Appendix-6

Sector Development Framework

THE PREPARATORY SURVEY

ON

WATER SUPPLY SYSTEM IMPROVEMENT

PROJECT

IN THE REPUBLIC OF PALAU

AP-6-1

Sector Development Framework

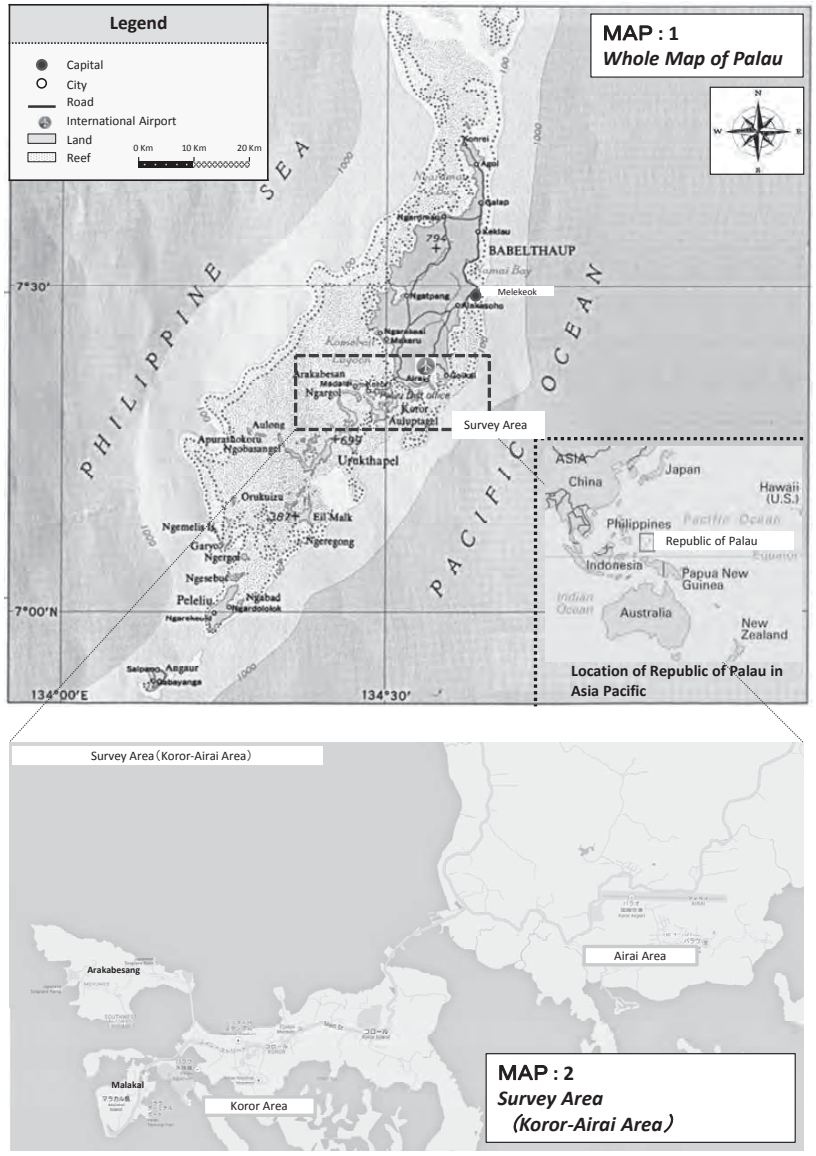
October 2014

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

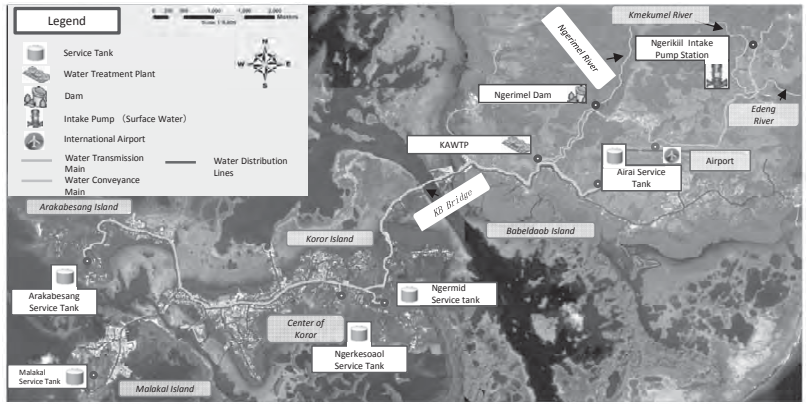
YACHIYO ENGINEERING CO., LTD.

NIHON SUIKO SEKKEI CO., LTD.

Exchange Rate:
USD1.00 = JPY103.86 (August 2, 2014)

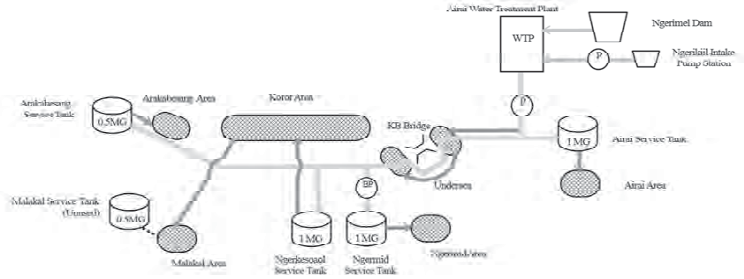


Location of the Survey Area

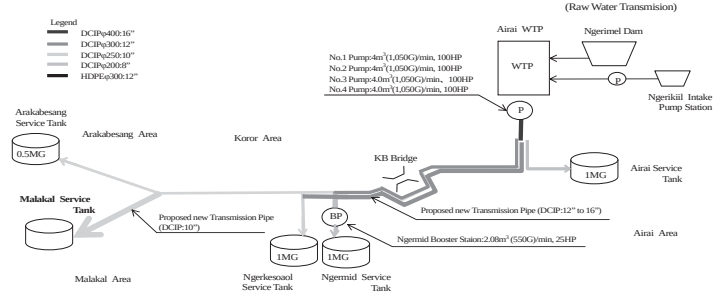


Source : GIS Data from PPUC

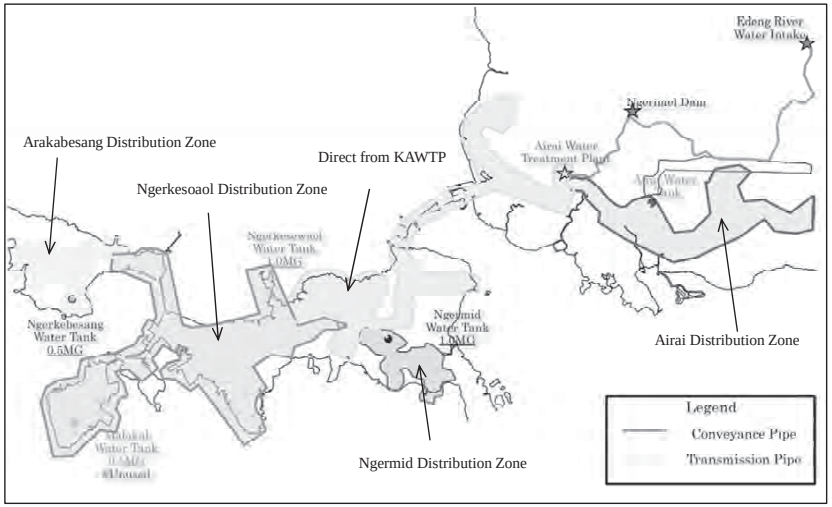
Diagram of Existing Koror-Airai water supply system



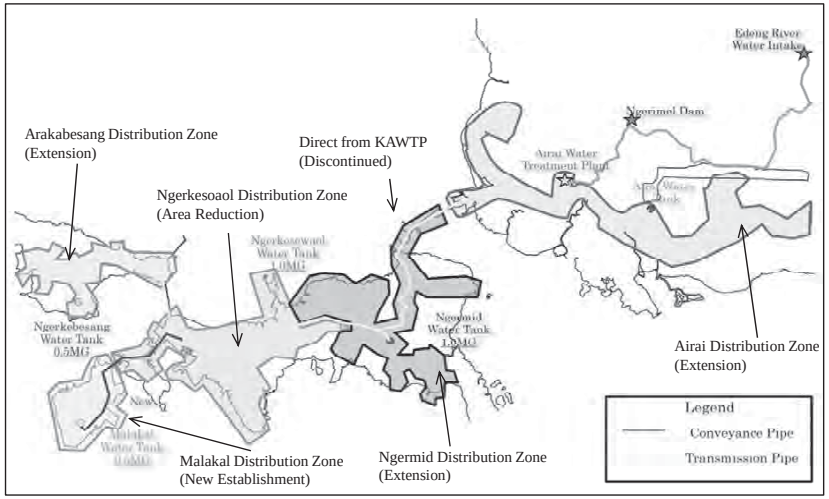
Existing Koror-Airai water supply system (Schematic Illustration)



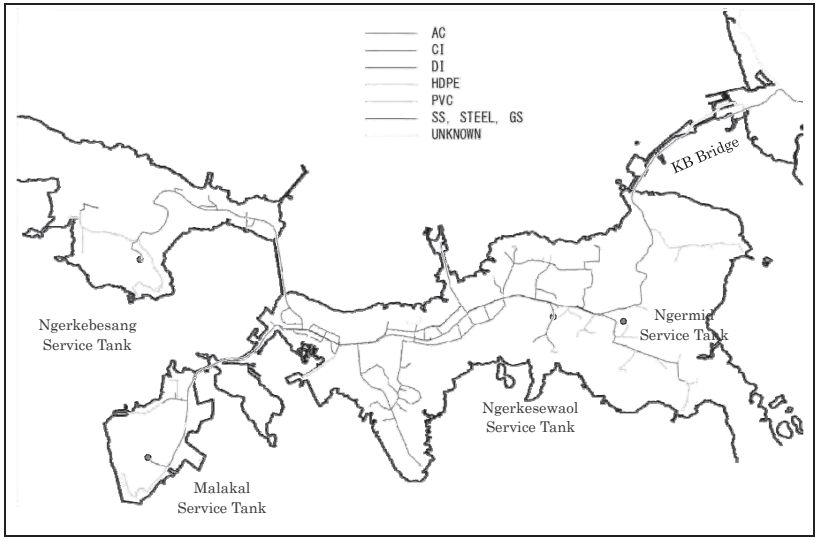
Koror-Airai water supply system after Execution of Urgent Components (Schematic Illustration)



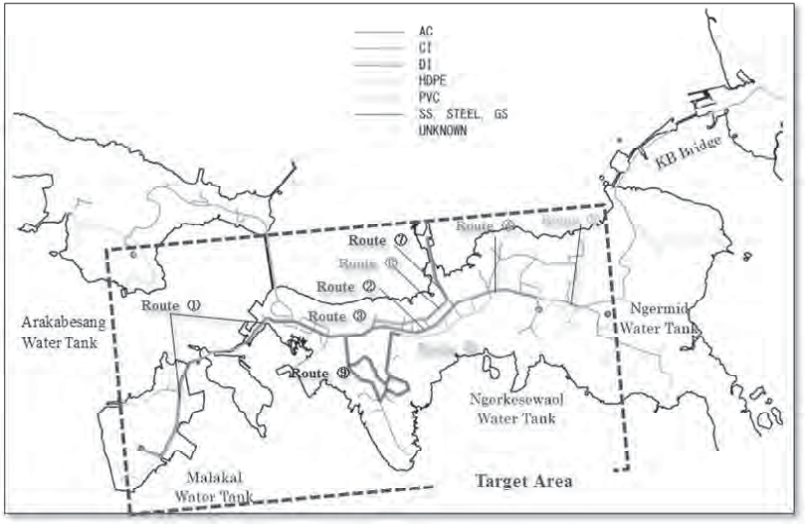
Existing Distribution Zones



Proposed Distribution Zones



Spread of the Existing Asbestos Cement (AC) Pipes



Proposed Routes for Urgent Replacement of Old AC Pipes

SUMMARY

1. Background

In July 2013, the Government of Republic of Palau (GoP) made a request for Grant Aid for the Water Supply System Improvement Project (the Project) to the Government of Japan (GoJ). The Japan International Cooperation Agency (JICA) decided to conduct a Preparatory Survey to examine the viability of the Project and sent the Survey team (the Team) headed by Ms. Eriko TAMURA, Director of Water Resources Management Team 1 in Global Environment Department of JICA.

The requested Project is to improve water supply conditions for Koror and Airai through development of alternative water sources, re-arrangement of water distribution zones and replacement of old asbestos cement (AC) pipelines.

The Team conducted the 1st field survey from June 23 to August 5, 2014 in Koror, Airai and other related states in Babeldaob island. The Team compiled all results of the 1st survey in this report. This report is not to show the plans of the Japan's Grant Aid. The report contains basic findings of the Team and recommendation for necessary inputs to be undertaken by the Palauan side and /or to be selected as components for the Japan's Grant Aid.

The Team expresses, herewith, its appreciation to all Palauan stakeholders of the Project and expects that this report be useful for further planning works for activities and inputs for water supply and sewerage improvement.

2. Outlines of Water Supply for Koror - Airai

Water supply is managed by Palau Public Utilities Corporation (PPUC). It is a public corporation and responsible for water supply, wastewater service and electricity distribution in Palau. Table S-1 shows the outlines of water supply for Koror - Airai. PPUC supplies the water currently for 14,126 persons (estimated for 2013) at 261G/capita/d (988L/capita/d), which includes non-domestic consumption. The large volume of non-revenue water (NRW), estimated at 48%, is remarkable.

Table S-1 Outlines of Water Supply for Koror - Airai

Item	Scale / Performance	Remark
Max Daily Production	4.03MG (15,253m^3) /d	Max in 2009 - 2013
Ave Daily Production	3.69MG (13,967m^3) /d	2013; 261G/capita/d (988L/capita/d)
Ave Daily Billed Water	1.91MG (7,229m^3) /d	Including estimated flat rate consumptions (17%).
- Domestic	0.96MG (3,634m^3) /d	
- Non-Domestic	0.95 MG(3,596m^3) /d	
Non-Revenue Water: NRW	1.78MG (6,737m^3) /d	
NRW Ratio	48%	
No of Connection	3,710 connections	Effective:3,341,Domestic:2,499, Non-Domestic:842
Metered Ratio	90%	
Service Population	14,126 persons	Estimated for 2013
Service Coverage	100%	
Unit Water Consumption	572G (2,165L) /connect/d	Average for total
Domestic	386G (1,461L) /connect/d	
Domestic	68G (257L) /capita/d	
Non-Domestic	1,128G (4,269L) /connect/d	
Service Hours	24 hours	
Number of Employees	51 persons	Excluding staffs for sewer and outlaying states
- per 1000 connections	13.7 persons	
Ratio of Cost Recovery	38%	Whole PPUC

Source: JICA Survey Team based on PPUC's data

3. Background of Sector Development

(1) Population

The population of Palau is decreasing from 2005. The Team forecast that the populations in Koror and Airai decrease to 11,171 and 2,439 respectively in 2020.

Table S-2 Population Forecast for Koror - Airai

Area	2012	2013	2014	2015	2016	2017	2018	2019	2020
Population: Koror	11,665	11,601	11,538	11,475	11,413	11,351	11,291	11,231	11,171
Population: Airai	2,537	2,525	2,512	2,500	2,487	2,475	2,463	2,451	2,439
Total	14,202	14,126	14,050	13,975	13,900	13,826	13,754	13,682	13,610

Source: JICA Survey Team, based on Statistical Yearbook 2013

(2) Number of Foreign Visitors

Palau receives more than 100 thousand of foreign visitors per year against its population which is less than 20 thousand. According to the Palau Visitors Authority (PVA), more than 118 thousand of foreign visitors are recorded in 2012. The Team forecast it to be 169,351 in 2020. Assuming the average staying period of foreign visitors at 4 days in accordance with PVA's information, 169,351 persons per year are converted into 1,856 persons per day.

Table S-3 Forecast of Foreign Visitors for the Project

Year	2008	2009	2010	2011	2012	2013	2014
No. of Foreign Visitors	79,259	71,887	85,593	109,057	118,754	105,061	112,468
Year	2015	2016	2017	2018	2019	2020	
No. of Foreign Visitors	120,400	128,895	137,993	147,737	158,173	169,351	

Data Source: Palau Visitors Authority until 2013

(3) Economic Development

The Gross Domestic Product (GDP) is increasing at 3.4% per year for the recent five years. It is clear that "transportation and storage" and "accommodation and food service" industries, which reflect the scale of foreign visitors, are increasing at around 10% per year. They account for 26% of total GDP and contribute to the GDP development. On the hand, the "public administration" is in flat trend for the five years.

Table S-4 GDP Increase Ratio

Category	GDP (million USD)					Annual increase Rate
	2009	2010	2011	2012	2013	(2009-2013)
Total GDP	156.2	160.9	168.9	178.0	177.3	3.4%
Accommodation & food service	22.4	25.6	29.4	35.3	35.1	14.2%
Transport and storage	7.7	8.5	10.1	11.4	10.6	9.4%
Sub-Total	30.1	34.1	39.5	46.7	45.7	13.0%
Public Administration	28.5	28.4	27.6	27.5	27.9	-0.5%

Data Source: 2013 Statistical Yearbook, Bureau of Budget & Planning, Ministry of Finance

(4) Rainfalls

The rainfall is heavy throughout the year at 147 inches (3,734mm) as annual average. The rainfall is enough to accommodate the people in Palau. The people of Koror and Airai, however,

experienced severe shortages of water caused by the draughts in 1983, 1998 and 1992. In Palau, less rainfalls are recorded in El Niño years. PPUC should undertake countermeasures against the draughts if more frequent El Niño is observed. Currently, the frequency of the severe draughts, which affects the water supply, is supposed at twice per 30years. According to the Japanese guidelines for water facilities design, the probability of drought in 10 years should be considered for designing facility's capacity. In this background, countermeasures for the drought will not be categorized in top urgent.

