Kingdom of Thailand

FY2020 Ex-Post Evaluation Report of Japanese ODA Loan

"The Eighth Bangkok Water Supply Improvement Project"

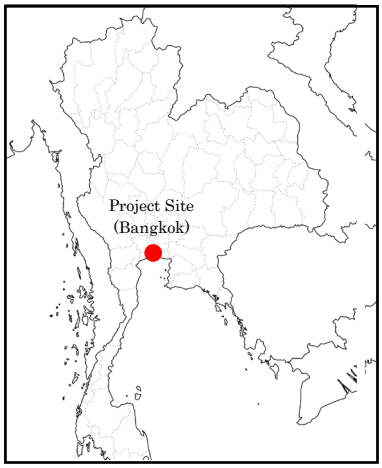
External Evaluator: Hajime Sonoda, Global Group 21, Japan, Inc.

0. Summary

"The Eighth Bangkok Water Supply Improvement Project" (hereinafter referred to as "the Project") was implemented to satisfy the pressing water demand of Bangkok Metropolitan Area by strengthening the water production capacity and developing/expanding water intake, transmission, and distribution facilities and distribution pipes of the Metropolitan Waterworks Authority (hereinafter referred to as the "MWA"), thereby contributing to the improvement of the living environment of the residents in the area. The Project is highly relevant with the development policy, development plan, and development needs of Thailand and the Bangkok Metropolitan Area, both at the time of planning and ex-post evaluation. The Project is also highly relevant with Japan's ODA policy at the time of the planning. Therefore, relevancy of the Project is high. The outputs were generally as planned except for the installation of pipelines, and the project cost was within the plan. However, since the length of the pipeline installed was less than planned and the project period was longer than planned, the efficiency of the Project is fair. As a result of the Project, the water production capacity of MWA increased as planned and the amount of water supply increased. This, together with the expansion of reservoirs and pumping facilities and the laying of water distribution pipes implemented under the Project, led to an improvement and expansion of MWA's water supply services. This has had an impact on improving the living environment and public health, and water users are highly satisfied with the results. In addition, the Project has provided an alternative water source to groundwater, which is considered to contribute to the mitigation of land subsidence. In summary, the effectiveness and impacts of this Project are high. No major problems have been observed in the institutional/organizational, technical, financial aspects of the operation and maintenance of the Project. Therefore, sustainability of the project effects is high.

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

1. Project Description



Project Location

Bangkhen Water Treatment Plant

1.1 Background

The Bangkok Metropolitan Area, consisting of Bangkok Metropolitan Administration (BMA) and five surrounding provinces, is the political and economic center of Thailand with a population of approximately 10.8 million people (2016), and MWA was operating water supply systems in BMA, Nonthaburi Province, and Samut Prakan Province. The maximum water demand was 5.13 million m^3/day in 2008, and was expected to reach 6.27 million m^3/day in 2017 according to the projection made in 2008. However, the capacity of the water production facilities in 2010 was 5.52 million m^3/day, so there were concerns that supply and demand would be tight and water shortages would occur. On the other hand, JICA had supported the water supply sector in the Bangkok Metropolitan Area through a total of 11 Japanese ODA loan projects and two technical cooperation projects.[1] Against the background of the above, the Thai government requested a yen loan project from Japan in 2008 to develop waterworks, including the expansion of water treatment plants, and the loan agreement for this project was signed in 2009.

1.2 Project Outline

To satisfy the pressing future water demand of Bangkok Metropolitan Area by strengthening the water supply capacity and developing/expanding water intake, transmission, and distribution facilities and distribution pipes of MWA, thereby contributing to the improvement of the living environment of the residents in the area.

[1] Eleven Japanese ODA Loan Projects from ”Bangkok Water Supply Improvement Project” (June 1979) to “Seventh Bangkok Water Supply Improvement Project” (September 1999) with total loan amount of 100,819 million Yen, Technical Cooperation Project “The National Waterworks Technology Training Institute Project” (1985 – 1991), “The National Waterworks Technology Training Institute Project (II)” (1994 – 1999).

Loan Approved Amount/ Disbursed Amount	4,462 million yen / 4,410 million yen
Exchange of Notes Date/ Loan Agreement Signing Date	December 2009 / December 2009
Terms and Conditions	Interest Rate: 0.8% (other than consulting services) 0.01% (consulting service) Repayment Period: 15 years (Grace Period: 5 years) Conditions for Procurement: General Untied
Borrower / Executing Agency	Metropolitan Waterworks Authority / Metropolitan Waterworks Authority (MWA)
Project Completion	October 2016
Target Area	Bangkok, Nonthaburi Province, Samutprakan Province
Main Contractors	Summit Grade Limited Partnership (Thai) /St Power Engineering Corp., Ltd. (Thai)(JV), Summit Grade Limited Partnership (Thai)
Main Consultants	Nihon Suido Consultants Co. Ltd. (Japan) / TEAM Consulting Engineering and Management., Ltd. (Thai) / Asdecon Corporation Ltd. (Thai)
Related Studies	MWA Master Plan (Revised on 2008) (MWA)
Related Projects	"Technical Assistance Related to Eighth Bangkok Water Supply Improvement Project" (2010 – 2013) 11 Japanese ODA Loan Projects from "Bangkok Water Supply Improvement Project" (June 1979) to "Seventh Bangkok Water Supply Improvement Project" (September 1999). "The National Waterworks Technology Training Institute Project" (1985 – 1991), "The National Waterworks Technology Training Institute Project (II)" (1994 – 1999).

2. Outline of the Evaluation Study

2.1 External Evaluator

Hajime Sonoda, Global Group 21 Japan, Inc.

2.2 Duration of Evaluation Study

The ex-post evaluation study for the Project was conducted over the following period.

Duration of the Study: October 2020 to November 2021

Duration of the Field Survey: March 2021 (by local research assistants)

2.3 Constraints during the Evaluation Study

Due to the pandemic of COVID-19, the external evaluator did not travel to Thailand, and the interviews with the Executing Agency, the field inspection of the water supply facilities constructed under the Project, and the interviews with the water users were conducted through

local research assistants.

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

3.1 Relevance (Rating: ③[3])

3.1.1 Consistency with the Development Plan of Thailand

At the time of planning of the Project (2009), the Government of Thailand was formulating the 10th National Economic and Social Development Plan as policies for economic and social development. In this plan, "conservation of natural resources and the natural environment" was positioned as one of the priority areas, pointing out the necessity of improving waterworks. On the other hand, since the 1970s, MWA has been promoting the phased development of waterworks facilities based on its water supply master plan, including the expansion of water treatment plants (WTPs) to increase water supply capacity, the construction of transmission and distribution pipes to expand the water distribution area, and the rehabilitation of transmission and distribution pipes to reduce water leakage. The Project is positioned as the "The Eighth Bangkok Water Supply Improvement Project" in the revised master plan prepared by MWA in 2009.

