Local Water Utilities Administration (LWUA)
The Republic of the Philippines

REPORT
FOR
THE FOLLOW-UP PROGRAMME
ON
THE PROJECT FOR
IMPROVEMENT OF WATER
QUALITY IN LOCAL AREAS
IN
THE REPUBLIC OF THE
PHILIPPINES

SEPTEMBER 2011

Japan International Cooperation Agency

Japan Techno Co., Ltd.

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SUMMARY

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1. Background of the Project

Rural water supply services in Philippines are conducted by the Water District (WD), whose main serving areas are small and middle sized cities, under the Local Water Utilities Administration (LWUA), which serves local cities with population size of 20,000 and up. LWUA provides financial and technical support to WD to promote development of the rural water supply system and sound administrative operation of WD. Despite the effort, WD's operation is often hindered by water quality issues resulting from geographical condition as many small scale water supply services rely on deep wells for their water resource. In many of these cases, unclean water with substances such as iron, manganese, color and odor exceeding the Philippine's water quality standard. This water is supplied with no treatment and water outage occurs regularly due to cleaning of the pipes.

Because of these problems, the residents tend to rely on expensive commercial or more treacherous shallow water sources rather than WD run water facilities, this cause outbreaks of hygiene related problems. In addition, aging of the water facilities resulted in an increase of un-accounted for water (UFW) rate to over 50%, posing difficulties to WD. To respond to the situation, LWUA asked Japan for Grant Aid assistance in July 1997, based on 'Project for Improvement of Water Quality in the Republic of the Philippines', which focuses on WDs in the island of Luzon, Panay, Leyte and Mindanao, who are identified to hold the most urgent needs for water quality improvement.

Japan in response conducted a basic design survey from 1999 to 2000 and the government of Philippines spent a lot of time to approve the implementation of this project. Two years had passed since the initial survey, a implementation review was conducted and discrepancies were found. From the review, a project for the improvement of water quality targeting 9 WDs was planned and an official exchange of note stating two terms construction programme of June 2002 and August 2003 was signed between the Japanese and Philippines governments. The site number was amended to 7 WDs (Panitan, Pontevedra, Dingle-Pototan, Abuyog, Binmaley, Lingayen and Pagsanjan) due to security concerns of 2 WDs in Mindanao island in the detail designing phase, and the constructions were completed in October 2004 for the first term and March 2005 for the second term respectively.

However, some of the constructed facilities were found to be not used properly. Ministry of Foreign Affairs (MOFA) and Japan International Cooperation Agency (JICA) attempted to improve the situation through dispatch of experts and technical assistance and surveys by consultants. However, the WTPs have not been used adequately.

Based on the above background, JICA suggested a plan for the proper use of the facilities to LWUA and WD, and LWUA requested in January 2010 a follow-up cooperation on restoration of the facilities and technical assistances for appropriate facility operation and maintenance.

With the request from LWUA, JICA resolved a plan for the follow-up cooperation. The purpose of this project is to draw up a detailed content that aims for the proper operation of the facilities constructed with Grant Aid cooperation under 'the Project for Improvement of Water Quality in the Republic of the Philippines' and based on the survey results, to perform construction supervision of the follow-up cooperation project implemented by JICA.

2. Outline of Survey Result and Content of Project

JICA dispatched an investigation team multiple times the dispatch between 11 April 2009 and 20 July 2011. As a result of the investigation, out of 6 WDs, Abuyog WD and Lingayen WD were removed due to the relationship of the technical cooperation project and the problem that the responsibility of the recipient was not implemented. Rehabilitation projects of some of the defect devices and the structure for the rest of 4 WDs were designed, and after discussion with the WDs, the final follow up rehabilitation plans were determined.

The bidding documents are prepared based on this plan, and the biddings and the rehabilitation work for Lot-1 and Lot-2 were implemented. Regarding the deep well pump for Dingle pototan WD, the specification of the pump will be decided after the examination of the pumping test in Lot-1. Therefore the procurement of this was excluded in Lot-1 and was procured by JICA Philippine office. The target sites of Lot-1 and Lot-2 are as follows.

Lot	WD	Remark
Lot-1	Dingle-Pototan and Pontevedra	
Lot-2	Binmaley, Pagsanjan, Dingle-Pototan※ and Pontevedra※	※mark: only pump procurement

3. Project Period and Cost

The cost and period of this follow-up cooperation are summarized in the table below.

Item	Cost	Period
Lot-1	10.8 million yen	3 Months
Lot-2	31.3 million yen	5 Months
Procurement by Philippine JICA office	1.3 million yen	4 Months
Total	43.4 million yen	

4. Project Evaluation

The defective facilities in each WTP were renewed by this project, and the impacts of the project are shown in the table below.

WD	Impact
Dingle-Pototan	The replacement of the old pipeline, the prerequisite for the implementation of the follow-up cooperation was implemented by the WD. And the WTP was resumed to operate by the rehabilitation of some facilities. As a result of these works, the distribution of the water quality that satisfy the Philippine standards is enabled.
Pontevedra	Although the maintenance had been difficult due to the corrosion of some of the facilities by the salt in the raw water, each facility was renewed to be the corrosion resistance. Therefore the original function of WTP was regained.
Binmaley	The old broken facilities were renewed and the sludge drying bed was constructed, therefore the drain system operates properly.
Pagsanjan	The old broken facilities were renewed, and the rehabilitation was executed to correspond to the present condition, as a result, the maintenance management was improved and the operation of the WTP became proper.

As shown above, this follow-up cooperation enabled the proper operation and maintenance of the WTPs through the renewal of some of the old broken facilities. This led to the suitable water supply for the consumer, and contributed to the improvement of living standard.

REPORT FOR THE FOLLOW-UP PROGRAMME
ON THE PROJECT FOR IMPROVEMENT OF WATER QUALITY IN
LOCAL AREAS IN THE REPUBLIC OF THE PHILIPPINES

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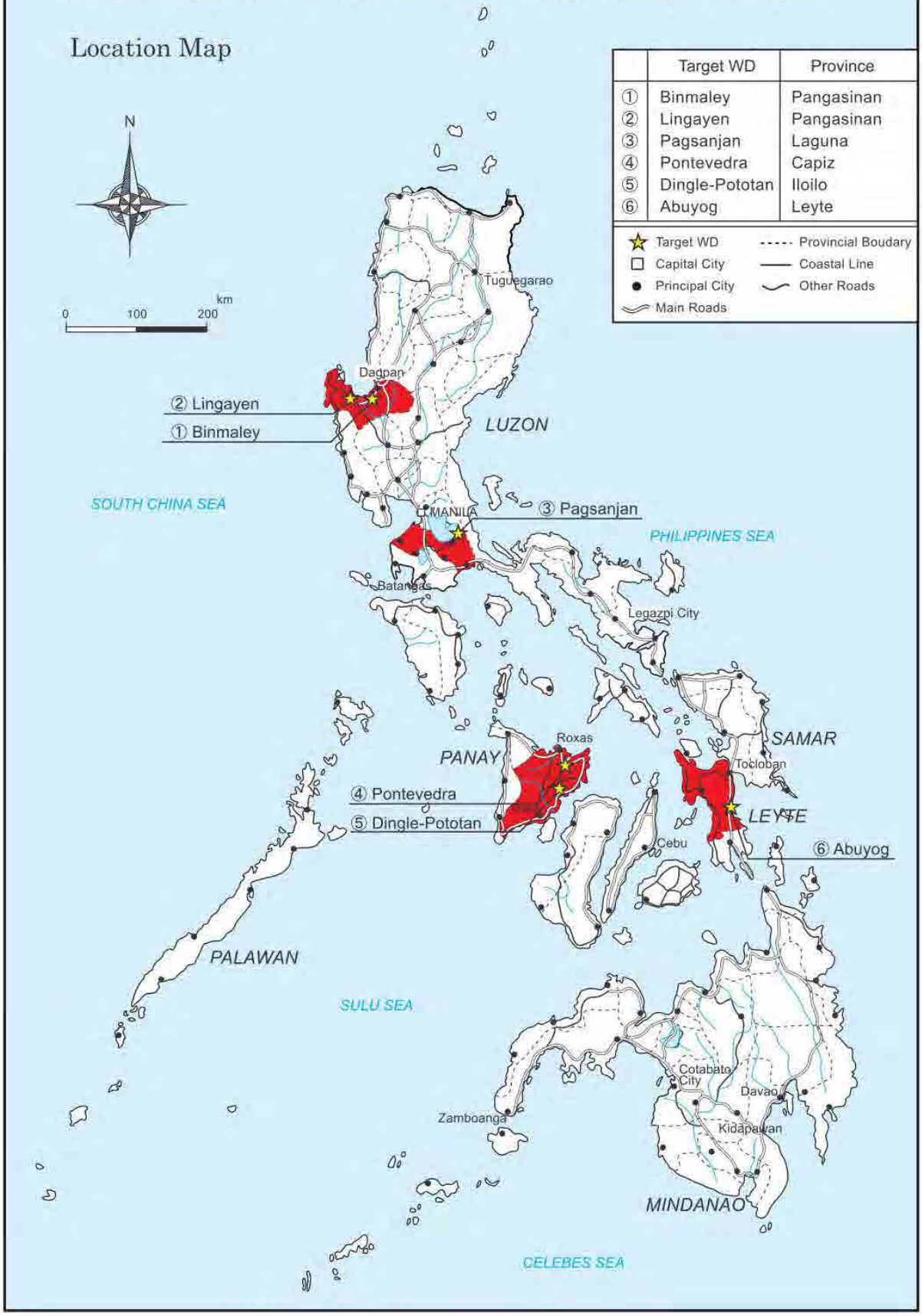
The Follow-Up Programme on the Project for Improvement of of Water Quality in Local Areas in the Republic of the Philippines

Location Map



PICTURES

Status before the rehabilitation of WTP in Abuyog WD

Transmission pump: pump No.2 is not in use due to a malfunction of the shaft. The motor has no problem. Currently pump No.1 and the surface-wash pump are operating alternatively.

Sedimentation basin: Sludge is removed only three times since the operation started. Therefore, the sludge is accumulated considerably.

Status before the rehabilitation of WTP in Dingle-Pototan WD

Aeration Tower: Leakage from the concrete joint.

Distribution pumps: Not in use due to a breakdown. Pump No.1 has shaft broken. Pump No.2 has problem with over-current; the motor has no problem, thus the pump is somehow defective.

Status before the rehabilitation of WTP in Pontevedra WD

Sedimentation basin, sludge drain pipes: Corrosion makes holes on the pipe.

Backwash pump: It has been removed since Oct 2009 because of mechanical failures.

Status before the rehabilitation of Caloocan WTP in Binmaley WD

Sludge drying bed: Bed sand has been removed due to clogging after being used for five times.

Post chlorination pump: It has been removed due to a breakdown.

Status before the rehabilitation of Fabia WTP in Binmaley WD

Sedimentation basin: Sludge drain pipe has holes due to corrosion.

Sludge Drying bed: An additional sludge storage basin was constructed by WD for receiving the excess sludge.

Status before the rehabilitation of WTP in Lingayen WD

Flocculator: Some baffle plates fell off due to breakage of holding bolts caused by corrosion.

Rapid sand filter: Surface wash pipe needs to be repaired due to rust.

Status before the rehabilitation of WTP in Pagsanjan WD

Sand separator: It was changed two times and finally removed because of holes.

Chlorination pump: Pumps were removed because of Corrosion.

LIST OF FIGURES AND TABLES

ABBREVIATIONS

DENR	Department of Environment and Natural Resources
JICA	Japan International Cooperation Agency
KfW	Kreditanstalt für Wiederaufbau
LWUA	Local Water Utilities Administration
PAC	Poly Aluminum Chloride
Peso	Phillipine Peso
PQ	Pre Qualification
SW	Scope of Work
UFW	Un-accounted For Water
WD	Water Districts
WTP	Water Treatment Plant

CHAPTER 1

BACKGROUND OF THE PROJECT

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1-1 Background of the project

Rural water supply services in Philippines are conducted by the Water District (WD), whose main serving areas are small and middle sized cities, under the Local Water Utilities Administration (LWUA), which serves local cities with population size of 20,000 and up. LWUA provides financial and technical support to WD to promote development of the rural water supply system and sound administrative operation of WD. Despite the effort, WD's operation is often hindered by water quality issues resulting from geographical condition as many small scale water supply services rely on deep wells for its water resource. In many of these cases, unclean water with substances such as iron, manganese, color, odor exceeding the Philippine's water quality standard. This water is supplied with no treatment, and water outage occurs regularly due to cleaning of the pipes.

Because of these problems, the residents tend to rely on expensive commercial or more treacherous shallow water sources rather than WD run water facilities, this cause outbreaks of hygiene related problems. In addition, aging of the water facilities resulted in increase of un-accounted for water (UFW) rate to over 50%, posing difficulties for WD. To respond to the situation, LWUA asked Japan for Grant Aid assistance in July 1997, based on 'the Project for Improvement of Water Quality in the Republic of the Philippines', which focuses on WDs in the island of Luzon, Panay, Leyte and Mindanao, who are identified to hold the most urgent needs for water quality improvement.

Japan in response conducted basic design study from 1999 to 2000 and the government of the Philippines spent a lot of time to approve the implementation of this project. Two years passed after the initial survey, a implementation review was conducted and discrepancies were found. From the review, a project for the improvement of water quality targeting 9 WDs was planned and official exchange of note stating two terms construction programme of June 2002 and August 2003 was signed between the Japanese and Philippines governments. The site number was amended to 7 WDs (Panitan, Pontevedra, Dingle-Pototan, Abuyog, Binmaley, Lingayen and Pagsanjan) due to security concerns of 2 WDs in Mindanao island in detail designing phase, and the constructions were completed in October 2004 for the first term and March 2005 for the second term respectively.

However, some of the constructed facilities were found to be not used properly. Ministry of Foreign Affairs (MOFA) and Japan International Cooperation Agency (JICA) attempted to improve the situation through dispatch of experts and technical assistance and surveys by consultants conducted in 2009 revealed followings:

- ✓ Change in external conditions for water facilities, such as decrease in water quantity of existing wells and change of source water quality.

- ✓ Some WD's WTPs are non-operational due to occurrence of a vicious circle of 1) high rate of UFW and inefficient water distribution system challenges WD's financial situation 2) causes WD to stint in amount of the chemical input, and the raw water gets delivered without any treatment as planned
- ✓ LWUA and WD personnel's operation and maintenance ability was lower than expected during the project design, resulting in mismanagement of coagulation basin and rapid sand filter. This led to the deterioration of the facility performance.

Based on the findings JICA suggested a plan for the proper use of the facilities to LWUA and WD, and LWUA requested in January 2010 a follow-up cooperation on restoration of the facilities and technical assistance for appropriate facility operation and maintenance.

With the request from LWUA, JICA resolved a plan for the follow-up cooperation. The purpose of the project is to draw up a detailed content that aims proper operation of the facilities constructed with Grant Aid cooperation 'the Project for Improvement of Water Quality in the Republic of the Philippines' and based on the survey results perform construction supervision of the follow-up cooperation project implemented by JICA.

Table 1-1 The background of the project

Year	Month	Activity	Transition of implementation site
1997	4	Request of the project from the Philippines government	Requested sites: Solana, Pagsanjan, Balayan, Matnog, Panitan, Pontevedra, Dingle - Pototan, Abuyog, Middsayap, Kabakan
1999	8-10	Field survey Ⅰ	Removal of Balayan and Matnog sites and addition of Lingayen, Binmaley sites. Consultant proposed of water resource development, but utilisation of existing resources was prioritised.
1999	11-12	Field Survey Ⅱ	
2000	3	Explanation of draft final report Ⅰ	
2000	6	Explanation of draft final report Ⅱ	
2002	2-3	Implementation review	Removal of Solana site for financial reasons
2002	6	The first term EN	Sites for the first term: Panitan, Pontevedra, Dingle-Pototan, Abuyog
2003	8	The second term EN	Sites for the second term: Lingayen, Binmaley, Pagsanjan. For security concerns, Midsayap and Kabakan were removed.
2003	4	The first term construction	Construction completed in Panitan, Pontevedra, Dingle-Pototan, and Abuyog
2004	10		
2004	4	The second term construction	Construction completed in Lingayen, Binmaley（Caloocan and Fabia） and Pagsanjan
2005	3		
2009	3-11	Survey of the improvement of this project	
2010	1	Request for the project follow-up	Requested site: above mentioned sites except Panitan

1-2 Purpose of the survey

This project aims to draw up the follow-up cooperation plan targeting 6 WDs based on detailed

design of Grant Aid assistance whose objective is the proper operation of the WTPs constructed in 2003 and 2004 with 'the Project for Improvement of Water Quality in the Republic of the Philippines' construction term1 and 2.

Table 1-2 Project Summery (Grant Aid assistance plan at the time of Implementation review)

Overall Objective	Financial performance of WD is improved.
Project Objective	Supply water that meets Philippines' water quality standard in 6 WDs where the quality of the underground water, which is used as the water source is extremely bad.
Outputs	Water purification facilities are constructed in the targeted 6 WDs (Dingle-Pototan、Pontevdra、Abuyog、Binmaley、Lingayen、Pagsanjan).
Beneficiaries	Direct beneficiaries: Water served population of 240,000 people in target areas(of a 2010 estimation)
Implementing Organisation	Local Water Utilities Administration：LWUA

	Verifying indicator items		Before implementation(2001)	After implementation(2010)
Project verifying indicators	Daily average water consumption		14,700 m^3/day	18,300 m^3/day
	Water quality of treated water	Iron	1～10 mg/L	<0.3 mg/L
		Manganese	0.5～2.0 mg/L	<0.05 mg/L
		Ammonia	0.5～7.2 mg/L	<0 mg/L
		Color	20～120 Degree	<5 Degree
		Odor/Taste	Odor of iron and hydrogen sulfide	No odor nor taste
		Residual chlorine	0 mg/L	0.1 mg/L or more

Project content	Contents of the request to Japan	✓ Construction of water purification facilities in target 6WDs ✓ Renewal of the well pumps and chlorination facilities ✓ Implementation of technical instruction regarding operation of the water purification facility
	Counterpart country's Inputs	✓ Continue appropriate operation of the WDs by their operating personnel ✓ WDs set an appropriate water service fee and gain residences' approval ✓ WDs perform appropriate measures against UFW

1-3 Target project areas

Target areas of this project are the 6 WDs as listed below. The key industry of the project sites is agriculture and fisheries; they are typical Philippines rural cities. Markets, banks and governmental establishments are concentrated at the centre of the city and city roads in each WD are paved. Transport method to nearby places consists of typical Philippines buses and for short distances tricycles or bicycle with side-cars are also used. Typical housing is one or two story houses made with bricks or timber. Although in some areas power cut occurs regularly, most of the houses in project sites have electricity.

Pumping equipment in pump station in targeted 6 WDs is power generated too, but some keeps a power generator because of the still frequently occurring power cuts. Sewage service is not developed enough: though some equips with septic tanks, most of residential water waste are directly discharged or filtrated to underground, human excreta is dealt with excreta collection or

also filtrated into underground. Rainwater is drained by street gutters and small waterways and garbage is dealt with open dumping to coastal or suburb area, which suggest risk of water contamination of the shallow water wells.

Table 1-3 Summary of the target areas

Survey target areas	Summary
Dingle-Pototan	Dingle-Pototan in Panay island is divided into two administrative wards of Dingle and Pototan, each with an independent town council, yet for WD function grouped together. Major industry is agriculture (rice, maize, sugar cane). There is an Iloilo power plant serving Iloilo state. There are also threshing plants for rice and maize, bamboo craft, china and shoe manual factory. Neighbouring major city is Iloilo, the capital of Iloilo state, locating 40km to the south.
Pontevedra	Situated in Panay island and its industry is agriculture, mainly cultivating sugar cane. For its sea side location, fishery composes 12% of its industry too. There is a market in the centre of the city, as well as petrol station, ice factory and other small shops. Neighbouring major city is Roxas, located 20km northwest of Ponteydra.
Abuyog	Located in Leyte island, a passing point of transport from Manila to Mindanao. The key industry is agriculture of copra and rice. Fishery and small enterprises also exist. Located 65km to the south from Tacloban, the capital of Leyte state with tourist beaches.
Binmaley	Belongs to Luzon island in Pangasinan state, sharing boundary with below listed Lingayen. Key industry is agriculture and fish farming. Farming field and fish farming pond consist of respectively 20% and 51%, making up 71% of the total land. Other industry includes furniture manufacturing and small shops. Its major neighbouring city is Dagupan, where EMB has a local office. Dagupan being merely 10km to the east from Binmaley, it is coming to be a commuter town for Dagupan.
Lingayen	Located in Luzon island and the capital of Pangasinan state, its main commerce and industry centre is aforementioned Dagupan, with governmental function concentrated in Lingayen. Just like Binmaley the key industry is agriculture and fish farming. Farming land makes up to 37% of the total land, mostly dedicated to rice production. Fish farming pond consists 27%. Its beaches facing Lingayen Gulf is a tourist stop. Major neighboring city is Dagupan, 15km east from Lingayen. As Binmaely, it is growing to become a commuter town for Dagupan.
Pagsanjan	Located in Luzon island in Laguna state. With a famous waterfall and its easy access distance from Manila, it is home to 110,000 visitors each year with 10 hotels of different sizes. Another industry is agriculture producing rice and coconut. Commerce is small with only small size shops. It is closest to Manila amongst all project sites with 90km of a distance to the northwest.

1-4 Project policy and points of concern

The cooperation for proper operation of WTPs that are constructed with 'the Project for Improvement of Water Quality in the Republic of the Philippines' term 1 and 2 of 2003 and 2004 consists of three parts as stated below. This project focuses on the 2nd of the three, which is further divided into four different kinds of work: conduct survey to design content of the follow-up cooperation, based on the established content support tender for the rehabilitation work which JICA Philippines office procures, supervise the process of construction, and provide initial operation instruction of the facilities.