(5) Hydrogeological Conditions

There are relatively many areas with flat plains and gentle slopes in Babeldaob, Koror, Arakabesang and Malakal islands. Basaltic tuff breccia is distributed in those islands. Babeldaob is a good candidate site for groundwater development.

(6) Organization of PPUC

115 staff-members are mainly working in PPUC for water and wastewater services against 4,776 connections. It is converted into 24 persons per 1,000 connections. This large number of employees caused by inefficiency of activities in Outlying States. Besides the inefficiency in number of employees, system establishments are necessary for water distribution / NRW management and water quality management.

(7) Financial Condition

Although PPUC is required to be sustainable by tariff incomes, the cost recovery rate is 38% in 2013 as shown in Table S-5. PPUC, accordingly, has commenced a step-wised improvement (increase) of water tariff.

Table S-5 Revenue and Expenditure for the past five years

Fiscal Year			2009	2010	2011	2012	2013
1	Revenue (USD)	Water Utility Charges	649,179	665,004	936,109	1,700,767	1,762,528
2	Expenditures (USD)	WWO Operation	3,974,413	4,605,422	4,744,917	4,476,446	4,693,439
3	Subsidy (USD)		(3,325,234)	(3,940,418)	(3,808,808)	(2,775,679)	(2,930,911)
4	Cost Recovery Ratio (%)	(=1/2)	16%	14%	20%	38%	38%
			Avg. subsidy for the past 5 years (2009 to 2013)				(3,356,210)

Source: PPUC, based on GoP Audited Financial Statement

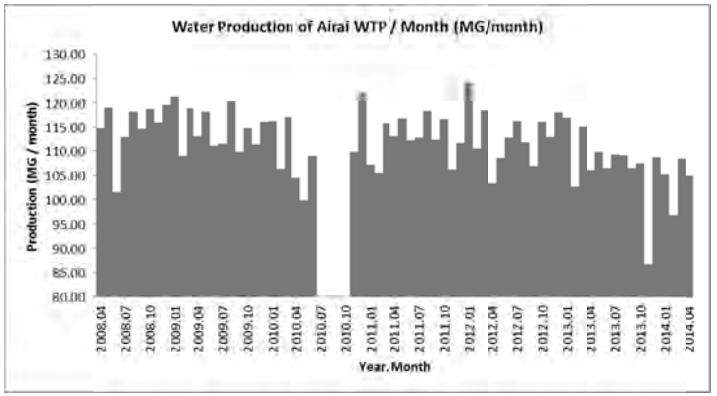
On the other hand, the inefficiency caused by NRW should be noted. The current cost for water transmission is assumed at USD600.00/MG (USD0.16/m^3). If NRW was reduced by 0.5MG/d (1,893m^3/d), PPUC could reduce the water production by 182.5MG/y (690,763m^3/y) and could save the electricity cost for water transmission by USD 110 thousand /y.

4. Water Demand

(1) Current Volume of Water Supply and Consumption

The water production from Koror - Airai Water Treatment Plant (KAWTP) tends to decrease as shown in Figure S-1. This tendency is explained by the population decrease.

The average consumption is 1.91MG/day (7,229m^3/d) against the production of 3.69MG/day (13,967m^3/d) as shown in Table S-6. NRW is, accordingly, calculated at 1.78MG/day (6,737m^3/d) and 48%.



Remark 1: Low production was recorded in November 2013 due to leakage accident at KB Channel.

Remark 2: Blanks show that no data is available.

Source: Daily report of KAWTP

Figure S-1 Trend of Water Production of KAWTP

Table S-6 Unit Production / Consumption (Assumption for the Current Volume)

No.	Item	Population	Number of Customer	Unit Production / Consumption		Daily Production / Consumption	
				G/Cap/d	G/Connect/d	MG/d	m^3/d
1	Water Production	14,126	3,341	**261**	**1,105**	3.69	13,967
2	Domestic Consumption	14,126	2,499	**68**	**386**	0.96	3,634
3	Non-Domestic Consumption (gov)		144		**634**	0.09	341
4	Non-Domestic Consumption (com/flat)		24		**533**	0.01	38
5	Non-Domestic Consumption (com/metered)		674		**1,255**	0.85	3,217
6	Total Consumption	14,126	3,341	**135**	**572**	1.91	7,229
7 = 1 - 6	**NRW**					**1.78**	6,737
8 = 7 / 1	**NRW Ratio (%)**					**48%**	48%

Remark: Flat rate consumptions are adjusted to be same as metered ones per connection for domestic and governmental customers. Flat rate consumptions for commercial customers are adjusted by the adjustment factor (average for domestic and governmental customers).

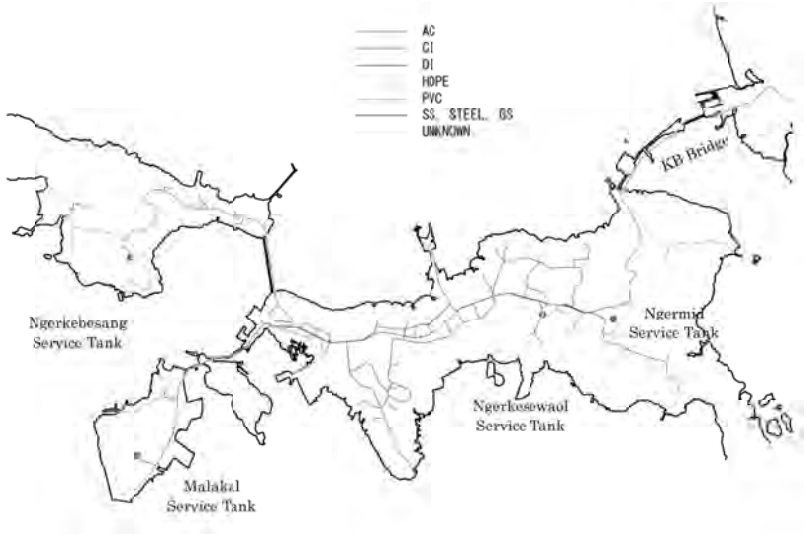
Source: JICA Survey Team

(2) Reduction of NRW

Since illegal connections and un-authorized consumptions are not serious issues, the Team assumes that most of NRW is generated by leakage.

Old asbestos cement (AC) pipes, which were laid 40 years ago or more, accounts for 67% in the water distribution networks. The spread of AC pipelines is shown in Figure S-2. 61% out of the 67% of the AC pipes are larger diameter pipes (6 inches: 150mm diameter or more). This old and larger AC pipes network, including lateral connections from the pipes, is believed to be a cause of large amount of leakage. According to length, diameter and material, the Team assumes that 81% of leakages are caused by the larger diameter AC pipes and lateral pipes of those AC pipes. The team assumes the breakdown for the current NRW and replacement effectiveness of the larger diameter

AC pipes as shown in Table S-7. The Team recommends replacing the larger diameter AC pipes (20.3 miles or 15.5km) in steps and before 2022.



Data Source: PPUC

Figure S-2 Spread of AC Pipes

Table S-7 Assumed Breakdown for Current NRW and Replacement Effectiveness

Rate to Replace Larger AC Pipes (6 inches or more) Total 32.5km / Water Production / NRW	Current	2017	2018	2019	2020	2021	2022
	Current	1st year	2nd year	3rd year	4th year	5th year	6th year
		3.4 mi	6.9 mi	10.4 mi	13.8 mi	17.3 mi	20.3 mi
		5.5 km	11.1 km	16.6 km	22.1 km	27.6 km	32.5 km
Production (MG/d)	3.69	3.47	3.25	3.03	2.81	2.59	2.39
Total NRW (MG/d)	1.78	1.56	1.34	1.12	0.90	0.68	0.48
NRW Ratio for total base	**48%**	**45%**	**41%**	**37%**	**32%**	**26%**	**20%**
a NRW difficult to eliminate (5% of total NRW)	0.09	0.08	0.07	0.06	0.05	0.03	0.02
b Meter malfunction (5% of total NRW)	0.09	0.08	0.07	0.06	0.05	0.03	0.02
c Leakage on pipelines	1.60	1.38	1.16	0.94	0.72	0.50	0.30
Impact of AC pipes (6inches or more)	81%	78%	74%	68%	58%	40%	0%
Impact of other pipes	19%	22%	26%	32%	42%	60%	100%
Leakage on AC pipes (6inches or more)	1.3	1.08	0.86	0.64	0.42	0.20	0.00
Leakage on other pipes	0.3	0.3	0.3	0.3	0.3	0.3	0.3

Remark: The water volumes are calculated under the present value basis and with/without replacement. The changes of real demands of citizens (consumption) are not considered in the above calculation.
Source: JICA Survey Team

For simulating the Table S-7, the Team assumes the following:

- 81% of the leakages will be eliminated if all the larger diameter AC pipes are replaced with new pipes.
- NRW ratio will be 20% if 81% of leakages are reduced.
- NRW ratio will be less than 33% in 2020 if PPUC starts replacement of the larger diameter AC pipes in 2016 and completes within six years. "33% in 2020" is a recommended target by a study of Asian Development Bank (ADB) in 2009.

(3) Demand Forecast

It is noted that many leaks and worthless consumptions are found in private plots after meters. PPUC should promote the awareness of citizen for water conservation and reduction of worthless water. It is, however, difficult to control it for PPUC. The Team recommends, therefore, not accounting the possible reduction in the demand forecast and applying the current unit consumption, 68G/capita/d (257L/capita/d), for the Project.

Commercial consumption, as a part of non-domestic consumption, should be forecast, considering the economic growth as well as the increase of for foreign visitors. The activities related to foreign visitors contribute much to the economic growth. Moreover, GDP is developing in parallel of increase of foreign visitors. The Team recommends, accordingly, applying the GDP increase ratio as the increase ratio of the commercial water consumption; 3.4% per year is applied for the increase of commercial consumption.

In respect of governmental consumption, as the other part of non-domestic consumption, is recommended to be same as the current one for the project since the GDP for public administration is in flat trend for development.

Adding the NRW reduction previously mentioned, the water demand is forecast as shown in Table S-8. The daily average demand (production) will be reduced to 3.09MG/d (11,696m^3/d) in 2020.

(4) Daily Maximum Production

The daily average demand is not a design capacity for the facilities since the water demand fluctuates throughout the year. According to the data, the demand (production) of the peak day is around 1.07 times of the average. The design daily maximum demand should be, accordingly, 3.31MG/day (12,528m^3/d) for 2020.

"3.31MG/day" is not, however, a practical designing figure of the facilities for Koror - Airai water supply system. Since the actual daily maximum water production will decrease after the system improvements, the facilities' design for the beginning phase should be based on the current maximum production (4MG/day or 15,140m^3/d).

5. Current Conditions and Recommendation for Improvement on Water Supply Facilities

(1) Water Sources and Intake Facilities

The capacity of water sources is enough for 4MG/day (15,140m^3/d) of water supply. Additional / alternative water resources should be examined carefully, monitoring the demand / NRW reduction and observing the frequency of draughts. Construction of Airai well field is an option for the water resources development. Moreover, the Team recommends dredging Ngerimel Dam to increase the storage capacity since it is an option to minimize the cost for operation (energy).

Pumping equipment and emergency generator of Ngerikiil Intake Pump Station are old and deteriorated. It is recommended for PPUC to replace / repair it as usual maintenance works.

Table S-8 Demand Plan until 2020

Category	2013	2014	2015	2016	2017	2018	2019	2020
Population	**14,126**	**14,050**	**13,975**	**13,900**	**13,826**	**13,754**	**13,682**	**13,610**
Foreign visitors per day	1,151	1,233	1,319	1,413	1,512	1,619	1,733	1,856
Equivalent population	15,277	15,283	15,294	15,313	15,338	15,373	15,415	15,466
Domestic Consumption								
Unit consumption (G/capita/d)	68.0	68.0	68.0	68.0	68.0	68.0	68.0	68.0
Domestic consumption (MG/d)	0.96	0.96	0.95	0.95	0.94	0.94	0.93	0.93
Non-Domestic Consumption (Gov)								
Consumption (G/capita/d)	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09
Annual increase ratio		0%	0%	0%	0%	0%	0%	0%
Non-Domestic Consumption (Com)								
Flat rate consumption (MG/d)	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Annual increase ratio		3.4%	3.4%	3.4%	3.4%	3.4%	3.4%	3.4%
Metered consumption (MG/d)	0.85	0.88	0.91	0.94	0.97	1	1.03	1.07
Annual increase ratio		3.4%	3.4%	3.4%	3.4%	3.4%	3.4%	3.4%
Total Commercial consumption (MG/d)	0.86	0.89	0.92	0.95	0.98	1.01	1.04	1.08
Grand Total for Consumption (MG/d)	1.91	1.94	1.96	1.99	2.01	2.04	2.06	2.10
NRW								
NRW (MG/d)	1.78	1.79	1.81	1.70	1.64	1.42	1.21	0.99
NRW ratio %	48%	48%	48%	46%	**45%**	**41%**	**37%**	**32%**
Production (MG/d)	**3.69**	**3.73**	**3.77**	**3.69**	**3.65**	**3.46**	**3.27**	**3.09**
Reference								
Production (G/capita/d)	261	265	270	265	264	252	239	227
Production (G/equivalent population/d)	242	244	247	241	238	225	212	200

Source: JICA Survey Team

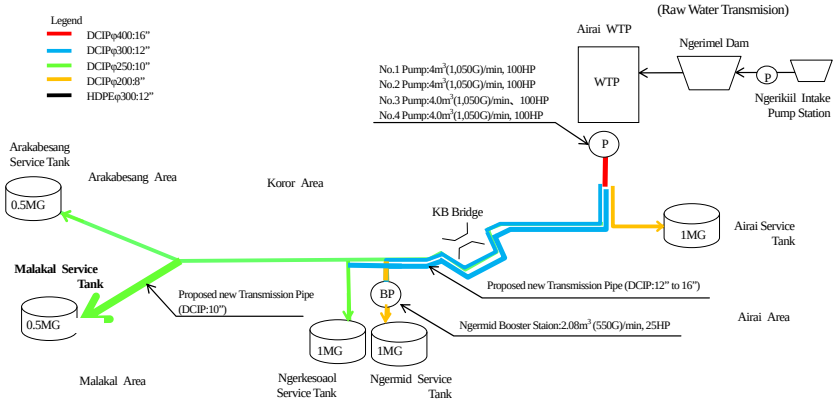
(2) Koror - Airai Water Treatment Plant (KAWTP)

The production capacity of Koror - Airai Water Treatment Plant (KAWTP) is 4MG/day (15,140m^3/d). Although some facilities, such as chemical injection devices and filters, are old and deteriorated, KAWTP secures the water quality at 2 - 3 NTU in turbidity. Accordingly, it is not urgently required for improvement / rehabilitation, but the rehabilitation should be undertaken in a middle term. The Team recommends the following for rehabilitation / improvement:

- Establishment Water Quality Management System (toward Water Safety Plan recommended by World Health Organization)
- Rehabilitation of Chemical Injection System
- Rehabilitation of Sand Filter
- Rehabilitation of Clear Water Well.
- Replacement of Raw Water Pumps and Installation of Flow Meters
- Improvement of Operation Procedures

(3) Water Transmission

The current water production reaches 4MG/d (15,140m^3/d). The exiting water transmission main was, however, designed for 2.1MG/d (7,949m^3/d). The current water flow exceeds the assured level by design. If no pipeline improvement is provided, much higher capacity is necessary for transmission pumps. To overcome the problem, the Team recommends laying additional pipeline for transmission up to Ngerkesewaol Service Tank as shown in Figure S-3. It is an urgent component to secure the stable water supply.



Source: JICA Survey Team

Figure S-3 Improvement for Koror and Airai Water Transmission System

(4) Water Distribution Zones

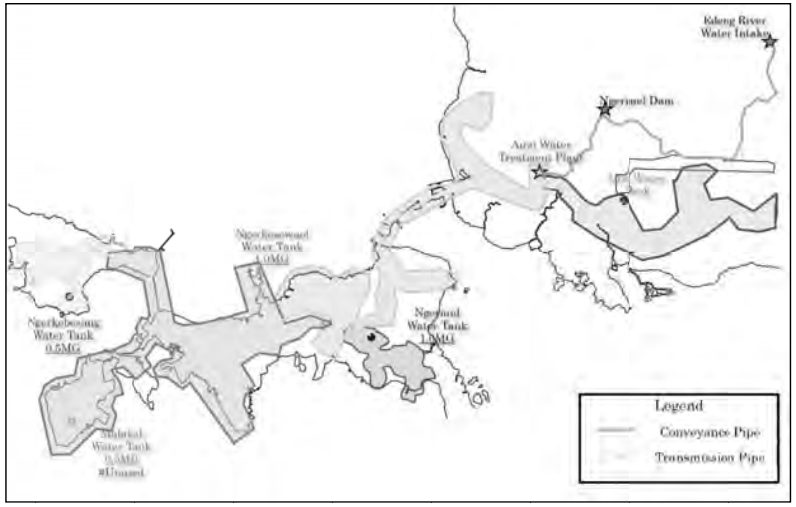
Current water distribution system is comprised of five water distribution zones, Airai, Ngermid, Ngerkesewaol, Arakabesang and direct distribution zone from KAWTP. Currently, water in Malakal zone is distributed through Ngerkesewaol Service Tank. Except for direct distribution zone from KAWTP, water is distributed by gravity. The amount of water is enough. However, there are some low pressure areas, such as Ngerbeched area, in Ngerkesewaol distribution zone and the water is not supplied to Malakal at the time of the accident for water transmission / distribution such as leakage. The current water distribution zones are shown in Figure S-4.