At the time of the ex-post evaluation (2021), the Government of Thailand, through the 12th National Economic and Social Development Plan (2017-2021), aims to achieve economic growth and reduce inequality based on the principles of "the sufficiency economy philosophy," "sustainable development, and "human-centered development," as well as development through productivity improvement through local knowledge and innovation. Its infrastructure and logistics development strategy mentions the spread of water supply facilities throughout the country, improvement of efficiency in water consumption, and promotion of technological innovation. In addition, the revised master plan of MWA (see above) shows a plan for phased development of water supply facilities to meet the increase in water demand until 2027, even after the Project.[4]

Based on the above, the Project is consistent with Thailand's development plan both at the time of planning and ex-post evaluation.

3.1.2 Consistency with the Development Needs of Thailand

As mentioned in "1.1 Background," at the time of planning, there was concern that the Bangkok Metropolitan Area would experience water shortages due to widening gap between demand and supply of water. At the time of the ex-post evaluation, the two WTPs expanded by

[2] A: Highly satisfactory, B: Satisfactory, C: Partially satisfactory, D: Unsatisfactory
[3] ③: High, ②: Fair, ①: Low
[4] MWA started the 9th Water Supply Improvement Project in 2017, and the water production capacity of Mahasawat WTP will be further increased by 1.5 times to meet the increasing water demand. As of April 2021, its construction has not yet started. At the time of the ex-post evaluation, MWA is preparing a new master plan.

the Project are fully utilized (see "Effectiveness"), and expansion of the Mahasawat WTP is planned to cope with further increase in water demand (see footnote 4). In addition, the water transmission and distribution facilities (pump facilities and distribution reservoirs) included in the Project are expected to continue to be utilized in the future to meet the increasing water demand due to population growth.

Based on the above, the Project is relevant with the development needs of Bangkok Metropolitan Area at the time of planning, and the need for the Project has been maintained at the time of ex-post evaluation.

3.1.3 Consistency with Japan's ODA Policy

At the time of planning, "Japan's Economic Cooperation Program for the Kingdom of Thailand" (2006) positioned "responses to issues that emerge with maturing of society" as a priority area, and support for solving urban problems and strengthening environmental management systems as development issues. In response to this, JICA had set a policy to carry out urban development projects in an organized manner to improve urban life and environment in Thailand. In view of the above, the Project is consistent with Japan's ODA policy at the time of planning.

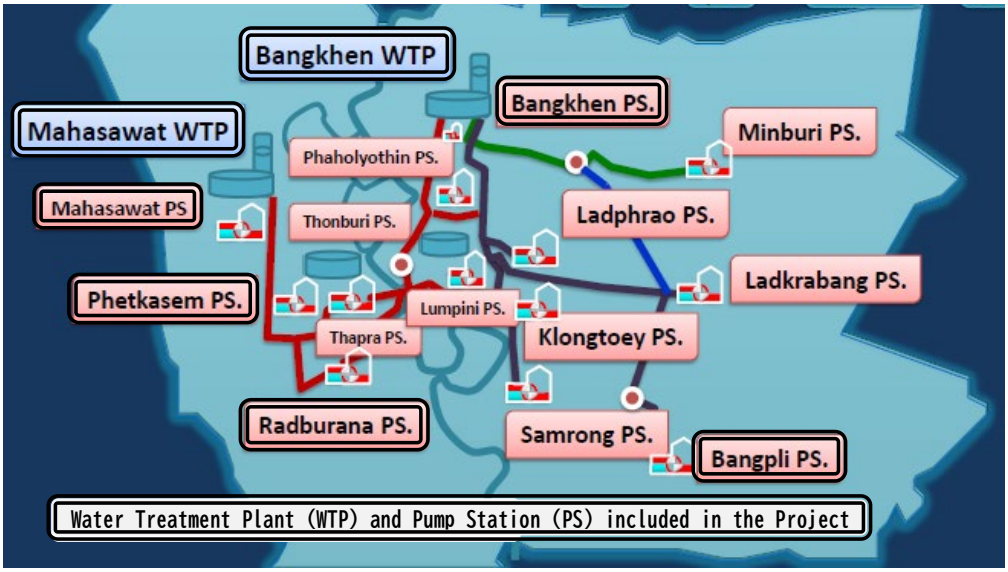
Based on the above the Project has been highly relevant to the country's development plan and development needs, as well as Japan's ODA policy. Therefore, its relevance is high.

3.2 Efficiency (Rating:②)

3.2.1 Project Outputs

In the water supply system operated by MWA in the Bangkok Metropolitan Area, Bangkhen WTP (water production capacity: 4 million m^3/day), which uses the Chao Phraya River as its source, and Mahasawat WTP (water production capacity: 1.6 million m^3/day), which uses the Mae Khlong River as its source, produce about 95% of the total water. The water supply area covers Bangkok, Nonthaburi Province, and Samut Prakan Province, which are divided into east and west by the Chao Phraya River. Mahasawat WTP supplies water on the west bank of the river and Bangkhen WTP supplies water on the east bank of the river, and the water transmission and distribution facilities on both banks are connected by a water transmission tunnel that crosses the Chao Phraya River. Water from both plants is distributed through 14 pumping stations. Most of the pumping stations are equipped with reservoirs.

The Project was to expand the service area of the MWA by expanding the major WTPs, expanding some pumping stations and reservoirs as needed, and laying new pipelines to meet the increased water demand until 2017. The planned and actual outputs of the Project are shown in Table 1.



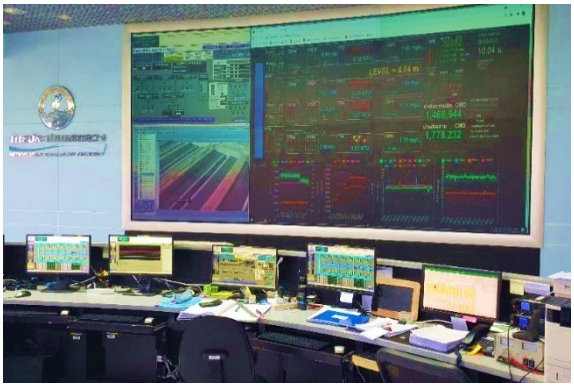
Note: Sam Lae pumping station for raw water intake is outside the scope of the above map.
Two small pumping stations are not shown.