- ✓ Design mid-long term plans for WDs with technical cooperation project 'Small Water Districts Improvement Project'
- ✓ With the follow-up survey and cooperation, improvement of the facilities (this project)
- ✓ Instruction on WTP's operation and maintenance provided by dispatched

technical cooperation expert

Table 1-4 Four main work in the project

Survey	・ Based on the detailed design work implemented in 2003 and 2004's the republic of Philippines 'the Project for Improvement of Water Quality in the Republic of the Philippines' term 1 and 2, conduct survey to design the follow-up cooperation (the rehabilitation work) proposal ・ After JICA decide the contents of the follow-up cooperation, compile tender-related documents with detailed design and cost estimation of the content of the follow-up cooperation based on each lot.
Support to the tendering	・ Support the tender for the follow-up cooperation conducted by JICA Philippines Office based on the tender related data compiled based on survey work.
Supervision of the construction process	・ After construction company of the follow-up cooperation and JICA Philippines Office made a contract, supervise the construction process ・ 'Supervision of the construction process' is a supporting work of JICA's supervision and designing; in the place of JICA's supervisor and sub supervisor, and based on the contract and drawing and specification, the job is to conduct temporary supervision, examinations, and verify the quality, amount and make. ・ Construction company will provide one year guarantee on facilities constructed with the follow-up cooperation, and towards the end of the guarantee period, defect examination will be conducted. ・ If technical failure is detected during the guarantee period, verify the situation and notify JICA without delay.
Verification of operational state of the Water purification facilities and provision of instruction on facility operation	・ Conduct test run for the facilities constructed by the follow-up cooperation for a set period and analyse the appropriate amount of chemical injection from test operation at the facility. ・ Prepare operation and maintenance manuals for each facility based on the result of test operation ・ Using the operation and maintenance manuals, provide instruction on initial facility operation to WD personnel and the facility operators.

CHAPTER 2

RESULT OF THE FIELD SURVEY

CHAPTER 2 RESULT OF THE FIELD SURVEY

2-1 Result of the Field Survey in Abuyog WD

2-1-1 Outline of the Follow-up Cooperation in Abuyog WD

The Water Treatment Plant (WTP) in Abuyog WD was implemented under *the Project for Improvement of Water Quality in the Republic of the Philippines* financed by the Government of Japan as the JICA Grant Aid project. The WTP was handed-over after the test operation in 2004. The WTP in Abuyog WD has been operating more efficiently than other WDs, because the WD utilizes the surface wash pump as transmission pump to adapt to the current water demand, and has the separate systems for the transmission and the distribution. Howerer, it is need the rehabilitation of the WTP because current operation is not proper due to aging.

There is the problem that filter sand becomes mud ball because the raw water contains high hardness. However, current operation is not done the surface-wash due to using the surface-wash pump for transmission pump. This makes the rapid sand filter not to function properly and there is a need for a replacement of the filter sand. Humic substances need to be removed by sedimentation after pH adjustment. For this, laboratory water quality analysis needs to be conducted on the possibilities of the trihalomethane formation as there is a possibility that the cancer causing trihalomethane can be generated by a reaction of the chlorination with the humic substance. The sedimentation basin and the filtration rate of the rapid sand filter also need an adjustment to the actual volume of water treatment.

2-1-2 Result of the Field Survey

2-1-2-1 Survey Method

A field survey was carried out in the Abuyog WD to investigate the current status of the water treatment facilities and to design the rehabilitation works.
The following surveys were conducted:

Water service study	: to confirm the water source and water service situation
System flow survey	: to confirm the current treatment process
Facility function study	: to investigate the function of the existing facilities
Water quality analysis	: to investigate the quality of the rawand treated water
Jar test	: to confirm the optimum dosage of coagulant
Breakpoint chlorination	: to determine the optimum dosage of chlorine
Test operation	: to confirm the treatment situation with changed dosage

2-1-2-2 Survey Result of Water Service Study

(1) Water survice

The situation of the water supply service is summarized in the table below according to the monthly report of Abuyog WD (Dec. 2009).

Compared to the water supply service in around 2000, the number of active connection is decreased because of the yellowish rice issues. However, recently WD has been trying to promote the entry, and the number of the connection is on the increase.

Table 2-1 Water Supply Service in Abuyog WD (Dec. 2009)

Item	Total
Service connection	1,516
Number of current active connection	621
Expected population served	3,726
Volume of water produced (m^3/d)	447
Volume of Water billed (m^3/d)	291
Unaccounted for water (%)	34.6

The total population of the Abuyog city as of 2010 is 57,100, the water supply rate in the city is only 6.5%. However, some of the Barangays[1] have their own waster supply system (especially in Poblacion, whose population is 17,990) and the water supply rate in the area where there is coverage of the service is 20.8%. The number of active connection in December 2009 is 621 households while the total service connection is 1,516; this leads to an assumption that there once has been 2.4 times more of the connection in the past than at present.

The water tariff structure of theAbuyog WD is shown in the table below. Compared to the national average water tariff of 0–10m^3 for household/public facility being 172.49 peso, the rate of Abuyog is nearly 1.4 times higher.

Table 2-2 Water Tafiff Structure in Abuyog WD

Unit:Peso

	0–10m^3	11–20m^3	21–30m^3	31m^3–Above
Household/public facility	240	25.7	28	30.85
Commercial/industrial facility	360	44.95	49	53.95

(2) Operation of the water sources

Present water supply in Abuyog WD is sourced only from Barayong deep well which is connected to the WTP. The other water sources are not being used at present. The yield, operating hours and daily product of water source is listed below.

[1] Barangay is the smallest administrative division in the Philippines and is the native Filipino term for a village, district or ward.

Table 2-3 Operation of Water Source in Abuyog

Name	Yield	Operating hours	Daily product
Barayong Deep Well	27 l/s	5hrs	484 m^3/d

2-1-2-3 Survey Result of Water Treatment Facilities

(1) Current System Flow

The current system flow and designed system flow are illustrated below.

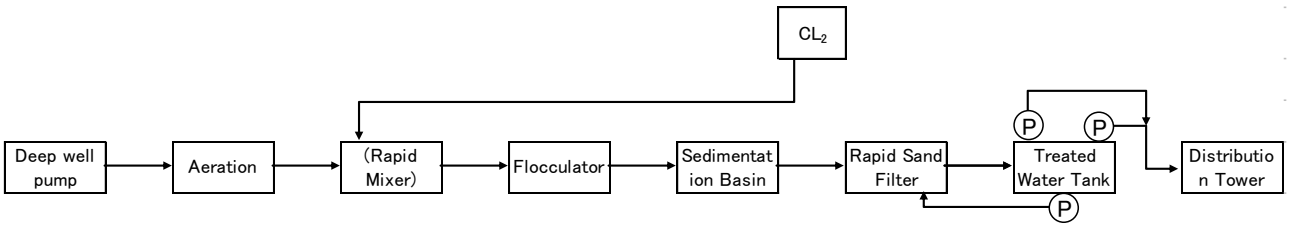

Figure 2-1 Current System Flow

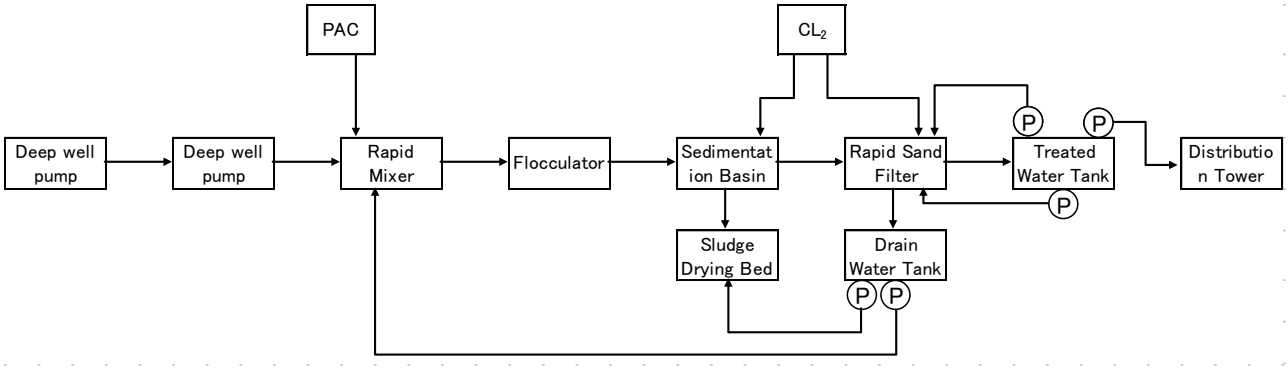

Figure 2-2 Designed System Flow

As shown in the figures, the current system flow is basically along the designed flow; however, the following problems are observed.

The flocculator, sedimentation basin and rapid sand filter can not fulfill their roles because the current operation does not use the coagulant.

- ✓ Regarding chlorinatin treatment, the intermediate chlorination is designed to be applied for manganese and ammonia removal and the post chlorination for disinfection. The current operation however altered it to only the pre chlorination at the mixing basin, thus the function is not operating properly.
- ✓ The rapid mixer at the mixing basin isn't used due to mechanical failures.
- ✓ The surface-wash pump is used as a transmission pump and the surface-wash processes is not practiced at all.
- ✓ The drained water from backwashing process is not recycled, thus it is not used as the basic design.
- ✓ The sludge drying bed has not been used, and the sludge has been accumulated in the sedimentation basin.

(2) Function of Facilities

Current state of each WTP facility including the structure, electrical wiring, plumbing and mechanical equipment were investigated. The result is summarized in the table below.

Table 2-4 Current State of the Facilities

Facility		Q'ty	Current State
Intake	Deep Well	1	Some sands are rising because screen might have been deteriorated.
	Deep Well Pump	1	Pump was replaced 2 years ago. No problem.
Treat-ment	Sand Separator	1	No problem
	Aeration Tower	2	Currently the door is opened during the operation, thus DO of raw water is 3mg/l, aerated water is 7mg/l. Also O_2 concentration in the tower after aeration was 20.7% which is not oxygen-deficient. Therefore no problem in aeration process. / The doors are decrepit; one of doors is already removed.
	Rapid Mixer	1	Failure
	Hydraulic Flocculator	1	Insufficient mixing intensity due to low flow velocity
	Sedimentation Basin	2	Floc settlement is not sufficient, and flocs are carried- over from the basin.
	Rapid Sand Filter	2	Filter sand cover surface-wash pipes and it is put up on the position of the outlet trough. As the result of above, the filtration areas are extremely decreased, and sand comes to flow out abundantly during the back wash.
	Backwash Pump	1	No problem
	Surface-wash Pump	1	Currently the surface-wash pump is used as transmission pump, thus the surface-wash is not conducted now. This is the major factors that caused the mud ball.
	Treated Water Tank	2	No problem
	Drainage Basin	1	Withdrawal of sludge has not been done.
	Recycling Pump	1	Not used, but no problem to operate.
	Sludge Drain Pump	1	Not used, but no problem to operate.
	Sludge Drying Bed	4	Not used, installation of bed sand is required for proper function to accommodate the change in Philippines effluent standard.
	Chemical Feeding Room	1	No problem
	Coagulant Agitator	2	Not used, but no problem to operate.
	Chemical Feeding Pump	1	Failure due to the leakage of oil.
	Chlorination Room	1	No problem
	Chlorine Agitator	2	Not used, but no problem to operate. However, about No.2, repair is necessary because the swith of control panel is not work.
	Intermediate Chlorination Pump	1	Although it is used now, the clog has occurred frequently and is performing decomposition repair at each time.
	Post Chlorination Pump	1	Failure
	Stand-by Generator	1	The injection pumpo should be adjusted.
Trans-mission	Transmission Pump	2	Currently only one pump is operated. The other pump is failure.
	Pressure Tank	1	Not used.

The function of each facility is diagnosed referring to the design criteria. The result is as follows.

- ✓ Average flow velocity in the flocculator is slower than the design criteria, which

means the floc formation is insufficient.

- ✓ Surface loading in the sedimentation basin satisfies the design criteria, while the retention time is fewerthan the standard of 3–5hours.
- ✓ To improve the function of the sludge drying bed, replenishment of the bed sand is needed. In the effluent standard at the time of basic design (enforcement in 1900), there was no necessity of effluent treatment because the amount of effluent was little. However, the clean water act was approved in 2004, it is required to keep the effluent standard even if the small amount of water. Therefore, enlargement is necessary because current capacity is less than the required capacity of current water quality.

Table 2-5 Function Diagnosis of the Facilities

Item	Unit	Design standard	Plan (Current)	Remarks
Water Volume	m^3/day		2,412 (484)	Average 5 hrs operation per day
	L/sec		28 (27)	
Intake				
Deep well pump			1.6m^3/min	Pump was replaced 2 years ago. No problem.
Aeration Tower				
Surface load	m^2/m^3/hr	0.4–1.0	0.48	
Rapid Mixer				
Type			Flush mixer	Failure
Flocculator				
Type			Vertical baffle	
Effective dimension	m		DWL: 2.0×1.0×30	
Effective capacity	m^3		60.0	
Retention time	min	20–40	35.8	
Flow velocity	m/s	0.15–0.30	0.04–0.11	Insufficient floc formation
G-value	sec^{-1}	10–75	19	
GT-value		23,–210,000	39,300	
Sedimentation Basin				
Type			Rectangular Horizontal flow	
Number of basins		> 2 basins	2	
Effective dimension	m		DWL: 3.2×2.5×13	
Weir load	m^3/d/m	< 500m^3/d/m	302	
Length/width ration		3–8 times	5.2	
Effective surface area	m^2		65.0	
Effective capacity	m^3		208	
Effective depth	m	3–4m	3.2	
Surface loading	mm/min	15–30	25.8	
Flow velocity	mm/min	< 400mm/min	127	
Retention time	hr	> 3–5hr	2.1	Insufficient floc Settlement
Rapid Sand Filter				
Type			Rapid Sand Filtration	
Number of basins		> 2 basins	2	
Effective dimension	m		WL: 2.5×3.8	
Filter area/basin	m^2		9.5	
Filtration rate	m/day	120–150	127	
Backwash pump			6.1m^3/min×12m×22kW, φ250	
Surface-wash pump			1.9m^3/min×30m×18.5kW, φ150	No surface-wash due to using as transmission pump
Intermediate Chlorination				
Dosing pump			9.0-10.8l/min×1.0MPa×0.2kW	Modification of injection pipe is required
Post Chlorination				
Dosing pump			0.25-0.3l/min×1.0MPa×0.2kW	
Sludge Drying Bed				
Effective dimension	m		DWL: 0.5×2.0×4.0	
Number of basins			4	
Total area	m^2		32	
Total capacity	m^3		16	
Sludge volume	kg/d		66.1	
Required capacity	m^3		106	Improvement (bed sand etc) required
Treated Water Tank				
Number of basins			2	
Effective dimension	m		DWL: 5.0×5.0×17.0	
Effective capacity	m^3		425	
Supply Facility				
Distribution pump			2.6m^3/min×50m×37kW, φ200	Over-capacity, down size required
Number of pumps			2	

Item	Unit	Design standard	Plan (Current)	Remarks
Stand-by Generator	kVA		165	Capacity change (down size) due to the change of distribution pumps

The followings are the pictures of current state of facilities.

Aeration tower: The doors are decrepit; one of doors is already removed.

Rapid mixer: Not in use due to breakdown. It was covered not to hit rain and it was decomposed and greased once.

Sedimentation basin: Sludge is removed only three times since the operation started. Therefore, the sludge is accumulated considerably.

Sedimentation basin: Sludge is black, it might be manganese.

Sedimentation basin, sludge drain pipes: Pipes are not corroded; however, the sludge is attached on the pipes.

Rapid sand filter: Filter sand is put more than requires, it must be removed.

Rapid sand filter: A sand layer thickness is 60cm by the plan, but currently 90cm; thus the surface-wash pipes are covered and filtration area has decreased due to no space between sand and trough.

Rapid sand filter, surface-wash pipe: Currently the surface-wash pump is used as transmission pump, thus the surface-wash is not conducted now. This is the major factors that caused the mud ball.

Transmission pump: No.2 pump is not in use due to shaft broken. The moter is no problem. Currently No.1 and surface-wash pump are operated alternatively.

Transmission pump: No.2 has removed due to the mechanical failures.

Intermediate chlorination, injection pump: Although it often stops due to mechanical failures, it is decomposed and fixed and so it can be used somehow.

Post chlorination, injection pump: broken down; does not work when it is powerd on.

Chemical feeding pump: broken down and not being used.

Elevated water tank: In front of WD's office.

(3) Water Quality Analysis

The following table shows the results of water quality analyses carried out using field test kits and in a laboratory in Manila. Note that the result of the field test kits is not accurate because the field tests apply the simplified analysis methods, and the color is not true color but apparent color which can be measured in the field. In the table, the value which is higher than the Philippine water quality standards is colored pink and the value which needs some consideration is colored yellow.

Remarks on the major parameters are as follows.

- ✓ Color in each process is above the Philippine standard.
- ✓ Manganese is removed from raw water by treatment process; however, the values after filtration and water tap are same as the standard, it needs to be improved.

- ✓ Total Dissolved Solid (TDS) was 1,613mg/l at the time of the basic design, much greater than the standard. In this survey it has been worsened to 1,900mg/l, which is about 3.8 times the standard.
- ✓ Total Hardness is 1,192mg/l at the time of the basic design and 703mg/l in this survey. The value of this survey is lower than the value of basic design; however, it is still 2.3 times higher than the standard.
- ✓ Chlorine is 850mg/l in this survey,about 3.4 times the standard, even though it was 41mg/l lower than the standard at the time of the basic design.
- ✓ Sodium is 230mg/l in this survey, which is over the standard slightly, even though it was 166mg/l at the time of the basic design, figure lower than the standard.
- ✓ Ammonia has no standard value, but it is related with chlorine consumption. It is 4mg/l after filtration, but it has become lower at the tap water; it may react with free chlorine in the pipeline.

Table 2-6 Water Quality Analysis

Parameter		Unit	PNSD	Basic Design	Field Water Test					Lab. Test
					Raw Water	After Aeration	After Sedimentation	After Filtration	At Water Tap	Raw Water
1	Temperature	℃	-	30.6						
2	pH		6.5–8.5	6.73	6.84	7.50	7.65	7.72	7.48	
3	DO	mg/l	-	0.42	3	7				
4	EC	mS/m	-	239	220	210	210	210	210	
5	Turbidity	NTU	5	1	3.2	6.5	3.7	0.8	0.1	
6	Color	CU	5	15	19	65	40	16	16	
7	Fe	mg/l	1.0	4.0	2.0	0.8	0.3	0.1	0.1	2.4
8	Mn	mg/l	0.5	1.9	1.0	0.7	0.7	0.5	0.5	1.0
9	Silica	mg/l	-	76	150	80	80	80	70	
10	TDS	mg/l	500	1613						1,900
11	Total Hardness	mg/l	300	1192						703
12	Ca Hardness	mg/l	-	425						
13	M-Alkalinity	mg/l	-	1610	1400	1600	1500	1300	1500	
14	Nitrate	mg/l	50	N.D.						N.D.
15	Nitrite	mg/l	3	0.05						N.D.
16	Ammonia	mg/l	-	7.2	10	10	7	4	0.3	
17	Sulfate	mg/l	250	N.D.						N.D.
18	COD	mg/l	-	4.7	13	10	9	8	4	
19	Cl	mg/l	250	41	> 200	> 200	> 200	> 200		850
20	Na	mg/l	200	166						230
21	Ca	mg/l	-	170						100
22	Mg	mg/l	-	184						110
23	H_2S	mg/l	0.05	-	N.D.					
24	Free Cl_2	mg/l		-			0.14	0.12	0.12	
25	Residual Cl_2	mg/l	0.2–1.5	-			0.26	0.14	0.14	
26	Odor		No obj.	※	Metallic odor					
27	Bromoform	mg/l	0.1	N.D.						N.D.
28	Dibromochloromethane	mg/l	0.1	N.D.						N.D.
29	Bromodichloromethane	mg/l	0.06	N.D.						N.D.
30	Chloroform	mg/l	0.2	0.0023						N.D.

Pink cell is the value which is higher than the PNSD and yellow cell is the value which needs some consideration.
※Metallic odor and hydrogen sulfide odor

(4) The Jar Test

In order to determine the most effective dosage of coagulant (PAC) for the raw water in the Abangay WTP, jar tests were carried out during the field survey. The condition of the jar test was: rapid agitation for 1 min at a speed of 300rpm, slow agitation for 10 min at a speed of 30rpm, and settling for 10 min. The value which is higher than the Philippine water quality

standards is colored pink and the value which needs some consideration is colored yellow in the table.

Table 2-7 Case-1 Injection of only coagulant

Item \ PAC(mg/l)	PNSD	After Aeration	20mg/l	40mg/l	60mg/l	80mg/l
Floc. size	-	-	Small	Small–Midium	Small–Midium	Midium
Sedimentation	-	-	Slow	Midium	Midium–Fast	Fast
pH	6.5–8.5	7.50	7.75	7.73	7.48	7.61
Turbidity (NTU)	5	6.5	1.7	1.2	1.1	0.6
Color (CU)	5	65	27.5	22.5	20.0	19.0
Fe (mg/l)	1.0	0.8	0.2	0.2	N.D.	N.D.
Mn (mg/l)	0.5	0.7	0.8	0.7	0.5	0.5

Pink cell is the value which is higher than the PNSD and yellow cell is the value which needs some consideration.

(5) Breakpoint Chlorination

The raw water is including the ammonia, and it is needs to inject much chlorine to react completely. However, combined chlorine residual disinfectant effect, the injection rate will be decided by the concentration of residual chlorine at the end of distribution area.