To eliminate low water pressure areas and to ensure stability of the water supply of Malakal area, it is urgently required to separate the Malakal area from Ngerkesewaol water distribution zone and re-arrange the covering areas of each zone as shown in Figure S-5. For this purpose, renewal of Malakal tank and an exclusive transmission main are necessary. Along the mentioned rehabilitation, district flow meters should be installed at tanks for distribution flow management.

(5) Replacement of Major Distribution Lines

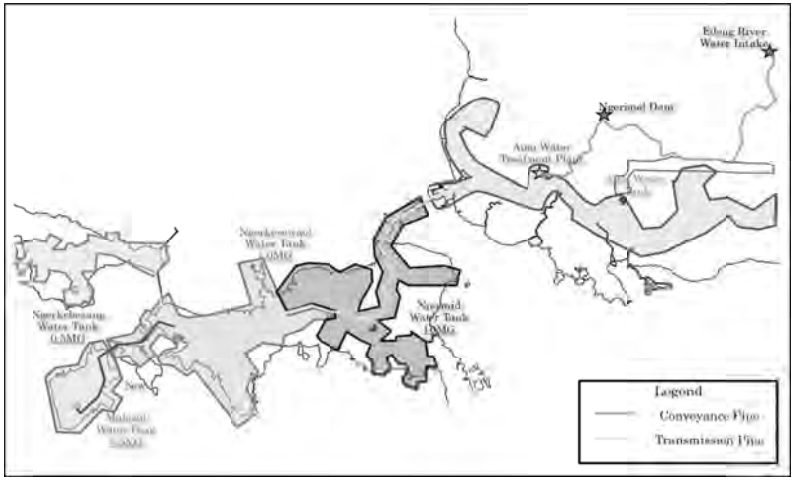
The Reduction of leakage is strongly required for PPUC to improve the business efficiency. The replacement of larger diameter AC pipes should be commenced immediately. Since it is difficult to replace all the pipelines at once, the works should be scheduled in short / medium terms. The works should include the replacement of lateral connection pipes.

As the urgent parts to be replaced, the Team recommends the routes shown in Figure S-6. Total length of the urgent routes is around 8.1 miles (13km).



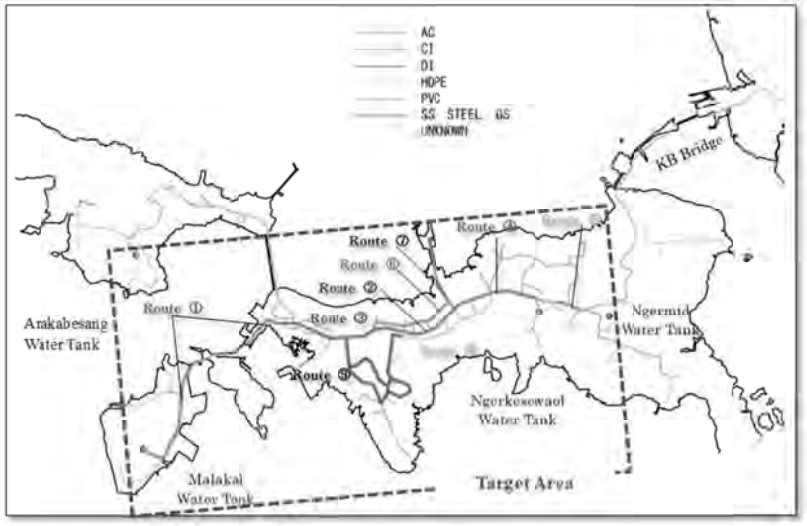
Source: JICA Survey Team, based on PPUC information

Figure S-4 Current Water Distribution Zones



Source: JICA Survey Team, based on PPUC information

Figure S-5 Proposed Water Distribution Zones



Source: JICA Survey Team

Figure S-6 Recommended Route for Urgent Replacement for Old Distribution Pipes

(6) Soft Approach

The following are recommended as soft approaches for capacity development:

- Management for Water Flow and Pressure
- Leak Detection
- Improvement of Water Quality Monitoring System
- Establishment of Well Management Section

6. Priority for Urgent Action Plans

Based on the previously mentioned recommendation, the Team recommends action plans as shown in Table S-9.

Table S-9 Priority for Urgent and Short / Medium Terms Action Plans

Priority	Plan	Note
Urgent Action Plans		
Priority-1	Meter Installation in Koror - Airai	Meter is the basic tool for management of water distribution. PPUC has been conducting this action since April 2014. It should be completed promptly.
Priority-2	Strengthening Transmission Main (additional transmission main)	The capacity of the existing transmission main has been insufficient. It is placed in a risky condition for the sudden stoppage of water transmission. This action should be conducted as soon as possible.
Priority-3	Modification of Distribution Zones (Re-arrangement of zones)	There are low pressure areas and a direct distribution zone where the flow / pressure control is difficult. Since such troubles appear on the network, this should be conducted as a higher component.
	Establishment of Malakal Zone and Transmission Main to Malakal Tank	Establishment of Malakal Distribution Zone is indispensable for the re-arrangement / modification of distribution zones for Koror - Airai. It should be a part of the action for modification of distribution zones.
	Management for Water Flow and Pressure (Soft Approach)	Along with the facilities construction / re-arrangement, management system should be established for management of water distribution and NRW, including data management for consumptions.
	Leak Detection (Soft Approach)	Staff members and equipment for leak detection are not enough for NRW management of the existing distribution networks. It is recommended to promote leak detection skills along with the improvement of water distribution management.
Priority-4	Replacement of Major Distribution Lines	To promote efficiency for water supply, the reduction of NRW / leakage is prioritized actions. As the first step, the major pipelines (8.1mi or 13km) are recommended to be replaced.
Short / Medium Terms Action Plans (5 - 10 years)		
Priority-5	Small Scale Water Supply Systems in Babeldaob	Since the issues are related to water quality, this is one of urgent actions. It is, however, not placed in urgent actions due to investment efficiency of the action. It is recommended commencing the action soon and complete within short term.
Priority-6	Painting the Existing Tanks	This action is not so difficult and costly. As one of periodical maintenances, it should be conducted promptly.
Priority-7	Rehabilitation of Koror - Airai Water Treatment Plant (KAWTP)	Including necessary land acquisition, a plan for rehabilitation should be formulated within a few years. After then, the rehabilitation works should be undertaken in short term.
	Improvement of Water Quality Monitoring System (Soft Approach)	Water quality monitoring system should be established, considering water safety plan. It includes skill trainings, equipment provision and formulation of a permanent team.
Priority-8	Improvement of Ngerikiil Intake Pump Station	As the exiting pumps and auxiliary equipment are deteriorated. A risk for sudden stoppage will be increased according to ages. It is recommended to conduct this action earlier in short term.
Priority-9	Improvement of Ngerimel Dam	As priority for water resources development is less, it should be managed within medium term. It is, however, recommended to be undertaken before development of Airal well field.
Priority-10	Establishment of Airai Well Field	It is less prioritized than the Improvement of Ngerimel Dam. Study for this component should be undertaken along with monitoring the NRW reduction.
	Establishment of Well Management Section (Soft Approach)	Once well field developed, a management section is necessary. Along with the facilities construction, PPUC should formulate a permanent team with enough technical trainings and equipment.
Priority-7	Replacement of Remained AC Pipelines (Continue after the project mentioned in the priority-3)	The major AC pipes are planned to be replaced within 6 years (8 years if adding preparation period). It should be managed within short / medium terms.

Source: JICA Survey Team

7. Development Framework for Sewerage

The basic assessment of the sewerage system described in Chapter 4 of the Sector Development Framework was compiled based on the information collected by the field survey conducted from June 23 to July 18 2014 by Ms. Hiroko KAMATA, Senior Advisor to JICA and the comments to the draft from PPUC and ADB received in October 2014. The response to the comments from PPUC and ADB were attached as the Appendix to the Sector Development Framework.

Developments since last October are not incorporated in this chapter, and the views expressed in this chapter are those of the author and do not necessarily represent the official positions of JICA. This chapter is expected to be used as a reference for PPUC for further development of sewerage sector in Palau.

Contents

Page

CHAPTER 1 Introduction 1

CHAPTER 2 Background of Sector Development 3

2.1 Population and Socio-Economic Conditions Rerated to Water Supply and Sewerage Plans 3

2.1.1 Population 3

2.1.2 Number of Foreign Visitors 5

2.1.3 Economic Development 7

2.2 Climate Conditions 8

2.3 Geological Conditions. 10

2.4 Existing Development Plan. 11

2.4.1 National Master Development Plan (The Foundation for Development), 1995 11

2.4.2 Actions for Palau's Future: The Medium-Term Development Strategy 2009-2014 12

2.4.3 The Babeldaob Water Supply Project 2009 12

2.5 Activities of Development Partners 13

2.5.1 Asian Development Bank 13

2.5.2 Other Development Partners 14

2.6 Organization and Financial Conditions for Water Supply and Sewerage Sector 15

2.6.1 Organization 15

2.6.2 Financial Condition 18

2.7 Evaluation and Effects of the Previous Japan's Grant Aid Project 20

2.7.1 Situations and Results of the Previous Project 20

2.7.2 Evaluation and Lessons from the Previous Project 24

CHAPTER 3 Development Framework for Water Supply 25

3.1 Water Demand and Current Conditions for Water Supply 25

3.1.1 Current Volume of Water Supply and Consumption 25

3.1.2 Demand Forecast 29

3.1.3 Conditions and Issues on Water Sources 39

3.1.4 Conditions and Issues on Koror-Airai Water Treatment Plant 43

3.1.5 Conditions and Issues on Water Transmission and Distribution Reservoirs 53

3.1.6 Conditions and Issues of Water Distribution Networks 57

3.1.7 Conditions and Issues of Small Scale Water Supply Systems in Babeldaob 62

3.1.8 Other Relevant Issues for Water Supply 63

3.1.9 Summary of Capacity Assessment 64

3.2 Short and Medium Terms Target for Water Supply Development 66

3.2.1 Water Demand 66

3.2.2 Capacity of Water Source 67

3.2.3 Reduction of NRW 67

3.2.4 Stable Water Transmission and Distribution 67

3.2.5 Assurance for Water Quality 68

3.3 Recommendation for Urgent Action Plan 68

3.3.1 Meter Installation 68

3.3.2 Strengthening Transmission Main 69

3.3.3 Modification of Distribution Zones 70

3.3.4 Establishment of Malakal Zone and Transmission Main to Malakal Tank 70

3.3.5 Replacement of Major Distribution Lines 74

3.3.6 Soft Approach 75

3.3.7 Priority for Urgent Action Plans 75

3.4 Recommendation for Short / Medium Action Plan 76

3.4.1 Rehabilitation of Koror-Airai Water Treatment Plant (KAWTP) 76

3.4.2 Improvement of Ngerimel Dam 78

3.4.3 Improvement of Ngerikiil Intake Pump Station 79

3.4.4 Establishment of Airai Well Field 80

3.4.5 Painting the Existing Tanks 84

3.4.6 Improvement of Small Scale Water Supply System in Babeldaob 84

3.4.7 Replacement of Remained AC Pipeline 85

3.4.8 Soft Approach 85

3.4.9 Priority for Short / Medium Terms Action Plans 86

CHAPTER 4 Development Framework for Water Supply

4.1 Introduction 87

4.2 Organization 87

4.2.1 Environmental Quality Protection Board (EQPB) 87

4.2.2 Palau Public Utilities Cooperation 88

4.2.3 Ministry of Health 91
4.2.4 Koror State Government, State & Culture Department, Sanitation Department 93
4.3 Strategy for Sewerage Development 95
4.3.1 Government Policy and Strategy 95
4.3.2 Asian Development Bank 95
4.4 Water Quality Regulation 96
4.4.1 Marine and Freshwater Quality Standard 96
4.4.2 Monitoring Result by EQPB 99
4.4.3 Permission in Malakal STP 101
4.4.4 Permission in Melekeok STP 103
4.5 Current Sanitation System in Palau 103
4.5.1 Outline of Sanitary Situation 103
4.5.2 Outline of Sewerage System 104
4.5.3 Koror-Malakal Sewerage System 104
4.5.4 Melekeok Sewerage System 116
4.5.5 Septic Tank 118
4.6 On-going Project in the Sewerage Sector 120
4.6.1 Koror Sewer System Upgrade Project Phase IV 120
4.6.2 Koror-Airai Sanitation Project (KASP) 122
4.6.3 Procurement of Plant - Design, Supply and Installation of the Malakal Sewerage System (Single-Stage: One-Envelope) 136
4.6.4 PIA Consultants 137
4.6.5 Issues to be considered based on MP and FS prepared GHD 139
4.7 Action Plan 141
4.7.1 Urgent Action Plan 141
4.7.2 Short/Medium Action Plan 141
4.8 Activity for Improving the Sewerage System in Palau 145
4.8.1 Dispatch of Senior Volunteer to PPUC 145
4.8.2 Revise of the Septic Tank Standard to EQPB 145
4.8.3 Country Based Training “Capacity Enhancement for Water Sanitation Management” 147
4.8.4 Dispatch of Senior Volunteer to DEH, MOH 148

Appendix 1: Comments on JICA Sector Development Framework October 2014-11-10
Appendix 2: PALAU –WATER SECTOR ASSESSMENT- CHAPTER 4
Appendix 3: Results of Capacity Assessment

ABBREVIATIONS

[Organizations]

ADB	Asian Development Bank
BBP	Bureau of Budget & Planning, Ministry of Finance
BPW	Bureau of Public Works
CIP	Capital Improvement Program
DEH	Division of Environmental Health
EQPB	Environmental Quality Pollution Board
EU	European Union
FEIM	Facility for Economic and Infrastructure Management
GoJ	Government of Japan
GoP	Government of Republic of Palau
JICA	Japan International Cooperation Agency
MOH	Ministry of Heath
MPIIC	Ministry of Public Infrastructure, Industries and Commerce
MRD	Ministry of Resources and Development
NCDC	National Climatic Data Center
NOAA	National Oceanic and Atmospheric Administration
ODA	Official Development Assistance
PIF	Pacific Islands Forum
PPUC	Palau Public Utilities Corporation
PVA	Palau Visitors Authority
PWSC	Palau Water and Sewer Corporation
UNDP	United Nations Development Programme
WHO	World Health Organization
WWO	Water and Wastewater Operation

[General]

AC	Asbestos Cement
ADWF	Average Dry Weather Flow
alum-sulphate	aluminum sulphate
As	Arsenic
CAPP	Community Action and Participation program
CCF	Climate Change Fund
CCTV	closed-circuit television
CDC	Center for Disease Control and Prevention
COBP	Country Operations Business Plan
C/P	Counter Part
CPS	Country Partnership Strategy
DCIP	Ductile Cast Iron pipe
DN	Diameter Nominal
DO	Dissolved Oxygen
E-coli	Escherichia coli
EP	Equivalent Person
ESP	Economic Stimulus Package
Fe	Iron
fl	fluorine
FS	Feasibility Study
FY	Fiscal Year (1st October -30th September)
GDP	Gross Domestic Product
GPS	Global Positioning System
GS	Galvanized Steel
HDPE	High Density Polyethylene
ICB	International Competitive Bidding
IDEA	Intermittent Decant & Extended Aeration
IEE	Initial Environmental Examination
IPS	Intake Pump Station
KASP	Koror-Airai Sanitation Project
KAWTP	Koror-Airai Water Treatment Plant
KB	Koror-Babeldaob
LCB	Local Competitive Bidding
MBR	Membrane Bio Reactor
MTDS	Medium Term Development Strategy
Mn	Manganese
MPN	Most Probable Number
NRW	Non-Revenue Water
ODA	Official Development Aid
O&M	Operation and Maintenance
P	Pump
P/S	Pump Station
PALARIS	Palau Automated Land and Resource Information System
PDWF	Peak Dry Weather Flow

pH	Ph value
PIA	Project Implementation Assistance
PMU	Project Management Unit
PPTA	Project preparatory Technical Assistance
PSC	Proposal Selection Committee
PVC	Polyvinyl Chloride
SBR	Sequencing Batch Reactor
SCADA	Supervisory Control And Data Acquisition
SID	Support Impact Doable
SP	Steel Pipe
SS	Structural rolled Steel
STP	Sewage Treatment Plant
SV	Senior Volunteer
TC	Technical Cooperation
TF	Trickling Filter
TKN	Total Kjeldahl Nitrogen
TSS	Total Suspended Solid
USD	United States Dollar
UV	Ultra Violet
VLGF	Valve Less Gravity Filter
WTP	Water Treatment Plant

[Unit]

#	Number
%	Percentage
cm	Centimeter
dia	diameter
Dep	Depth
ft	feet
G	Gallon
H	Height
h	hour
HDPE	High Density Polyethylene
HP	Horse Power
km	Kilometer
km^2	Square Kilometer
L	Liter
m	Meter
m^2	Square meter
m^3	Cubic meter
MG	Million Gallons
mg	milligram.
MGD	Million Gallons per Day
min	minute
MLD	Million Litter per Day
mm	millimeter
NTU	Nephelometric Turbidity Unit
ppm	parts per million
PSI	Pound-force per Square Inch

CHAPTER 1 Introduction

(1) Background

In July 2013, the Government of Republic of Palau (GoP) made a request for Grant Aid for the Water Supply System Improvement Project (the Project) to the Government of Japan (GoJ). The Japan International Cooperation Agency (JICA), the official agency implementing technical cooperation, ODA loans and Grant Aid, decided to conduct a Preparatory Survey to examine the viability of the Project and sent the Survey team (the Team) headed by Ms. Eriko TAMURA, Director of Water Resources Management Team 1 in Global Environment Department of JICA.