Figure 1: Overall view of Bangkok's water supply system

Table 1 Planned and Actual Outputs

Plan	Actual
Expansion of Mahasawat WTP*	
Raw water pumps (150 m^3/min x 2 units)	As planned
Transmission pump (300 m^3/min x 1 unit)	As planned
Expansion of capacity (400,000 m^3/day)	As planned
Reservoir	As planned
Expansion of Bangkhen WTP	
Raw water pumps (358 m^3/min x 2 units)	As planned
Transmission pumps (300 m^3/min x 3 units)	To be completed by December 2021
Expansion of capacity (400,000 m^3/day)	As planned
Filter press (400,000 m^3/day)	As planned
Electrical substation（69/6.6kV, 15MVA）	As planned
Installation of additional pumping equipment	
Distribution pump at Bang Plee PS (125 m^3/min x 1 unit)	As planned
Raw water pump at Sam Lae Intake (500 m^3/min x 1 unit)	As planned
Expansion of distribution reservoir	
Reservoir at Rat Burana PS (40,000 m^3)	10,000 m^3
Reservoir at Petch Kasem PS (40,000 m^3)	As planned
Installation of pipelines	
Water distribution main（112km）	74km
Water distribution branch（875km）	470km
Consulting services	
Detail design, bidding documents*	As planned
Supervision (except for Mahasawat WTP and pipelines)	
Supervision (Mahasawat WTP) *	

Source: Information provided by JICA and MWA
Note: *Output not covered by the ODA Loan
WTP=Water Treatment Plant, PS=Pumping Station




SCADA system[5] (left) and reservoir (right) at Mahasawat WTP


Raw water pump (left) and transmission pump (right) at Bangkhen WTP

As a result of the Project, both Bangkhen and Mahasawat WTPs were expanded to add 400,000 m^3/day of water production capacity each, as planned. Since the completion of detailed design by 2010 till the construction of various parts of the Bangkhen WTP during 2011 – 2017, the situation changed as MWA carried out necessary emergency works in many sections of the WTP. As a result, there were significant design changes in the power supply and water production facilities at Bangkhen WTP, which significantly increased the construction period and project cost for the expansion of the plant. The expanded facilities at Mahasawat and Bangkhen WTPs became operational in January 2013 and June 2016, respectively.[6] According to the site inspection of both WTPs and interviews with MWA field staff, in the facility design of the Project, there were some issues related to the efficiency and safety in operation and maintenance.[7] The staff at the WTPs pointed out that some of these issues

[5] SCADA（Supervisory Control And Data Acquisition）system is a system that collects and monitors information obtained from devices and equipment that make up a large facility or infrastructure in one place using a network, and controls it as necessary.

[6] The completion of some pumping facilities at both WTPs was delayed, but this did not affect the operation of the expanded water treatment facilities (see footnote 9).

[7] At the Mahasawat WTP, the weir (Parshall Flume) has a small drop and the chemical dosing there is inefficient, and the chlorine dosing capacity is insufficient, so MWA had to add equipment. In addition, float switches (sensors to detect level of water) for the submersible pump were not selected according to the water quality and frequently failed, and the SCADA system requires more time for data processing due to system design, making it difficult to switch operations quickly according to the situation. At the Bangkhen WTP, the chlorine injection equipment is a combination of inexpensive equipment, which causes frequent failures. In addition, the size of the chlorine/activated carbon storage room and the sludge dewatering facility and the layout of the equipment are inconvenient for operation and maintenance,

could have been prevented if sufficient consultations had been conducted during the detailed design and if the design of existing facilities and experience in their operation and maintenance had been reviewed and reflected into the detailed design.

For the six pumps planned for both WTPs,[8] contracts were terminated by MWA in November 2014 due to significant construction delays caused by the poor implementation capacity of the first contractor hired in September 2011. Of these, the contract for the two raw water pumps at Mahasawat WTP was signed in March 2016 and the construction under the new contract was completed in May 2018.[9] For the four transmission pumps at both WTPs, it took time to prepare the bidding documents to comply with the Public Procurement and Supplies Administration Act, which was enacted in 2017, and new contracts were signed in December 2019 for Mahasawat WTP and March 2020 for Bangkhen WTP. The water transmission pump for Mahasawat WTP was completed in June 2021. As of August 2021, the water transmission pumps for Bangkhen WTP are scheduled to be completed in December 2021.

The reservoir at Rat Burana Pumping Station (PS) was planned to be expanded to a storage capacity of 40,000 m^3, but after re-examining the required storage capacity in terms of both necessity and cost reduction, it was reduced to 10,000 m^3. The distribution reservoir is located at the connection point between the water transmission network from Bangkhen WTP and Mahasawat WTP, and by integrating water from both plants, stable water distribution is possible even with a small distribution reservoir capacity. Although the project cost was reduced by this change, the construction period of the distribution reservoir more than doubled and was completed in October 2016 due to the abovementioned design changes.

A total of 51 contracts, including 30 contracts for water distribution branches and 21 contracts for water distribution mains, were drawn for the construction of water pipelines under the Project but not covered by the ODA Loan. The water distribution network was completed between October 2010 and May 2013, with a total length of 470.0km, which was 54% of the planned length. In addition, the water distribution main installation was completed between June 2010 and January 2016 depending on the contract, and the actual pipe length of 73.5km was 66% of the planned length. The main reason for the lower-than-planned pipe length was that the implementation of the Project was postponed in some areas as a result of coordination with the investment plans for streets, sewage, drainage by the Bangkok Metropolitan Administration, the Department of Highways of the Ministry

and the lighting in the sedimentation tank is dark and the sample collection point is in a hidden location, making it unsafe to work.

[8] Three transmission pumps for Bangkhen WTP, and two raw water pumps and one transmission pump for Mahasawat WTP. Two raw water pumps at the Bangkhen WTP were procured under a separate contract along with the raw water pumps at the Sam Lae Intake.

[9] After the completion of the expansion work at this WTP, the capacity of the raw water pumps was insufficient, so MWA had to temporarily install several small pumps to compensate them. On the other hand, the four transmission pumps were planned as backup pumps to ensure that the existing pumping facilities at the two plants could pump water with increased stability. As the existing pumps were used to pump water from the two plants, and as of March 2021, the delay in their completion has not been a constraint to pumping water from the two plants.

of Transport, and the Department of Rural Roads of the Ministry of Transport. The planed pipelines that were not realized under the Project will be constructed, outside the scope of the Project, as soon as the coordination with the relevant organizations is completed.

The consulting services were carried out as planned under the following three contracts. Detailed design and construction supervision of the pipeline installation were carried out directly by MWA.

① Detailed design and bidding support for the entire project except for the pipe laying (completed in January 2010, not covered by the ODA Loan)

② Construction supervision of the ODA Loan portion (other than pipe laying and Mahasawat WTP) (completed in September 2020, subject to the ODA Loan)

③ Construction supervision of the Mahasawat WTP which was started in advance (completed in June 2014, not covered by the ODA Loan)

As a part of JICA's technical cooperation related to the Project, "the Technical Assistance Related to Eighth Bangkok Water Supply Improvement Project" was implemented from October 2010 to March 2013,[10] and as a part of this cooperation, knowledge on pipe laying such as improvement of construction supervision and introduction of non-excavation method was transferred. Part of the water main installation in the Project was carried out using non-excavation methods, and it is inferred that the knowledge gained through the technical cooperation was utilized.