(6) Test Operation

Currently the operation of WTP is only chlorination; coagulant is not dosed due to the technical failure of the chemical feeding pump and the rapid mixer. The test operation was conducted with a manual mixing to confirm the operational status using coagulant PAC 80mg/l. The current chlorine dosage is 1.0mg/l, and as the result of breakpoint chlorination, the rate was found appropriate. Therefore current chlorine dosage is left unchanged. The status of floc in sedimentation was confirmed. The floc after 4 hours operation with injecting coagulant was floating thus the growth of floc is considered to be not well. However, the floc was sedimented in flocculation basin and sedimentation basin after 2 hours of stopping the operation, and the water in the basin became clear. It is thought to be preferable to improve the flocculator and increase the intensity of agitation because the floc will be settled in the sedimentation basin once the formulatation of the big floc with coagulant injuection occurs.

2-2 Result of the Field Survey in Dingle-Pototan WD

2-2-1 Outline of the Follow-up Cooperation in Dingle-Pototan WD

The Abangay Water Treatment Plant (WTP) in Dingle-Pototan WD was implemented under *the Project for Improvement of Water Quality in the Republic of the Philippines* financed by the Government of Japan as the JICA Grant Aid project. The WTP was handed-over after test operation in 2004, but it has not been operated since then. The reason for this suspension is the high rate of the unaccounted for water (UFW) due to the leakage from the distribution pipes.

The renewal of the distribution pipes was the responsibility of the WD, however, the WD has not implemented this work. In order to solve this problem, the Dingle-Pototan WD has been implementing the renewal of the distribution pipes under LWUA loan project since 2008. This plumbing work is scheduled to complete in October 2010 as of July 2010. The WD office has been moved to the WTP plot.
And the test operation was carried out to confirm the function of the equipment such as distribution pumps, backwash pumps, chlorine feeding pumps and an agitator.

2-2-2 Result of the Field Survey

2-2-2-1 Survey Method

A field survey was carried out in the Dingle-Pototan WD to investigate the current status of the water treatment facilities and to design the rehabilitation works.
The following surveys were conducted:

Water service study	: to confirm the water source and water service situation
System flow survey	: to confirm the current treatment process
Facility function study	: to investigate the function of the existing facilities
Water quality analysis	: to investigate the quality of the raw and treated water
Jar test	: to confirm the optimum dosage of coagulant
Breakpoint chlorination	: to determine the optimum dosage of chlorine
Test operation	: to confirm the treatment situation with changed dosage

2-2-2-2 Survey Result of Water Service Study

(1) Water survice

The water supply pipes in Dingle-Pototan WD used to be connected between Dingle city and Pototan city. Recently the service pipes have been separated and each city supplies water from different sources. The WTP to be rehabilitated under this Programme is supplying water to Pototan city.

The situation of the water supply service is summarized in the table below according to the monthly report of Dingle-Pototan WD (Dec. 2009). In the table below, the unaccounted for water (UFW) is considerably high with 62.2%. This is because the distribution pipes are wearing out with age. As of July 2010 the installation of new distribution pipes was being carried out by Dingle-Pototan WD.

Table 2-8 Water Supply Service in Dingle-Pototan WD (Dec. 2009)

Item	Dingle	Pototan	Total
Service connection	2,025	1,760	3,785
Number of current active connection	1,475	993	2,458
Expected population served	8,850	5,968	14,808
Volume of water produced (m^3/d)			4,351
Volume of Water billed (m^3/d)			1,646
Unaccounted for water (%)			62.2

The total population of the Pototan city as of 2009 is 69,581 and the water supply rate in the city is only 8.6%. The number of current active connection is 993 households while the total service connection is 1,760; this indicates that the number of active connection has halved in recent years.

The water tariff structure of the Dingle-Pototan WD is shown in the table below. Since the water rate for household/public facility was 69.5 peso in 1999, it has tripled in 10 years. Compared to the national average water tariff of 0–10m^3 for household/public facility at 172.49 peso, the rate of Dingle-Pototan is nearly 1.4 times higher.

Table 2-9 Water Tariff Structure in Dingle-Pototan WD

Unit:Peso

	0–10m^3	11–20m^3	21–30m^3	31–40m^3	41m^3–Above
Household/public facility	235.2	24.70	29.90	35.60	42.80
Commercial/industrial facility	470.40	49.40	59.80	71.20	85.60
Semi‐Commercial	411.60	43.20	52.30	62.30	74.90
Semi‐Commercial B	352.80	37.05	44.85	53.40	64.20

(2) Water sources

Present water supply in Dingle-Pototan WD is sourced from two deep wells. The yield, operating hours and daily product of each water source are listed below. Among them the Abangay deep well is the water source of the WTP to be rehabilitated.

Table 2-10 Operation of Water Sources in Dingle-Pototan

Name	Yield	Operating hours	Daily product
Abangay Deep Well	15 l/s	20hrs	1,080 m^3/d
Vida Grande Deep Well	15 l/s	7hrs	378 m^3/d
Total			Approx. 1,460 m^3/d

2-2-2-3 Survey Result of Water Treatment Facilities

(1) Current System Flow

As a reference, the designed system flow is illustrated below.

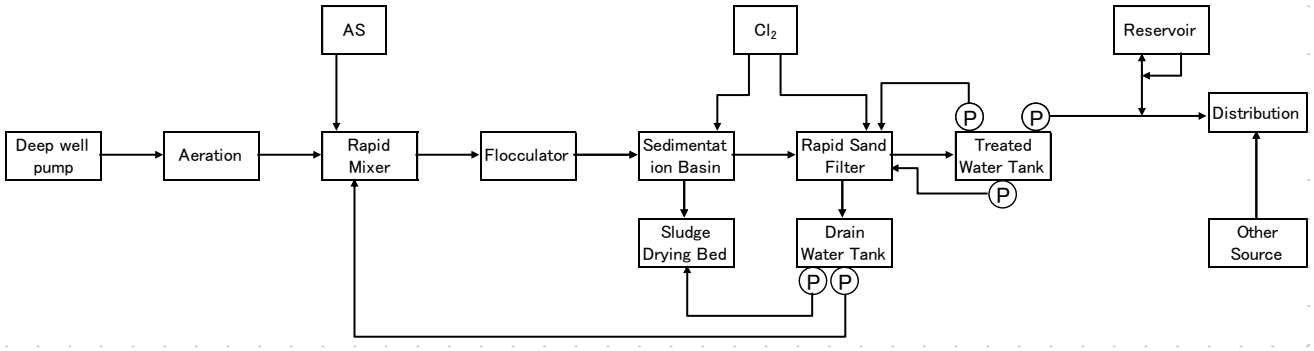

Figure 2-3 Designed System Flow

(2) Function of Facilities

Current state of each WTP facility including the structure, electrical wiring, plumbing and mechanical equipment were investigated. The result is summarized in the table below.

Table 2-11 Current State of the Facilities

Facility		Q'ty	Current State
Intake	Deep Well	1	No problem
	Deep Well Pump	1	Capacity of existing pump is 15l/s while the planned pumping rate is 30l/s.
	Stand-by Generator	1	Overcapacity for the existing pump
Treat-ment	Sand Separator	1	No problem
	Aeration Tower	2	Aeration is no problem / Leakage from concrete joint
	Rapid Mixer	1	No problem
	Hydraulic Flocculator	1	Insufficient mixing intensity due to low flow velocity
	Sedimentation Basin	2	Floc settlement is not sufficient, and flocs are carried- over from the basin.
	Rapid Sand Filter	2	Inlet trough of the filter basin should be modified.
	Backwash Pump	1	No problem
	Surface-wash Pump	1	No problem
	Treated Water Tank	2	No problem
	Drainage Basin	1	No problem
	Recycling Pump	1	No problem
	Sludge Drain Pump	1	No problem
	Sludge Drying Bed	4	Installation of bed sand is required for proper function to accommodate the change in Philippines effluent standard.
	Chemical Feeding Room	1	No problem
	Coagulant Agitator	2	No problem
	Chemical Feeding Pump	1	No problem
	Chlorination Room	1	Door of the chlorination room is corroded.
	Chlorine Agitator	2	No problem
	Intermediate Chlorination Pump	1	Injection pipe should be modified due to the uneven Cl feeding.
	Post Chlorination Pump	1	No problem
	Stand-by Generator	1	Review of capacity due to the change of distribution pumps. Battery is run down.
Distri-bution	Distribution Pump	2	Breakdown. Review of capacity due to the current water consumption.
	Pressure Tank	1	No problem

The function of each facility is diagnosed referring to the design criteria. The result is as

follows.

- ✓ Average flow velocity in the flocculator is slower than the design criteria, which means the floc formation is insufficient.
- ✓ Surface loading in the sedimentation basin satisfies the design criteria, while the retention time is fewerthan the standard of 3–5hours.
- ✓ To improve the function of the sludge drying bed, replenishment of the bed sand is needed. In the effluent standard at the time of basic design (enforcement in 1900), there was no necessity of effluent treatment because the amount of effluent was little. However, the clean water act was approved in 2004, it is required to keep the effluent standard even if the small amount of water. Therefore, enlargement is necessary because current capacity is less than the required capacity of current water quality.

Table 2-12 Function Diagnosis of the Facilities

Item	Unit	Design standard	Plan (Current)	Remarks
Water Volume	m^3/day		2,592 (1,080)	
	L/sec		30 (15)	
Intake				
Deep well pump			0.9m^3/min×49m×11kW	Capacity is half of planned pumping rate
Stand-by Generator	kVA		132	Over-capacity for existing pump
Aeration Tower				
Surface load	m^2/m^3/hr	0.4–1.0	0.40 (0.80)	
Rapid Mixer				
Type			Flush mixer	
Flocculator				
Type			Vertical baffle	
Effective dimension	m		DWL: 2.0×1.0×30	
Effective capacity	m^3		60.0	
Retention time	min	20–40	33.3 (66.7)	
Flow velocity	m/s	0.15–0.30	0.04-0.12 (0.02-0.06)	Insufficient floc formation
G-value	sec^{-1}	10–75	20.4 (7.2)	
GT-value		23,–210,000	42,000 (30,000)	
Sedimentation Basin				
Type			Rectangular Horizontal flow	
Number of basins		> 2 basins	2	
Effective dimension	m		DWL: 3.2×2.5×13	
Weir load	m^3/d/m	< 500m^3/d/m	324	
Length/width ration		3–8 times	5.2	
Effective surface area	m^2		65.0	
Effective capacity	m^3		208	
Effective depth	m	3–4m	3.2	
Surface loading	mm/min	15–30	27.7 (13.9)	
Flow velocity	mm/min	< 400mm/min	113 (57)	
Retention time	hr	> 3–5hr	1.9 (3.8)	Insufficient floc Settlement
Rapid Sand Filter				
Type			Rapid Sand Filtration	
Number of basins		> 2 basins	2	
Effective dimension	m		WL: 2.5×3.8	
Filter area/basin	m^2		9.5	
Filtration rate	m/day	120–150	136 (68)	
Backwash pump			6.1m^3/min×12m×22kW, φ250	
Surface-wash pump			1.9m^3/min×30m×18.5kW, φ150	
Intermediate Chlorination				
Dosing pump			1.7-2.0l/min×0.8MPa×0.2kW	Modification of injection pipe is required
Post Chlorination				
Dosing pump			0.25-0.3l/min×1.0MPa×0.2kW	
Sludge Drying Bed				
Effective dimension	m		DWL: 0.5×1.5×3.0	
Number of basins			4	
Total area	m^2		18	
Total capacity	m^3		9	
Sludge volume	kg/d		42.9	
Required capacity	m^3		15	Improvement (bed sand etc) required
Treated Water Tank				
Number of basins			2	
Effective dimension	m		DWL: 5.0×5.0×17.0	
Effective capacity	m^3		425	
Supply Facility				
Distribution pump			2.6m^3/min×55m×45kW, φ150	Over-capacity, down size required
Number of pumps			2	

Item	Unit	Design standard	Plan (Current)	Remarks
Stand-by Generator	kVA		160	Capacity change (down size) due to the change of distribution pumps

The followings are the pictures of current state of facilities.

Aeration Tower: Leakage from the concrete joint.

Hydraulic Flocculator: Adjustment of vertical baffles is required.

Rapid sand filter, inlet trough: Improvement is required to prevent the destruction of the floc.

Sludge drying bed: Installation of bed sand is required due to accommodate the change in Philippines effluent standard..

Chlorination room: The entrance door and its frame are corroded.

Intermediate chlorination, injection pipe: Chlorine injection at 4 injection points is not even.

Distribution pumps: Not in use due to breakdown. Pump No.1 has a broken shaft. Pump No.2 has a problem with over-current; the motor has no problem, thus a problem in the pump is presumed.

(3) Water Quality Analysis

The following table shows the results of water quality analysis carried out using field test kits and in a laboratory in Manila. Note that the result of the field test kits is not accurate because the field tests apply the simplified analysis methods, and the color is not true color but apparent color which can be measured in the field. In the table, the value which is higher than the Philippine water quality standards is colored pink and the value which needs some consideration is colored yellow.

Remarks on the major parameters are as follows.

- ✓ Turbidity in the raw water has been decreased from 8NTU at the time of the basic design to 1.6NTU which is below the Philippine water quality standard. Also the values of turbidity after each process is lower the standard.
- ✓ Color in the raw water is 9.5 Color Unit (CU), as high as that of the time of the basic

design. Color after filtration is 6.5CU, and color in the treated water of the current simple treatment is 13.5CU, which are higher than the standard.

- ✓ Iron concentrations are 1.1mg/l; the same level as at the detailed design phase.
- ✓ Manganese is 0.3mg/l, below the standard; however, it is better to remove as much manganese as possible because it will react with chlorine and cause the coloring of the water.
- ✓ Total Dissolved Solid (TDS) is 1,140mg/l, higher than the standard. This is because the raw water contains dissolved inorganic salts, sodium and calcium.
- ✓ Total hardness is rather high of 260mg/l which is near the standard of 300mg/l.
- ✓ Ammonia in the raw water is 4mg/l which may affect chlorine consumption; however, it was reduced to 1mg/l after filtration.
- ✓ Sodium is 190mg/l and within the standard of 200mg/l though rather high.
- ✓ Residual Chlorine is below the standard thus the chlorination is not properly done.

Table 2-13 Water Quality Analysis

Parameter		Unit	PNSD	Basic Design	Field Water Test						Labo. Test
					Raw Water	After Aeration	After Sedimentation	After Filtration	At Water Tap	Simple Treatmen	Raw Water
1	Temperature	℃	-	27.8	27.0						
2	pH		6.5–8.5	7.35	7.04	7.97	7.96	7.98	6.90	7.77	
3	DO	mg/l	-	0.23	6	6					
4	EC	mS/m	-	149	73	140	143	137	67	120	
5	Turbidity	NTU	5	8	1.6	1.0	0.8	0.6	1.6	0.6	
6	Color	CU	5	10	9.5	16.0	10.5	6.5	0.0	13.5	
7	Fe	mg/l	1.0	1.0	0.2	0.2	N.D.	N.D.	N.D.	N.D.	1.1
8	Mn	mg/l	0.5	0.68	< 0.5	< 0.5	< 0.5	N.D.	N.D.	N.D.	0.3
9	Silica	mg/l	-	63	30	30			8	50	
10	TDS	mg/l	500	941							1,140
11	Total Hardness	mg/l	300	433							260
12	Ca Hardness	mg/l	-	298							
13	M-Alkalinity	mg/l	-	570	450	600	550	550	350	600	
14	Nitrate	mg/l	50	0.2							0.7
15	Nitrite	mg/l	3	N.D.							0.1
16	Ammonia	mg/l	-	4	4	4	4	1	0.5	4	
17	Sulfate	mg/l	250	0.7							0.6
18	COD	mg/l	-	1.8	18	9	16	15	3	4	
19	Cl	mg/l	250	202	< 200					< 200	150
20	Na	mg/l	200	217							190
21	Ca	mg/l	-	119							64
22	Mg	mg/l	-	33							25
23	H_2S	mg/l	0.05	-	N.D.						
24	Free Cl_2	mg/l		-					0.14	0.16	
25	Residual Cl_2	mg/l	0.2–1.5	-					0.08	0.30	
26	Odor		No obj.	Metallic odor	N.D.				N.D.	N.D.	

Pink cell is the value which is higher than the PNSD and yellow cell is the value which needs some consideration.

(4) The jar Test

In order to determine the most effective dosage of coagulant (PAC) for the raw water in the Abangay WTP, jar tests were carried out during the field survey. The condition of the jar test was: rapid agitation for 1 min at a speed of 300rpm, slow agitation for 10 min at a speed of 30rpm, and settling for 10 min. The value which is higher than the Philippine water quality standards is colored pink and the value which needs some consideration is colored yellow in the table.

The test results are shown in the table below. The dosage of PAC 40mg/l will be adopted as the dosage as it was proven more effective than the others.

Table 2-14 The Jar Test Results

Item \ PAC(mg/l)	PNSD	After Aeration	10mg/l	20mg/l	30mg/l	40mg/l
Floc size	-	-	Small	Small–Mid.	Small–Mid.	Medium
Sedimentation	-	-	Slow	Slow	Slow	Fast
pH	6.5–8.5	7.97	7.93	7.87	7.83	7.68
EC (mS/m)	-	140	121	122	117	132
Turbidity (NTU)	5	1.0	1.1	1.1	0.8	0.4
Color (CU)	5	16.0	18.0	18.0	15.5	11.5
Fe (mg/l)	1.0	0.2	N.D.	N.D.	N.D.	N.D.
Mn (mg/l)	0.5	< 0.5	N.D.	N.D.	N.D.	N.D.
M-Alkalinity (mg/l)	-	600	600	600	550	550
NH_4 (mg/l)	-	4	5	5	5	5
COD (mg/l)	-	9	12	12	11	11

Pink cell is the value which is higher than the PNSD and yellow cell is the value which needs some consideration.

(5) Breakpoint Chlorination

The relation of chlorine dosage and residual chlorine was examined in order to determine the optimum chlorine dosage. The result is shown in the figure below. Breakpoint was not clearly found, but the optimum chlorine dosage is found as 2.5mg/l. Manganese concentration in the raw water is not considerable, therefore chlorine is not consumed by oxidation of manganese.

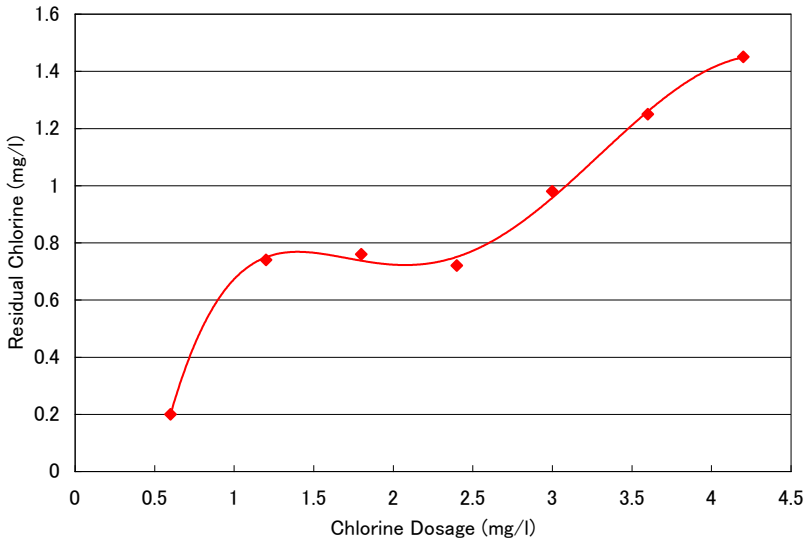

Figure 2-4 Chlorine Dosage and Residual Chlorine

(6) Test Operation

The test operation was executed with PAC 40mg/l and intermediate chlorine 2.5mg/l acoording to the result of the jar test and the breakpoint chlorination.

The following table shows the results of water quality analysis after the sedimentation and after the filtration by using field test kits. In the table, the value which is higher than the Philippine standards is colored pink and the value which needs some consideration is colored yellow.

- ✓ Color after filtration decreased from 16CU after aeration to 6.5CU after filtration with the use of coagulant. It is expected to decrease more after rehabilitation work becase the mixing intensity will be improved.
- ✓ Residual Chlorine is 0.08mg/l, below the standard with intermediate chlorine dosage at 2.5mg/l. The dosage of chlorine needs to be increased.

Table 2-15 Water Analysis at the Test Operation

Parameter		Unit	PNSD	After Aeration	After Sedimentation	After Filtration
1	pH		6.5–8.5	7.97	7.96	7.98
2	EC	mS/m	-	140	143	137
3	Turbidity	NTU	5	1.0	0.8	0.6
4	Color	CU	5	16.0	10.5	6.5
5	Fe	mg/l	1.0	0.2	N.D.	N.D.
6	Mn	mg/l	0.5	< 0.5	< 0.5	N.D.
7	M-Alkalinity	mg/l	-	600	550	550
8	NH_4	mg/l	-	4	4	1
9	COD	mg/l	-	9	16	15
10	Free Cl_2	mg/l	-			0.14
11	Residual Cl_2	mg/l	0.2–1.5			0.08

Pink cell is the value which is higher than the PNSD and yellow cell is the value which needs some consideration.

2-3 Result of the Field Survey in Pontevedra WD

2-3-1 Outline of the Follow-up Cooperation in Pontevedra WD

The Sublangon Water Treatment Plant (WTP) in Pontevedra WD was implemented under *the Project for Improvement of Water Quality in the Republic of the Philippines* financed by the Government of Japan as the JICA Grant Aid project. Since the launch of the operation of the WTP, however, the salinity level of the deep well water source has been increasing. This creates an unfavorable taste to water and causes corrosion of metals in the treatment plant. The WTP was designed to remove mainly iron (Fe) and manganese (Mn) but not salinity. Due to this problem, the household connection of the water supply service has reduced by half from around 2,000 households to currently 987 households (December 2009, Pontevedra WD Monthly Report).

Under this circumstance, the Pontevedra WD prepared a project to develop another water source and applied for the loan from LWUA. The new borehole is expected to contain low salinity level

and the WTP will be treating less saline water after the water source is developed.

