treatment plant, which will lead to the improvement of the quality of treated water. From the above, there is no particular problem with the financial status of the company.

Table 17. Financial status of Xi'an City Sewage Treatment Co., Ltd.

(Unit: million yuan)

	2006	2007	2008	2009	2010	2011
Annual sales (gross revenue)	36.63	67.00	58.42	54.01	90.55	151.95
Costs of sales	5.18	5.46	5.56	7.57	9.63	10.35
Operation and maintenance cost	53.36	67.91	50.96	49.34	97.30	146.54
Operating profit/loss	-21.91	-6.37	1.90	-2.9	-16.38	-4.94
Total assets	545.74	596.35	387.36	843.45	882.51	1,428.03
Current assets	24.50	35.83	65.62	96.94	82.34	141.82
Non-current assets	521.24	560.52	321.74	746.51	800.17	1,286.20
Current liabilities	67.83	138.67	134.53	310.00	328.76	531.01
Shareholder's equity	436.01	431.12	218.74	497.21	513.16	831.72
Liabilities	109.73	165.23	168.62	346.24	369.35	596.30
Equity ratio	79.9%	72.3%	56.5%	58.9%	58.1%	58.2%
Debt to total assets ratio	*(20.1%)*	*(27.7%)*	*(43.5%)*	*(41.1%)*	*(41.9%)*	*(41.8%)*

Source: Questionnaire responses

According to the Public Utility Bureau of Xi'an Municipal Government, the operation and maintenance cost of infrastructures was 470 million yuan in 2010 and 570 million yuan in 2011. They estimate that about 8% of it is for the drainage pipelines in Xi'an, which was 38 million yuan in 2010 and 46 million yuan in 2011. They consider that they keep sufficient fund for operation and maintenance of the drainage pipelines.

3.5.4 Current Status of Operation and Maintenance

The wastewater treatment plants have annual operation and maintenance plans and implement the work according to them. According to the observation during the site visits, the plants and equipment were in good condition and no particular problems were observed.

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[9] The liabilities are 648.8 million yuan (596.3+52.5). The total assets are 1,375.53 million yuan (1,428.03-52.5).

[10] Xi'an Municipal Government plans to raise the unit price of the wastewater treatment to 1.0 yuan/ m^3.

[11] Trial calculation using the figures of 2011: amount of wastewater treated was 189.93 million m^3 (151.95 million yuan (gross revenue in 2011) divided by 0.8 yuan/ m^3). Increase of unit price by 0.2 yuan (189.93 million m^3 x 0.2 yuan/ m^3 = 37.99 million yuan) covers the operational loss of 2011 (-4.94 million yuan).

The drainage pipelines are maintained similarly: the Public Utility Bureau has annual operation and maintenance plans and implements the work according to them. Normal wear and tear of the pipelines are taken care of at appropriate intervals considering the years passed since they were laid. Unexpected damages caused by natural disasters or accidents are repaired on a case by case basis. Damages caused by the third parties are subject to the claims for compensation.

No major problems have been observed in the operation and maintenance system, therefore sustainability of the project effect is high.

4. Conclusion, Lessons Learned and Recommendations

4.1 Conclusions

The objective of this project was to contribute to the enhancement of wastewater treatment capacity in Xi'an by constructing No.3 and No.4 Wastewater Treatment Plants and developing drainage pipeline networks, and then to the water quality improvement of the rivers and better living conditions. This project was highly relevant with China's development plans, development needs, as well as Japan's ODA policy; therefore its relevance is high. It has contributed to the enhancement of the wastewater treatment capacity in Xi'an as planned and also to the water quality improvement of the rivers to a certain extent; therefore its effectiveness and impact are high. The project cost was higher than planned and the project period was significantly longer than planned; therefore the efficiency is low. Sustainability of the project effect is high as no major problems have been observed in structural, technical and financial aspects of the operation and maintenance system.

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

4.2 Recommendations

4.2.1 Recommendations for the executing agencies

None.

4.2.2 Recommendations for JICA

None.

4.3 Lessons learned

The project aimed to contribute to the water quality improvement of the rivers and had set up baseline data and target at appraisal to measure the water quality of Wei River along which No.4 Wastewater Treatment Plant was located, while the water inspection points were not specified. Regarding Chan River along which No.3 Plant was located, no baseline data or target of the

water quality was specified. Therefore, it was not possible to compare the current data with the baseline and the target. At appraisal of loan projects to construct wastewater treatment plants, it is necessary to agree with the executing agency on the water inspection points to measure the water quality.

The water quality data of the rivers did not clearly indicate that the river water quality had been improved by the new wastewater treatment plants constructed by the project. Water quality data are affected more largely by the geographical conditions of the inspection points and by the inflow of the wastewater from other sources of pollution that are not covered by the wastewater treatment plants in question. Therefore, the contribution of the wastewater plants to the improvement of water quality of the rivers is limited, at least on the data. Other similar wastewater treatment projects have experienced the same. The indicators of the water quality, the inspection points and the targets should be agreed to the extent that the effects of the wastewater treatment plants are visible.

Comparison of the Original and Actual Scope of the Project

Item	Original	Actual
1. Project Outputs	No.3 Wastewater Treatment Plant: 100,000 m^3/day (Oxidation ditch method (Orbal method)) plus recycled water 50,000 m^3/day No.4 Wastewater Treatment Plant: 250,000 m^3/day (A2O method) Drainage pipelines: Total extension 117.6km (17 sections)	As planned. No.3 Wastewater Treatment Plant: 100,000 m^3/day (Oxidation ditch method (Orbal method)) plus recycled water 50,000 m^3/day No.4 Wastewater Treatment Plant: 250,000 m^3/day (A2O method) Drainage pipelines: Total extension 117.6km (17 sections)
2. Project period	March 2002 – April 2006 (50 months)	March 2002 – October 2008 (80 months)
3. Project cost Amount paid in Foreign currency Amount paid in Local currency Total Japanese ODA Loan portion Exchange rate	 9,764 million yen 5,226 million yen (348 million yuan) 14,990 million yen 9,764 million yen 1 yuan = 15 yen (As of September 2001)	 8,917 million yen 9,239million yen (691 million yuan) 18,156million yen 8,917million yen 1 yuan = 13.37 yen (Average between March 2002 and January 2010)