The requested Project is to improve water supply conditions for Koror and Airai, which are centers for the Palauan economy, through development of alternative water sources, re-arrangement of water distribution zones and replacement of old asbestos cement (AC) pipelines. The Team commenced the survey on the requested Project in June 2014 for a survey area consisting of Koror, Airai and other related states in Babeldaob island.

The 1st field survey was conducted from June 22 to August 5, 2014. The Team compiles all results of the 1st survey in this report and shares the information among concerned parties from both Palauan and Japanese sides. The Team expresses, herewith, its appreciation to all Palauan stakeholders of the Project and expects that this report be useful for further planning works for activities and inputs for water supply and sewerage improvement.

This report is not to show the plans of the Japan's Grant Aid. The report contains the following points which are basic findings of the Team and recommendation for necessary inputs to be undertaken by the Palauan side and /or to be selected as components for the Japan's Grant Aid:

1) Background of sector development as well as water demand and natural conditions.
2) Existing conditions and development framework for near future.
3) Recommendation for urgent, short / medium term plans.

(2) Outlines of Water Supply for Koror - Airai

Water supply is managed by Palau Public Utilities Corporation (PPUC). It is a public corporation and responsible for water supply, wastewater service and electricity distribution in Palau. Table 1.1-1 shows the outlines of water supply for Koror - Airai. PPUC supplies the water currently for 14,126 persons (estimated for 2013) at 261G/capita/d (including non-domestic consumption). PPUC has good performances for water supply coverage and distribution volume, while many facilities are old and deteriorated. Old and deteriorated facilities may cause the large volume of NRW. This large volume of non-revenue water (NRW) is a remarkable issue for PPUC.

The Preparatory Survey on Water Supply System Improvement Project in the Republic of Palau Sector Development Framework

Table 1.1-1 Outlines of Water Supply for Koror - Airai

Item	Scale / Performance	Remark
Max Daily Production	4.03 MG/d	Max in 2009 - 2013
Ave Daily Production	3.69 MG/d	2013
Ave Daily Billed Water	1.91 MG/d	Including 17% of estimated volume for flat rate customers.
- Domestic	0.96 MG/d	
- Non-Domestic	0.95 MG/d	
Non-Revenue Water: NRW	1.78 MG/d	
NRW Ratio	48%	
No of Connection	3,710 connections	Effective:3,341（Domestic:2,499, Non-Domestic:842）
Metered Ratio	90%	
Service Population	14,126 persons	
Service Coverage	100%	
Unit Water Consumption	572G/connect/d	Average for total
Domestic	386G/connect/d	
Domestic	68G/capita/d	
Non-Domestic	1,128G/connect/d	
Service Hours	24 hours	
Number of Employees	51 persons	Excluding staffs for sewer and outlaying states
- per 1000 connections	13.7 persons	
Ratio of Cost Recovery	38%	Whole PPUC

Source: JICA Survey Team based on PPUC's data

CHAPTER 2 Background of Sector Development

2.1 Population and Socio-Economic Conditions Rerated to Water Supply and Sewerage Plans

2.1.1 Population

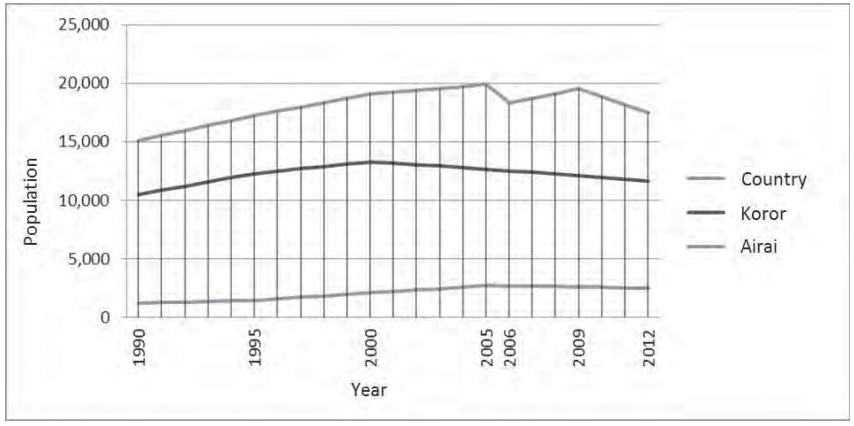
(1) Trend of Population Increase / Decrease

According to the Bureau of Budget & Planning, Ministry of Finance, the population of Palau is decreasing from 2005, and in Koror from 2000, as shown in Table 2.1-1 and Figure 2.1-1. Effective measures have not been taken against the population decrease. It is, therefore, forecast that the population decrease will continue for a several years.

Table 2.1-1 Trend of Population Increase / Decrease

Area	1990	1995	2000	2005	2006	2009	2012	Increase Ratio
Population: Whole Country	15,122	17,225	19,129	19,907	18,324	19,535	17,501	-1.7%
Population: Koror	10,501	12,299	13,303	12,676	N/A	N/A	11,665	-1.1%
Population: Airai	1,234	1,481	2,104	2,723	N/A	N/A	2,537	-1.0%

"Increase Ratio" shows ones between 2005 and 2012.
Populations per State are not available in Statistical Yearbook 2013 for 2006 and 2009.
Data Source: Statistical Yearbook 2013 and 2005 Census Monograph



Source: JICA Survey Team, based on Statistical Yearbook 2013 and 2005 Census Monograph

Figure 2.1-1 Tendency of Population Increase / Decrease

(2) Population Forecast for Koror and Airai

GoP has no officially authorized forecasts of the future population. The forecast will be conducted by the next census which GoP is planning to conduct in 2015. The Team, therefore, estimates the future population as follows:

1) High Scenario

The Team assumed, as the high scenario, that the population will remain unchanged until 2020. It was assumed that effective solutions will be taken by GoP in the near future against the population decrease. The population forecast is shown in Table 2.1-2.

Table 2.1-2 Population Forecast (High Scenario)

Area	2012	2013	2014	2015	2016	2017	2018	2019	2020
Population: Koror	11,665	11,665	11,665	11,665	11,665	11,665	11,665	11,665	11,665
Population: Airai	2,537	2,537	2,537	2,537	2,537	2,537	2,537	2,537	2,537
Total	14,202	14,202	14,202	14,202	14,202	14,202	14,202	14,202	14,202

Data Source: JICA Survey Team, based on Statistical Yearbook 2013

2) Low Scenario

The low scenario was calculated by the population increase ratio between 2005 and 2012, which shows the decreasing tendency. It was assumed that no solution is taken by GoP for the population decrease. Utilizing the population increase ratio of -1.1% and -1.0% for Koror and Airai respectively, the Team calculated the population as shown in Table 2.1-3.

Table 2.1-3 Population Forecast (Low Scenario)

Area	2012	2013	2014	2015	2016	2017	2018	2019	2020
Population: Koror	11,665	11,537	11,410	11,284	11,160	11,037	10,916	10,796	10,677
Population: Airai	2,537	2,512	2,487	2,462	2,437	2,413	2,389	2,365	2,341
Total	14,202	14,049	13,897	13,746	13,597	13,450	13,305	13,161	13,018

Data Source: JICA Survey Team, based on Statistical Yearbook 2013

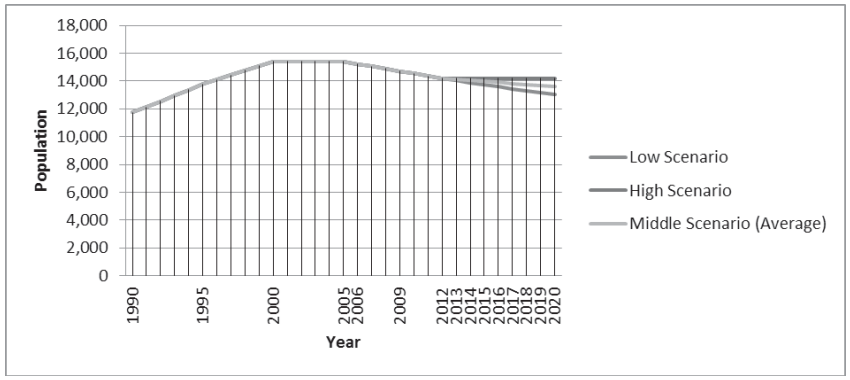
3) Preliminary Result of Planed Population

The above two estimations shows the high and low scenarios of the population growth. However, assuming some countermeasures are taken by GoP against the population decrease, the Team selected the average value of the two scenarios as the population forecast to be used in the Project design.

Table 2.1-4 Population Forecast (Middle Scenario: Planned Population)

Area	2012	2013	2014	2015	2016	2017	2018	2019	2020
Population: Koror	11,665	11,601	11,538	11,475	11,413	11,351	11,291	11,231	11,171
Population: Airai	2,537	2,525	2,512	2,500	2,487	2,475	2,463	2,451	2,439
Total	14,202	14,126	14,050	13,975	13,900	13,826	13,754	13,682	13,610

Source: JICA Survey Team, based on Statistical Yearbook 2013



Source: JICA Survey Team, based on Statistical Yearbook 2013 and 2005 Census Monograph

Figure 2.1-2 Comparison of Population Forecast

2.1.2 Number of Foreign Visitors

(1) Increasing Trend of Foreign Visitors

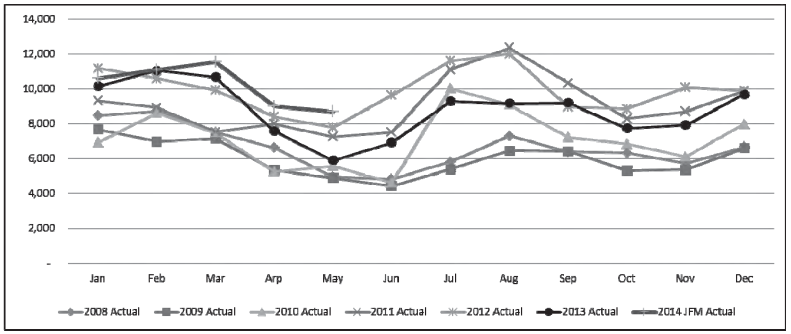
Palau receives more than 100 thousand of foreign visitors per year against its population which is less than 20 thousand. An international airport for Palau is located in Airai. Koror is a base for business and tourism for foreign visitors and 93% of rooms for accommodation facilities, such as hotels, are concentrated in Koror. Therefore, the number of foreign visitors is indispensable to estimate socio-economic activities as well as water demand for Koror - Airai water supply system.

The Palau Visitors Authority (PVA) reported an increasing trend of the foreign visitors as shown in Table 2.1-5 and Figure 2.1-3. In general, the 1st and 2nd peaks are recorded in July - August and January - February. The 2011 – 2013 data shows that visitors in the peak season are 1.27 times of the average number of visitors.

Table 2.1-5 Trend of Foreign Visitors

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
2008	8,467	8,726	7,500	6,623	4,945	4,817	5,801	7,281	6,389	6,327	5,719	6,664	79,259
2009	7,656	6,964	7,148	5,329	4,878	4,428	5,385	6,456	6,411	5,300	5,345	6,587	71,887
2010	6,909	8,630	7,463	5,233	5,568	4,610	10,008	9,078	7,203	6,833	6,096	7,962	85,593
2011	9,308	8,905	7,515	7,979	7,240	7,489	11,091	12,335	10,327	8,286	8,693	9,889	109,057
2012	11,161	10,577	9,909	8,402	7,770	9,627	11,591	12,002	8,949	8,829	10,075	9,862	118,754
2013	10,141	11,030	10,657	7,558	5,879	6,909	9,264	9,140	9,173	7,722	7,909	9,679	105,061
2014	10,597	11,073	11,528	8,975	8,691								50,864

Data Source: Palau Visitor Authority



Source: Palau Visitors Authority

Figure 2.1-3 Trend of Foreign Visitors

Although GoP has no officially authorized forecasts of foreign visitors, PVA has its own estimate of visitors for the coming two years (for 2014 and 2015). The PVA estimate shows an increasing trend of the number of foreign visitors.

Table 2.1-6 Forecast of Foreign Visitors (PVA)

Year	Jan	Feb	Mar	Arp	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
2014	10,597	11,073	11,528	8,975	8,691	8,007	11,058	10,501	9,541	8,118	9,080	10,123	117,292
2015	11,407	11,861	11,895	9,255	7,520	9,348	12,759	12,106	10,674	9,090	10,301	11,318	132,616

Data Source: Palau Visitors Authority (but adjusted by the Team for 2014)

(2) Forecast of Foreign Visitors

Number of foreign visitors is a significant parameter to estimate the socio-economic scale of Koror - Airai. The increasing number of foreign visitors should be considered in the water demand forecast. According to PVA, average period of stays of the foreign visitors is approximately 4 days per person. 118,754 persons, which are 2012 visitors and the highest record of foreign visitors, are converted into approximately 1,301 persons per day. It is more than 10% of the population of Koror. The number of foreign visitors is forecasted at 169,351 in 2020 as shown in Table 2.1.7 and Figure 2.1.4. The Team took the following into account in the forecasting:

1) Since the Japan's Grant Aid is extended for urgent issues, the Team forecasts the water demand until 2020. In order to forecast the number of foreign visitors for the coming 5 - 6 years, a short-term history of trend for around 5 years is appropriate. The sharp increase for 3 years between 2010 and 2013 and the moderate one for 5 years between 2008 and 2013 on the number of foreign visitors should be taken into consideration.

2) Increase ratio for the 3 years between 2010 and 2013, which is 7.6% per year, is applied for estimation of high scenario.

3) Increase ratio for the 5 years between 2008 and 2013, which is 6.5% per year, is applied for estimation of low scenario.

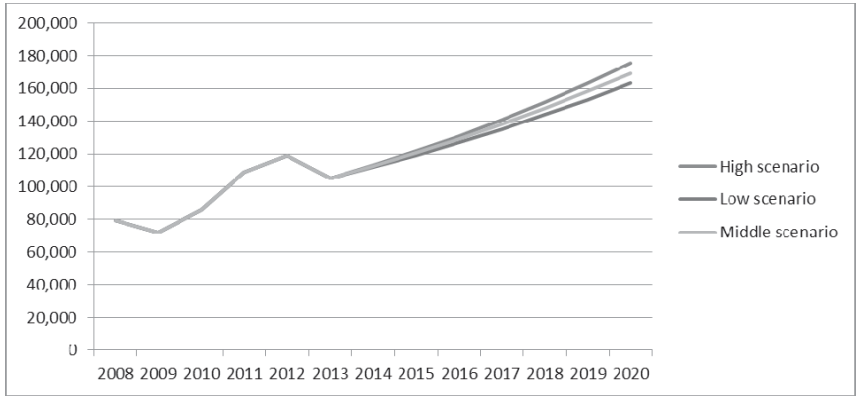
4) The averages of the above figures (middle scenario) are preliminary applied for the Project as the forecast of foreign visitors.

Assuming the average staying period of foreign visitors at 4 days, 169,351 persons per year are converted to 1,856 persons per day.

Table 2.1-7 Forecast of Foreign Visitors for the Project

Category	2008	2009	2010	2011	2012	2013	2014
High scenario	79,259	71,887	85,593	109,057	118,754	105,061	113,046
Low scenario	79,259	71,887	85,593	109,057	118,754	105,061	111,890
Middle scenario	79,259	71,887	85,593	109,057	118,754	105,061	112,468
Category	2015	2016	2017	2018	2019	2020	
High scenario	121,637	130,881	140,828	151,531	163,047	175,439	
Low scenario	119,163	126,909	135,158	143,943	153,299	163,263	
Middle scenario	120,400	128,895	137,993	147,737	158,173	169,351	

Data Source: Palau Visitors Authority until 2013



Source: JICA Survey Team, based on Palau Visitors Authority Data until 2013

Figure 2.1-4 Forecast of Foreign Visitors

2.1.3 Economic Development

Non-Domestic Consumption depends on socio-economical activities and scale. Table 2.1-8 shows the recent trend of Gross Domestic Product (GDP) by industry. The total scale of GDP is in increasing trend for the recent five years. It is clear that "transportation and storage" and "accommodation and food service" industries, which reflect the scale of foreign visitors, are increasing, and they contribute to the GDP development as shown in Table 2.1-9. They also account for 26% of total GDP.

The "public administration" is in flat trend for the five years.

The mentioned GDP trend should be reflected in the demand forecast.