2-3-2 Result of the Field Survey

2-3-2-1 Survey Method

A field survey was carried out in the Ponteverda WD to investigate the current status of the water treatment facilities and to design the rehabilitation works.

The following surveys were conducted:

Water service study	: to confirm the water source and water service situation
System flow survey	: to confirm the current treatment process
Facility function study	: to investigate the function of the existing facilities
Water quality analysis	: to investigate the quality of the rawand treated water
Jar test	: to confirm the optimum dosage of coagulant
Breakpoint chlorination	: to determine the optimum dosage of chlorine
Test operation	: to confirm the treatment situation with changed dosage

2-3-2-2 Survey Result of Water Service Study

(1) Water survice

The situation of the water supply service is summarized in the table below according to the monthly report of Pontevedra WD (Dec. 2009). In the table below, the unaccounted for water (UFW) is 50%, while the "*Improvement Plan for Management and Services on The Water Supply System of Pontevedra Water Distirict* (NJS, 2010)" says 62% and the JICA's technical cooperation project "*Guidance plan for Water Treatment Plant of Additional Water Districts for Small Water Districts Improvement Project 5th year* (NJS, 2009)" reports 70%: the figures are different but all data on the UFW in Pontevedra are quite high. The leakage from the pipe as the cause of UFW is unlikely as the water supply network was just installed in 1991-1996. Since there is no detailed study on the UFW in this WD, the cause is still unknown.

Table 2-16 Water Supply Service in Pontevedra WD (Dec. 2009)

Item	Total
Service connection	2,173
Number of current active connection	987
Expected population served	5,778
Volume of water produced (m^3/d)	1,106
Volume of Water billed (m^3/d)	556
Unaccounted for water (%)	50

The total population of the Pontevedra city as of 2009 is 42,560, the water supply rate in the city is only 13%. The number of current active connection is 987 households while the total service connection is 2,173; this indicates that the number of active connection has halved in recent

years.

The water tariff structure of the Pontevedra WD is shown in the table below. Since the water rate of 0-10m^3 for household/public facility was 130 peso in 1999, it has doubled in 10 years. Compared to the national average water tariff of 0-10m^3 for household/public facility at 172.49 peso, the rate of Pontevedra is nearly 1.7 times higher.

Table 2-17 Water Tariff Structure in Pontevedra WD

Unit:Peso

	0–10m^3	11–20m^3	21–30m^3	31m^3–Above
Household/public facility	287	35.85	41.4	46.95
Commercial/industrial facility	574	71.7	82.8	93.9
Bulk water supply	15	15	15	15

(2) Water sources

Present water supply in Pontevedra WD is sourced from three deep wells. The yield, operating hours and daily product of each water source are listed below. Among them the Sublangon deep well is the water source of the WTP to be rehabilitated.

Table 2-18 Operation of Water Sources in Pontevedra

Name	Yield	Operating hours	Daily product
Sublangon Deep Well	29.3 l/s	8–10hrs	850–1,050 m^3/d
Yatigan Deep Well	7.5 l/s	24 hrs	650 m^3/d
Hipona Deep Well	4 l/s	6 hrs	86.4 m^3/d
Total			Approx. 1,700 m^3/d

2-3-2-3 Survey Result of Water Treatment Facilities

(1) Current System Flow

The current system flow and designed system flow are illustrated below.

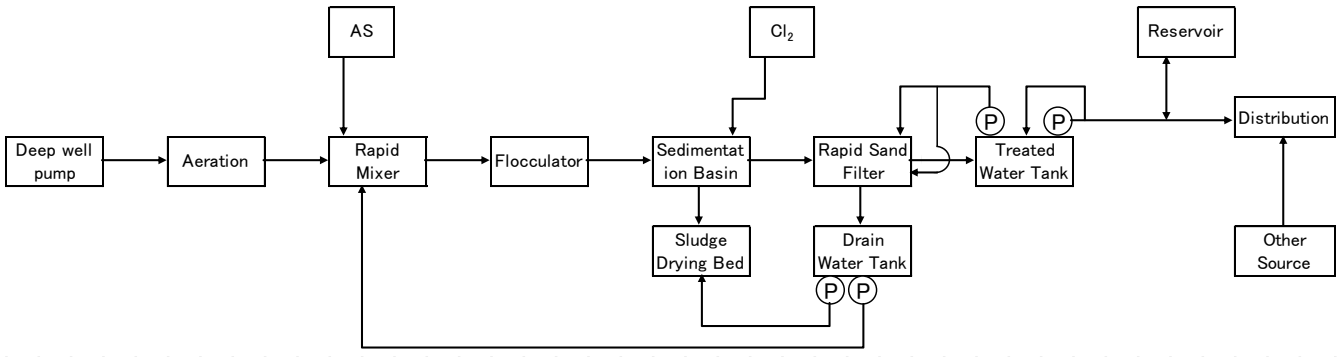

Figure 2-5 Current System Flow

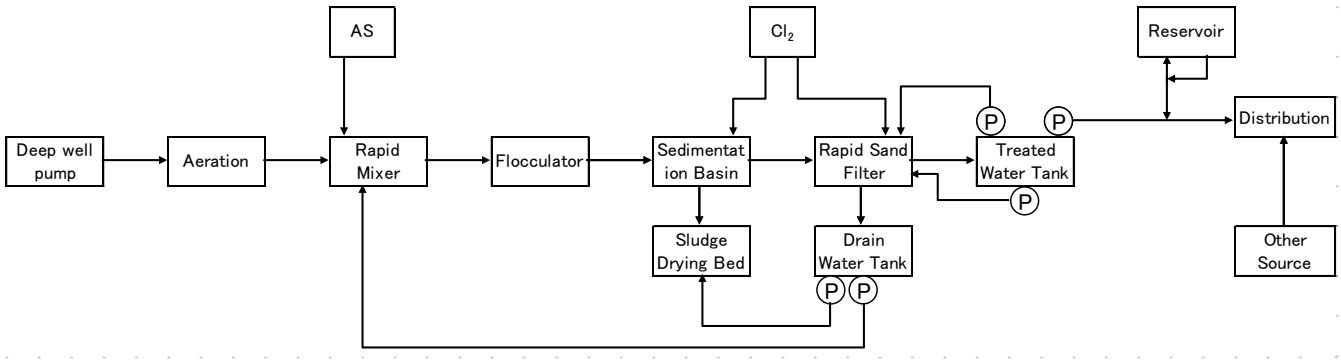

Figure 2-6 Designed System Flow

As shown in the figures, the current system flow is basically along the designed flow; however, the following problems are observed.

- ✓ Due to mechanical failures of the backwash pump, a bypass line connecting the surface-wash pump and backwash pipes has been installed. When the filter sand is washed, backwash and surface-wash processes are done simultaneously, but the washing is insufficiently done because of low water flow from the surface-wash pump.
- ✓ Regarding chlorinatin treatment, the intermediate chlorination is designed to be applied for manganese and ammonia removal and the post chlorination for disinfection. The current operation however, injects intermediate chlorination only due to the breakdown of the post chlorination pump. As a consequence, management of residual chlorine is inappropriate.
- ✓ The existing transmission pipe is connected to both the reservoir and supply network. And also a bypass line is connected from another water source to dilute the saline water in the reservoir during night time. Those connections make the valve operation of inlet and outlet of the reservoir and treated water tank complicated.

(2) Function of Facilities

Current state of each WTP facility including the structure, electrical wiring, plumbing and mechanical equipment were investigated. The result is summarized in the table below.

Table 2-19 Current State of the Facilities

Facility		Q'ty	Current State
Intake	Deep Well	1	Structure is no problem. However, the water contains high concentration of Chloride.
	Deep Well Pump	1	Pump was replaced 2 years ago. No problem.
Treat-ment	Sand Separator	1	No problem
	Aeration Tower	2	DO of raw water is 1mg/l, aerated water is 6.5mg/l. Also O_2 concentration in the tower after aeration was 20.6% which is not oxygen-deficient. Therefore no problem in aeration process. / Opening of maintenance manholes is required.
	Rapid Mixer	1	No problem
	Hydraulic Flocculator	1	Insufficient mixing intensity due to low flow velocity
	Sedimentation Basin	2	Floc settlement is not sufficient, and flocs are carried- over from the basin. / Sludge drain pipes and inlet valves are need to be replaced due to serious corrosion.
	Rapid Sand Filter	2	Surface-wash pipes are corroded. / Inlet trough of the filter basin should be modified.
	Backwash Pump	1	Failure
	Surface-wash Pump	1	Used as backwash/surface-wash combined pump, but the washing capacity is low and the filter is clogged rapidly. / Flow meter is out of use.
	Treated Water Tank	2	No problem
	Drainage Basin	1	No problem
	Recycling Pump	1	No problem
	Sludge Drain Pump	1	No problem
	Sludge Drying Bed	4	Installation of bed sand is required for proper function to accommodate the change in Philippines effluent standard..
	Chemical Feeding Room	1	No problem
	Coagulant Agitator	2	No problem
	Chemical Feeding Pump	1	No problem
	Chlorination Room	1	Door of the chlorination room is corroded.
	Chlorine Agitator	2	No problem. But agitator support is corroded.
	Intermediate Chlorination Pump	1	Leakage from diaphragm. / Injection pipe should be modified due to the uneven Cl feeding.
	Post Chlorination Pump	1	Failure. / Change of the injection point (directly to the transmission pipe) is requested.
	Stand-by Generator	1	Review of capacity due to the change of distribution pumps.
Trans- mission	Transmission Pump	2	Fear of sudden failure due to the deterioration of rust / Flow meter is out of use.
	Pressure Tank	1	No problem
	Transmission Pipe	—	Functioning as the transmission/supply pipe, the valve operation is quite complicated.

The function of each facility is diagnosed referring to the design criteria. The result is as follows.

- ✓ Average flow velocity in the flocculator is slower than the design criteria, which means the floc formation is insufficient.
- ✓ Surface loading in the sedimentation basin satisfies the design criteria, while the retention time is fewerthan the standard of 3–5hours.

Table 2-20 Function Diagnosis of the Facilities

Item	Unit	Design standard	Plan (Current)	Remarks
Water Volume	m^3/day		2,708 (1,056)	Max.10hrs operation (4am - 2pm)
	L/sec		31.3 (29.3)	
Intake				High salinity
Deep well pump			1.76m^3/min×15Kw	Replaced 2 years ago (40HP→20HP)
Aeration Tower				
Surface load	m^2/m^3/hr	0.4–1.0	0.43 (0.45)	
Rapid Mixer				
Type			Flush mixer	
Flocculator				
Type			Vertical baffle	
Effective dimension	m		DWL: 2.0×1.0×30	
Effective capacity	m^3		60.0	
Retention time	min	20–40	31.9 (34.1)	
Flow velocity	m/s	0.15–0.30	0.04–0.13 (0.04–0.12)	Insufficient floc formation
G-value	sec^{-1}	10–75	21.7 (19.7)	
GT-value		23,–210,000	43,000 (42,000)	
Sedimentation Basin				
Type			Rectangular Horizontal flow	
Number of basins		> 2 basins	2	
Effective dimension	m		DWL: 3.2×2.5×13.8	
Weir load	m^3/d/m	< 500m^3/d/m	339	
Length/width ration		3–8 times	5.5	
Effective surface area	m^2		69.0	
Effective capacity	m^3		221	
Effective depth	m	3–4m	3.2	
Surface loading	mm/min	15–30	27.3 (25.5)	
Flow velocity	mm/min	< 400mm/min	118 (110)	
Retention time	hr	> 3–5hr	2.0 (2.1)	Insufficient floc Settlement
Rapid Sand Filter				
Type			Rapid Sand Filtration	
Number of basins		> 2 basins	2	
Effective dimension	m		WL: 2.5×4.0	
Filter area/basin	m^2		10.0	
Filtration rate	m/day	120–150	135 (127)	
Backwash pump			6.4m^3/min×12m×30kW, φ250	Backwash Pump failure
Surface-wash pump			2.0m^3/min×30m×18.5kW, φ150	Flow meter failure, pipe corroded
Intermediate Chlorination				
Dosing pump			1.7-2.0l/min×0.8MPa×0.2kW	Leakage from pump
Post Chlorination				
Dosing pump			0.25-0.3l/min×1.0MPa×0.2kW	Pump failure
Sludge Drying Bed				
Effective dimension	m		DWL: 0.5×2.0×4.0	
Number of basins			4	
Total area	m^2		32	
Total capacity	m^3		16	
Sludge volume	kg/d		34.3	
Required capacity	m^3		12 (11)	Improvement (bed sand etc) required
Treated Water Tank				
Number of basins			2	
Effective dimension	m		DWL: 5.0×7.5×12.0	
Effective capacity	m^3		450	
Transmission Facility				Complicated valve operation
Transmission Pump			2.7m^3/min×50m×37kW, φ200	Over-capacity, down size required
Number of pumps			2	

Item	Unit	Design standard	Plan (Current)	Remarks
Stand-by Generator	kVA		165	Capacity change (down size) due to the change of transmission pumps

The followings are the pictures of current state of facilities.

Aeration tower: Oxygen concentration is sufficient.

Aeration tower: There are no steps for existing manholes. New manholes will be opened for effective maintenance.

Hydraulic Flocculator: Adjustment of vertical baffles is required.

Sedimentation basin, inlet valve: Covered by lumps of rust due to corrosion.

Sedimentation basin, sludge drain pipes: All pipes are corroded by high salinity of the raw water.

Sedimentation basin, sludge drain pipes: Corrosion makes holes on the pipe.

Rapid sand filter, surface-wash pipe: After drainage of water from the filter basin, settled flocs and sludge adhere to the surface-wash pipes.

Rapid sand filter, surface-wash pipe: Contact with saline flocs caused corrosion, making holes on the surface-wash pipe.

Backwash pump: It has been removed since Oct 2009 because of mechanical failures.

Backwash pipe: Bypass connection from the surface- wash pipe was installed as an emergency measure.

Flow meter for surface-wash pipe: Flow meter has been removed.

Sludge drying bed: Installation of bed sand is required due to accommodate the change in Philippines effluent standard..

Chlorination room: The entrance door and its frame are corroded and decayed.

Chlorination agitator support: Covered by rust of corrosion.

Pre/Intermediate chlorination, injection pump: Leakage from diaphragm of the pump.

Intermediate chlorination, injection pipe: Chlorine injection at 4 injection points is not even.

Post chlorination, injection pump: Not in use due to the breakdown.

Transmission pipe: A bypass line is connected from another water source to dilute the saline water in the reservoir.

(3) Water Quality Analysis

The following table shows the results of water quality analyses carried out using field test kits and in a laboratory in Manila. Note that the result of the field test kits is not accurate because the field tests apply the simplified analysis methods, and the color is not true color but apparent color which can be measured in the field. In the table, the value which is higher than the Philippine water quality standards is colored pink and the value which needs some consideration is colored yellow.

Remarks on the major parameters are as follows.

- ✓ Turbidity in the raw water is low, but it rises after the aeration due to oxidation of dissolved iron. Turbidity after the sedimentation is 7.9NTU, which means current sedimentation process is not effective. The filtration process, however, is properly working as turbidity is 0.2NTU after the filtration.
- ✓ Color in the raw water is low, but it increases after the aeration for the oxidized iron. Color is removed after the filtration to 0.5 Color Unit (CU).
- ✓ Iron concentrations have increased from 1.4mg/l of the basic design data (2001) to 4.2mg/l as the laboratory test. However, iron concentrations after the sedimentation are 0.1mg/l which is under the Philippine standard.
- ✓ Total Dissolved Solid (TDS) is 2,470mg/l in the raw water, which exceeds the Philippine standard highly. This is because of the dissolved inorganic salts such as calcium and magnesium.
- ✓ Total Hardness is also higher than the standard due to the dissolved salts.
- ✓ Chloride concentrations have increased from 280mg/l at the time of the basic design phase to 920mg/l. This actually affects the taste of supplied water.
- ✓ Residual Chlorine is below the Philippine standard that means the chlorination is not properly done.

Table 2-21 Water Quality Analysis

Parameter		Unit	PNSD	Basic Design	Field Water Test					Laboratory Test	
					Raw Water	After Aeration	After Sedimentation	After Filtration	At Water Tap	Raw Water	After Filtration
1	Temperature	℃	-	27.6	27.5						
2	pH		6.5-8.5	6.6	6.40	6.90	7.10	7.20	7.30		
3	DO	mg/l	-	0.38	1	6.5					
4	EC	mS/m	-	114	300	290	290	270	300		
5	Turbidity	NTU	5	0	1.6	8.9	7.9	0.2	0.2		
6	Color	CU	5	0	1.5	> 50	41.5	0.5	1.0		
7	Fe	mg/l	1.0	1.4	7	1	0.2	N.D.	N.D.	4.2	0.1
8	Mn	mg/l	0.5	0.96	2	2	2	N.D.	N.D.	2.0	0.3
9	Silica	mg/l	-	88	90	90	100	90	80		
10	TDS	mg/l	500	1040						2,470	2,440
11	Total Hardness	mg/l	300	549						1,420	1,430
12	Ca Hardness	mg/l	-	450							
13	M-Alkalinity	mg/l	-	136	200	200	200	200	150		
14	Nitrate	mg/l	50	N.D.						2.7	2.7
15	Nitrite	mg/l	3	N.D.						0.2	0.1
16	Ammonia	mg/l	-	0.5	0.5	0.3	0.3	0.2	0.2		
17	Sulfate	mg/l	250	33.7						74	75
18	COD	mg/l	-	1.6	10	6	6	3	3		
19	Cl	mg/l	250	280	> 300	> 300	> 300	> 300	> 300	920	880
20	Na	mg/l	200	25						41	41
21	Ca	mg/l	-	180						450	450
22	Mg	mg/l	-	24						72	74
23	H_2S	mg/l	0.05	-	N.D.						
24	Free Cl_2	mg/l		-				0.10	0.26		
25	Residual Cl_2	mg/l	0.2-1.5	-				0.10	0.14		
26	Odor		No obj.	Metallic odor	Metallic odor				N.D.		

Pink cell is the value which is higher than the PNSD and yellow cell is the value which needs some consideration.

(4) The Jar Test

In order to determine the most effective dosage of coagulant for the raw water in the Sublangon WTP, jar tests were carried out during the field survey. The condition of the jar test was: rapid agitation for 1 min at a speed of 300rpm, slow agitation for 10 min at a speed of 30rpm, and settling for 10 min. Currently aluminum sulfate is used as a coagulant; however, in the jar tests PAC was also used to compare the efficiency of coagulation.

The test results are shown in the table below. Basically, PAC is more effective than aluminum sulfate in removal of turbidity and color. In the table, the value which is higher than the Philippine water quality standards is colored pink and the value which needs some consideration is colored yellow.

Case-1: PAC

Case-2: Aluminum Sulfate

As shown in the table below, PAC performs better on the removal of the color and turbidity and thus has higher coagulantive effect.

Table 2-22 Case-1 PAC

Item \ PAC(mg/l)	PNSD	After Aeration	10mg/l	20mg/l	30mg/l	40mg/l
Floc size	-	-	Midium	Big	Big	Big
Sedimentation	-	-	Slow	Midium	Midium	Fast
pH	6.5–8.5	6.90	7.16	7.14	7.11	7.06
EC (mS/m)	-	290	310	270	270	310
Turbidity (NTU)	5	8.9	1	0.6	0.6	0
Color (CU)	5	> 50	10	6	4.5	1
Fe (mg/l)	1.0	1	0.2	0.1	0.1	0.1
Mn (mg/l)	0.5	2	2.0	2.0	2.0	2.0
M-Alkalinity (mg/l)	-	200	150	150	150	150
NH_4 (mg/l)	-	0.3	0.2	0.2	0.2	0.2
COD (mg/l)	-	6	7	5	5	5

Pink cell is the value which is higher than the PNSD and yellow cell is the value which needs some consideration.

Table 2-23 Case-2 Aluminum Sulfate

Item \ Aluminum Sulfate (mg/l)	PNSD	After Aeration	20mg/l	40mg/l	60mg/l	80mg/l
Floc size	-	-	Small	Midium	Big	Big
Sedimentation	-	-	Slow	Midium	Midium	Fast
pH	6.5–8.5	6.90	7	6.9	6.81	6.68
EC (mS/m)	-	290	300	290	260	300
Turbidity (NTU)	5	8.9	6.1	3.7	1.5	0.7
Color (CU)	5	> 50	31	17	8	4.5
Fe (mg/l)	1.0	1	0.2	0.2	0.2	0.2
Mn (mg/l)	0.5	2	2.0	2.0	2.0	2.0
M-Alkalinity (mg/l)	-	200	150	150	150	150
NH_4 (mg/l)	-	0.3	0.1	0.1	0.1	0.1
COD (mg/l)	-	6	7	5	7	7

Pink cell is the value which is higher than the PNSD and yellow cell is the value which needs some consideration.

(5) Breakpoint Chlorination

The relation of chlorine dosage and residual chlorine was examined in order to determine the optimum chlorine dosage. The result is shown in the figure below. Breakpoint was not found, but the residual chlorine was 0.34mg/l with 1mg/l of chlorine dosage, thus the optimum chlorine dosage is found as 1.0-1.5mg/l.