3.2.2 Project Inputs

3.2.2.1 Project Cost

The total project cost was planned to be 21,099 million yen with ODA Loan of 4,462 million yen. The actual amount (including some estimated amounts) was 20,586 million yen (98% of the plan with ODA Loan of 4,410 million yen) (Table 2).

The cost of laying the pipelines was almost in line with the planned project cost (excluding price increases), but the output was 55% of the plan; the total planned length of the water distribution branches and water distribution mains was 987 km, while the actual output was 544 km, which means low efficiency. According to MWA, the construction cost increased compared to the output due to unexpected price escalation of labor and construction material, and increased night works due to worsening traffic congestion. Although the actual total project cost was almost same as the plan, if the pipeline laying length, which was 55% of the plan, had reached

[10] In this technical cooperation, with the aim of improving MWA's capacity to operate and maintain waterworks facilities by sharing the technology and experiences of Japanese water utilities, training in Japan and dispatch of short-term experts were made by the water utilities of Osaka Prefecture, Nagoya City, and Tokyo Metropolitan Government. Osaka Prefecture provided technical support on water production and transmission, Nagoya on water distribution management, and Tokyo on measures against non-revenue water.

100% of the plan, it is estimated that the total project cost would have been about 29,000 million yen,[11] which is about 1.4 times higher than the plan. Therefore, the efficiency of the project cost is judged to be fair.

Table 2: Planned and Actual Project Cost

(Unit: million yen)

	Planned Amount			Actual Amount		
	Total	Loan	MWA	Total	Loan	MWA
Bangkhen Water Treatment Plant, Reservoir, Pumping equipment	4,338	3,508	830	6,634	4,102	2,532
Mahasawat Water Treatment Plant	2,117	0	2,117	2,532	0	2,532
Pipeline	9,680	0	9,680	9,026	0	9,026
Consulting Services	475	364	111	579	308	271
Price escalation	2,334	395	1,939	0	0	0
Physical contingency	929	195	734	0	0	0
Tax, Administration	1,109	0	1,109	1,699	0	1,699
Others	116	0	116	116	0	116
Total	21,099	4,462	16,637	20,586	4,410	16,176

Source: Prepared from materials provided by JICA and MWA.
Note: Actual results are compiled based on MWA's questionnaire responses. For some contracts that were not completed, the final contract amount was used.

3.2.2.2 Project Period

The Project was planned to be implemented over a period of 53 months, from the signing of the loan agreement in September 2009 until the completion of all construction and consulting services in January 2014. In fact, the loan agreement was signed in December 2009. The completion dates for each component are as follows.

Bangkhen WTP expansion:	Started operation in June 2016 (water transmission pumps to be completed in December 2021)
Mahasawat WTP expansion:	Started operation in January 2013 (water transmission pumps to be completed in June 2021)
PS distribution reservoir expansion:	October 2016
PS pump expansion:	April 2013
Pipeline installation:	June 2016
Consulting service:	June 2016

[11] Since the actual cost for pipe laying of 9,026 million yen was for 55% of the total length. To finish the remaining 45% of the pipe laying, additional cost of approximately 7,385 million yen (9,026 million yen / 55% x 45%) would be needed. By adding taxes and administrative costs (14%), the total additional cost is estimated to be 8,419 million yen. Adding this amount to the actual total project cost, the adjusted total project cost would be 29,005 million yen, which is 137% of the planned 21,099 million yen.

As for the main factors that affected the project period, the design changes of the Bangkhen WTP, the cancellation of the contracts for the pumping facility of the WTPs, and the design change of the distribution reservoir have been mentioned above. The following can be pointed out as other factors.

- Extension of construction period due to floods in 2011: The floods in Thailand caused by the 2011 monsoon inundated parts of Bangkok. The Mahasawat WTP construction site and part of the pipe laying site were submerged in water, and the construction of other sites was severely affected due to the disruption of the city's road network. Regarding the extension of the construction period due to the floods, the Cabinet decided to exempt the public works from compensation for delay for 180 days for civil works and 120 days for equipment procurement. The contract period of all construction contracts for the Project has been extended accordingly.

- Labor shortage since 2013: New policies by the Thai government have led to a significant increase in the minimum wage in Thailand since 2013. The wage gap between Bangkok and the provinces has narrowed, resulting in a labor shortage in Bangkok. As a result, the labor market became a seller's market and it became difficult to secure an appropriate workforce at the expected wages. As a result, the construction period of many public projects, including the Project, was extended by 150 days to cope with the shortage.

- The construction contract for the raw water pumps for the Bangkhen WTP more than tripled the construction period (from 22 months planned to 68 months actual) due to the contractor's severe financial difficulties caused by the minimum wage increase.

Of the Project, the Bangkhen and Mahasawat WTPs started operation in June 2016 and January 2013, respectively, and this can be considered as the completion date of the WTPs. On the other hand, the expansion of the distribution reservoirs, enhancement of pumps at the pumping stations, and installation of pipelines are for the development of water transmission and distribution facilities, and their effects can be obtained independently from the expansion of the two WTPs. Therefore, the completion of the two WTPs cannot be regarded as the completion of the entire Project, and it is appropriate to define the time of completion of the entire Project as the time when the operation of the two WTPs started and the completion of the expansion of the distribution reservoir, pump reinforcement, and the installation of pipelines at the pumping stations are all completed. Based on the above, it is judged that the Project was completed in October 2016 (completion of the expansion of the distribution reservoir at the pumping station) and the actual project period is 6 years and 11 months (83 months).[12]

[12] Regarding the completion date of the Project, MWA and JICA agreed in September 2020 to redefine the completion

On the other hand, in the Project, the contract period was extended for 180 days for civil works and 120 days for equipment procurement due to the floods in 2011. This is due to force majeure caused by natural disasters and should be excluded from the judgment of efficiency. Therefore, the project period is 77 months, which is 83 months minus 180 days (6 months), or 145% of the planned 53 months. Based on the above, the efficiency of the project period is fair.

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

At the time of planning, the financial internal rate of return (FIRR) and economic internal rate of return (EIRR) for the expansion of WTPs by the Project were calculated to be 10.2% and 21.4%, respectively, based on the following assumptions.

Cost	FIRR:	Project cost, water supply cost, and maintenance cost
	EIRR:	Project cost, water supply cost, and maintenance cost (economic costs)
Benefit	FIRR:	Water tariff revenue
	EIRR:	Willingness to pay for increased water use (existing customers)
		Cost savings from alternative water sources (new customers)
Project life:		30 years from start of operation

The updated FIRR and EIRR are 10.1% and 22.2%, respectively, after recalculation based on actual costs and benefits using the same assumptions in the ex-post evaluation. The difference from the original figures is due to the revision of the project cost, water supply cost, and water supply volume in consideration of the actual results since the original plan.

Based on above, both the project cost and project period exceeded the plan. Therefore, efficiency of the Project is fair.