Table 2.1-8 GDP by Industry

Industry	Constant Prices of FY2005, in US$ millions						
	FY07	FY08	FY09	FY10	FY11	FY12	FY13
Agriculture and forestry	2.6	2.7	2.5	2.4	2.3	2.3	2.2
Fishing	7.5	7.0	5.7	5.4	5.4	5.5	5.5
Mining and quarrying	1.5	1.5	1.1	0.8	0.8	0.9	0.6
Manufacturing	1.4	1.6	1.4	1.3	1.5	1.7	1.9
Electricity, gas, steam and air conditioning supply	0.7	0.7	0.8	0.8	0.9	0.8	0.8
Water supply; sewerage, waste management and remediation activities	1.2	1.2	1.2	1.1	1.0	1.0	1.1
Construction	20.8	14.9	9.6	10.5	11.4	10.2	7.5
Wholesale and retail trade; repair of motor vehicles and motorcycles	28.7	26.8	21.8	23.1	24.4	26.0	28.5
Transportation and storage	9.5	8.3	7.7	8.5	10.1	11.4	10.8
Accommodation and food service activities	26.8	24.7	22.4	25.6	29.4	35.3	35.1
Information and communication	8.8	7.5	7.2	6.8	6.9	7.6	7.7
Financial Intermediation	9.0	7.9	7.7	7.7	8.3	9.5	9.5
Real estate activities	16.1	16.9	16.7	16.1	16.5	16.0	16.3
Professional, scientific and technical activities	2.4	2.0	1.7	2.0	1.7	1.5	1.6
Administrative and support service activities	2.3	2.0	1.7	2.0	2.2	2.4	2.5
Public Administration	29.0	28.8	28.5	28.4	27.6	27.5	27.9
Education	9.2	9.0	8.9	8.9	8.7	8.4	8.0
Human health and social work activities	6.0	5.9	5.6	5.9	6.0	6.1	6.6
Arts, entertainment and recreation	1.6	1.4	1.4	1.6	1.9	2.2	1.9
Other service activities	2.2	1.8	1.7	1.7	1.8	1.9	1.8
Private Households With Employed Persons	3.9	3.6	3.4	3.3	3.0	2.6	2.3
less intermediate FISIM	-2.8	-2.5	-2.6	-2.8	-2.8	-2.7	-2.7
GDP at basic prices	**183.7**	**173.9**	**156.2**	**160.9**	**168.9**	**178.0**	**177.3**
Taxes on products	23.6	22.0	16.8	19.6	21.4	23.1	23.1
less subsidies	-0.4	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5
GDP at purchasers prices	**206.9**	**195.4**	**174.4**	**180.2**	**189.8**	**200.6**	**199.9**

Source: 2013 Statistical Yearbook, Bureau of Budget & Planning, Ministry of Finance

Table 2.1-9 Increase / Decrease of GDP

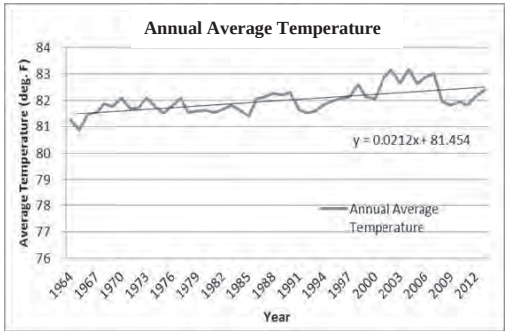
Category	2009	2010	2011	2012	2013
Total GDP (Million USD)	156.2	160.9	168.9	178.0	177.3
Increase from previous year		4.7	8.0	9.1	-0.7
Activities related to Foreign Visitors					
Accommodation & food service	22.4	25.6	29.4	35.3	35.1
Transport and storage	7.7	8.5	10.1	11.4	10.8
Sub-Total	30.1	34.1	39.5	46.7	45.9
Increase from previous year		4.0	5.4	7.2	-0.8
Public Administration	28.5	28.4	27.6	27.5	27.9
Increase from previous year		-0.1	-0.8	-0.1	0.4

Source: 2013 Statistical Yearbook, Bureau of Budget & Planning, Ministry of Finance

2.2 Climate Conditions

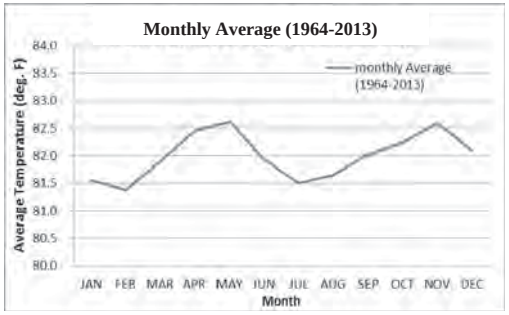
Palau is located in a region of tropical climate. The average daily temperature is 82.0ºF (27.8°C). The fluctuation of the temperature by season is relatively small (1.2ºF or 0.7°C). The annual average temperature has increased at a rate of 0.21 ºF (0.11°C) per decade since 1964 (Figure 2.2-1 and 2.2-2).

Rainfall is heavy throughout the year, and the annual average is 147 inches (3,734 mm). More than about 8 inches (200 mm) rainfall is recorded every month. The maximum rainfall is recorded in July, the least in March (Figure 2.2-3, 2.2-4).



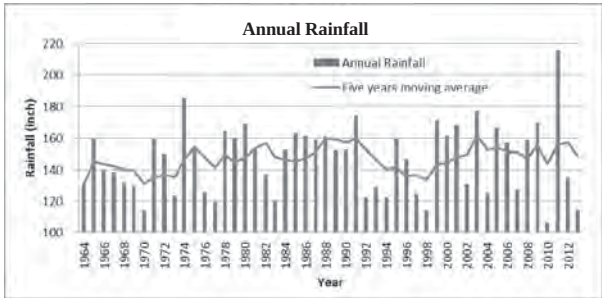
Source: NOAA's National Climatic Data Center (NCDC)

Figure 2.2-1 Annual Average Temperature



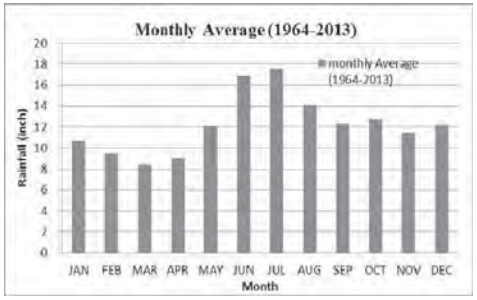
Source: NOAA's National Climatic Data Center (NCDC)

Figure 2.2-2 Monthly Average Temperature



Source: NOAA's National Climatic Data Center (NCDC)

Figure 2.2-3 Annual Average Rainfall



Source: NOAA's National Climatic Data Center (NCDC)

Figure 2.2-4 Monthly Average Rainfall

2.3 Geological Conditions

(1) General Geology

The geology of Palau consists of mainly volcanic rocks and limestone as shown in Table 2.3-1. Volcanic rocks are classified into basalt, andesite and dacite, which erupted on the bottom of the sea. Subsequently the volcanic rocks were lifted up above the sea to form the basement of the islands. On the other hand, the limestone was originally deposited covering the volcanic rocks on the bottom of the sea. Subsequently the limestone was lifted up above the sea to form the small islands that are currently called as Rock Islands. Rock Islands show characteristic Karst topography with several sinkholes.

Table 2.3-1 Geology of Palau

Age	Formation		Lithology	
Holocene	Palau limestone	Alluvium beach deposit	Limestone	Sand, silt, clay
Pleistocene		Terrace gravels		Sand and gravel
Pliocene		Airai Clay		Shale and shaley siltstone and pebble conglomerate
Oligocene	Ngeremlengui		Andesitic and dacitic volcanic breccia with tuff, flow conglomerate	
Eocene	Aimeliik Formation		Basaltic andesite volcanic breccia, tuff breccia and tuff	
	Babledaob Formation		Basalt and basaltic andesite flow a and flow breccia's	

Source: "History and Geology of Palau Islands" (1990)

Coastal terraces were well developed in the Survey area. There are 5 coastal plains recognized in Babeledaob Island as summarized in Table 2.3-2.

Table 2.3-2 Classification of Coastal Terrace Plain

Plain classification	Altitude	Condition of the Terrace plain
1st plain	240m above sea level	Peneplain
2nd plain	100m above sea level	Erosional plain
3rd plain	40m above sea level	Deposited plain
4th plain	20m above sea level	Deposited plain
5th plain	2m above sea level	Current alluvial plain

Source: "Topography, Geology, and coral reef of Palau Islands" (1935)

(2) Hydrogeology

There are relatively many areas with flat plains and gentle slopes in Babeldaob, Koror, Arakabesang and Malakal islands, where people can reside. Basaltic tuff breccia is distributed in those islands. On the other hand, steep slopes face the sea directly in the other islands called as Rock Islands, where people cannot reside. Limestone is distributed in those islands. The characteristics of the aquifer in the survey area are shown in Table 2.3-3. Airai area of Babeldaob Island is proposed as a candidate for groundwater development of this survey considering both aquifer capacity and accumulation of the existing data on groundwater.

Table 2.3-3 Aquifer Distribution

Aquifer geology	Distribution area	Aquifer characteristics
Andesitic tuff breccia	Babeldaob Koror, Arakabesang, Malakal	Aquifer consists of weathered parts of tuff breccia. It seems that sea water intrudes into aquifer, though the toe of the interface between fresh and salt water has not yet reached the inland area. Groundwater development is more suitable for larger islands.
Limestone	Rock Islands	Limestone is originated from the coral reef with extreme high permeability. Groundwater is distributed as fresh water lens beneath the entire islands. It is expected that sea water will easily intrude into boreholes by pumping. Rock Islands show too steep slopes to set borehole drilling machines within islands. Therefore, groundwater development is not possible in the Rock islands.

Source: “History and Geology of Palau Islands" (1990) but arranged by JICA Survey Team

AP-6-19

2.4 Existing Development Plan

2.4.1 National Master Development Plan (The Foundation for Development), 1995

GoP prepared “National Master Development Plan” in 1995 under joint finance of United Nations for Development Programme (UNDP) and the United States of America (USA). The plan points out the following as issues:

(1) Current Situation of Water Supply Systems in Republic of Palau (RoP)

The Koror-Airai water supply system is the largest public water supply system in RoP, and the raw water from Edeng River and Ngirimel dam is fed to Koror-Airai Water Treatment plant (KAWTP). The small-scale water supply systems located throughout Babeldaob derived their water supply from dammed streams.

(2) Issues of Water Supply Systems and Project Plan

As for Koror Airai water supply system, the yield of the catchment areas is substantially in excess of the current and future demands for the growth of population and tourism. The availability became, however, only 0.8MG/day in the drought of 1983. Water supply shortage occurred at that time.

In 1993, the average daily water production from KAWTP was 3.7MG/day. However, the Bureau of Public Works (BPW) can only account for 1.6MG/day. Only 80% of consumers were metered. And it is estimated that system leaks, unmetered consumers and operator errors may cause the loss of 2MG/day. If the drought conditions such as that experienced in 1983 occur in the future, the

system will be incapable of meeting the present demand, particularly with system losses being at such high level. As countermeasures for the mentioned problems, the following projects are programed for improvement of system losses and shortage of water supply:

1) Hydraulic Analysis and Leak Detection Survey Undertaken

A hydraulic analysis and leak detection survey should be conducted on the Koror-Airai water system to account for production losses of the KAWTP.

2) Water Meters Installed

Five hundred new and replacement water meters should be purchased and installed at consumers facilities in the Koror-Airai area.

3) Additional Water Source for Koror-Airai Identified

Additional water sources for the Koror-Airai water system should be identified.

There are a number of technical problems with the current RoP water systems. As for Koror-Airai water system, during the power outage, the water supply ceases due to the lack of standby electric power generators at both the Ngirikiil pump station and at the KAWTP. Besides, a considerable amount of treated water is wasted at KAWTP due to the low holding capacity of the existing clear water well. Therefore, a new 100,000 gallon clear water well is needed at the KAWTP not only to prevent the waste of treated water, but also to allow the existing clear water well to be emptied for maintenance and repair without having to shut down the KAWTP operation.

2.4.2 Actions for Palau’s Future: The Medium-Term Development Strategy 2009-2014

The action plan for 2009 - 2014 was prepared under assistance of Asian Development Bank (ADB). It points out a cost recovery problem as follows:

The water supply systems, including treatment works, have been improving. However, the operations are still inefficient. The revenue from water charges is less than 50 percent of the operating budget, so there is a need for a substantial government subsidy. Moreover, unmetered usage continues in many areas should be metered.

2.4.3 The Babeldaob Water Supply Project 2009

In 2007, GoP requested technical assistance from ADB to prepare a project to develop water supply and sanitation systems on the island of Babeldaob. As a result, a project preparatory technical assistance (PPTA) was prepared to develop a water supply sector development plan for the island of Babeldaob and Koror State and carry out feasibility studies to improve the security of the treated water supplies to communities on Babaldaob and within the State of Koror and to enable the expansion of the Koror-Airai water supply network to the State of Aimelik. The PPTA proposed various projects as shown in Table 2.4-1.

The proposed projects, however, are not realized completely. Most components for infrastructure construction / rehabilitation are not implemented due to shortage of budget. The study results are currently utilized as a guideline for the development of water supply business / facilities.

Table 2.4-1 Component and Budget of the Babeldaob Water Supply Project 2009

No	Component	Contents	Budget (USD)
1	Strengthening sector planning, management and regulation	It aims to strengthen the water supply sector and improve sector sustainability. It is proposed that a dedicated Water (and Sewerage) Authority be established to plan, manage and develop the Palau water supply sector in conjunction with a water regulating authority.	750,000
2	Development of water supply wells and associated Water Source Works	It aims to develop a way to augment the supply to the existing Koror Airai water supply system. This will improve the reliability of supply during periods of drought and will reduce current treatment and quality problems during periods of high rainfall.	1,501,000
3	Community action and participation program (CAPP)	It is designed to enhance and sustain the benefits from investments in water supply systems in Palau.	270,000
4	Rehabilitation and extension of the Koror-Airai water supply Network	It includes rehabilitation works to improve supply reliability, make operations more effective and allow for full metering of the Koror Airai water supply system. A full leak detection and repair operation will be undertaken as part of this component. There is also an extension of the pipeline along Compact Road into Aimaliik.	4,270,000
5	Project implementation and capacity building	・Project implementation assistance which will provide consulting services to assist the Project Management Unit (PMU) to implement the Project by providing technical and management support, capacity building and training to the PMU throughout the implementation stage. ・Administration support which will provide allowances, vehicles, office, and computer equipment for the PMU office for project implementation.	1,450,000
Total (No.1-5)			**8,241,000**
Contingencies			1,190,000
Interest and service charges during construction			463,000
Total Project Budget			**9,894,000**

Source: TA 4977-PAL Preparing The Babeldaob Water Supply Project

2.5 Activities of Development Partners

2.5.1 Asian Development Bank

(1) Water Sector Improvement Program

In 2010, ADB approved a program loan for the sum of USD 16 million to be utilized for improvement of water sector. USD 6 million out of the USD 16 million is allocated for capital investment for water supply. It is, however, managed as a governmental subsidy for PPUC. The finance should be approved and allocated by GoP according to requests of PPUC per project.

The remained balance is around USD 2 million or less. PPUC is currently conducting or planning the projects shown in Table 2.5-1, utilizing the program loan.

Table 2.5-1 Expected Projects to be Done through Program Loan (as of 2014)

No	Item, Project	Status	Budget (USD)
1	Rehabilitation / construction of Field Offices	Completed, Subsidy under claim	50,000
2	Rehabilitation of Ngermid Booster Pump Station	Completed, Subsidy under claim	52,280
3	Installation of remote monitoring system for water level of service reservoirs.	Under progress, Subsidy under claim	36,400
4	Installation / replacement of meters	Under progress, Subsidy under claim	279,075
5	Business software	Under progress, Subsidy under claim	108,700
6	Replacement of Water Transmission Pumps at KAWTP	Under progress, Subsidy under claim	237,773
7	Bridge-attached pipelines along KB Bridge	Under evaluation of tenders, Subsidy under claim	990,000
Total			**1,754,228**

Source: PPUC

(2) Sanitation Sector Development Project

ADB conducted a study for sanitation development for Koror - Airai area and its result were compiled in June, 2013 as “Sanitation Master Plan”. After that, ADB concluded the loan agreement for sewerage development in March 2014, to implement projects described in the master plan. The current situation and schedule for the sanitation development are as follows:

Estimated Cost	USD 30 million (Loan USD 28.8 million, GoP finance USD 1.2 million).
Loan Agreement	March 2014.
Implementation Period	Three years.
Current Progress	Selection for project management consultant is under progress. It is expected to be finalized in the end of September 2014.
Basic Components	1) Gravity mains (2,850m for Koror and 6,000m for Airai) 2) Force mains (2,900m for Koror and 260m for Airai) 3) Construction / rehabilitation of pump stations 4) Remote monitoring system 5) Construction / rehabilitation of public toilets 6) Rehabilitation of wastewater treatment plant

2.5.2 Other Development Partners

Besides GoJ and ADB, several international organizations assist PPUC in water and wastewater development / management. Table 2.5-2 shows recent activities of other development partners. The organizations which are currently assisting the Koror - Airai System are only GoJ and ADB.

Table 2.5-2 Current Activities of Other Development Partners

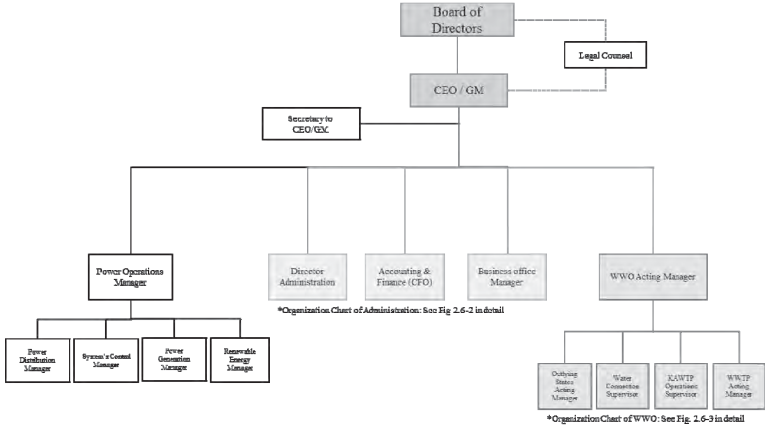
Organization	Cost	Period	Project Title and Contents / Activities
Pacific Islands Forum (PIF)	USD 4.0 million	2012 - 2014	**Title:** Project of Desalination and Solar Power Generation System **Contents / Activities:** Design, equipment procurement and installation of desalination and solar power system in Peleliu State.
European Union (EU)	USD 650 thousand	2013 - 2015	**Title:** Project addressing Water Sector Climate Change Vulnerabilities in the Outlying States of Palau **Contents / Activities:** Enhancing capacity for water supply system in Kayangel, Peleliu, Angaur, Sonsorol and Hatohobei States.
United Nations Development Programme (UNDP)	USD 199 thousand	2014 - 2015	**Title:** Sustaining Renewable Energy and Efficiency Measures in Micronesia **Contents / Activities:** Evaluating the existing system for Kayangel State. Installing solar powered pumps in Kayangel State.