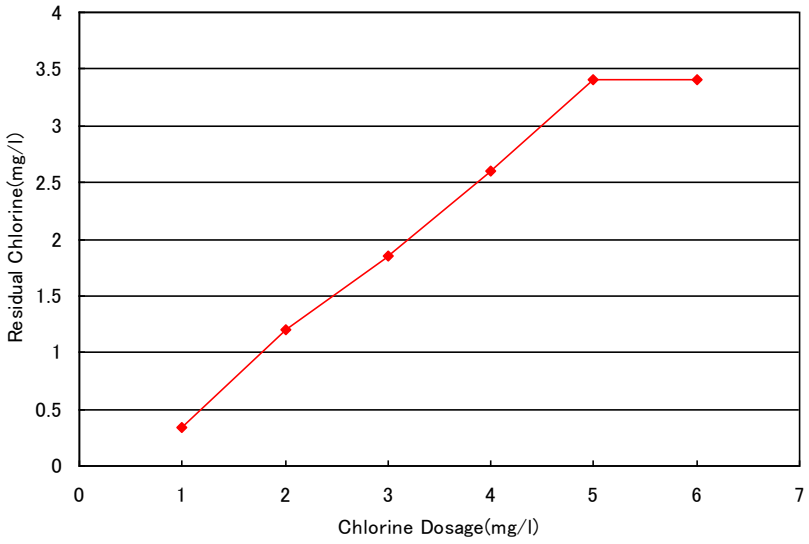

Figure 2-7 Chlorine Dosage and Residual Chlorine

(6) Test Operation

The current dosage of coagulant is 10.7mg/l of aluminum sulfate and of chlorine is 0.20mg/l; however, the jar test result indicates the dosage of coagulant is insufficient. Therefore to confirm the effect of the optimum dosage determined by the jar tests, the WTPperformed a test operation. In the test operation, PAC was used as coagulant and PAC dosage is 20mg/l according to the result of the jar test, and chlorine dosage was left unchanged.

During the test operation, treated water after sedimentation and filtration was collected and analyzed using the field test kits. The results of water analysis are shown in the table below. In the table, the value which is higher than the Philippine standards is colored pink and the value which needs some consideration is colored yellow.

- ✓ After sedimentation, turbidity was to 2.0NTU and color was 12.0CU while current turbidity and color after sedimentation are 7.9NTU and 41.5CU respectively. Also after filtration the value of both turbidity and color were 0, while current water quality after filtration is 0.2NTU and 0.5CU.
- ✓ As the chlorine dosage was not changed from the current operation, the residual chlorine was both below the standard.

Table 2-24 Water Analysis after the Test Operation

Parameter		Unit	PNSD	After Sedimentation		After Filtration	
				Curent	Test Operation	Curent	Test Operation
1	pH		6.5–8.5	7.10	7.12	7.20	7.23
2	EC	mS/m	-	290	310	270	310
3	Turbidity	NTU	5	7.9	2.0	0.2	0
4	Color	CU	5	41.5	12.0	0.5	0
5	Fe	mg/l	1.0	0.2	N.D.	N.D.	N.D.
6	Mn	mg/l	0.5	2	2	N.D.	N.D.
7	M-Alkalinity	mg/l	-	200	150	200	150
8	NH4	mg/l	-	0.3	0.3	0.2	0.2
9	COD	mg/l	-	6	6	3	3
10	Free Cl_2	mg/l	-			0.10	0.08
11	Residual Cl_2	mg/l	0.2–1.5			0.10	0.08

Pink cell is the value which is higher than the PNSD and yellow cell is the value which needs some consideration.

2-4 Result of the Field Survey in Binmaley WD

2-4-1 Outline of the Follow-up Cooperation in Binmaley WD

The deep wells around Binmaley WD contain colored organic matters associated with humus fracture of soil and therefore the color value is higher than the Philippine standard. In order to remove the color, two Water Treatment Plants (WTPs) were constructed under *the Project for Improvement of Water Quality in the Republic of the Philippines* financed by the Government of Japan as the JICA Grant Aid project, and handed over in 2005. BInmaley WD is relatively well managed and these WTPs are operating well since the hand-over. Still, some facilities were perceived to have needs for modification, so the field survey was conducted to identify the problems and design the rehabilitation plan for the facilities.

2-4-2 Result of the Field Survey

2-4-2-1 Survey Method

The following surveys were conducted to investigate the current status of the water treatment facilities and to design the rehabilitation works:

Water service study : to confirm the water source and water service situation
System flow survey : to confirm the current treatment process
Facility function study : to investigate the function of the existing facilities
Water quality analysis : to investigate the quality of the rawand treated water
Jar test : to confirm the optimum dosage of coagulant

Breakpoint chlorination : to determine the optimum dosage of chlorine

Test operation : to confirm the treatment situation with changed dosage

2-4-2-2 Survey Result of Water Service Study

(1) Water survice

There are 7 water sources in the WD and those wells are connected together. The water distribution system is shown in the figure below. The water from two sources are treated in the WTPs while others are distributed without treatment even the color value is high.

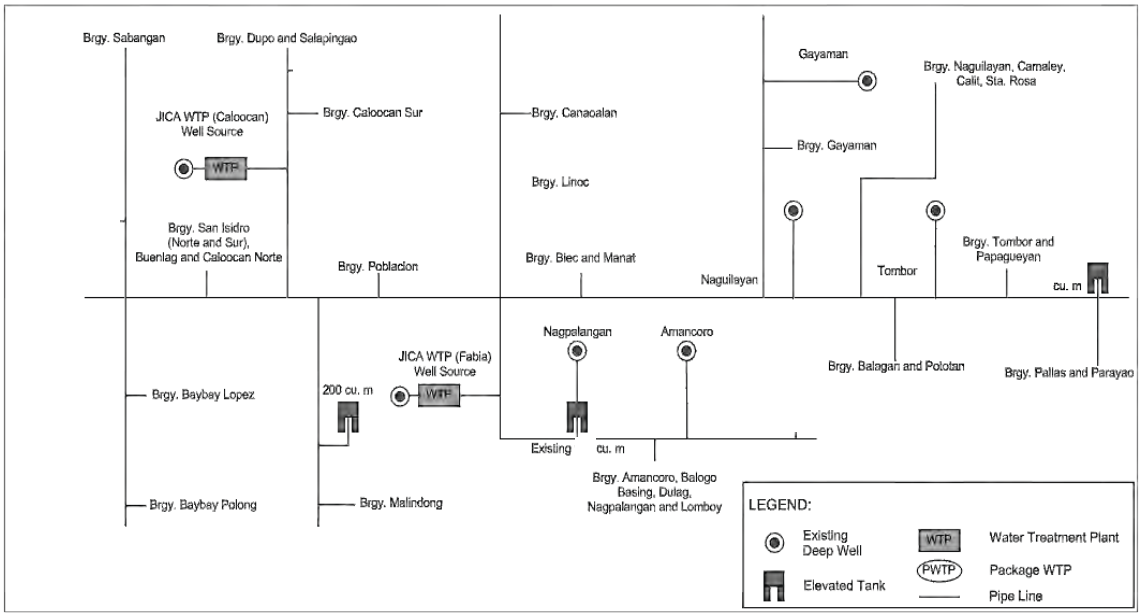

Figure 2-8 Water Supply System in Binmaley WD

The situation of the water supply service is summarized in the table below according to the monthly report of Binmaley WD (Dec. 2009). The unaccounted for water (UFW) is relatively low with 22.6%.

Table 2-25 Water Supply Service in Binmaley WD (Dec. 2009)

Item	Total
Service connection	9,276
Number of current active connection	8,174
Expected population served	49,044
Volume of water produced (m^3/d)	6,186
Volume of Water billed (m^3/d)	4,782
Unaccounted for water (%)	22.6

The total population of Binmaley city in 2009 was 78,810, and the water supply rate in the city was only 62.2%. The supply rate is planned to be developed futher. The densely populated area, however, is already covered by the water service network. Therefore the supply network shall be extended to the thinly populated area where the investment efficiency is lower.

The water tariff structure of the Binmaley WD is shown in the table below. Since the water rate for household/public facility was 80 peso in 1999, it has doubled in 10 years. Compared to the national average water tariff of 0-10m^3 for household/public facility being 172.49 peso, the rate of Binmaly is lower than the average.

Table 2-26 Water Tariff Structure in Binmaley WD

Unit:Peso

	0–10m^3	11–20m^3	21–30m^3	31–40m^3	41m^3–Above
Household/public facility 1/2”	169.00	18.75	21.45	25.05	29.50
Household/public facility 1”	540.80	18.75	21.45	25.05	29.50
Semi‐Commercial facility	253.50	28.15	32.20	37.60	44.25
Commercial facility 1/2”	338.00	37.50	42.90	50.10	59.00
Commercial facility 1”	1,081.60	37.50	42.90	50.10	59.00
Commercial facility 2”	6,760.00	37.50	42.90	50.10	59.00

(2) Water sources

Water supply service in Binmaley WD is sourced from the deep wells listed below. The yield, operating hours and daily product of each water source are shown in the table. Color of the water from each deep well is between 10 to 31 CU but the water is distributed directly from the water source except Caloocan and Fabia.

Table 2-27 Operation of Water Sources in Binmaley

Water source name	Yield (l/s)	Operating hour (hrs)	Daily product (m^3/d)	Color (CU)
Caloocan	22	22	1,177	31
Fabia	22	18	1,255	27
Amancoro	8.2	14	421	21
Gayaman	4	16	225	22.5
Nagulayan	21	24	1,674	29.5
Nagpalangan	2	Uk	91	—
Tombor	15	16	932	10
Total			5,775	

2-4-2-3 Survey Result of Caloocan Water Treatment Facilities

(1) Current System Flow

The current system flow and initially designed system flow are illustrated below.

- ✓ In current operation, pre chlorination is done to oxidize the colored matter.
- ✓ Only backwash of the rapid sand filter is operated but surface wash is missing.
- ✓ Recycle and drainage pumps have been broken down and replaced by a submersible pump installed by WD.
- ✓ A sludge storage basin was constructed due to complaint about the sludge drainage from the land owner of the adjacent area.

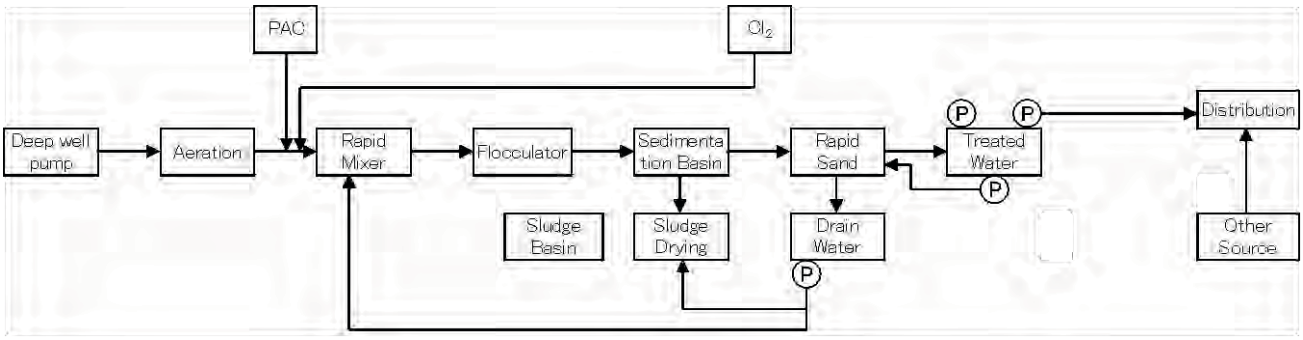

Figure 2-9 Current System Flow (Caloocan)

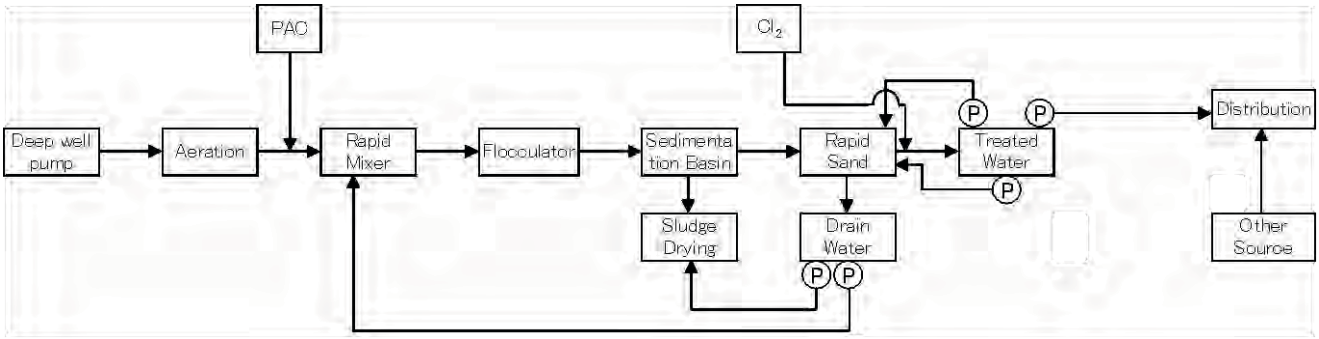

Figure 2-10 Initial Design System Flow (Caloocan)

(2) Function of Facilities

Current state of each facility including the structure, electrical wiring, plumbing and mechanical equipment were investigated. The result is summarized in the table below.

Table 2-28 Current State of the Facilities (Caloocan)

Facility		Q'ty	Current State
Intake	Deep Well	1	No problem
	Deep Well Pump	1	Current water flow of 18l/s is the same as designed capacity. Motor was failure and replaced in 2008.
Treat-ment	Sand Separator	1	No problem
	Aeration Tower	2	The door and opening were replaced by WD. The DO and concentrations of O_2 in the air are no problem.
	Rapid Mixer	1	No problem
	Hydraulic Flocculator	1	Insufficient mixing intensity due to low flow velocity. / Some bolts holding the baffle plate are broken.
	Sedimentation Basin	2	Floc settlement is not sufficient, and flocs are carried- over from the basin. / Sludge drain pipes need to be replaced due to corrosion.
	Rapid Sand Filter	2	Inlet trough of the filter basin should be modified.
	Backwash Pump	1	No problem
	Surface-wash Pump	1	No problem of pump operation. However, it is not used. Because the floc has been carried over to the filtration basin due to the lack of coagulant and insufficient floc formantion at the flocurration basin. And surface-washing breaks flocs on the surface of filter and the broken flocs infiltrate through the filter sand. Therefore WD stopped surface-washing. The water after washing is clear even if no surface-washing.
	Treated Water Tank	2	No problem
	Drainage Basin	1	No problem
	Recycling Pump	1	Initial pump has been replaced with a single phase pump by WD. The flow meter is also broken.
	Sludge Drain Pump	1	Initial pump was broken down. The recycle pump installed by WD is used for sludge draining.
	Sludge Drying Bed	4	The sludge storage basin constructed by WD is not sufficient to accommodate the change in Philippines effluent standard.
	Chemical Feeding Room	1	No problem
	Coagulant Agitator	2	No problem
	Chemical Feeding Pump	1	No problem
	Chlorination Room	1	Chlorination tank has leakage but repaired by WD.
	Intermediate Cl Pump	1	Used as pre chlorination. / Some pipes are corroded.
	Post Chlorination Pump	1	It was broken down and removed.
	Stand-by Generator	1	No problem
Distri-bution	Distribution pump	2	Currently only No.1 pump is used but No.2 is also working without problem. / Flow meter is broken.
	Pressure Tank	1	No problem

The function of each facility is diagnosed referring to the design criteria. The result is as follows.

- ✓ Average flow velocity in the flocculator is slower than the design criteria, which means the floc formation is insufficient.
- ✓ Surface loading in the sedimentation basin satisfies the design criteria, while the retention time is fewerthan the standard of 3–5hours.
- ✓ To improve the function of the sludge drying bed, replenishment of the bed sand is needed. In the effluent standard at the time of basic design (enforcement in 1900), there was no necessity of effluent treatment because the amount of effluent was little. However, the clean water act was approved in 2004, it is required to

keep the effluent standard even if the small amount of water. Therefore, enlargement is necessary because current capacity is less than the required capacity of current water quality.

Table 2-29 Function Diagnosis of the Facilities (Caloocan)

Item	Unit	Design standard	Plan (Current)	Remarks
Water Volume	m^3/day		1,555 (ditto)	22hr operation (Max.24hrs)
	L/sec		18 (ditto)	
Intake				
Deep well pump			1.2m^3/min×35m×11kW	Motor is replaced 2 years ago
Aeration Tower				
Surface load	m^2/m^3/hr	0.4–1.0	0.41	
Rapid Mixer				
Type			Flush mixer	
Flocculator				
Type			Vertical baffle	
Effective dimension	m		DWL: 2.0×0.8×26.2	
Effective capacity	m^3		41.9	
Retention time	min	20–40	38.8	
Flow velocity	m/s	0.15–0.30	0.04-0.11	Insufficient floc formation
G-value	sec^{-1}	10–75	18.5	
GT-value		23,–210,000	41,500	
Sedimentation Basin				
Type			Rectangular Horizontal flow	
Number of basins		> 2 basins	2	
Effective dimension	m		DWL: 3. 2×2.0×10	
Weir load	m^3/d/m	< 500m^3/d/m	258	
Length/width ration		3–8 times	5.0	
Effective surface area	m^2		40.0	
Effective capacity	m^3		128	
Effective depth	m	3–4m	3.2	
Surface loading	mm/min	15–30	27.0	
Flow velocity	mm/min	< 400mm/min	84	
Retention time	hr	> 3–5hr	2.0	Insufficient floc settlement
Rapid Sand Filter				
Type			Rapid Sand Filtration	
Number of basins		> 2 basins	2	
Effective dimension	m		WL: 2.5×2.5	
Filter area/basin	m^2		6.3	
Filtration rate	m/day	120–150	124	
Backwash pump			4.4m^3/min×10m×15kW, φ200	
Surface-wash pump			1.3m^3/min×30m×11kW, φ80	
Intermediate Chlorination				
Dosing pump			0.6l/min×1.0MPa×0.2kW	
Post Chlorination				
Dosing pump			0.12l/min×1.0MPa×0.2kW	Pump break down
Sludge Drying Bed				
Effective dimension	m		DWL: 0.5×1.5×3.0	
Number of basins			4	
Total area	m^2		18	Basin of 39.5m^2 was constructed by WD
Sludge volume	kg/d		56.7	Insufficient area for the sludge volume
Required capacity	m^3		90.8	Basin of 39.5m2 was constructed by WD
Treated Water Tank				
Number of basins			2	
Effective dimension	m		DWL: 5.0×10.0×11.0	
Effective capacity	m^3		550	
Transmission Facility				
Transmission Pump			1.7m^3/min×45m×22kW, φ100	
Number of pumps			2	
Stand-by Generator	kVA		114.5	

The followings are the pictures of current state of facilities.

Aeration tower: Aluminum door installed by WD

Aeration tower: Aluminum louver installed by WD

Aeration tower: Paint of exterior wall is peeling off. WD requested to remove all.

Flocculator: Some baffle plates fell off due to breakage of holding bolts by corrosion.

Flocculator: Last two lines of baffle plates were removed for cleaning.

Sedimentation basin: Due to insufficient settlement of flocs, sludge is accumulated at the end of the basin.

Sedimentation basin: Paint of sludge drain pipe peels off and some pipes are corroded.

Sedimentation basin: Hole on the sludge drain pipe has been repaired with rubber sheet.

Rapid sand filter: Inlet structure needs to be modified to avoid small flocs breakdown.

Rapid sand filter: Colored particles are not removed in the sedimentation basin, thus the influent water is colored.

Rapid sand filter: Backwashing of the filter sand

Rapid sand filter: After backwash the water is relatively clear.

Drainage basin: Recycle pump has been replaced with a single phase pump and connected to existing pipe by WD.

Drainage basin: The single phase pump installed by WD.

Drainage basin: The single phase power is provided from the distribution pump room using an extension cord.

Drainage basin: The single phase socket is covered by a sheet for insulation.

Sludge drying bed: Bed sand has been removed due to causing clog after using five times.

Sludge Storage basin: A sludge storage basin was constructed by WD for receiving the excess sludge.

Sludge Storage basin: It takes about 3-4 weeks for drying sludge by natural evaporation in the sludge storage basin.

Pre/Intermediate chlorination pipe: Some parts are corroded.

Post chlorination pump: It has been removed due to breakdown.

Chlorine tank: Leakage of chlorine solution has been repaired by WD.

Generator: Maintenance of generator is so favorable that it looks as good as new.

(3) Water Quality Analysis

The following table shows the results of water quality analysis carried out using field test kits

and in a laboratory in Manila. Note that the result of the field test kits is not accurate because the field tests apply the simplified analysis methods, and the color is not true color but apparent color which can be measured in the field. In the table, the value which is higher than the Philippine water quality standards is colored pink and the value which needs some consideration is colored yellow.

Remarks on the major parameters are as follows.

- ✓ Color in the raw water has been decreased to around 30CU while it was 80CU at the time of the basic design study in 2002. The color value is 23CU after sedimentation and 17CU after filtration. However, the value is still above the Philippine standard.
- ✓ pH in the raw water and aerated water is near the standard.
- ✓ Hydrogen Sulfate is diffused after aeration thus has no problem.

Table 2-30 Water Quality Analysis (Callocan)

Parameter		Unit	PNSD	Basic Design	Field Water Test					Lab. Test
					Raw Water	After Aeration	After Sedimentation	After Filtration	At Water Tap	Raw Water
1	Temperature	℃	-	30.0	30.7					
2	pH		6.5–8.5	8.30	8.25	8.36	8.01	8.16	8.02	
3	DO	mg/l	-	0.71	1	7				
4	EC	mS/m	-	50	46	46	47	51	49	
5	Turbidity	NTU	5	0	0.4	0.6	0.5	0	0.2	
6	Color	CU	5	80	31.0	33.5	23.0	17.0	18.5	
7	Fe	mg/l	1.0	0.06	N.D.					
8	Mn	mg/l	0.5	0.05	N.D.					
9	Silica	mg/l	-	80	50					63
10	TDS	mg/l	500	338						330
11	Total Hardness	mg/l	300	32	10					23
12	Ca Hardness	mg/l	-	27						
13	M-Alkalinity	mg/l	-	240	245					
14	Nitrate	mg/l	50	N.D.						N.D.
15	Nitrite	mg/l	3	N.D.						N.D.
16	Ammonia	mg/l	-	N.D.	2.0	2.0	2.0	1.0	0.3	
17	Sulfate	mg/l	250	N.D.						N.D.
18	COD	mg/l	-	7.6	20	20	20	12	5	9
19	Cl	mg/l	250	30	< 200					12
20	Na	mg/l	200	101						110
21	Ca	mg/l	-	11						7.5
22	Mg	mg/l	-	1.3						1.0
23	H_2S	mg/l	0.05	-	0.1					
24	Free Cl_2	mg/l		-			0.42	0.30	0.10	
25	Residual Cl_2	mg/l	0.2–1.5	-			2.30	0.30	0.12	
26	Odor		No obj.	H_2S	N.D.				N.D.	
27	Bromoform	mg/l	0.1	N.D.						N.D.
28	Dibromochloro methane	mg/l	0.1	N.D.						N.D.
29	Bromodichloro methane	mg/l	0.06	0.0006						N.D
30	Chloroform	mg/l	0.2	0.0019						N.D

Pink cell is the value which is higher than the PNSD and yellow cell is the value which needs some consideration.