3.3 Effectiveness and Impacts[13] (Rating: ③)

3.3.1 Effectiveness

3.3.1.1 Quantitative Effects (Operation and Effect Indicators)

The purpose of the Project was to meet the pressing water supply demand in Bangkok Metropolitan Area. At the time of planning, the following indicators were set for the WTPs: water production capacity, average daily water production, maximum daily water production, and estimated beneficiary population. This section analyzes the achievement status of these indicators

of the Project as the commencement of operation of both WTPs. Since the uncompleted water pumps were planned as a backup facility and both WTPs have maintained the planned water production capacity without any problem since they started operation, it is considered that there is no problem in redefining the completion date of both WTPs in the Project in this way. On the other hand, in the ex-post evaluation, the project completion date was determined by taking into account the fact that the Project includes both WTPs and water transmission / distribution facilities.

[13] Sub-rating for Effectiveness is to be put with consideration of Impacts.

for the WTPs. For the water transmission and distribution facilities (additional pumps, expansion of reservoirs, and installation of pipelines), no indicators were set at the time of planning, but their contribution to the Project objectives will be analyzed based on their utilization.

3.3.1.2 Water Treatment Plants

Table 3 shows the planned and actual water production capacities, average daily water production, and maximum daily water production of the Bangkhen and Mahasawat WTPs, which were expanded by the Project, and the entire MWA. The two plants are the WTPs accounting for 90% of the total water production capacity and about 95% of the total water production of the MWA.

Table 3: Planned and actual performance of the indicators for WTPs

(Unit: million m^3/day)

	Baseline 2008	Target 2016	2012	2013	2014	2015	2016	2017	2018	2019	2020
Bangkhen WTP (the expanded facilities start operation in June 2016)											
Water production capacity	3.60	4.00	3.60	3.60	3.60	3.60	4.00	4.00	4.00	4.00	4.00
Average daily water production	3.39	3.66	3.40	3.23	3.53	3.64	3.62	3.93	3.70	3.94	3.97
Maximum daily water production	3.58	3.88	3.94	3.59	3.95	4.03	3.95	4.24	4.12	4.19	4.24
Mahasawat WTP (the expanded facilities start operation in January 2013)											
Water production capacity	1.20	1.60	1.20	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60
Average daily water production	1.07	1.47	1.15	1.48	1.34	1.45	1.47	1.40	1.36	1.47	1.59
Maximum daily water production	1.17	1.56	1.48	1.70	1.53	1.69	1.68	1.53	1.54	1.64	1.72
Total MWA											
Water production capacity	-	-	5.52	5.92	5.92	5.92	6.72	6.72	6.72	6.32	6.32
Average daily water production	-	-	4.96	5.05	5.19	5.46	5.44	5.67	5.38	5.72	5.84
Maximum daily water production	-	-	5.66	5.52	5.75	6.02	5.84	6.13	5.93	6.17	6.23

Source: Material provided by JICA for baseline and target, material provided by MWA for actual.
Note: The shaded area is the figures that are above the target value for 2016.

As a result of the Project, the water production capacity of the Mahasawat WTP increased from 1.2 million m^3/day to 1.6 million m^3/day, and that of the Bangkhen WTP from 3.6 million m^3/day to 4.0 million m^3/day. This is in line with the plan and the achievement of the planned water production capacity is high. However, its realization was delayed by one to two and a half years from the planned time (February 2012 for Mahasawat WTP and December 2013 for Bangkhen WTP).

The average daily water production in 2020 increased to 117% for Bangkhen WTP and 149% for Mahasawat WTP compared to 2008. The combined total of both WTPs increased to

125%. Compared to the 2016 target set at the time of planning, as of 2016, the Bangkhen WTP slightly fell short of the plan (98.9% target achievement rate), while the Mahasawat WTP was on target (100% target achievement rate).

The maximum daily water production for both WTPs has achieved the target for 2016, and reached 106% and 108% of the production capacity of Bangkhen and Mahasawat WTPs in 2020, respectively.

At the time of planning, it was assumed that the Project would benefit about 1.25 million people based on the per capita water supply.[14] The capacity of the water production facilities added by the Project was 800,000 m^3/day as planned. Both plants produced water at their full capacity,[15] and the capacity utilization rate (water production divided by water production capacity) in 2020 was 99.3%, which means that about 794,000 m^3/day of additional water was produced by the Project. This is equivalent to about 14% of the total water production of 5.84 million m^3/day in the same year. Therefore, the estimated beneficiary population is calculated to be about 1.16 million, which is equivalent to 14% of the total water supply population of 8.28 million by MWA (at the end of 2019). This is 93% of the target of 1.25 million people. As the water from both plants is supplied to the entire MWA water supply area, MWA's total water supply population of 8.28 million people have actually benefited.

As described above, the achievement rate of the indicators set for both WTPs is high. In addition, since 2016, Bangkok has maintained 24-hour water supply and has not experienced any serious water shortage except for the period of temporary water shutdown due to flood, etc. Therefore, the expansion of both WTPs is considered to have fully achieved the target.

3.3.1.3 Transmission and Distribution Facility

Changes in water distribution volume of the three PSs strengthened by the Project among the water distribution pumping stations operated by MWA, and the overall distribution volume are shown in Table 5. The Project enhanced the distribution reservoir at the Petch Kasem PS, the distribution reservoir at the Rat Burana PS, and the distribution pump at the Bang Plee PS.

Overall, there was a 17% increase in water distribution during the period 2012 – 2020. The increase by pumping station was 50% at the Phet Kasem PS, 20% at the Bang Plee PS, and 7% at the Rat Burana PS. The difference in the increase rate by PS reflects the difference in the rate of population increase in the areas covered by each PS. It is believed that the facilities of the Project were utilized at all pumping stations and contributed to the increase in the volume of water distributed.

[14] Calculated based on average water supply per capita, including all uses and leakage, as 641 liters/day.
[15] The facility utilization rate (water production divided by water production capacity) was 82% for the Bangkhen WTP and 92% for the Mahasawat WTP in 2016, and has been maintained above 85% since then, reaching 99% by 2020.

Table 4: Changes in the volume of water distributed by pump stations

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

	2012	2013	2014	2015	2016	2017	2018	2019	2020	Increase 2012～2020
Petch Kasem PS	24	27	34	36	33	35	34	37	36	50%
Rat Burana PS	42	41	42	43	44	44	41	43	45	7%
Bang Plee PS	35	39	37	37	40	41	38	40	42	20%
All PSs of MWA	474	483	461	493	513	541	527	547	553	17%

Source: Material provided by MWA

About 470 km of water distribution branches was laid under the Project. MWA is supplying water to about 8.28 million people in 2019 with a total of 36,453 km of distribution branches, which means that the connected population per 1 km of distribution branch is about 227 people. Based on this, it is estimated that about 107,000 people have newly come to use the water supply system by the Project. This is equivalent to 1.3% of the 8.28 million people served by the MWA.