Source: PPUC

2.6 Organizational and Financial Conditions of Water Supply and Sewerage Sector

2.6.1 Organization

Palau Water and Sewer Corporation (PWSC) was the former authority for water supply and sewerage. It was established in line with ADB's Act in 2011 to improve Operation and Maintenance (O&M) of the facilities and tariff collection necessary for water supply and sewerage sector. PWSC merged, however, with Palau Public Utilities Corporation (PPUC) at the end of July 2013. Currently, PPUC is organized with 3 sections, namely, Power Operation, Administrative Section and Water and Wastewater Operation (WWO) as shown in Figure 2.6-1.

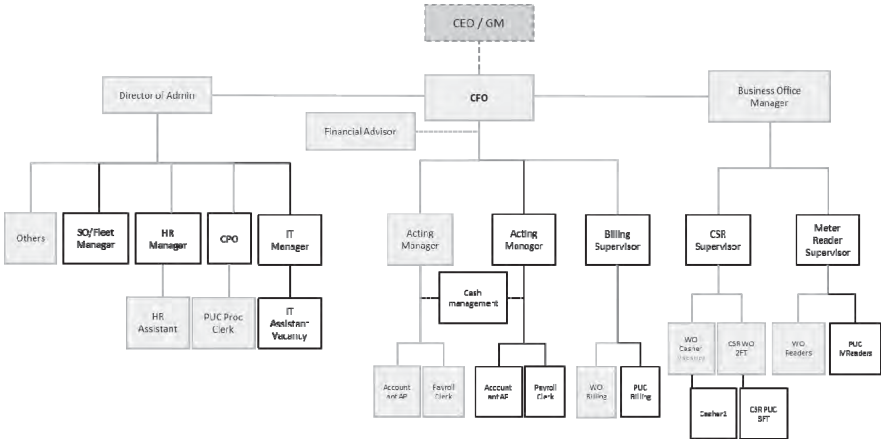


Source: PPUC

Figure 2.6-1 Organization Chart of PPUC

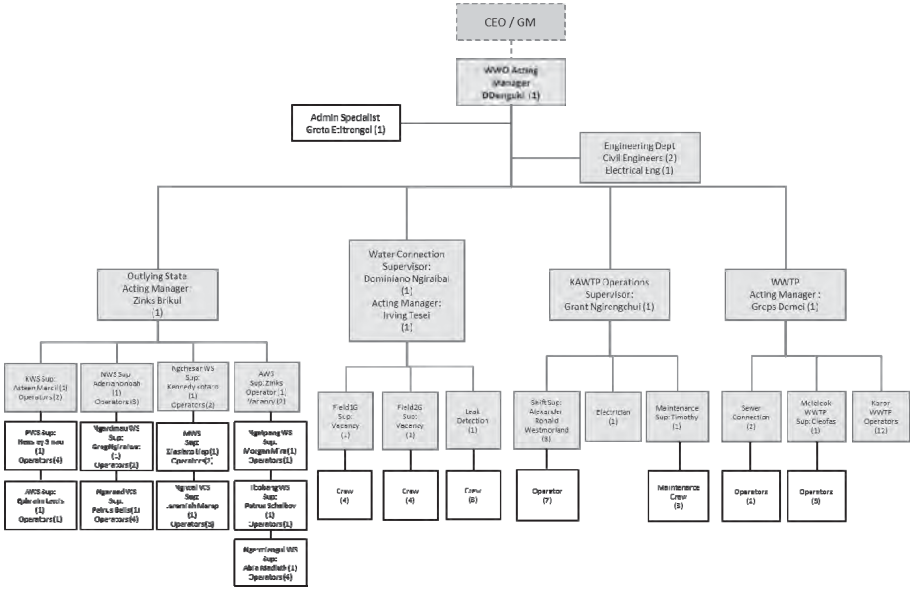
The organization chart of administrative section of PPUC is shown in Figure 2.6-2. The highlighted staffs are mainly for WWO. PPUC is now trying to promote efficiency of administration works, utilizing scale merits. Unifying invoice for utilities charges is one of examples of efficiency improvement attempts.

The organization chart of WWO is shown in Figure 2.6-3. WWO has currently 99 staff-members.



Source: PPUC

Figure 2.6-2 Organization Chart of administrative section of PPUC



Source: PPUC

Figure 2.6-3 Organization Chart of WWO of PPUC

Totaling, 115 staff-members are mainly working for water and wastewater activities against 4,776 connections. It is converted into 24 persons per 1,000 connections as shown in Table 2.6-1. This number of employees is much large against the number of customers. The inefficiency in Outlying States brings the inefficient situation. On the other hand, the number of employees for Koror - Airai water supply system is in a good level for small entities.

Besides the inefficiency due to number of employees, the establishment for water distribution / NRW management and water quality management is an issue for safer and more stable water supply.

Table 2.6-1 Number of Employee by Section for Water and Wastewater Services

Total Water & Wastewater	Roles	Employee By Role	Remark
115 persons 24 persons per 1000 connections (4,776 connections)	HQ administration	16 persons	
	KAWTP & Connection (Koror - Airai system for main jobs)	35 persons	9.4 per 1000 connections (3,710 connections)
	Outlying States	43 persons	43.3 per 1000 connections (1,066 connections)
	Sewer	21 persons	

Source: JICA Survey Team

2.6.2 Financial Condition

(1) Income and Expenditure

The vulnerability of management capability is pointed out by necessity of governmental subsidy. Although PPUC is required to be sustainable by tariff incomes, about 60% of the expenditure is currently covered by the subsidy as shown in Table 2.6-2. Strengthening activities for management capability and financial efficiency are in progress through the ADB recommendations.

Table 2.6-2 Revenue and Expenditure for the past five years

Fiscal Year			2009	2010	2011	2012	2013
1	Revenue (USD)	Water Utility Charges	649,179	665,004	936,109	1,700,767	1,762,528
2	Expenditures (USD)	WWO Operation	3,974,413	4,605,422	4,744,917	4,476,446	4,693,439
3	Subsidy (USD)		(3,325,234)	(3,940,418)	(3,808,808)	(2,775,679)	(2,930,911)
4	Cost Recovery Ratio (%)	(=1/2)	16%	14%	20%	38%	38%

Avg. subsidy for the past 5 years (2009 to 2013) (3,356,210)

Source: GoP Audited Financial Statement

(2) Water Tariff

Table 2.6-3 shows the previous and current tariff for water and wastewater service. Common tariff is used for all water and wastewater services in Palau. After merging WWO to the electricity power sector (former PPUC), PPUC collects the water and wastewater charges by a common invoice together with electricity charges. Water charge and wastewater charge are basically USD1.06–1.91 per 1,000G (USD0.28–0.50 per m^3) and USD0.30–1.70 per 1,000G (USD0.08–0.45 per m^3) respectively. From the recent billing data, around USD2.70–3.10 per 1000G are collected for water and wastewater services as shown in Table 2.6-4. Its average is USD2.77 per 1000G.

Assuming the billed volume as 720 MG/year, the billed amount is calculated to be USD 2 million or less. Since the operation cost (expenditure) for the water and wastewater services is around USD 4.5 million / year, it is difficult to sustain the services by the tariff income.

In this weak financial background, PPUC commenced the tariff improvement of the water and wastewater charges, according to ADB recommendations made in 2009. Although the tariffs were revised in 2011 and 2012, it does not reach a possible level for cost recovery.

Table 2.6-3 Tariff for Water and Wastewater Services

Water Tariff					
Category		Unit	Condition	Effective Date 2011/2/7	Effective Date 2012/2/7
Metered	Domestic	per 1,000G/month	Up to 5,000G/month	$1.06	$1.17
	Domestic		More than 5,000G/month	$1.28	$1.91
	Non-domestic			$1.28	$1.91
Flat Rate	Domestic	per month	Single family	$12.00	$15.00
			Single family (Airai)	$7.50	$12.50
			Multi-family	$12.00	$15.00
	Employee Barracks	per month	1-10 employees	$12.00	$15.00
			11-25 employees	$30.00	$35.00
			26-50 employees	$60.00	$75.00
			51 employees or more	$125.00	$150.00
	Restaurants / Dining Facilities / Bars / Cocktail lounges	per month	1-25 seats	$15.00	$20.00
			26-50 seats	$20.00	$25.00
			51 seats or more	$35.00	$40.00
	Laundry / Laundromat	per month	1-5 washers	$30.00	$40.00
			6-10 washers	$50.00	$60.00
			11 washers or more	$90.00	$100.00
	Hotel / Motel	per room per month		$2.00	$3.00
	Governmental / Unlisted commercial activities	per month	1-25 employees	$15.00	$20.00
			26-50 employees	$20.00	$25.00
			51-100 employees	$35.00	$40.00
			101 employees or more	$50.00	$60.00
	Hospital	per bed per month		$1.25	$1.25
	Schools / Colleges (non-boarding) 50% of rate when school is not in session.	per month	1-50 students	$15.00	$15.00
			51-100 students	$20.00	$20.00
			101-200 students	$30.00	$30.00
			200 students or more	$60.00	$60.00
	Schools / Colleges (boarding) 50% of rate when school is not in session.	per month	1-50 students	$35.00	$35.00
			51-100 students	$70.00	$70.00
			101-200 students	$140.00	$140.00
			200 students or more	$250.00	$250.00
	Churches / Assembly Halls	per month		$10.00	$10.00
Wastewater Tariff					
Category		Unit	Condition	Effective Date 2011/2/7	Effective Date 2012/2/7
Metered	Domestic	per 1,000G/month of water consumption	Up to 5,000G/month	$0.30	$0.30
	Domestic		More than 5,000G/month	$0.30	$0.30
	Non-domestic			$1.28	$1.70
Flat Rate	Domestic	per month	Single family	$1.50	$2.50
			Single family (Airai)	$1.50	$2.50
			Multi-family	$1.50	$2.50
	Employee Barracks	per month	1-10 employees	$1.50	$2.50
			11-25 employees	$2.00	$3.00
			26-50 employees	$3.00	$4.00
			51 employees or more	$4.00	$5.00
	Restaurants / Dining Facilities / Bars / Cocktail lounges	per month	1-25 seats	$1.50	$2.50
			26-50 seats	$2.00	$3.00
			51 seats or more	$3.00	$4.00
	Laundry / Laundromat	per month	1-5 washers	$3.00	$4.00
			6-10 washers	$5.00	$6.00
			11 washers or more	$9.00	$10.00
	Hotel / Motel	per room per month		$2.00	$3.00
	Governmental / Unlisted commercial activities	per month	1-25 employees	$1.50	$2.50
			26-50 employees	$2.00	$3.00
			51-100 employees	$3.00	$4.00
			101 employees or more	$5.00	$6.00
	Hospital	per bed per month		$1.25	$1.25
	Schools / Colleges (non-boarding) 50% of rate when school is not in session.	per month	1-50 students	$1.50	$1.50
			51-100 students	$2.50	$2.50
			101-200 students	$5.00	$5.00
			200 students or more	$7.50	$7.50
	Schools / Colleges (boarding) 50% of rate when school is not in session.	per month	1-50 students	$3.00	$3.00
			51-100 students	$5.00	$5.00
			101-200 students	$10.00	$10.00
			200 students or more	$15.00	$15.00
	Churches / Assembly Halls	per month		$1.50	$1.50

Source: PPUC

Table 2.6-4 Recent Billed Amount

Item	Nov 2013	Dec 2013	Jan 2014	Feb 2014	Mar 2014	Apr 2014	May 2014	Jun 2014
Billed Volume (G/month)	90,477,263	58,476,355	60,960,615	60,424,269	58,346,580	63,858,562	60,764,276	62,364,120
Billed Amount (USD/month)	243,420	157,637	142,898	167,062	183,245	192,625	171,701	170,372
Average Charge (USD/1000G)	2.69	2.70	2.34	2.76	3.14	3.02	2.83	2.73

Remark: In November 2013, charges for previous months are billed together.

Source: PPUC

In respect of the water charge per person, it is calculated at 0.5% of GNI as shown below. Assuming the affordability of citizens for water and wastewater service at 3 - 5% of GNI, the current tariff rate may be lower than the collectable level.

Assumption :	67G/capita/day (24,455G/capita/y) and USD1.91 per 1,000G USD46 /capita/y for water charge. It is 0.5% of GNI (USD9,860 /capita/y).

2.7 Evaluation and Effects of the Previous Japan's Grant Aid Project

2.7.1 Situations and Results of the Previous Project

(1) Background and Contents of the Previous Project

In 1990 - 1993, a previous Japan's Grant Aid Project "the Project for Improvement of Water Supply System" was implemented to improve Koror - Airai water supply system (hereinafter referred to as "the Previous Project"). Main components of the Previous Project are shown below and in Figure 2.7-1.

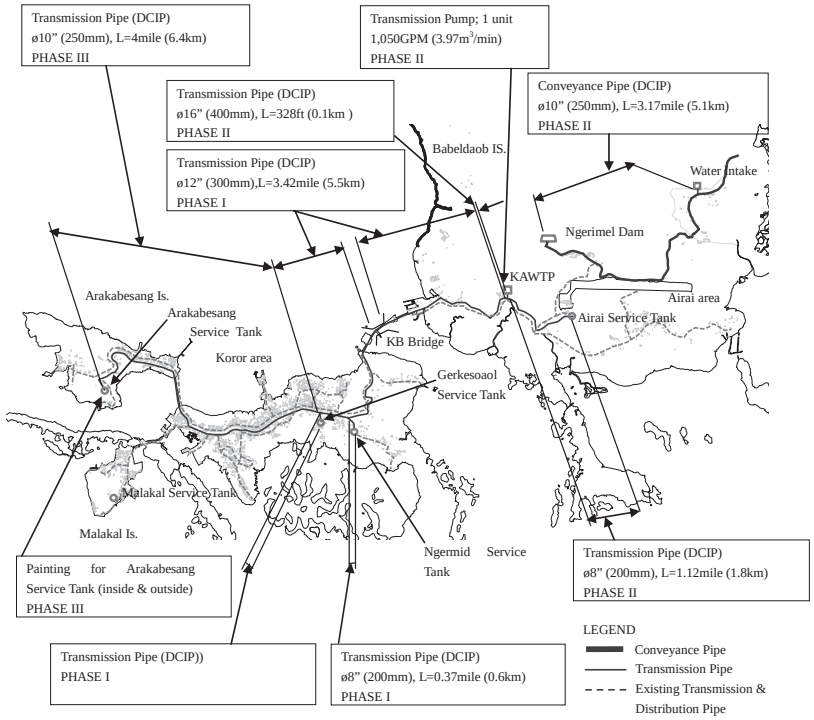
- Raw water conveyance pipe: Ductile Cast Iron Pipe (DCIP) (Dia. 250mm), Total length 5.1km
- Transmission main: DCIP (Dia. 300-250mm, partially 400mm & 200mm), Total length 14.8km, One transmission pump
- Water level control valves for 4 Service Tanks (valve and control equipment): for Airai, Ngermid, Ngerkesoaol and Arakabesang Service Tanks
- Clean and re-painting work for Arakabesang Service Tank: Inside and outside surfaces

Before the Previous Project, there was no exclusive pipeline for transmission purpose. Distribution lines were utilized for transmission purpose, too. Such pipelines caused the excessive imbalance of the service water pressure and the water supply quantity among the served areas. And it was difficult to fill the service tanks appropriately with water. Accordingly, the water supply had been regulated for 16 hours service per day.

In the mentioned background, the Previous Project was designed to secure stable water conveyance and to separate the transmission from distribution networks according to the following conditions:

Design Conditions for the Previous Project

1) Target year: 2000
2) Population in 2000: 20,600 persons
3) Estimated Foreign Visitors per day: 548 persons (based on number of hotels' rooms)
4) Design Maximum Daily Water Production: 2.1MG/day



Data Source: Basic Design Study Report for the Project for Improvement of Water Supply System, 1990, JICA

Figure 2.7-1 Location of Facilities Constructed in the Previous Project

(2) Result of the Previous Project

After the Previous Project, the treated water from KAWTP have been appropriately delivered to each service tank, i.e. Airai, Ngermid, Ngerkesoaol and Arakabesang Service Tanks, through the new water transmission main. Since the tanks are filled with water, 24 hours water supply has been realized and the accesses of the citizens to the water has been improved. It may be one of the reasons for increase of water consumptions / supplied volumes. Unit water production have been dramatically increased because of the access improvement for water and the recent economic growth. The unit water productions per population are shown in Table 2.7-1.

Table 2.7-1 Water Production (Target and Current Situation)

Items	2000 (Target of the Previous Project	2013 (Current Situation)
Population	20,600	14,126
Average Water Production	1.4MG/d (Max. 2.1MG/d)	3.69MG/d (Max. 4.0MG/d)
Unit water Production (incl. non-domestic water)	68G/capita/d	261G/capita/d

Remark: Refer Chapter 3 for the water production in 2013
Data Source: Basic Design Study Report for the Project for Improvement of Water Supply System, 1990, JICA

(3) Condition of the Previous Project's Facilities in 2014

The current conditions of main water facilities are inspected in this survey. Although the transmission main became insufficient for capacity, the conditions of pipelines are good for operation. In general, the rusts are observed on steel structures. It is necessary for PPUC to maintain / repair the facilities, especially for steel structures.