(4) The Jar Test

In order to determine the most effective dosage of coagulant (PAC) for the raw water in the Abangay WTP, jar tests were carried out during the field survey. The condition of the jar test was: rapid agitation for 1 min at a speed of 300rpm, slow agitation for 10 min at a speed of 30rpm, and settling for 10 min. The value which is higher than the Philippine water quality standards is colored pink and the value which needs some consideration is colored yellow in the

table.

Case-1: Changing of injection rate of PAC

Case-2: Changing of pH at PAC 30mg/l

Case-3: Changing of injection rate of PAC at pH6.5

The test results are shown in the table below. The color has been decreased to 6.5CU at the dosage of PAC 40mg/l and pH6.5.

Table 2-31 Case-1 Changing of injection rate of PAC

Item \ PAC(mg/l)	PNSD	After Aeration	10mg/l	20mg/l	30mg/l	40mg/l
Floc. size	-	-	Small	Midium	Mid.–Big	Big
Sedimentation	-	-	Slow	Slow–Mid.	Midium	Fast
pH	6.5–8.5	8.36	8.29	8.15	7.99	7.85
EC (mS/m)	-	46	52	53	53	53
Turbidity (NTU)	5	0.6	0.6	0.2	0.2	0.1
Color (CU)	5	33.5	29.5	22.0	21.0	16.0

Pink cell is the value which is higher than the PNSD and yellow cell is the value which needs some consideration.

Table 2-32 Case-2 Changing of pH at PAC 30mg/l

Item \ pH	PNSD	After Aeration	pH6.0	pH6.5	pH7.0	pH7.5
Floc. size	-	-	Mid.–Big	Mid.–Big	Mid.–Big	Mid.–Big
Sedimentation	-	-	Slow	Slow	Slow	Slow–Mid.
pH	6.5–8.5	8.36	6.06	6.51	6.98	7.40
EC (mS/m)	-	46	61	58	54	50
Turbidity (NTU)	5	0.6	0.2	0	0.1	0.2
Color (CU)	5	33.5	9.0	7.0	12.5	15.5

Pink cell is the value which is higher than the PNSD and yellow cell is the value which needs some consideration.

Table 2-33 Case-3 Changing of injection rate of PAC at pH6.5

Item \ PAC(mg/l)	PNSD	After Aeration	10mg/l pH6.5	20mg/l pH6.5	30mg/l pH6.5	40mg/l pH6.5
Floc. size	-	-	Small	Midium	Mid.–Big	Big
Sedimentation	-	-	Slow	Midium	Fast	Fast
pH	6.5–8.5	8.36	6.57	6.51	6.52	6.47
EC (mS/m)	-	46	57	57	55	56
Turbidity (NTU)	5	0.6	0.6	0.1	0	0
Color (CU)	5	33.5	32.0	14.0	8.5	6.5

Pink cell is the value which is higher than the PNSD and yellow cell is the value which needs some consideration.

(5) Breakpoint Chlorination

The relation of chlorine dosage and residual chlorine was examined, in order to determine the optimum chlorine dosage. The result is shown in the figure below. Breakpoint was not found, but the residual chlorine was 0.54mg/l with 1mg/l of chlorine dosage, thus the optimum chlorine

dosage is found as 1.0-1.5mg/l.

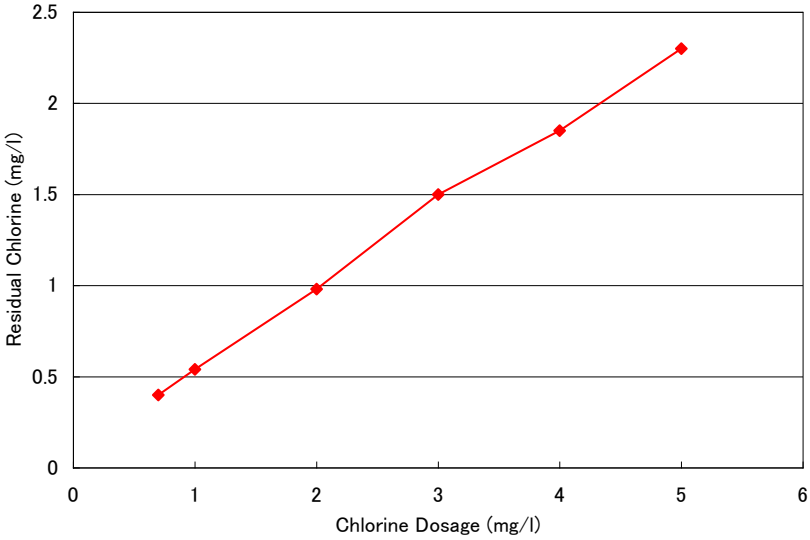

Figure 2-11 Chlorine Dosage and Residual Chlorine

(6) Test Operation

The current dosage of coagulant is about 25mg/l of PAC. The jar test result indicates the dosage of PAC 40mg/l and pH6.5 is expected to decrease color to 6.5CU; however, because the procurement of acid for pH adjustment is difficult, to the WTP is unable to conduct a test operation with pH6.5..Only a test operation of equipment was conducted since the dosage rate of PAC was not changed significantly.

2-4-2-4 Survey Result of Fabia Water Treatment Facilities

(1) Current System Flow

The current system flow and initially designed system flow are illustrated below.

- ✓ In current operation, pre chlorination is done to oxidize the colored matter.
- ✓ Only backwash of the rapid sand filter is operated but surface wash is missing.
- ✓ A sludge storage basin was constructed and the effluent was stocked at the basin but it takes a lot of time to dry up.

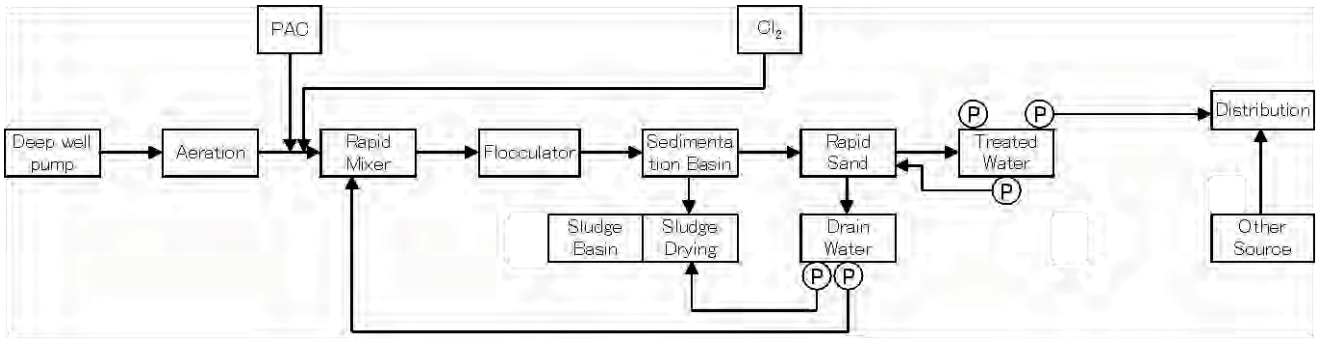

Figure 2-12 Current System Flow (Fabia)

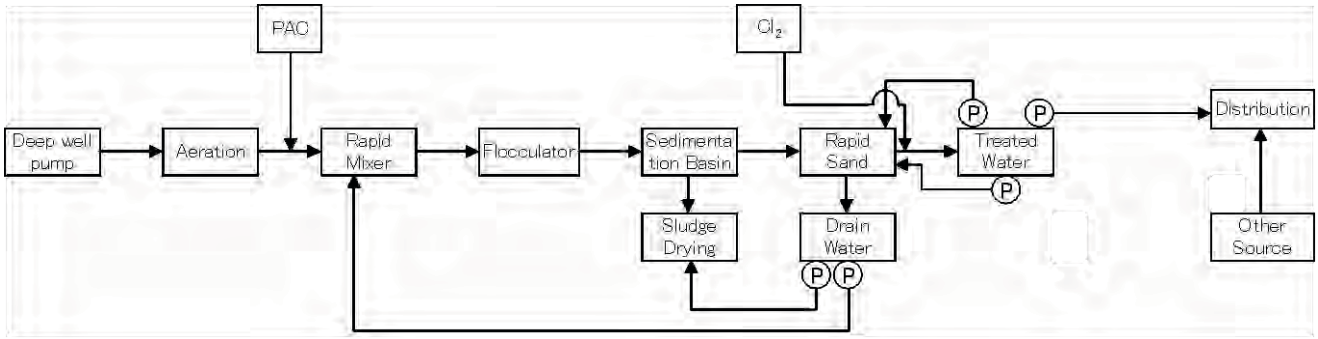

Figure 2-13 Initial Design System Flow (Fabia)

(2) Function of Facilities

Current state of each facility including the structure, electrical wiring, plumbing and mechanical equipment were investigated. The result is summarized in the table below.

Table 2-34 Current State of the Facilities (Fabia)

Facility		Q'ty	Current State
Intake	Deep Well	1	No problem but raising sand.
	Deep Well Pump	1	Current water flow of 20l/s is the same as designed capacity.
Treat-ment	Sand Separator	1	No problem
	Aeration Tower	2	The door and opening were replaced. The DO and concentrations of O_2 in the air are no problem.
	Rapid Mixer	1	No problem
	Hydraulic Flocculator	1	Insufficient mixing intensity due to low flow velocity.
	Sedimentation Basin	2	Floc settlement is not sufficient, and flocs are carried- over from the basin. / Sludge drain pipes need to be replaced due to corrosion.
	Rapid Sand Filter	2	Inlet trough of the filter basin should be modified.
	Backwash Pump	1	No problem
	Surface-wash Pump	1	No problem of pump operation. However, it is not used. Because the floc has been carried over to the filtration basin due to the lack of coagulant and insufficient floc formantion at the flocurration basin. And surface-washing breaks flocs on the surface of filter and the broken flocs infiltrate through the filter sand. Therefore WD stopped surface-washing. The water after washing is clear even if no surface-washing.
	Treated Water Tank	2	No problem
	Drainage Basin	1	No problem
	Recycling Pump	1	No problem
	Sludge Drain Pump	1	No problem
	Drainage Pump	1	Over current occurs when operating the pump.
	Sludge Drying Bed	4	The sludge storage basin constructed by WD is not sufficient to accommodate the change in Philippines effluent standard.
	Chemical Feeding Room	1	No problem
	Coagulant Agitator	2	No problem
	Chemical Feeding Pump	1	No problem
	Chlorination Room	1	Chlorination tank has leakage of Cl solution at the pipe connection. / Ventilation fan is out of use.
	Intermediate Cl Pump	1	Used as pre chlorination. /Some pipes are corroded.
	Post Chlorination Pump	1	malfunction due to corrosion of the diaphragm.
	Stand-by Generator	1	No problem
Distri-bution	Distribution pump	2	No problem./ Flow meter and No.1 pump pressure gauge are not properly working.
	Pressure Tank	1	Trace of leakage is found. Need to be replaced.

The function of each facility is diagnosed referring to the design criteria. The result is as follows.

- ✓ Average flow velocity in the flocculator is slower than the design criteria, which means the floc formation is insufficient.
- ✓ Surface loading in the sedimentation basin satisfies the design criteria, while the retention time is fewerthan the standard of 3–5hours.
- ✓ To improve the function of the sludge drying bed, replenishment of the bed sand is needed. In the effluent standard at the time of basic design (enforcement in 1900), there was no necessity of effluent treatment because the amount of effluent was little. However, the clean water act was approved in 2004, it is required to

keep the effluent standard even if the small amount of water. Therefore, enlargement is necessary because current capacity is less than the required capacity of current water quality.

Table 2-35 Function Diagnosis of the Facilities (Fabia)

Item	Unit	Design standard	Plan (Current)	Remarks
Water Volume	m^3/day		1,728 (ditto)	22hr operation (Max.24hrs)
	L/sec		20 (ditto)	
Intake				
Deep well pump			1.2m^3/min×35m×11kW	
Aeration Tower				
Surface load	m^2/m^3/hr	0.4–1.0	0.40	
Rapid Mixer				
Type			Flush mixer	
Flocculator				
Type			Vertical baffle	
Effective dimension	m		DWL: 2.0×0.8×26.2	
Effective capacity	m^3		41.9	
Retention time	min	20–40	34.9	
Flow velocity	m/s	0.15–0.30	0.04-0.13	Insufficient floc formation
G-value	sec^{-1}	10–75	21.7	
GT-value		23,–210,000	43,700	
Sedimentation Basin				
Type			Rectangular Horizontal flow	
Number of basins		> 2 basins	2	
Effective dimension	m		DWL: 3.2×2.0×10	
Weir load	m^3/d/m	< 500m^3/d/m	286	
Length/width ration		3–8 times	5.0	
Effective surface area	m^2		40.0	
Effective capacity	m^3		128	
Effective depth	m	3–4m	3.2	
Surface loading	mm/min	15–30	30.0	
Flow velocity	mm/min	< 400mm/min	94	
Retention time	hr	> 3–5hr	1.8	Insufficient floc Settlement
Rapid Sand Filter				
Type			Rapid Sand Filtration	
Number of basins		> 2 basins	2	
Effective dimension	m		WL: 2.5×2.5	
Filter area/basin	m^2		6.3	
Filtration rate	m/day	120–150	138	
Backwash pump			4.4m^3/min×10m×15kW, φ200	
Surface-wash pump			1.3m^3/min×30m×11kW, φ80	
Intermediate Chlorination				
Dosing pump			0.6l/min×1.0MPa×0.2kW	
Post Chlorination				
Dosing pump			0.12l/min×1.0MPa×0.2kW	Pump Break down
Sludge Drying Bed				
Effective dimension	m		DWL: 0.5×1.5×4.0	
Number of basins			4	
Total area	m^2		18	Basin of 36.1m^2 was constructed by WD
Sludge volume	kg/d		52.3	
Required capacity	m^3		83.7	Improvement (bed sand etc) required
Treated Water Tank				
Number of basins			2	
Effective dimension	m		DWL: 5.0×10.0×11.0	
Effective capacity	m^3		550	
Transmission Facility				
Transmission Pump			1.7m^3/min×45m×22kW, φ100	
Number of pumps			2	
Stand-by Generator	kVA		114.5	

The followings are the pictures of current state of facilities.

Sand separator: Sand raise is observed.

Sand separator: Sand is raised by pumping from the well.

Sedimentation basin: Flocs are carried over from the effluent trough.

Sedimentation basin: Sludge is accumulated at the end of the basin.

Sedimentation basin: A large amount of blown sludge is accumulated.

Sedimentation basin: Sludge drain pipe has holes due to corrosion.

Sludge Drying bed: An additional sludge storage basin was constructed by WD to receive the excess sludge.

Sludge Drying bed: Drained sludge is being discharged into the drying bed.

Post chlorination pump: Diaphragm part is malfunction due to corrosion. Post chlorination is missing.

Chlorine tank: Leakage of chlorine solution at the pipe connection is observed.

Chlorination room: Ventilation fan has been removed due to breakdown.

Pressure tank: The trace of leakage is found. It needs to be replaced.

(3) Water Quality Analysis

The following table shows the results of water quality analysis carried out using field test kits and in a laboratory in Manila. Note that the result of the field test kits is not accurate because the field tests apply the simplified analysis methods, and the color is not true color but apparent color which can be measured in the field. In the table, the value which is higher than the Philippine water quality standards is colored pink and the value which needs some consideration is colored yellow.

Remarks on the major parameters are as follows.

- ✓ Color in the raw water has been decreased to around 30CU while it was 50CU at the time of the basic design study in 2002. The color value is 23CU after sedimentation and 17CU after filtration. However, the value is still above the Philippine standard.
- ✓ pH in the raw water and aerated water is near the standard.
- ✓ Hydrogen Sulfate is diffused after aeration thus has no problem.
- ✓ Residual Chlorine is under the Philippine standard. In current operation, intermediate chlorination pump is used as pre chlorination to oxidize the colored matter. Post chlorination pump is broken down and not being used, so it is difficult to operate with proper chlorination.

Table 2-36 Water Quality Analysis (Fabia)

Parameter		Unit	PNSD	Basic Design	Field Water Test					Lab. Test
					Raw Water	After Aeration	After Sedimentation	After Filtration	At Water Tap	Raw Water
1	Temperature	℃	-	32.0	29.9					
2	pH		6.5–8.5	8.20	8.18	8.32	7.69	7.78	7.66	
3	DO	mg/l	-	0.78	3	6				
4	EC	mS/m	-	53	55	57	64	61	61	
5	Turbidity	NTU	5	0	0.2	0.4	0.5	0.2	0.2	
6	Color	CU	5	50	27.0	30.5	23.0	20.5	20.5	
7	Fe	mg/l	1.0	0.14	N.D.					
8	Mn	mg/l	0.5	0.06	N.D.					
9	Silica	mg/l	-	78	75					55
10	TDS	mg/l	500	300						330
11	Total Hardness	mg/l	300	24	20					23
12	Ca Hardness	mg/l	-	19						
13	M-Alkalinity	mg/l	-	242	310					
14	Nitrate	mg/l	50	N.D.						N.D.
15	Nitrite	mg/l	3	N.D.						N.D.
16	Ammonia	mg/l	-	N.D.	2.0	1.5	1.5	0.5	0.2	
17	Sulfate	mg/l	250	1.0						N.D.
18	COD	mg/l	-	8.3	20	20	20	15	13	9
19	Cl	mg/l	250	11	< 200					12
20	Na	mg/l	200	103						110
21	Ca	mg/l	-	8						7.5
22	Mg	mg/l	-	1.2						1.0
23	H_2S	mg/l	0.05	-	0.1					
24	Free Cl_2	mg/l		-			0.04	0.04	0.02	
25	Residual Cl_2	mg/l	0.2–1.5	-			0.64	0.22	0.06	
26	Odor		No obj.	H_2S	H_2S				N.D.	
27	Bromoform	mg/l	0.1	N.D.						N.D.
28	Dibromochloro methane	mg/l	0.1	N.D.						N.D.
29	Bromodichloro methane	mg/l	0.06	0.0006						N.D.
30	Chloroform	mg/l	0.2	0.0019						N.D.

Pink cell is the value which is higher than the PNSD and yellow cell is the value which needs some consideration.

(4) The Jar Test

In order to determine the most effective dosage of coagulant (PAC) for the raw water in the Abangay WTP, jar tests were carried out during the field survey. The condition of the jar test was: rapid agitation for 1 min at a speed of 300rpm, slow agitation for 10 min at a speed of 30rpm, and settling for 10 min. The value which is higher than the Philippine water quality standards is colored pink and the value which needs some consideration is colored yellow in the

table.

Case-1: Changing of injection rate of PAC

Case-2: Changing of pH at PAC 20mg/l

Case-3: Changing of injection rate of PAC at pH6.5

Case-4: A mass of injection rate of PAC

The test results are shown in the table below. The color has been decreased to 8.0CU at the dosage of PAC 30mg/l and pH6.5. And also as the PAC dosage rate increased, the color decreased. There might be a connection between this phenomenon and the fact that PAC injection decreases the pH.

Table 2-37 Case-1 Changing of injection rate of PAC

Item \ PAC(mg/l)	PNSD	After Aeration	10mg/l	20mg/l	30mg/l	40mg/l
Floc. size	-	-	Small	Midium	Big	Big
Sedimentation	-	-	Fast	Fast	Fast	Fast
pH	6.5–8.5	8.32	8.10	7.93	7.77	7.64
EC (mS/m)	-	57	60	60	61	63
Turbidity (NTU)	5	0.4	0.1	0	0	0
Color (CU)	5	30.5	25.0	21.5	17.0	12.5

Pink cell is the value which is higher than the PNSD and yellow cell is the value which needs some consideration.

Table 2-38 Case-2 Changing of pH at PAC 20mg/l

Item \ pH	PNSD	After Aeration	pH6.0	pH6.5	pH7.0	pH7.5
Floc. size	-	-	Small–Mid.	Midium	Midium	Midium
Sedimentation	-	-	Fast	Fast	Fast	Fast
pH	6.5–8.5	8.32	5.97	6.60	6.95	7.32
EC (mS/m)	-	57	70	66	63	61
Turbidity (NTU)	5	0.4	0.6	0.1	0	0
Color (CU)	5	30.5	15.0	10.5	12.0	16.0

Pink cell is the value which is higher than the PNSD and yellow cell is the value which needs some consideration.

Table 2-39 Case-3 Changing of injection rate of PAC at pH6.5

Item \ PAC(mg/l)	PNSD	After Aeration	10mg/l pH6.5	20mg/l pH6.5	30mg/l pH6.5	40mg/l pH6.5
Floc. size	-	-	Fine	Midium	Mid.–Big	Big
Sedimentation	-	-	Fast	Fast	Fast	Fast
pH	6.5–8.5	8.32	6.45	5.86	6.32	6.22
EC (mS/m)	-	57	71	76	74	75
Turbidity (NTU)	5	0.4	0.6	0.5	0.2	1.1
Color (CU)	5	30.5	22.5	12.5	8.0	17.5

Pink cell is the value which is higher than the PNSD and yellow cell is the value which needs some consideration.