MWA manages the water quality according to a Water Safety Plan with an aim to ensure that water production and transmission meet the WHO guidelines for drinking-water quality. According to the data of MWA for September 2020, the water quality of Bangkhen and Mahasawat WTPs was within the standard values for all water quality items. In addition, more than 95% of the samples collected from faucets in the water supply area in 2019 were within the standard range for turbidity and more than 99% were within the standard range for residual chlorine concentration.

From the above, it can be concluded that the objective of the project, “to meet the pressing water supply demand in Bangkok Metropolitan Area,” has been fully achieved.

3.3.2 Impacts

3.3.2.1 Intended Impacts

The intended impact of the Project was “improvement of living environment and sanitary conditions” caused by the improvement of water supply service (expansion of water supply area and improvement of water supply service in existing water supply area), which is the outcome of the Project. As broader impacts, changes in household life and socio-economic conditions resulting from these improvements are also expected. After an overview of the improvement of water supply services by the Project, based on the results of the qualitative survey[16], the economic and social impacts of the Project were analyzed in the areas where MWA’s

[16] In order to understand the nature and manifestation of typical impacts, as a qualitative survey, the following were interviewed through a local research assistant on the current water supply services in MWA, the changes in water supply

water supply service was provided before the Project (existing water supply areas) and in the areas where MWA's water supply service was newly provided by the Project (expanded water supply areas).

(1) Changes in water supply service

Among the outcomes, the expansion of the water supply area was realized by the installation of distribution pipelines under the Project (water supply expansion area). The beneficiary population is estimated to be about 107,000 (see "Effectiveness"), which is equivalent to 1.3% of the total population of 8.28 million (2019) who receive water from MWA.

The Mahasawat and Bangkhen WTPs account for 95% of the total water supply of the MWA (see "Effectiveness"), and water from both WTPs is provided to the entire service area of the MWA. The per capita water supply increased from 565 liters/day in 2006 to 705 liters/day in 2019.[17] Therefore, the increase in the amount of water supplied by both WTPs is considered to have contributed to the improvement of water supply service for the entire existing water supply area. In addition, the Project increased the number of distribution reservoirs at two distribution PSs and the number of distribution pumps at one PS. This has contributed to the stabilization of water distribution in the distribution areas of each PS, and is considered to have led to the improvement of water supply services. It should be noted that, in parallel with the Project, MWA has been implementing projects such as the reinforcement of distribution PSs and the repair and installation of distribution mains and distribution branches, with an investment of about 25 billion yen planned and implemented from 2013 to 2022. It is also working to reduce leakage by using the Water Leakage Management Application System, which manages leakage in each Distribution Management Area. In addition, water quality management is being strengthened through a real-time water quality monitoring system. The improvement of water supply services in existing water supply areas is a synergistic effect of the Project and these projects.

According to interviews with residents about the water supply service, the water pressure is generally good, but in areas where the population is growing rapidly, the water pressure may drop depending on the time of day. Water quality is also generally good, but some residents pointed out that the water is sometimes hard and over-chlorinated. Most of the residents were

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services before and after the Project, and the associated changes in their daily life and business operations.

Target areas: Bangkok, Samut Prakan Province, Nonthaburi Province, where "MWA's water supply service was provided before this Project (existing water supply area)" and "MWA's water supply service had been newly provided by the Project (expanded water supply area)."

60 residents (24 male and 36 female): Individual and group interviews with several people at each of an existing water supply area and an expanded water supply area in the three target areas.

12 business operators: Individual interviews with business operators at three schools (elementary, junior high, and university), three medical institutions, and six commercial facilities (large-scale commercial and recreational facilities, stores, factories, etc.)

[17] Per capita water supply is the total water supply of MWA divided by the total population served, which is different from per capita water use. The figure for year 2006 was calculated from the forecast by MWA at the time of planning, and the figure for year 2019 was calculated from the actual value.

satisfied with MWA's customer service and water rates, including advance notice of water shutoffs and prompt response to water leaks. Ninety percent of the residents interviewed said they were "very satisfied" or "satisfied" with MWA's water service. On the other hand, most of the business operators were also generally satisfied with the water pressure and quality. However, some hospitals and large commercial facilities conduct their own water quality tests and may add chlorine on their own if the residual chlorine concentration is not sufficient. In the existing water supply areas, all residents and businesses reported that the water pressure and water quality had improved compared to 10 years ago.

(2) Impacts in existing water supply areas

Most of the residents are equipped with pumps to compensate for the water pressure, but since the water pressure has improved, they no longer need to use the pumps as often as before. No significant changes in the amount and frequency of water use in households were reported. Businesses such as hospitals, schools, and ice factories reported that they stopped using groundwater because of the improved water pressure of MWA's water service. As a result of the improved water quality, most of the residents and businesses such as schools reported that they now drink tap water that they did not drink before, after passing it through a water purifier that is connected to the faucet for use. Households that use the water purifiers have reduced the purchase of bottled drinking water, leading to a reduction in water-related expenditures. The improved water pressure and quality of MWA's water supply service is greatly welcomed by many businesses, as they consider it important for their business to have stable access to water of more reliable quality.

(3) Impact on expanded water supply area

Before being connected to the water supply service of MWA, the Subdistrict Administrative Organization provided water supply service using groundwater as the source. In the past, water was often cut off and there were sometimes disputes with neighbors over the use of water due to low water pressure. Water quality was poor, and the first water that came out of the faucet was so cloudy that they had to leave it running until it was clean or use chemicals to improve the water quality. Being connected to the MWA's water supply service has eliminated these problems and increased the convenience about water.

Residents did not report any significant changes in the amount and frequency of water use in their households. Some residents who used to buy bottled water for drinking are now using tap water for drinking using water purifiers after being connected to MWA's water supply service. In addition, some residents reported that a laundry store has been established in the neighborhood and that they have started selling foods at home. The improvement in water quality was highly appreciated, and all of them believe that it has led to improved sanitation in their homes. However,

residents have always been very careful about sanitation and drinking water management, and waterborne diseases have rarely occurred before being connected to the MWA's water supply service, so no particular changes were reported concerning their health.

Before connecting to MWA's water supply service, the offices used groundwater from on-site wells and rainwater. Some schools still use mainly groundwater, but most of them use MWA's water service. No specific changes in water use associated with the changes in water sources were reported. Universities reported that water management has become easier with MWA's water service. Most of the business appreciated the improvement in water pressure and quality, as it is important for their operation to have stable access to water of more reliable quality.

From the above, although the expanded water supply area was smaller than planned due to the lower-than-planned length of the distribution pipes, it can be concluded that the expected impact of the Project has been realized to some extent in both existing and expanded water supply areas.