Table 2.7-2 Current Condition of Main Facility

Item	Facility	Current situation
Construction of conveyance pipe	DCIP (dia. 250mm) , Total length 5.1km	The raw water conveyance pipeline between Ngerkiil Intake Pump Station and Ngimel Dam was under the dirt road in the previous Project; however now it is covered with the paved road. The pipeline across river is supported by the sound bridge and maintained properly. There are no defects.
Construction of Transmission pipeline	DCIP (dia. 300-250mm, partially 400 & 200mm), Total length 14.8km	1. Water volume transferred from the Water Treatment Plant (KAWTP) was increased from 2.1MG/day at Target year (2000) of the Previous Project to 4MG/day in 2014 due to significant growths of economy and water demand. The Capacity of transmission main is currently insufficient for the water production under the design calculation basis. 2. Surging Tanks (No.1 and No.2) which were placed on the transmission main for avoiding water hammer action were not properly maintained. 1) No.1 Surging Tank; The steel tank and steel structures rust severely due to overflow caused by the breakdown of the floating valve. The proper periodical maintenance has not been properly conducted, such as clean and repainting for the tank and the steel structures and tree trimming around the fence. 2) No.2 Surging Tank; The floating valve is good for operation. However, the base plate of tank and the steel structures rust. It is necessary to clean and repaint the tank and steel structures and to trim trees around the fence.
Water level control valve for Service Tank: 1) Valve 2) Control equipment	For total of 4 Service Tanks	In the previous Project, a simple control system was installed to stop the in-flow into the service tank by float switch when the tank is filled with water. The system has been out of service due to no action for repairing the float switches. However, PPUC arranged a new system for monitoring of water level information in June 2014 (ADB's program loan is utilized). It send an alarm to the managers when water reaches the full water level.
Installation of Transmission pump		The large size pump which was installed in the previous Project is in operation properly.
Clean and painting work for Arakabesang Service Tank (inside and outside surfaces)		The peeling of paint on outside surfaces is observed. The horizontal member's ribs, anchor plates and anchor bolts, which are directly exposed to the weather, have seriously rusted and damaged. It is necessary to re-paint the exterior surface as soon as possible.

Source: JICA Survey Team

(4) Review of "Recommendations" to be followed-up by Palauan side

The Previous Project pointed out several issues to be undertaken by the Palauan side as recommendations. In this survey, the situation of recommended items were reviewed as shown in Table 2.7-3. Organization for water supply was turned into a public corporation to promote efficiency and self-sustain the activities. On the other hand, reinforcement for maintenance organization as well as for water distribution management has not been undertaken well.

Table 2.7-3 Current Status for the Issues pointed out as Recommendations

No.	Recommendation	Current Status
1	The Bureau of Public Works is comprised of the Power Generation Branch, Water Works Branch, Power Distribution Branch and Sewer Works Branch. However, since Palau needs to secure a reliable and stable water supply and establish a profitable water supply system, a new and separate Bureau of Water Works for the management and operation of the water works system should be established. Financial solvency and profitability will be a priority for this new organization.	Several procedures were undertaken until the current organization of PPUC. The organization was separated from the Bureau of Public Works and merged with a public corporation for electricity distribution in 2013.
2	This new organization should employ several technical personnel to oversee the operation and maintenance of the water facilities. These personnel will participate in this project on a full-time basis from the first stage of construction to acquire sufficient knowledge of the technical aspects of the water facilities.	As mentioned above, since the organization went through transitions, it is not well organized in the fields for engineer's training, arrangement of technical specifications and management of technical documents.
3	Educate the residents on the proper use of water to prevent wastage of water.	Education for proper use of water is operated as a program at PPUC, but it is not frequently taking place. Its effect is limited.
4	A complete billing and collection system should be established to bill water consumers according to actual water use to prevent wastage of water.	Billing system is improved to be managed together with electricity bills. Billing and tariff collecting ratio are nearly 100%. It is, however, pointed out that waste of water is still occurring since water charge is set at a low rate.
5	Monthly metered water consumption of households and establishments should be compared with water quantity from the water treatment plant for operation and maintenance of the water facilities. Examples of how the data may be used are described below. 1) Check on waste at residences and establishments 2) Check for leakage in the water transfer and distribution pipelines	District flow meters have not yet been installed. 13% of customers are not metered. Accordingly, it has been still difficult to compare the consumption with the production data.
6	Periodical checkup and maintenance of facilities, equipment and rotating operation of equipment together with periodical testing of standby equipment and valves which are not in ordinary use.	Periodical function and driving checks for valves are not conducted. Also Service Tanks and Surging Tanks are not painted after their construction.
7	A settling basin as a pre-filtering device at the water treatment plant to improve the sand filtering function, water quality and long term service of the facility should be installed.	The following facilities were additionally constructed in the premises of water treatment plant in 1996-1998 as "Koror-Airai Water System Pre-Treatment Plant Project No.089-95", which was funded by US Department of Interior: 1. Additionally constructed small size Clear Water Well; 2. Newly constructed Chemical Storage and Laboratory Building; 3. Newly constructed Flocculation/Sedimentation Basin; 4. Newly constructed Sludge Drying Bed; and 5. Newly constructed Filter Backwash Lagoon.

No.	Recommendation	Current Status
8	A storage reservoir at the water treatment plant should be installed to provide a stable water supply during peak times.	As mentioned above, Clear Water Well has additionally constructed in 1996-1998, but it is insufficient for storage volume. It is necessary to construct further Clear Water Well.

Source: JICA Survey Team

2.7.2 Evaluation and Lessons from the Previous Project

The Previous Project has been contributing to stable water transmission / distribution to Koror - Airai. The system is currently operated well. The system is simple and applicable to PPUC's technical staffs. On the other hands, it is observed that periodical maintenance and operation management systems have not been developed and spread well in PPUC, as described below:

- Insufficient periodical clean and repaint on the tanks and steel structures.
- Little execution for data analysis for water distribution and consumption.
- Lack of periodical inspection for function on valves and other related devices.

The reasons of insufficient maintenance are not always technical skills or budgets. Main reasons might be carelessness for preventive maintenance. Accordingly, sophisticated systems should be escaped from installation under current awareness on maintenance, until enough development for awareness and technical organization. If introducing sophisticated systems, capacity development programs should be undertaken in parallel of facilities construction.

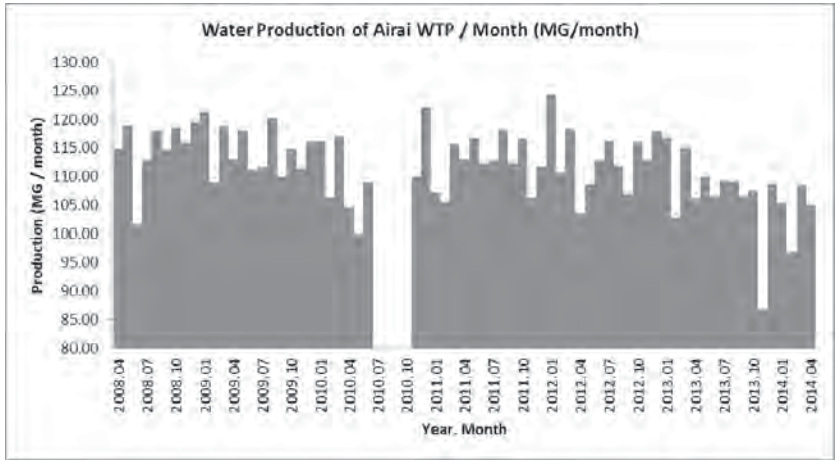
CHAPTER 3 Development Framework for Water Supply

3.1 Water Demand and Current Conditions for Water Supply

3.1.1 Current Volume of Water Supply and Consumption

(1) Trend of Water Production and Consumption

The water production (volume of water supply from KAWTP) has a tendency of decreasing as shown in Figure 3.1-1. This decreasing tendency is explained by the population decrease. PPUC observes also the promotion of public awareness contributing to water conservation. In 2013, the water production was recorded at 107 MG/month on average.



Remark 1: Very low water production was recorded in November 2013 due to leakage accident at KB Channel.

Remark 2: Blanks show that no data is available.

Source: Daily report of KAWTP

Figure 3.1-1 Trend of Water Production of KAWTP

(2) Average Volume of Water Production and Consumption

Utilizing the available data for production and consumption (data available period between October 2012 and May 2013), the Team summarized the current water production and consumption (recorded basis) as shown in Table 3.1-1. The average consumption is 1.89 MG/day against the production of 3.69 MG/day. Since the consumption is the recorded volumes of billed water, the balance (1.80 MG/day) is considered as non-revenue water (NRW).

Table 3.1-1 Monthly Water Production and Consumption

Category	Oct. 2012	Nov. 2012	Dec. 2012	Jan. 2013	Feb. 2013	Mar. 2013	Apr. 2013	May 2013	Total	Average (MG/day)
Water Production (MG/month)	115.99	112.95	117.87	116.84	102.75	115.01	106.09	109.85	897.35	3.69
Total Consumption (MG/month)	56.96	58.32	61.44	59.46	49.71	65.37	55.80	52.25	56.96	1.89
Domestic (flat rate)	3.72	3.72	3.71	3.72	3.70	3.69	3.67	3.68	3.72	0.12
Domestic (metered)	26.28	24.73	24.25	26.87	21.15	27.35	27.21	24.01	26.28	0.83
Non-Domestic (gov/flat rate)	1.10	1.27	1.28	1.28	1.15	1.27	1.28	1.28	1.10	0.04
Non-Domestic (gov/metered)	1.37	0.85	1.41	1.08	0.94	0.94	1.86	1.26	1.37	0.04
Non-Domestic (com/flat rate)	0.35	0.35	0.35	0.35	0.31	0.31	0.31	0.31	0.35	0.01
Non-Domestic (com/metered)	24.14	27.40	30.44	26.16	22.46	31.81	21.47	21.71	24.14	0.85

Remark: Consumption means volume of billed water.

Source: PPUC (KAWTP and Financial Department)

(3) Water production / Consumption per Population / Connection

Table 3.1-2 shows the average number of connections calculated from PPUC's billing data and the estimated population for 2013. According to PPUC, it is supposed that all houses and entities are connected to the piped water supply system of PPUC in Koror and Airai. Piped water coverage could be assumed as 100%. The service population of Koror - Airai Water Supply System could be, therefore, estimated at 14,126 persons in 2013.

Table 3.1-2 Number of Customers and Population (Average for Oct. 2012 - May 2013)

Item	Number
Total Connections	3,341
Domestic Connection (flat)	345
Domestic Connection (metered)	2,154
Governmental Connection (flat)	81
Governmental Connection (metered)	63
Commercial Connection (flat)	24
Commercial Connection (metered)	674
Population (2013)	14,126

Source: JICA Survey Team based on PPUC's Data

Utilizing the above number of connections and population, the unit water production and consumption per customer category (recorded basis) are calculated as shown in Table 3.1-3. The breakdown for the number of customers and consumptions is shown in Table 3.1-4. It is noted that 13% of the customers are not metered and charged by flat rate tariff. The consumptions of the flat rate customers are estimated and recorded by PPUC, utilizing business category for subscription and unit prices for metered customer.

In Airai, the water consumptions have not been metered since establishment of water supply. The consumptions have been managed by old agreements for water supply and have not yet been updated. In 2014, PPUC is conducting a metering project to install meters for all customers in Airai. In Koror, most of the consumptions are metered. The following customers, however, are not

metered:

- Old connections existing from 1940s, especially governmental facilities in old and congested area (center of Koror). For such facilities, it is difficult to identify lateral connections appropriately. Metering is, therefore, delayed for such facilities.
- New connections are to be metered. However, the meter installation is not always properly done due to shortage of meters.
- PPUC conducting the metering project in Koror, too. It is expected that all consumptions become metered by the end of 2014.

Table 3.1-3 Unit Production / Consumption as Recorded before Adjustment for Flat Rate Consumption

No.	Item	Total Vol. (243days: Oct2012-May2013)		Unit Production / Consumption			
		MG	MG/d	G/Cap/day	L/Cap/day	G/Connect/d	L/Connect/d
1	Water Production	897.35	3.69	261	988	1,105	4,182
2	Domestic Consumption (flat)	29.61	0.12	67	254	353	1,336
3	Domestic Consumption (metered)	201.85	0.83			386	1,461
4	Non-Domestic Consumption (gov/flat)	9.91	0.04			503	1,904
5	Non-Domestic Consumption (gov/metered)	9.71	0.04			634	2,400
6	Non-Domestic Consumption (com/flat)	2.64	0.01			453	1,715
7	Non-Domestic Consumption (com/metered)	205.59	0.85			1,255	4,750
8	Total Consumption	459.31	1.89			566	2,142
9 = 1 -8	NRW	438.04	1.80				
10 = 9 / 1	NRW Ratio (%)	49%					

Note: The figures shown in the table are recorded ones. They are before adjustment for flat rate consumptions.

Source: JICA Survey Team based on PPUC's Data

Table 3.1-4 Water Consumption by Customer Category

Month	Flat Rate Customer			Metered Customer			Total		
	No. Connection	Registered Consumption (G/month)	Average G/connection (G/month)	No. Connection	Registered Consumption (G/month)	Average G/connection (G/month)	No. Connection	Registered Consumption (G/month)	Average G/connection (G/month)
Domestic									
Oct 2012	347	3,724,359	10,733	2,197	26,278,881	11,961	2,544	30,003,240	11,794
Nov 2012	347	3,724,359	10,733	2,174	24,725,624	11,373	2,521	28,449,983	11,285
Dec 2012	346	3,713,676	10,733	1,988	24,254,906	12,201	2,334	27,968,582	11,983
Jan 2013	347	3,724,359	10,733	2,194	26,866,495	12,245	2,541	30,590,854	12,039
Feb 2013	345	3,702,992	10,733	2,164	21,149,726	9,773	2,509	24,852,718	9,905
Mar 2013	344	3,690,171	10,727	2,180	27,353,077	12,547	2,524	31,043,248	12,299
Apr 2013	342	3,668,803	10,727	2,166	27,205,812	12,560	2,508	30,874,615	12,310
May 2013	343	3,679,487	10,727	2,169	24,010,402	11,070	2,512	27,689,889	11,023
Average	345	3,703,526	10,735	2,154	25,230,615	11,713	2,499	28,934,141	11,578
Non-Domestic (Government)									
Oct 2012	81	1,102,941	13,617	64	1,374,791	21,481	145	2,477,732	17,088
Nov 2012	81	1,265,707	15,626	64	847,047	13,235	145	2,112,754	14,571
Dec 2012	81	1,276,178	15,755	65	1,407,974	21,661	146	2,684,152	18,385
Jan 2013	81	1,276,178	15,755	63	1,084,571	17,215	144	2,360,749	16,394
Feb 2013	81	1,145,288	14,139	64	939,911	14,686	145	2,085,199	14,381
Mar 2013	80	1,265,707	15,821	64	939,911	14,686	144	2,205,618	15,317
Apr 2013	81	1,276,178	15,755	65	1,862,503	28,654	146	3,138,681	21,498
May 2013	81	1,276,178	15,755	57	1,262,215	22,144	138	2,538,393	18,394
Average	81	1,235,544	15,254	63	1,214,865	19,284	144	2,450,410	17,002
Non-Domestic (Commercial)									
Oct 2012	24	353,403	14,725	671	24,139,261	35,975	695	24,492,664	35,241
Nov 2012	24	347,120	14,463	678	27,398,979	40,411	702	27,746,099	39,524
Dec 2012	24	353,403	14,725	679	30,440,152	44,831	703	30,793,555	43,803
Jan 2013	24	353,403	14,725	676	26,162,508	38,702	700	26,515,911	37,880
Feb 2013	24	305,882	12,745	672	22,461,555	33,425	696	22,767,437	32,712
Mar 2013	24	305,430	12,726	674	31,813,639	47,201	698	32,119,069	46,016
Apr 2013	25	312,217	12,489	668	21,471,319	32,143	693	21,783,536	31,434
May 2013	25	312,217	12,489	670	21,706,691	32,398	695	22,018,908	31,682
Average	24	330,384	13,766	674	25,699,263	38,129	698	26,029,648	37,305
Non-Domestic (Total)									
Oct 2012	105	1,456,344	13,870	735	25,514,052	34,713	840	26,970,396	32,108
Nov 2012	105	1,612,827	15,360	742	28,246,026	38,067	847	29,858,853	35,252
Dec 2012	105	1,629,581	15,520	744	31,848,126	42,807	849	33,477,707	39,432
Jan 2013	105	1,629,581	15,520	739	27,247,079	36,870	844	28,876,660	34,214
Feb 2013	105	1,451,170	13,821	736	23,401,466	31,795	841	24,852,636	29,551
Mar 2013	104	1,571,137	15,107	738	32,753,550	44,382	842	34,324,687	40,766
Apr 2013	106	1,588,395	14,985	733	23,333,822	31,833	839	24,922,217	29,705
May 2013	106	1,588,395	14,985	727	22,968,906	31,594	833	24,557,301	29,481
Average	105	1,565,929	14,914	737	26,914,128	36,518	842	28,480,057	33,829
Grand Total									
Average	450	5,269,455	11,710	2,891	52,144,743	18,037	3,341	57,414,198	17,185

Source: PPUC (Financial Department)

According to the above tables, the following are noted:

- The unit production is as large as 261G/capita/day. However, much NRW is included in the production.
- The number of flat rate customers accounts for 13% of the total. It is remarkable that the consumptions of the metered customers are larger than that of the flat rate customers. It is possible that actual consumption for flat rate customers are larger than the recorded values.
- 14% of domestic customers are categorized as the flat rate customers. The average consumption per connection for the metered customers is 1.09 times larger than the flat rate customers' one.
- 56% of the governmental consumption is not metered (managed by flat rate). The average consumption per connection for the metered customers is 1.26 times larger than the flat rate customers' one.