Table 2-40 Case-4 A mass of injection rate of PAC

PAC(mg/l) / Item	PNSD	After Aeration	50mg/l	75mg/l	100mg/l	125mg/l
Floc. size	-	-	Big	Big	Big	Big
Sedimentation	-	-	Fast	Fast	Fast	Fast
pH	6.5–8.5	8.32	7.44	7.28	7.18	7.07
EC (mS/m)	-	57	62	64	65	61
Turbidity (NTU)	5	0.4	0	0	0	0
Color (CU)	5	30.5	11.5	8.5	6.0	5.0

Pink cell is the value which is higher than the PNSD and yellow cell is the value which needs some consideration.

(5) **Breakpoint Chlorination**

The relation of chlorine dosage and residual chlorine was examined, in order to determine the optimum chlorine dosage. The result is shown in the figure below. Breakpoint was not found, but the residual chlorine was 0.44mg/l with 1.5mg/l of chlorine dosage, thus the optimum chlorine dosage is found as 1.5–2.5mg/l.

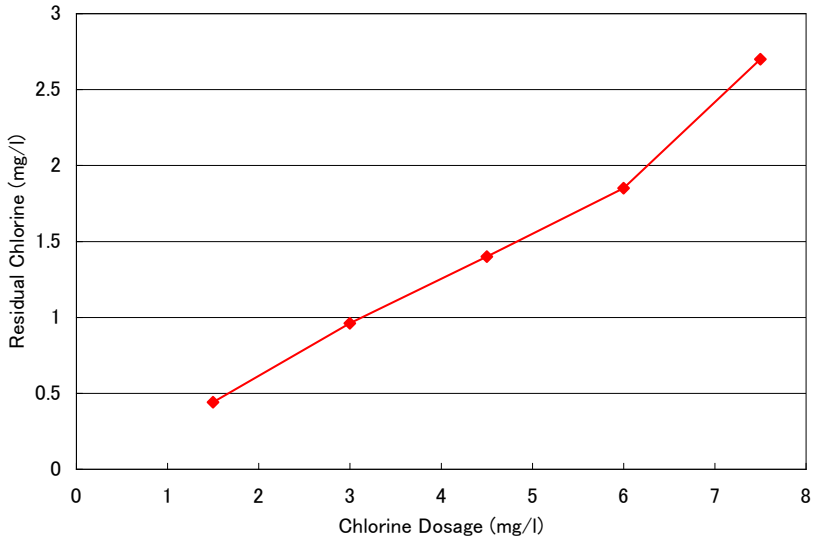

Figure 2-14 Chlorine Dosage and Residual Chlorine

(6) Test Operation

The current dosage of coagulant is about 25mg/l of PAC. The jar test result indicates the dosage of PAC 40mg/l and pH6.5 is expected to decrease color to 6.5CU; however, because the procurement of acid for pH adjustment is difficult, to the WTP is unable to conduct a test operation with pH6.5.Only a test operation of equipment was conducted since the dosage rate of PAC was not changed significantly.

2-5 Result of the Field Survey in Lingayen WD

2-5-1 Outline of the Follow-up Cooperation in Lingayen WD

The Water Treatment Plant (WTP) in Lingayen WD was implemented under *the Project for Improvement of Water Quality in the Republic of the Philippines* financed by the Government of Japan as the JICA Grant Aid project. The WTP was handed-over after a test operation in 2005, but it has been intermittently operated since then and after that they stopped the operation. The reason of this suspension is high rate of the unaccounted for water (UFW) due to leakage from the distribution pipes. In order to solve this problem, WD applied to Loan project to LWUA, and it will be implemented by KFW this fiscal year as of October 2010.

This KfW lone project will be completed only after 2 years or more because it only starts after funding is allocated and the detailed survey is conducted. The scope of this follow-up study does not include the rehabilitation work of Lingayen since WTPs cannot be in operation until the distribution pipelines are renewed.

The following surveys were conducted to investigate the current working condition of chemical injection pumps, distribution pumps, back wash pumps and mixers and no significant problem was found.

2-5-2 Result of the Field Survey

2-5-2-1 Survey Method

The following surveys were conducted to investigate the current status of the water treatment facilities and to design the rehabilitation works:

Water service study	: to confirm the water source and water service situation
System flow survey	: to confirm the current treatment process
Facility function study	: to investigate the function of the existing facilities
Water quality analysis	: to investigate the quality of the rawand treated water
Jar test	: to confirm the optimum dosage of coagulant
Breakpoint chlorination	: to determine the optimum dosage of chlorine
Test operation	: to confirm the treatment situation with changed

2-5-2-2 dosage Survey Result of Water Service Study

(1) Water survice

There are 4 distribution systems in this WD and these systems are connected to each other but have their own respective water source. The Largest system (No.1) includes WTPs and sources

the water from 4 wells. The other three systems have one well as the water source respectively. Raw water from these water sources has color like that of Binmaley.

The situation of the water supply service is summarized in the table below according to the monthly report of Lingayen WD (Dec. 2009). The unaccounted for water (UFW) is considerably high with 50.8% because of the decrepit of the distribution pipelines.

Table 2-41 Water Supply Services in Lingayen WD (Dec. 2009)

Item	Total
Number of service connections	5,047
Number of current active connections	3,048
Expected population served	18,126
Volume of water produced (m^3/d)	3,749
Volume of Water accounted (m^3/d)	1,845
Rate of Unaccounted for water (%)	50.8

Total population of the Lingayen city as of 2009 is 97,836 andthe water supply rate in the city is only 18.5%. The number of current active connection is 3,048 households while the total service connection is 5,047; this indicates that there used to be 1.7 times more connection in the past.

The water tariff structure of the Lingayen WD is shown in the table below. Since the water rate 0–10m^3 for household/public facility was 115 peso in 1999, it has tripled in 10 years. Compared to the national average water tariff of 0-10m^3 for household/public facilitybeing 172.49 peso, the rate of Lingayen is nearly double the average.

Table 2-42 Water Tariff Structure in Lingayen WD

Unit:Peso

	0–10m^3	11–20m^3	21–30m^3	31–40m^3	41m^3–Above
Household/public facility	230.00	24.00	25.15	26.50	28.20
Commercial/Industrial facility	460.00	48.00	50.30	53.00	56.40

(2) Water sources

Water supply service in Lingayen WD is sourced from the deep wells listed below. The yield, operating hours and daily product of each water source are shown in the table below. Color of the water from each deep well is between 17 to 35 CU and water is distributed directly from these water sources. Some water sources contain high salt concentration.

Table 2-43 Operation of Water Sources in Lingayen

Water source name	Section	Yield (l/s)	Operating hour (hrs)	Daily product (m^3/d)	Color (CU)	Note
P-7(Libsong West)	No1	11	24	950	32	Large quantity of Sand pumped
P-4(Libsong West)		11	19	765	27	Well is almost collapsed
P-6(Libsong East)		25	18	1,620	35	
P-3(Tong tong)		6	24	518	17.5	
P-5(Baay)	No2	6	20	432		Salt contained
P-8(Naguelguel)	No3	6.5	2.5	59	17	
P-9	No4					Unused due to salt
Total				4,344		

2-5-2-3 Survey Result of Water Treatment Facilities

(1) Current System Flow

The initially designed system flow is illustrated below. These WTPs are not in operation because of the high leakage from the distribution pipelines that results in unprofitability.

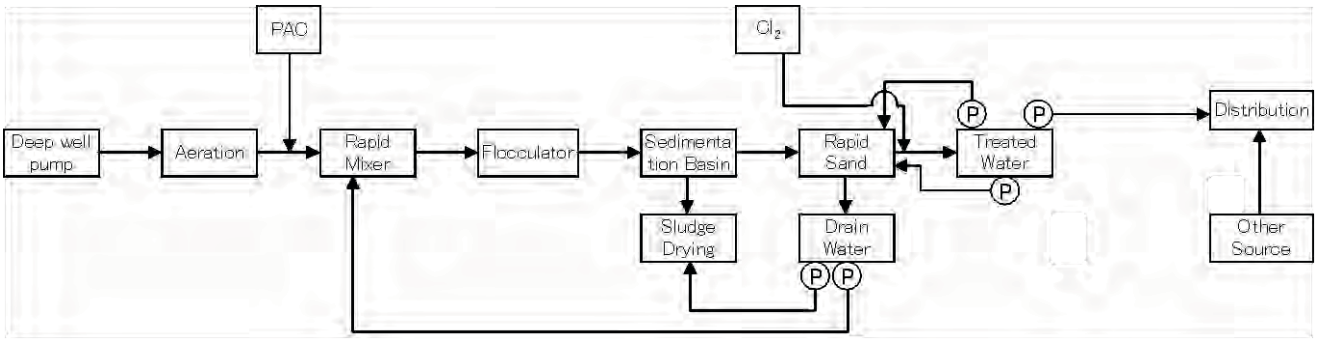

Figure 2-15 Initial Design System Flow

(2) Function of Facilities

Current state of each facility including the structure, electrical wiring, plumbing and mechanical equipment were investigated. The result is summarized in the table below.

Table 2-44 Current State of the Facilities

Facility		Q'ty	Current State
Intake	Deep Well	1	No.4 well produced 11l/s which is less than a half of the planned amount(28l/s), and the water production amount of No.7 well is also only 10.51l/s . No.6 well produced 24.4l/s which is close to the planned value.
	Deep Well Pump	1	No problem
Treat-ment	Sand Separator	1	No problem
	Aeration Tower	2	No problem with aeration treatment.
	Rapid Mixer	1	No problem
	Hydraulic Flocculator	1	Insufficient mixing intensity due to low flow velocity. / Some bolts holding the baffle plates are broken.
	Sedimentation Basin	2	Floc settlement is not sufficient, and flocs are carried-over from the basin. / Sludge drain pipes need waterproof painting due to rust.
	Rapid Sand Filter	2	Inlet trough of the filter basin should be modified. Rehabilitation of some surface wash pipes is needed due to corrosion.
	Backwash Pump	1	No problem
	Surface-wash Pump	1	No problem.
	Treated Water Tank	2	No problem
	Drainage Basin	1	No problem
	Recycling Pump	1	No problem. Pressure gauge needs to be replaced.
	Sludge Drain Pump	1	No problem. Pressure gauge needs to be replaced.
	Sludge Drying Bed	4	The function of sludge storage basin needs to be improved to accommodate the change in Philippines effluent standard.
	Chemical Feeding Room	1	No problem
	Coagulant Agitator	2	No problem
	Chemical Feeding Pump	1	No problem
	Chlorination Room	1	There is a possibility of leakage from pipe connection parts of Chlorination tank.
	Intermediate Cl Pump	1	No problem.
	Post Chlorination Pump	1	No problem.
	Stand-by Generator	1	Battery needs to be replaced.
Distri-bution	Distribution pump	2	Review of capacity due to the current water consumption.
	Pressure Tank	1	No problem

The function of each facility is diagnosed referring to the design criteria. The result is as follows;

- ✓ Average flow velocity in the flocculator is slower than the design criteria, which means the floc formation is insufficient.
- ✓ Surface loading in the sedimentation basin satisfies the design criteria, while the retention time is fewerthan the standard of 3–5hours.
- ✓ To improve the function of the sludge drying bed, replenishment of the bed sand is needed. In the effluent standard at the time of basic design (enforcement in 1900), there was no necessity of effluent treatment because the amount of effluent was little. However, the clean water act was approved in 2004, it is required to keep the effluent standard even if the small amount of water. Therefore, enlargement is necessary because current capacity is less than the required capacity of current water quality.

Table 2-45 Function Diagnosis of the Facilities

Item	Unit	Design standard	Plan (Current)	Remarks
Water Volume	m^3/day		2,434 (2.108)	In case of using the No.6 well as a water source
	L/sec		28.2 (24.4)	
Intake				
Deep well pump			1.46m^3/min×35m×11kW	In case of using the No.6 well as a water source
Aeration Tower				
Surface load	m^2/m^3/hr	0.4–1.0	0.43(0.49)	
Rapid Mixer				
Type			Flash mixer	
Flocculator				
Type			Vertical baffle	
Effective dimension	m		DWL: 2.0×0.8×26.2	
Effective capacity	m^3		64.3	
Retention time	min	20–40	31.7 (36.5)	
Flow velocity	m/s	0.15–0.30	0.04-0.12(0.03–0.10)	Insufficient floc formation
G-value	sec^{-1}	10–75	19.7 (14.9)	
GT-value		23,–210,000	43,600 (38,000)	
Sedimentation Basin				
Type			Rectangular Horizontal flow	
Number of basins		> 2 basins	2	
Effective dimension	m		DWL: 3. 4×2.5×13	
Weir load	m^3/d/m	< 500m^3/d/m	404 (350)	
Length/width ratio		3–8 times	5.2	
Effective surface area	m^2		65.0	
Effective capacity	m^3		221	
Effective depth	m	3–4m	3.4	
Surface loading	mm/min	15–30	26.0 (22.5)	
Flow velocity	mm/min	< 400mm/min	99 (86)	
Retention time	hr	> 3–5hr	2.2 (2.5)	Insufficient floc Settlement
Rapid Sand Filter				
Type			Rapid Sand Filtration	
Number of basins		> 2 basins	2	
Effective dimension	m		WL: 2.5×3.8	
Filter area/basin	m^2		9.5	
Filtration rate	m/day	120–150	128 (111)	
Backwash pump			6.7m^3/min×10m×15kW, φ200	
Surface-wash pump			1.9m^3/min×30m×11kW, φ80	
Intermediate Chlorination				
Dosing pump			0.6l/min×1.0Mpa×0.2kW	
Post Chlorination				
Dosing pump			0.12l/min×1.0Mpa×0.2kW	
Sludge Drying Bed				
Effective dimension	m		DWL: 0.5×2.0×4.0	
Number of basins			4	
Total area	m^2		32	
Sludge volume	kg/d		130.8	
Required capacity	m^3		209	Insufficient area for the sludge volume
Treated Water Tank				
Number of basins			2	
Effective dimension	m		DWL: 5.0×10.0×11.0	
Effective capacity	m^3		850	
Transmission Facility				
Transmission Pump			2.4m^3/min×50m×30kW, φ100	Inappropriate capacity to water demand
Number of pumps			2	
Stand-by Generator	kVA		114.5	

The followings are the pictures of current state of facilities.

No.4 Well: Quantity of water intake is 11l/s, which is less than planned value, 28l/s.

No.7 Well: Quantity of water intake is 10.5l/s which is less than planned value, 28l/s.

No.7 Well: Excess sand is pumped up.

No.6 well: Quantity of water intake is 24.4l/s which is close to planned value, 28l/s.

Flocculator: Some baffle plates fell off due to breakage of holding bolts caused by corrosion.

Sedimentation basin: Pipes needs waterproof painting due to rust.

Rapid sand filter: Surface wash pipe needs to be repaired due to rust.

Rapid sand filter: Surface wash pipe needs to be repaired due to rust.

Distribution pump: Rusting but no problem for operation.

Back wash pump: Rusting but no problem for operation.

Pressure gauge for Recycle pump: Pressure gauge is broken.


Sludge drying bed: Gravel has been filled but it is not used.

(3) Water Quality Analysis

The following table shows the results of water quality analysis carried out using field test kits and in a laboratory in Manila. This water analysis is for the trial operation of No.6 well since this water treatment plant has not been in operation due to the high leakage and unprofitablity. Note that the result of the field test kits is not accurate because the field tests apply the simplified analysis methods, and the color is not true color but apparent color which can be measured in the field. In the table, the value which is higher than the Philippine water quality standards is colored pink and the value which needs some consideration is colored yellow.

No.4 and No.7 well will not be used because they lack yield. And also for the aspect of the water quality, No.6 well is better.

Remarks on the No.6 well parameters are as follows.

- ✓ Color in the raw water is 40 CU. The color value after trial operation with coagulant decreased to 24.5 CU after sedimentation, and 25 CU after filtration. However, their values are still above the values of Philippine standard.
- ✓ Total dissolved solid is 470mg/l which is high.

Table 2-46 Water Quality Analysis

Parameter		Unit	PNSD	Basic Design No.4	Field Water Test						Laboratory Test	
					Raw Water No.4	Raw Water No.6	Raw Water No.7	After Aeration No.6	After Sedimentation No.6	After Filtration No.6	Raw Water No.6	Raw Water No.7
1	Temperature	℃	-	28.0	32.6	31.7	33.1					
2	pH		6.5–8.5	8.38	8.27	8.15	8.37	8.30	8.22	8.09		
3	DO	mg/l	-	0.83	1	1	3					
4	EC	mS/m	-	128	115	71	120	69	79	75		
5	Turbidity	NTU	5	0	0.2	0.3	4.3	0.1	0	0		
6	Color	CU	5	40	28.0	39.5	34.0	46.0	24.5	25.0		
7	Fe	mg/l	1.0	0.10	N.D.	N.D.	N.D.					
8	Mn	mg/l	0.5	N.D.	N.D.	N.D.	N.D.					
9	Silica	mg/l	-	26	40	150	40				50	23
10	TDS	mg/l	500	698							470	730
11	Total Hardness	mg/l	300	68	60	30	60				34	58
12	Ca Hardness	mg/l	-	59								
13	M-Alkalinity	mg/l	-	162	200	300	200					
14	Nitrate	mg/l	50	N.D.							N.D.	N.D.
15	Nitrite	mg/l	3	N.D.							N.D.	N.D.
16	Ammonia	mg/l	-	N.D.	1.0	1.0	1.0					
17	Sulfate	mg/l	250	N.D.							N.D.	N.D.
18	COD	mg/l	-	11.1	35	35	35				19	25
19	Cl	mg/l	250	318	250		> 300				99	320
20	Na	mg/l	200	243							160	250
21	Ca	mg/l	-	24							12	20
22	Mg	mg/l	-	2.2							1.1	2.0
23	H_2S	mg/l	0.05	-	0.1	N.D.	0.1					
24	Free Cl_2	mg/l		-								
25	Residual Cl_2	mg/l	0.2–1.5	-								
26	Odor		No obj.	H_2S	H_2S	N.D.	H_2S					
27	Bromoform	mg/l	0.1	N.D.							N.D.	
28	Dibromochloromethane	mg/l	0.1	N.D.							N.D.	
29	Bromodichloromethane	mg/l	0.06	0.0046							N.D.	
30	Chloroform	mg/l	0.2	0.0415							N.D.	

Pink cell is the value which is higher than the PNSD and yellow cell is the value which needs some consideration.

(4) The Jar Test

In order to determine the most effective dosage of coagulant (PAC) for the raw water in the Abangay WTP, jar tests were carried out during the field survey. The condition of the jar test was: rapid agitation for 1 min at a speed of 300rpm, slow agitation for 10 min at a speed of 30rpm, and settling for 10 min. The value which is higher than the Philippine water quality standards is colored pink and the value which needs some consideration is colored yellow in the

table.

The sample water of the jar test is collected from the No.6 well (the source well of the WTP) and two wells located in the WTP site (No.4 and No.7) for reference.

Case-1: No.6 Well-Changing of injection rate of PAC

Case-2: No.6 Well-Changing of pH at PAC 60mg/l

Case-3: No.6 Well-Changing of injection rate of PAC at pH6.5

The test results are shown in the table below. The color on the No.6 well was decreased to 16.0 CU at the dosage of PAC 60mg/l and pH6.5.

Table 2-47 Case-1 No.6 Well-Changing of injection rate of PAC

Item \ PAC(mg/l)	PNSD	After Aeration	20mg/l	40mg/l	60mg/l	80mg/l
Floc. size	-	-	Fine	Midium	Big	Big
Sedimentation	-	-	Midium	Mid.–Fast	Fast	Fast
pH	6.5–8.5	8.30	8.10	7.95	7.85	7.72
EC (mS/m)	-	69	60	60	60	60
Turbidity (NTU)	5	0.1	0.4	0.3	0.2	0.1
Color (CU)	5	46.0	38.0	30.5	24.0	20.0

Pink cell is the value which is higher than the PNSD and yellow cell is the value which needs some consideration.

Table 2-48 Case-2 No.6 Well-Changing of pH at PAC 60mg/l

Item \ pH	PNSD	After Aeration	pH6.0	pH6.5	pH7.0	pH7.5
Floc. size	-	-	Fine–Mid.	Midium	Midium	Mid.–Big
Sedimentation	-	-	Midium	Slow–Mid.	Midium	Fast
pH	6.5–8.5	8.30	6.11	6.58	6.95	7.27
EC (mS/m)	-	69	60	60	60	60
Turbidity (NTU)	5	0.1	0.8	0.4	0.3	0.2
Color (CU)	5	46.0	21.5	18.5	19.0	20.5

Pink cell is the value which is higher than the PNSD and yellow cell is the value which needs some consideration.

Table 2-49 Case-3 No.6 Well-Changing of injection rate of PAC at pH6.5

Item \ PAC(mg/l)	PNSD	After Aeration	20mg/l pH6.5	40mg/l pH6.5	60mg/l pH6.5	80mg/l pH6.5
Floc. size	-	-	Fine	Midium	Big	Big
Sedimentation	-	-	Slow	Midium	Fast	Fast
pH	6.5–8.5	8.30	6.72	6.79	6.76	6.73
EC (mS/m)	-	69	60	60	60	60
Turbidity (NTU)	5	0.1	0.8	0.5	0.3	0.3
Color (CU)	5	46.0	39.0	25.5	16.0	12.0

Pink cell is the value which is higher than the PNSD and yellow cell is the value which needs some consideration.

Case-4: No.4 Well-Changing of injection rate of PAC

Case-5: No.4 Well-Changing of pH at PAC 30mg/l

Case-6: No.4 Well-Changing of injection rate of PAC at pH6.5

The test results are shown in the table below. The color on the No.4 well was decreased to 10.0 CU at the dosage of PAC 60mg/l and pH6.5.