3.3.2.2 Other Positive and Negative Impacts

(1) Impacts on the Natural Environment

According to MWA, all the construction works of the Project were carried out in accordance with the guidelines set by the Bangkok Metropolitan Administration with due considerations for environmental and social aspects, and no particular problems were encountered. In addition, the expansion of the WTPs and pumping facilities were both carried out within the premises of MWA and did not cause any environmental or social problems. In addition, the sludge generated at the two WTPs has been properly disposed of.

Through this project, the use of groundwater is believed to have been suppressed due to the improvement and expansion of water supply services using surface water as the source. In Bangkok, groundwater abstraction has increased since the 1980s due to rapid economic growth and population increase, and subsidence of the land in the city, which was originally low in elevation, became a major problem. In 1977, the government enacted the Groundwater Act, which established Groundwater Area and Critical Zone, and introduced a system of water extraction regulation and tolling, as well as encouraging the conversion of water sources from groundwater to surface water through the construction of waterworks. At the time of the ex-post evaluation, land subsidence in Bangkok continues to be 1 to 2 cm per year depending on the district, but the Project can be regarded as contributing to its control.[18]

[18] Groundwater extraction in the Bangkok Metropolitan Area, which reached 1 million m^3/day in 1997, decreased to 400,000 m^3/day in 2008. On the other hand, since it is estimated that 107,000 people have newly come to receive water supply services in the water supply expansion area of the Project, and the per capita purified water supply is 705 liters/day in 2019, and the residents reported that the amount of water used did not change significantly before and after the project (see 3.2.2.1(1) and (3)), it is estimated that groundwater extraction has been reduced by about 75,000 m^3/day.

(2) Social Impact

The expansion of the water production facilities and pumping facilities under the Project were all carried out within the premises of the existing facilities of MWA, and no land acquisition or resettlement occurred. No land acquisition or relocation of residents was required for the installation of the pipelines which was carried out after coordination with the relevant organizations that manage and own the land.

To summarize the effectiveness and impacts of the Project, it has improved and expanded water supply services by increasing the water production capacity of the MWA, enhancing the reservoir and pumping facilities, and installing water transmission mains and water distribution branches. This has had an impact on improving the living environment and sanitation conditions, and water users are highly satisfied. The Project provided an alternative source of water to groundwater and contributes to the reduction of land subsidence, and there is no significant undesirable impact on the environment and society. In summary, the effectiveness and impacts of the Project are high.

3.4 Sustainability (Rating: ③)

3.4.1 Institutional/Organizational Aspect of Operation and Maintenance

MWA, a state-owned enterprise under the jurisdiction of the Ministry of Interior, is responsible for the operation and maintenance of the Project and consists of nine departments, which are, the Governor's Office, Administration, Finance, Planning and Development, Engineering and Construction, Water Production and Transmission, Eastern Services, Western Services, and Information Technology. The number of employees is 4,303 permanent and 1,075 contractual (as of September 30, 2019).

MWA has been providing water supply services in the Bangkok Metropolitan Area for more than 50 years since its establishment in 1967. In the 4th MWA Management Strategies (2019-2021), MWA has been working on financial stability by expanding the service area, strengthening organizational capacity through the use of IT, and developing a stable water supply system by improving distribution pipes and monitoring water quality. In the 5th MWA State Enterprise Plan (2020-2022), MWA is working on stable water supply, organizational adaptability, building sustainable partnerships with stakeholders, improving financial administration, etc. MWA also has risk management, internal controls, internal audit systems, CSR and environmental initiatives, and has won various awards in Japan, demonstrating its high level of organizational strength.[19]

[19] According to the 2019 MWA Annual Report, in the same year the following were awarded: AREA 2019 for Health Promotion and Corporate Governance Category, 2019 Outstanding Public Information Center Award, 2019 Public Sector Excellence Award for Service Development and Corporate Governance, Honorable Prize for Transparent Organization from the 8th NACC Integrity Awards

The Project is operated by the Raw Water Transmission System Department, Bangkhen WTP Department, Mahasawat WTP Department, Water Distribution Pumping Station Department, Water Transmission and Distribution Control Department, etc. under the Deputy Governor for Water Production and Transmission. The maintenance of facilities and equipment will be carried out by Electrical System Maintenance Department, Mechanical System and Civil Maintenance Department, Instrument and Automation System Maintenance Department, etc., under the supervision of the same Deputy Governor. MWA's system for operation and maintenance has clearly defined the roles for each department, and from the actual operation and maintenance performance, it is believed that the system is adequate for operation and maintenance.

Based on the above, there are no institutional/organizational issues in the operation and maintenance of the Project.

3.4.2 Technical Aspect of Operation and Maintenance

MWA has introduced advanced technologies such as advanced water treatment using activated carbon, District Metered Area (DMA)-based water pressure and leakage management, and real-time water quality monitoring. MWA provides various training programs mainly for MWA staff at the Waterworks Technical Training Center (renamed in 2017 to MWA Waterworks Institute of Thailand), which was established with JICA's technical cooperation. The training conducted in 2019 includes executive training, IT utilization, Water Safety Plan (water purification and water quality management), leakage management, labor standards, pipeline installation, and automatic control. External lecturers from universities and international organizations are also invited. Training is also provided to the staff of other waterworks companies in the country. In addition, the technical cooperation related to the Project has provided extensive technology transfer on advanced water treatment, risk management manuals, and leakage reduction and distribution management, etc. This is considered to have contributed to the operation and maintenance of the Project through the strengthening of MWA's technical capabilities.

The Bangkhen WTP obtained international standards (ISO, HACCP) for quality management and environmental management, and the Mahasawat WTP as well obtained international standards for environmental management and sanitation management. During the site visit, the on-site staff at the water treatment and pumping stations were judged to have appropriate knowledge about operation and maintenance.

Based on the above, the technical level of MWA is sufficiently high, and there are no technical issues regarding the operation and maintenance of the Project.

3.4.3 Financial Aspect of Operation and Maintenance

MWA's income and expenditure for 2017-2019 are shown in Table 6. Revenues, mainly

from water tariffs, are much higher than expenditures, with an annual operating profit of around 7,000 million Baht (approximately 21 billion Yen). The operating profit margin is 34-38%, indicating that MWA's waterworks business is highly profitable. With a current ratio of 371-511% and a debt ratio of less than 27%, MWA's financial safety is high enough. In addition, the site inspection did not report any particular financial constraints for the operation and maintenance of the Project. Therefore, there are no financial issues in the operation and maintenance of the Project.