Table 2-50 Case-4 No.4 Well-Changing of injection rate of PAC

PAC(mg/l) / Item	PNSD	Raw Water	20mg/l	40mg/l	60mg/l	80mg/l
Floc. size	-	-	Small	Midium	Mid.–Big	Big
Sedimentation	-	-	Fast	Fast	Fast	Fast
pH	6.5–8.5	8.27	8.00	7.83	7.67	7.55
EC (mS/m)	-	115	90	100	100	110
Turbidity (NTU)	5	0.2	0.2	0.0	0.1	0.1
Color (CU)	5	28.0	25.0	20.5	16.5	14.0

Pink cell is the value which is higher than the PNSD and yellow cell is the value which needs some consideration.

Table 2-51 Case-5 No.4 Well-Changing of pH at PAC 30mg/l

pH / Item	PNSD	Raw Water	pH6.0	pH6.5	pH7.0	pH7.5
Floc. size	-	-	No floc.	Big	Big	Big
Sedimentation	-	-	No floc.	Fast	Fast	Fast
pH	6.5–8.5	8.27	5.88	6.49	6.85	7.11
EC (mS/m)	-	115	100	100	110	100
Turbidity (NTU)	5	0.2	1.7	0.2	0.2	0.2
Color (CU)	5	28.0	43.5	9.5	11.5	12.0

Pink cell is the value which is higher than the PNSD and yellow cell is the value which needs some consideration.

Table 2-52 Case-6 No.4 Well-Changing of injection rate of PAC at pH6.5

PAC(mg/l) / Item	PNSD	Raw Water	20mg/l pH6.5	40mg/l pH6.5	60mg/l pH6.5	80mg/l pH6.5
Floc. size	-	-	Small	Mid.–Big	Big	Big
Sedimentation	-	-	Slow	Midium	Fast	Fast
pH	6.5–8.5	8.27	6.62	6.60	6.60	6.60
EC (mS/m)	-	115	113	120	123	124
Turbidity (NTU)	5	0.2	0.7	0.2	0.2	0.2
Color (CU)	5	28.0	23.0	13.0	10.0	8.5

Pink cell is the value which is higher than the PNSD and yellow cell is the value which needs some consideration.

Case-7: No.7 Well-Changing of injection rate of PAC

Case-8: No.7 Well-Changing of pH at PAC 30mg/l

Case-9: No.7 Well-Changing of injection rate of PAC at pH6.5

The test results are shown in the table below. The color on the No.7 well was decreased to 15.0 CU at the dosage of PAC 60mg/l and pH6.5.

Table 2-53 Case-7 No.7 Well-Changing of injection rate of PAC

Item \ PAC(mg/l)	PNSD	Raw Water	20mg/l	40mg/l	60mg/l	80mg/l
Floc. size	-	-	Small	Midium	Mid.–Big	Mid.–Big
Sedimentation	-	-	Midium	Fast	Fast	Fast
pH	6.5–8.5	8.37	7.88	7.84	7.67	7.55
EC (mS/m)	-	120	100	110	110	110
Turbidity (NTU)	5	4.3	0.2	0.2	0.1	0.1
Color (CU)	5	34.0	29.0	23.0	18.0	15.0

Pink cell is the value which is higher than the PNSD and yellow cell is the value which needs some consideration.

Table 2-54 Case-8 No.7 Well-Changing of pH at PAC 30mg/l

Item \ pH	PNSD	Raw Water	pH6.0	pH6.5	pH7.0	pH7.5
Floc. size	-	-	Small	Midium	Mid.–Big	Mid.–Big
Sedimentation	-	-	Slow	Midium	Fast	Fast
pH	6.5–8.5	8.37	6.00	6.54	6.87	7.08
EC (mS/m)	-	120	100	110	110	110
Turbidity (NTU)	5	4.3	1.3	0.6	0.2	0.2
Color (CU)	5	34.0	28.0	17.0	15.0	13.5

Pink cell is the value which is higher than the PNSD and yellow cell is the value which needs some consideration.

Table 2-55 Case-9 No.7 Well-Changing of injection rate of PAC at pH6.5

Item \ PAC(mg/l)	PNSD	Raw Water	20mg/l pH6.5	40mg/l pH6.5	60mg/l pH6.5	80mg/l pH6.5
Floc. size	-	-	Small	Small–Mid.	Midium	Mid.–Big
Sedimentation	-	-	Slow–Mid.	Midium	Midium	Fast
pH	6.5–8.5	8.37	6.66	6.62	6.57	6.57
EC (mS/m)	-	120	123	132	134	135
Turbidity (NTU)	5	4.3	2.3	1.2	0.9	0.7
Color (CU)	5	34.0	32.0	20.5	15.0	10.5

Pink cell is the value which is higher than the PNSD and yellow cell is the value which needs some consideration.

(5) Breakpoint Chlorination

The relation of chlorine dosage and residual chlorine was examined, in order to determine the optimum chlorine dosage. The result is shown in the figure below. Breakpoint was not found, but the residual chlorine was 0.5mg/l with 0.5mg/l of chlorine dosage, thus the optimum chlorine dosage is found as 0.5–1.0mg/l.

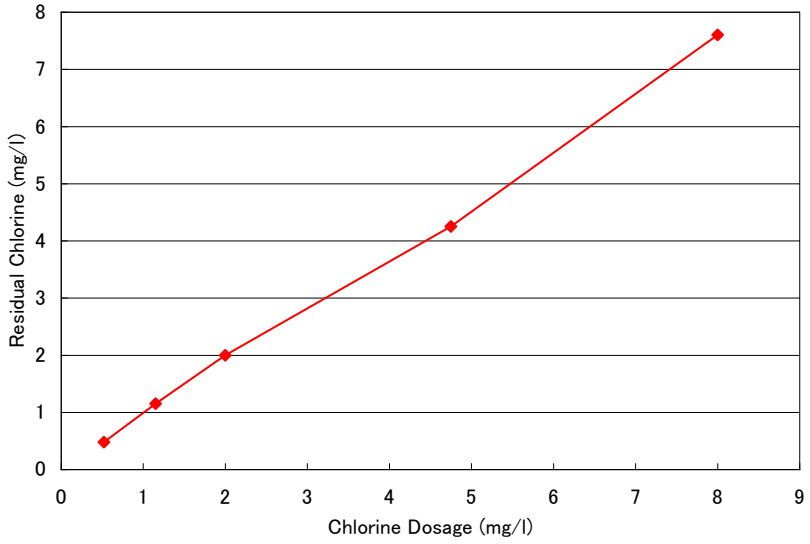

Figure 2-16 Chlorine Dosage and Residual Chlorine

(6) Test Operation

The sample water of test operation was performed at the No.6 well. The test operation was executed with PAC 60mg/l according to the result of the jar test.

The following table shows the results of water quality analysis after the sedimentation and after the filtration by using field test kits. In the table, the value which is higher than the Philippine standards is colored pink and the value which needs some consideration is colored yellow.

- ✓ Color after filtration has been decreased from 46.0 CU after aeration to 25.0 CU after filtration by using PAC as coagulant; however, it can't be decreased to below 5 CU with the use of PAC alone as indicated in the result of the jar test. Even when pH was adjusted at 6.5, the color decreased only up to 16.0 CU with PAC 60 mg/l. There is a possibility to decrease the color more by using a mass of PAC, but the cost of operation will be high.

Table 2-56 Water Analysis after the Test Operation

Parameter		Unit	PNSD	After Aeration	After Sedimentation	After Filtration
1	pH		6.5–8.5	8.30	8.22	8.09
2	EC	mS/m	-	69	79	75
3	Turbidity	NTU	5	0.1	0.0	0.0
4	Color	CU	5	46.0	24.5	25.0

Pink cell is the value which is higher than the PNSD and yellow cell is the value which needs some consideration.

2-6 Result of the Field Survey in Pagsanjan WD

2-6-1 Outline of the Follow-up Cooperation in Pagsanjan WD

The Water Treatment Plant (WTP) in Pagsanjan WD was implemented under *the Project for Improvement of Water Quality in the Republic of the Philippines* financed by the Government of Japan as the JICA Grant Aid project. The WTP was handed over after a test operation in 2005. This WTP is designed to remove iron only and the main treatment facility is the rapid sand filter. PagsanjanWD is relatively well managed and the WTP has been managed well since the hand-over. Still, some facilities were perceived to have needs for modification, and so the field survey was conducted to identify the problems and design the rehabilitation plan for the facilities.

2-6-2 Result of the Field Survey

2-6-2-1 Survey Method

The following surveys were conducted to investigate the current status of the water treatment facilities and to design the rehabilitation works:

Water service study : to confirm the water source and water service situation
System flow survey : to confirm the current treatment process
Facility function study : to investigate the function of the existing facilities
Water quality analysis : to investigate the quality of the rawand treated water
Test operation : to confirm the treatment situation with changed dosage

2-6-2-2 Survey Result of Water Service Study

(1) Water survice

There are several water sources in the WD; one spring and four wells, among them one well is for an emergency use. Those water sources are connected together for distribution of water. Except for the water source of the WTP and the emergency well, the quality of the water sources

is acceptable after chlorination.

The situation of the water supply service is summarized in the table below according to the monthly report of Pagsanjan WD (Dec. 2009). The unaccounted for water (UFW) is relatively low with 30.0%.

Table 2-57 Water Supply Service in Pagsanjan WD (Dec. 2009)

Item	Total
Service connection	6,657
Number of current active connection	5,401
Expected population served	39,942
Volume of water produced (m^3/d)	3,749
Volume of Water billed (m^3/d)	1,845
Unaccounted for water (%)	30.0

The water tariff structure of the Pagsanjan WD is shown in the table below. Since the water rate for household/public facility was 107 peso in 1999, it has doubled in 10 years. Also compared to the national average water tariff of 0–10m3 for household/public facility being 172.49 peso, the rate of Pagsanjan is rather high.

Table 2-58 Water Tariff Structure in Pagsanjan WD

Unit:Peso

	0–10m^3	11–20m^3	21–30m^3	31–40m^3	41m^3–Above
Household/public facility	200	22	24	26	29
Commercial/industrial facility	400	44	48	52	58
Semi‐Commercial A	350	38.5	42	45	50.75
Semi‐Commercial B	300	33	36	39	43.5

(2) Water sources

Water supply service in Pagsanjan WD is sourced from several water sources as listed in the table below. The yields of each water source are shown in the table. Except for the well No.1 which needs treatment with the WTP, the water is distributed directly after chlorination.

Table 2-59 Operation of Water Sources in Pagsanjan

Water source name	Yield (l/s)	Remarks
No 4	24	Deep well
No 5	23	Deep well
No 2a	11	Spring
No 2b	6	Spring
No 6	For emergency	
No 1	Unknown	Source for WTP

2-6-2-3 Survey Result of Water Treatment Facilities

(1) Current System Flow

The current system flow and initially designed system flow are illustrated below.

- ✓ Current operation of chlorination is executed after aeration.

✓ The drained water from backwashing process is not recycled and discharged to the river directly. This drained water is small amount and below the Philippines effluent standard.

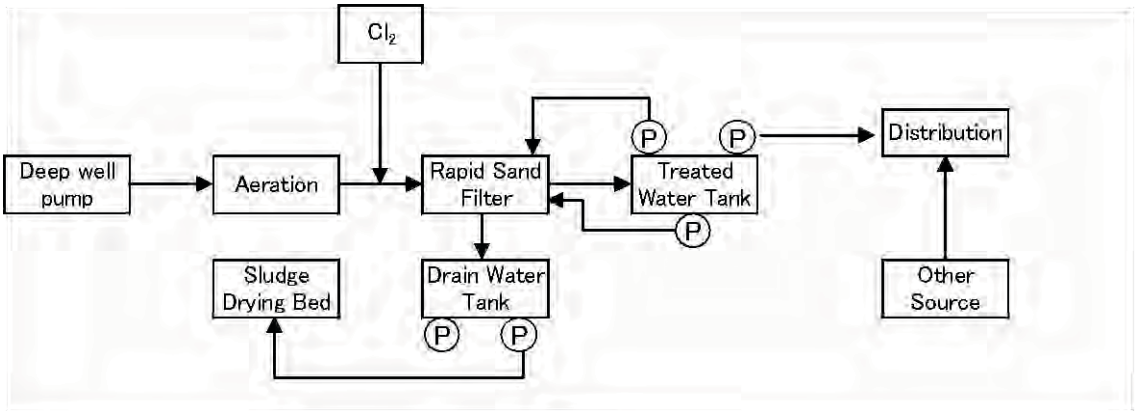

Figure 2-17 Current System Flow

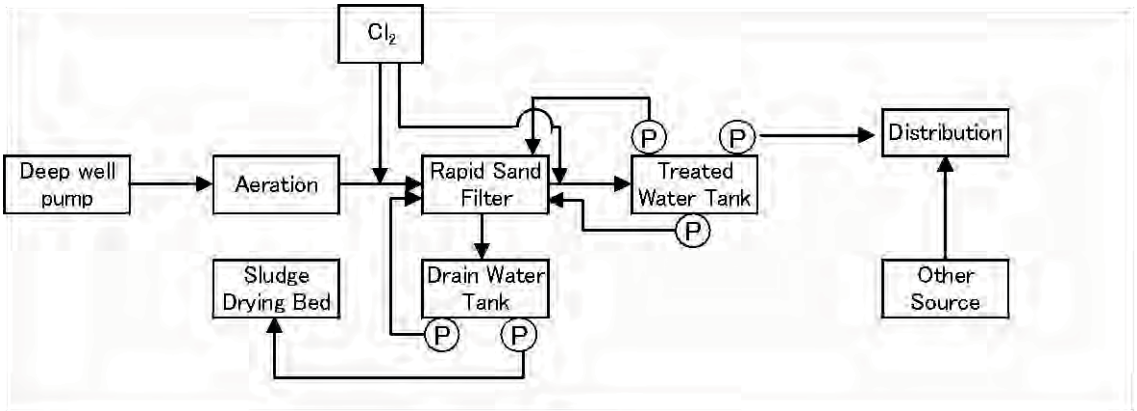

Figure 2-18 Initial Design System Flow

(2) Function of Facilities

Current state of each facility including the structure, electrical wiring, plumbing and mechanical equipment were investigated. The result is summarized in the table below.

Table 2-60 Current State of the Facilities

Facility		Q'ty	Current State
Intake	Deep Well	1	No problem
	Deep Well Pump	1	Currently no problem. Sand was raised before and the pump was broken 2years ago. The pump installation depth was rectified and no sand raise occurred.
Treat-ment	Sand Separator	1	Removed due to failure. The initially installed pump had holes and broken. Another sand separator was installed but it was also broken down. After pump depth modified, sand raise is reduced. However, without sand separator the flow meter was broken down due to the sand thus it needs to be installed.
	Aeration Tower	2	No problem on aeration process. The jet nozzle was clogged so the holes were enlarged. That affected the intense of water jet which now does not reach to the ceiling. However, the dissolved oxygen after aeration is 7mg/l that is no need for improvement.
	Rapid Sand Filter	2	Surface-wash pipes are corroded thus need to be repaired.
	Backwash Pump	1	No problem
	Surface-wash Pump	1	Pump is no problem. Flow meter need to be changed.
	Treated Water Tank	2	No problem
	Drainage Basin	1	No problem
	Recycling Pump	1	Pump was removed 1year ago due to its failure. Currently the drained water of backwashing is not recycled and discharged to the river. This drained water is small amount and below the Philippines effluent standard. Therefore, no need to be replaced.
	Sludge Drain Pump	1	No problem
	Sludge Drying Bed	4	As no coagulant is added, it is difficult to produce sludge cake in the sludge drying bed. Currently the drained sludge is directly discharged to the river. Current state is no problem because this is below the standard.
	Chlorination Room	1	Intermediate and post chlorination pumps have been removed due to corrosion. Chlorination is done by injection pump installed by WD.
	Intermediate Cl Pump	1	
	Post Chlorination Pump	1	
	Stand-by Generator	1	No problem
Distri-bution	Distribution pump	2	No problem
	Pressure Tank	1	No problem

The function of each facility is diagnosed referring to the design criteria. The result is as follows.

- ✓ Surface load in the aeration tower and filtration rate in the rapid sand filter are satisfying the design criteria. Also the ventilation of the aeration tower has no problem as the dissolved oxygen after aeration is nearly saturated 4–7mg/l.

Table 2-61 Function Diagnosis of the Facilities

Item	Unit	Design standard	Plan (Current)	Remarks
Water Volume	m^3/day		1,097 (-)	Current water flow cannot be measured due to malfunction of flow meter
	L/sec		12.7 (-)	
Intake				
Deep well pump			0.8m^3/min×36m×7.5kW	Capacity of initially installed pump
Aeration Tower				
Surface load	m^2/m^3/hr	0.4–1.0	0.42	
Rapid Sand Filter				
Type			Rapid Sand Filtration	
Number of basins		> 2 basins	2	
Effective dimension	m		WL: 1.9×2.5	
Filter area/basin	m^2		4.8	
Filtration rate	m/day	120–150	115	
Backwash pump			3.4m^3/min×10m×11kW, φ150	
Surface-wash pump			1.0m^3/min×30m×11kW, φ80	
Intermediate Chlorination				
Dosing pump			0.12l/min×1.0MPa×0.2kW	Removed due to breakdown
Post Chlorination				
Dosing pump			0.12l/min×1.0Mpa×0.2kW	Removed due to breakdown
Sludge Drying Bed				
Effective dimension	m		DWL: 0.5×1.5×4.0	
Number of basins			4	
Total area	m^2		18	
Treated Water Tank				
Number of basins			2	
Effective dimension	m		DWL: 5.0×5.0×17.0	
Effective capacity	m^3		175	
Transmission Facility				
Transmission Pump			3.4m^3/min×50m×15kW, φ80	
Number of pumps			2	
Stand-by Generator	kVA		95	

The followings are the pictures of current state of facilities.

Sand separator: It was changed two times and finally removed because of holes.

Sand separator: It was used with the holes filled until break down.

Sand separator: Holes have been filled with pate.

Aeration tower: Water pressure decreased so the jet does not reach to the ceiling. DO in the water is sufficient.

Rapid sand filter: Filter basins are covered by the net to prevent the leaves dropping in.

Rapid sand filter: Surface-wash pipes are corroded thus need to be repaired.

Rapid sand filter: Under back washing.

Rapid sand filter: After the back wash.

Drainage basin: Recycle pump has been removed due to breakdown.

Chlorination pump: Single phase power is supplied by using the extension electric cord.

Chlorination pump: Pumps were removed because of corrosion.

Intermediate Chlorination pump: installed by the WD

Intermediate Chlorination pump: installed by the WD

(3) Water Quality Analysis

The following table shows the results of water quality analysis carried out using field test kits and in a laboratory in Manila. Note that the result of the field test kits is not accurate because the

field tests apply the simplified analysis methods, and the color is not true color but apparent color which can be measured in the field. In the table, the value which is higher than the Philippine water quality standards is colored pink and the value which needs some consideration is colored yellow.

Remarks on the major parameters are as follows.

- ✓ Turbidity in the raw water is zero. Although it rises after the aeration due to oxidation of dissolved iron, it is removed after the filtration. However, at the end of the distribution pipe, turbidity exceeds the standard caused by the sedimentation of the particulate matters in the pipes.
- ✓ Color in the raw water is low at 3 CU, but it increases after the aeration for the oxidized iron. Color is then removed after the filtration to 5 CU. At the end of the pipe, color also increase for the same cause as for turbidity.
- ✓ Iron concentrations in the raw water are 1.8 mg/l which exceeds the standard. However, iron is removed after the filtration.
- ✓ Total Dissolved Solid (TDS) in the raw water is 500mg/l, which is the same value as the Philippine standard. This is unfavorable but it cannot be removed by the exiting treatment process.
- ✓ Total Hardness is also the same value as the standard of 300mg/l. But it cannot be removed by the exiting treatment process.
- ✓ Residual Chlorine is below the standard in the WTP, but it increases at the tap. The cause is unknown but there are complaints about chlorine odor from the water users. The water is drained periodically from the end of the pipes to control the chlorine concentrations from rising.

Table 2-62 Water Quality Analysis

Parameter		Unit	PNSD	Basic Design	Field Water Test				Lab. Test
					Raw Water	After Aeration	After Filtration	At Water Tap (End)	Raw Water
1	Temperature	℃	-	28.5	26.8				
2	pH		6.5–8.5	7.28	7.15	7.42	7.76	7.70	
3	DO	mg/l	-	1.01	4	7			
4	EC	mS/m	-	88	77	77	78	76	
5	Turbidity	NTU	5	1	0	2.4	0.2	13.1	
6	Color	CU	5	0	3.0	34.0	5.0	44.0	
7	Fe	mg/l	1.0	2.20	1.8	0.3	0	0	1.6
8	Mn	mg/l	0.5	0.28	< 0.5	< 0.5	< 0.5	< 0.5	0.2
9	Silica	mg/l	-	86	100	100	100	100	
10	TDS	mg/l	500	343					500
11	Total Hardness	mg/l	300	230	50	50	50	70	300
12	Ca Hardness	mg/l	-	98					
13	M-Alkalinity	mg/l	-	313	390	450	400	400	
14	Nitrate	mg/l	50	0.50					N.D.
15	Nitrite	mg/l	3	0.60					N.D.
16	Ammonia	mg/l	-	N.D.	0.7	0.3	0		
17	Sulfate	mg/l	250	N.D.					8.5
18	COD	mg/l	-	3.2	7	3	3	5	
19	Cl	mg/l	250	65	< 200	< 200	< 200	< 200	67
20	Na	mg/l	200	43					58
21	Ca	mg/l	-	39					45
22	Mg	mg/l	-	31.7					45
23	H_2S	mg/l	0.05	-					
24	Free Cl_2	mg/l		-		0.06	0.04	1.05	
25	Residual Cl_2	mg/l	0.2–1.5	-		0.66	0.20	1.3	
26	Odor		No obj.	Metallic odor	Metallic odor			N.D.	

Pink cell is the value which is higher than the PNSD and yellow cell is the value which needs some consideration.

(4) Test Operation

The test operation was executed only on the equipment, because the chemical dosing is only chlorination in this WTP, and current dosage is done properly.