Table 5: MWA's Financial Performance

(Unit: million Baht)

	2017	2018	2019
Operating Revenues	18,850	18,801	19,510
Water sales	16,785	16,631	17,349
Water meter fees	955	971	985
Water connection fees	407	397	386
Work contract revenues	443	541	506
Other operating income	260	261	284
Operating Expenses	11,651	11,636	12,944
Raw materials and consumables	2,429	2,184	2,312
Personal cost	3,499	3,623	3,902
Depreciation	4,345	4,493	4,770
Other operating expenses	1,378	1,336	1,960
Operating Profit	7,199	7,165	6,566
Non-Operating Profit	369	354	437
Net Profit	7,568	7,519	7,003
Operating Profit Margin	38%	38%	34%
Current Ratio	371%	484%	511%
Debt Ratio	27%	24%	24%

Source: Material provided by MWA
Note: Operating Profit Margin: Operating Profit / Operating Revenue
Current Ratio: Current Assets / Current Liabilities
Debt Ratio: Liabilities / Capital

3.4.4 Status of Operation and Maintenance

According to the site inspection and interviews with the field staff, some of the water production, transmission and distribution facilities that were expanded and upgraded by the Project have malfunctioned, but MWA has been able to repair them and the capacity of the facilities has generally been maintained adequately. The major repairs that MWA has completed and those repairs in progress as of June 2021 are as follows.

- The repairs completed

- At Mahasawat WTP, installation of additional facilities for dosing chemicals such as flocculant and chlorine, repair of damaged submersible pumps were made.
- At Bangkhen WTP, repair of the remote-control device for the sedimentation tank was made. In addition, due to a chlorine gas leak at the chlorine injection facility, the equipment was damaged by the gas, and the valves, chlorine gas cylinder scales, and gas detection and alarm devices were repaired.
- Leaks in reservoirs at two pumping stations were repaired.

➢ The repairs in progress (as of June 2021)

- Bids are being prepared for the repair of a crack in the floor (K-Floor) of one of the 14 filtration tanks at Bangkhen WTP. As a result of this failure, the water production capacity of the plant has been reduced by nearly 10% since November 2020.
- Sam Lae PS: The installed raw water pump is not in operation as of June 2021 due to bearing and lubrication system failure, and is awaiting repair while spare parts have been ordered from the manufacturer. The raw water pump is useful for efficient intake of water during the time when the salinity of the river, which is the water source, is low.

Based on the above, no major problems have been observed in the institutional/ organizational, technical, financial aspects and current status of the operation and maintenance. Therefore, sustainability of the Project effects is high. The problems at the WTPs are expected to be repaired, and it is judged that they will not affect the sustainability of the Project.

4. Conclusion, Lessons Learned and Recommendations

4.1 Conclusion

The Project was implemented to satisfy the pressing water demand of Bangkok Metropolitan Area by strengthening the water production capacity and developing/expanding water intake, transmission, and distribution facilities and distribution pipes of MWA, thereby contributing to the improvement of the living environment of the residents in the area. The Project is highly relevant with the development policy, development plan, and development needs of Thailand and the Bangkok Metropolitan Area, both at the time of planning and ex-post evaluation. The Project is also highly relevant with Japan's ODA policy at the time of the planning. Therefore, relevancy of the Project is high. The outputs were generally as planned except for the installation of pipelines, and the project cost was within the plan. However, since the length of the pipeline installed was less than planned and the project period was longer than planned, the efficiency of

the Project is fair. As a result of the Project, the water production capacity of MWA increased as planned and the amount of water supply increased. This, together with the expansion of reservoirs and pumping facilities and the laying of water distribution pipes implemented under the Project, led to an improvement and expansion of MWA's water supply services. This has had an impact on improving the living environment and public health, and water users are highly satisfied with the results. In addition, the Project has provided an alternative water source to groundwater, which is considered to contribute to the mitigation of land subsidence. In summary, the effectiveness and impacts of this Project are high. No major problems have been observed in the institutional/organizational, technical, financial aspects of the operation and maintenance of the Project. Therefore, sustainability of the project effects is high.

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

4.2 Recommendations

4.2.1 Recommendations to the Executing Agency (MWA)

- MWA should complete the water transmission pumps at the Bangkhen WTP, which is included in the scope of the Project, as soon as possible to guarantee reserve water transmission capacity to ensure smooth water transmission at all times.
- MWA should immediately repair the faulty filter floor of the Mahasawat WTP to restore the water production capacity of the plant, and the raw water pump at Sam Lae PS will be repaired as soon as possible to restore the pumping capacity. Also, consideration needs to be given to safety improvements, such as adding lighting equipment to the sedimentation tank at the Bangkhen water treatment plant.
- MWA should install the pipelines that could not be constructed under the Project as soon as possible, in coordination with the relevant organizations.

4.2.2 Recommendations to JICA

JICA should encourage the implementation of the above recommendations by MWA and monitor the implementation status.

4.3 Lessons Learned

<u>Involvement of operation and maintenance staff in the design of facility expansions</u>

In the two WTPs expanded in the Project, there were some design issues that affected the efficiency and safety in the operation and maintenance of some facilities. Some of these issues could have been prevented if the design and experience of operation and maintenance of the existing facilities had been sufficiently referred to, for example, by seeking the opinions of the

on-site staff of the WTPs during the detailed design. Therefore, in the projects to expand existing facilities, it is important to provide sufficient opportunities to hear the opinions of the engineers and operators who operate and maintain the existing facilities, and to conduct the design with sufficient reference to the specifications and capabilities of the existing facilities and their various experiences in operation and maintenance.

Comparison of the Original and Actual Scope of the Project

Items	Plan	Real
1. Project Outputs	Expansion of Mahasawat WTP Raw water pumps (150 m^3/min x 2 units) Transmission pump (300 m^3/min x 1 unit) Expansion of capacity (400,000 m^3/day) Reservoir Expansion of Bangkhen WTP Raw water pumps (358 m^3/min x 2 units) Transmission pumps (300 m^3/min x 3 units) Expansion of capacity (400,000 m^3/day) Filter press (400,000 m^3/day) Electrical substation（69/6.6kV, 15MVA） Installation of additional pumping equipment Distribution pump at Bang Plee PS (125 m^3/min x 1 unit) Raw water pump at Sam Lae Intake (500 m^3/min x 1 unit) Expansion of distribution reservoir Reservoir at Rat Burana PS (40,000 m^3) Reservoir at Petch Kasem PS (40,000 m^3) Installation of pipelines Water distribution main (112km) Water distribution branch (875km) Consulting services Detail design, bidding documents, supervision	Expansion of Mahasawat WTP as planned as planned as planned as planned Expansion of Bangkhen WTP as planned To be completed in December 2021 as planned as planned as planned Pumping equipment as planned as planned Reservoir Reservoir at Rat Burana PS (10,000 m^3) as planned Pipelines Water distribution main (74km) Water distribution branch (470km) Consulting services as planned
2. Project Period	September 2009 – January 2014 (53 months)	December 2009 – October 2016 (77 months excluding the period of force majeure due to floods, 145% of the planned period)
3. Project Cost	ODA Loan 4,462 million Yen Fund from Thai side 16,637 million Yen Total 21,099 million Yen Exchange rate: 1Baht ＝2.80Yen (April 2009)	4,410 million Yen 16,176 million Yen 20,586 million Yen 1Baht ＝3.09 Yen (Average rate applied for the disbursement of ODA Loan)
4. Final Disbursement	March 2017	