- Commercial unit consumptions could vary, depending on business scale and activity. It is difficult to say that unit consumptions of the flat rate and the metered customers would be nearly the same for commercial customers. However, ones for domestic and governmental customers might be averagely the same.
- Commercial unit consumptions for flat rate customers might be recorded less than real consumptions. It should be, therefore, adjusted by the average ratio for domestic and governmental ones.
- Although NRW is calculated as 1.80MG/d (49% of NRW Ratio) from the recorded figures, it could be larger than actual one since the flat rate consumptions would be larger than recorded figures. Accordingly, data for consumption should be adjusted and the NRW should be newly calculated to make the figures closer to realistic ones.

Assuming the adjustment ratios for the flat rate consumptions as shown in Table 3.1-5, the Team adjusted the current consumptions as shown in Table 3.1-6. The Team recommends adopting the mentioned and adjusted unit consumption and NRW in the table as the baseline for the facility plan. The real consumption would be larger than the recorded one by 0.02 MG/day and the Adjusted NRW ratio would be 48%. In the mentioned assumption, meter mal-functions are not accounted. It should be, therefore, accounted in NRW.

Table 3.1-5 Adjusted Ratios for Flat Rate Consumptions

Category	Average Consumption / connection (G/month)		Adjustment Ratio	Remark
	a: Flat Rate	b: Metered	c: b / a	
Domestic	10,735	11,713	1.0911	Flat rate unit consumption is assumed the same as the metered one.
Non-Domestic (Government)	15,254	19,284	1.2642	
Non-Domestic (Commercial)	13,766	16,244	1.1777	Average adjustment ratio of domestic and governmental ones.

Source: JICA Survey Team

Table 3.1-6 Adjusted Unit Production / Consumption (Assumption for the Current Volume)

No.	Item	Population	Number of Customer	Unit Production / Consumption		Daily Production / Consumption	
				G/Cap/d	G/Connect/d	MG/d	m^3/d
1	Water Production	14,126	3,341	**261**	**1,105**	3.69	13,967
2	Domestic Consumption	14,126	2,499	**68**	**386**	0.96	3,634
3	Non-Domestic Consumption (gov)		144		**634**	0.09	341
4	Non-Domestic Consumption (com/flat)		24		**533**	0.01	38
5	Non-Domestic Consumption (com/metered)		674		**1,255**	0.85	3,217
6	Total Consumption	14,126	3,341	**135**	**572**	1.91	7,229
7 = 1 - 6	**NRW**					**1.78**	6,737
8 = 7 / 1	**NRW Ratio (%)**					**48%**	48%

Source: JICA Survey Team

3.1.2 Demand Forecast

(1) Recommendation of "Preparing The Babeldaob Water Supply Project" by ADB

Final report for "Preparing The Babeldaob Water Supply Project" was submitted by ADB in July 2009. The report describes development plans for Koror - Airai water supply system rather than for Outlying States in Babeldaob. The report is currently utilized as a development guideline for water supply. The report recommended the demand as follows and as shown in Table 3.1-7:

Unit demand in 2009	225 G/capita/day (according to actual data and including non-domestic demand and NRW)
Unit demand in 2013 - 2023	180 G/capita/day (including non-domestic demand and NRW)
Equivalent Population	1) Population to be applied for demand calculation is "Equivalent Population". 2) The equivalent population is the sum of residents and visitors. 3) Assumption: 17,000 in 2009, 18,000 in 2013 and 19,500 in 2020.
Major assumption for plan of unit demand	1) Domestic consumption will decrease by around 20% according to tariff improvement (tariff-up). 2) NRW ratio will decrease to 33% (2020) from 42% (2009).

Table 3.1-7 Demand Plan Shown in "Preparing The Babeldaob Water Supply Project"

Item	2009	2013	2020
Equivalent Population	17,000	18,000	19,500
Unit demand (G/capita/day)	225	180	180
Demand (Production) MG/year	1,396	1,183	1,281
Demand (Production) MG/day	3.82	3.24	3.51

Source: Final report "Preparing The Babeldaob Water Supply Project", 2009, ADB

This demand plan was recommended based on the increasing population, which is estimated through the census result for 2005. The Team recommends not applying the above figures directly for this study due to the following reasons:

- ADB study was conducted in assumption that the population is increasing. However, it is reported in 2012 that the population is decreasing. The reported population for 2012 is 14,202 in the Statistical Yearbook 2013. The number of foreign visitors in 2012 (118,754) is converted to 1,301 persons per day. The equivalent population is, accordingly, calculated as 15,503. It is smaller than the 2009 estimation.
- Although the population is decreasing, the number of foreign visitors is increasing. Since the visitors' unit consumption, including commercial consumption related to foreign visitors, are different, it is not appropriate to fix the unit demand at 180 G/capita/day for equivalent population.

(2) Reduction of Water Consumption

The adjusted total average water consumption of the metered customers is 572 G/connection/day (68 G/capita/day only for domestic customers). Although it is difficult to judge whether the "572 G/capita/day" is higher or lower since it includes the business purpose water, "68 G/capita/day" is relatively high. PPUC, therefore, conducts promotion activities for public awareness for water conservation.

It is difficult to have accurate volumes for worthless water in the consumption. And it is also difficult for PPUC to control by public facilities. Accordingly, it is difficult to say how much of the consumption could be reduced. The Team recommends, therefore, not accounting the consumption reduction in this study.

However, PPUC should continue activities to reduce the consumption according to middle - long terms schedule to reduce future investment in facility construction. The following are examples for possibilities of the reduction:

1) Reduction of Water Leakage in the Private Plots after Meters

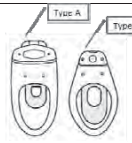
As described in Section 3.1.6, 585 leakages were reported in 14 months (2012 - 2013). 548 out of the 585 (94%) are found in private plots after meters. It is equivalent to 470 leakages per year. The leakages accounts for 14% of the total customers. The leakages found in the 470 customers is not NRW, but it is a kind of worthless consumptions to be reduced. Assuming the leakage flow per location at 1G/hour as a precursor of reported leakage accident, the possible reduction can be calculated for 14% of the customers as follows:

- 1G/hour of water leakage, existing on lateral connections (private side) at 14% of the customers in average: the leakage volume is calculated for 0.01MG/day (0.01MG = 3,341 customers x 14% x 1G x 24hours).

2) Repair and Improvement of Water Stoppage

Bureau of Waterworks, Tokyo Metropolitan Government in Japan, estimates and announces the estimated leakage volume as shown in Table 3.1-8.

Table 3.1-8 Estimated Leakage Volume at Leak of Customers

Location of Leak			Situation of Leakage	Estimated Leakage Volume per month
Tap			Continuous leakage in around 1mm diameter.	1,585 G (6 m^3)
			Continuous leakage in around 2mm diameter.	4,227 G (16 m^3)
Toilet	Type A		Continuous leakage in around 3mm diameter (similar to edge of chopstick).	5,284 G (20 m^3)
	Type B		Water surface is wavy.	39,630 G (150 m^3)

Source: Tokyo Metropolitan Government, Japan, based on 20mm service connection
https://www.waterworks.metro.tokyo.jp/customer/life/k_more.html

If the assumption below is made, the daily consumption is able to be reduced for 0.08MG/day from the total.

- 4,227 G/month of water leakage (2mm diameter leakage), existing in 5% of customers in average: the leakage volume is calculated for 0.71MG/month (0.71MG = 3,341 customers x 5% x 4,227G). It is converted 0.02MG/day.

3) Introduction of Water-saving type Devices

Tariff increase, which is planned by PPUC, will contribute to awareness promotion for water conservation and consumption reduction. If 20% of the domestic customers introduce the water shower head with 20% saving ratio, 0.01 MG/day of domestic consumption could be reduced as shown in Table 3.1-9.

Table 3.1-9 Estimated Water-Save by Improved Showerhead

Item	Unit	Figure
Basic Flow of Current shower	G/min	3
Duration of showering time	min	5
Consumption per each showering	G/shower	15
Family Number	person	5.7
Consumption per day/household for shower	G/day	86
Possible saving ratio	%	20%
Possible saved volume	G/day	17
Number of applying domestic customers (20% of current one)	Customer	500
Total volume to be saved in Koror - Airai	MG/day	0.01

Source: Estimation of JICA Survey Team

(3) Domestic Consumption

As described before, there are possibilities to reduce the domestic consumption. It is, however, difficult for PPUC to control by facilities. The Team recommends, therefore, to apply the current level of consumption, which is 68G/capita/day, for urgent and short term projects.

(4) Non-Domestic Consumption

1) Commercial Consumption

As described in Chapter 2, activities related to foreign visitors contribute to the economic development. The GDP increase ratios for the mentioned activities, as well as for the total GDP, are calculated as shown in Table 3.1-10.

Table 3.1-10 GDP Increase Ratio

Category	GDP (million USD)					Annual increase Rate
	2009	2010	2011	2012	2013	(2009-2013)
Total GDP	156.2	160.9	168.9	178.0	177.3	3.4%
Accommodation & food service	22.4	25.6	29.4	35.3	35.1	14.2%
Transport and storage	7.7	8.5	10.1	11.4	10.6	9.4%
Sub-Total	30.1	34.1	39.5	46.7	45.7	13.0%
Public Administration	28.5	28.4	27.6	27.5	27.9	-0.5%

Data Source: 2013 Statistical Yearbook, Bureau of Budget & Planning, Ministry of Finance

According to the following reasons, the Team recommends applying 3.4% for increase rate of commercial water consumption:

- Share of activities related to foreign visitors is around 26% in GDP. It is highly developing by 13% of the increase rate. The number of foreign visitors is also increasing at a rate of 6 - 7%. Such increase rates, however, are not the same as the trend for total development of Koror - Airai region.
- Contribution of the foreign visitors is widely spread to almost all activities. It is difficult to pick up separately the contribution of the foreign visitors.
- The trend of water production is flat or slightly decreasing in the recent years. It is difficult to assume that the commercial consumption increase by 13% or 6 - 7% of annual increase rate.
- GDP is good to show the economic development as well as activities related to foreign visitors. It is recommended to apply the GDP increase rate to forecast the commercial consumption.

- Since the increase of foreign visitors is accounted in the GDP increase, it will not be necessary to count the number of foreign visitors separately in demand forecasting as equivalent population.

2) Governmental Consumption

GDP of public administration has not increased and shown a flat trend. The Team recommends, therefore, keeping the current level of consumption at 0.09 G/day for demand forecast.

(5) Non Revenue Water

As described before, water production is around 3.69 MG/day on average. According to daily reports of KAWTP, daily maximum water production (maximum figure in a year) is around 4.0 MG/day. Those figures are equivalent to 2,562 G/min or 2,778 G/min. Since two or three pumps (1,050 G/min capacity) are usually operated for water transmission from KAWTP, the mentioned production volumes are nearly the same as the estimated from the pumping capacity. It is, therefore, assumed that the indicated volumes by flow meter of KAWTP show the actual water production.

It is difficult to grasp water consumption (water volume to be billed) and NRW accurately, due to no deployment of district flow meters and no calibration system for customers' meter. Furthermore, meters are not installed for 13% of the customers. The Team, therefore, assumed the following as the current situation:

1) Illegal Connection

Illegal connection is not a serious issue in Palau and rarely observed. The Team, therefore, did not count it separately. Water flow for the illegal connections is included in "NRW difficult to eliminate", which is described in the next clause.

2) NRW Difficult to Eliminate

It is difficult to eliminate NRW perfectly. This kind of NRW includes the following:

- Illegal connections which are difficult to be detected.
- Leakages which are difficult to be detected or to be repaired quickly.
- Emergency uses.

No data is available for such water losses. The losses, except the emergency uses, are essentially low if countermeasures are appropriately undertaken like scheduled replacement of pipelines, periodical detection or patrol for leakage and illegal connection, etc. Expecting the provision of mentioned countermeasures, such losses should be accounted at lower. The Team, therefore, assumed it as 5% of NRW.

3) Meter Malfunctions and Mis-reading

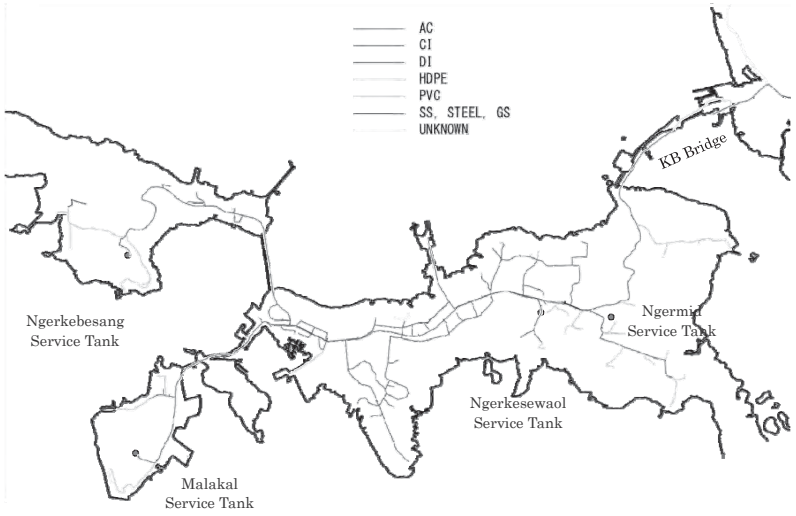
Meter accuracy becomes lower with age. Moreover, mis-readings of meter indications should be accounted in NRW. There are not sufficient data to analyze those commercial losses. The Team, however, assumes it at low according to the following reasons:

- If recorded consumptions were small in water volume, a large volume of commercial losses could be assumed.
- Since the recorded water consumptions in Koror - Airai is relatively large, no higher commercial losses could be assumed.

Although PPUC is conducting meter installation / replacement project in 2014, it is difficult to replace all old meters and to secure the perfect accuracy due to limited number of purchased meters. The team, therefore, assumed it as 5% of NRW.

4) Current Leakage from Pipeline

Old asbestos cement (AC) pipes, which were laid 40 years ago or more, accounts for 67% in the water distribution networks. The spread of AC pipelines is shown in Figure 3.1-2.



Data Source: PPUC

Figure 3.1-2 Spread of AC Pipes

Moreover, 61% out of the 67% of the AC pipes are larger diameter pipes (6 inches diameter or more). This old AC pipe network, including lateral connections from the pipes, is believed to be a cause of the large amount of leakage. Since there are no data for leakage volume and generation frequency, the Team attempted to analyze "leakage impacts" of the exiting pipes by pipe diameter, length and material (material includes the factor for age, since AC pipes are older than 40 years and others were installed later than them.). The result is shown in Table 3.1-11. According to the table, larger diameter AC pipes (6 inches diameter or more) may cause 81% of the leakage. For the above analysis, the Team took the following assumptions into consideration:

- Leakage probability can be calculated by diameter x length.
- AC pipes have more generation frequency than others. Accordingly, the Team adjusted the leakage probabilities (impacts) by adjustment factor (1.5 for AC and 1.1 for others).
- Japan Water Works Association (JWWA) analyzes the probabilities of pipeline accident as shown in Table 3.1-12. According to the table, the accident probability of AC pipes is 1.33 times higher than that of polyvinyl chloride (PVC) pipes. When the Team define the adjustment factor at 1.1 for PVC pipes, the factor for AC pipes should be calculated at 1.5 (=1.1 x 1.33). No data is available for high density polyethylene (HDPE) pipe. Accordingly,

the Team recommends it to be same as PVC pipe. As for steel pipe, details of material are unknown. The Team, accordingly, recommend the average value (=1.1) between steel and cast iron.

Table 3.1-11 Impacts to Leakage for Existing Pipelines

Category	Pipe Diameter	AC	HDPE	PVC	Steel	Unknown	Total
Length	6 inches or more	32,449	786	5,784	208		39,227
(m)	Less than 6 inches	3,380	0	7,725	580	2,623	14,308
	Total	35,829	786	13,509	788	2,623	53,535
Share of	6 inches or more	61%	1%	11%	0%	0%	73%
Pipe	Less than 6 inches	6%	0%	14%	1%	5%	27%
(%)	Total	67%	1%	25%	1%	5%	100%
Section Area of pipe	6 inches or more (assume 8 inches)	50	50	50	50	50	
(sq. inches)	Less than 6 inches (assume 4inches)	13	13	13	13	13	
	Total						
Estimated impact for NRW	6 inches or more	1,630,238	39,489	290,588	10,450	0	1,970,765
by diameter & length	Less than 6 inches	42,453	0	97,026	7,285	32,945	179,709
(m x sq. inches)	Total	1,672,691	39,489	387,614	17,735	32,945	2,150,474
Adjustment factor	6 inches or more	1.5	1.1	1.1	1.1	1.1	
by pipe material	Less than 6 inches	1.5	1.1	1.1	1.1	1.1	
(%)	Total						
Adjusted impact for NRW	6 inches or more	2,445,357	43,438	319,647	11,495	0	2,819,937
by diameter & length	Less than 6 inches	63,680	0	106,729	8,014	36,240	214,663
(m x sq. inches)	Total	2,509,037	43,438	426,376	19,509	36,240	3,034,600
Estimated impact for NRW	6 inches or more	**81%**	1%	11%	0%	0%	93%
by diameter & length	Less than 6 inches	2%	0%	4%	0%	1%	7%
(%)	Total	83%	1%	14%	1%	1%	100%

AC: Asbestos cement pipe, HDPE: High density polyethylene pipe, PVC: Polyvinyl chloride pipe

Source: JICA Survey Team

Table 3.1-12 Accident Probability by Pipe Materials

Pipe Material	Accident Probability
Ductile Cast Iron	0.02 accident / km / year
Cast Iron	0.20 accident / km / year
Steel	0.02 accident / km / year
PVC	0.30 accident / km / year
AC	0.40 accident / km / year

Data Source: JWWA (Guideline for Replacement of Water Facilities, 2004)

5) Assumed Breakdown of Current Leakage

According to the above mentioned assumptions, the Team estimated the current situation as shown in Table 3.1-13. The leakage is generated on not only distribution pipes but also lateral pipelines. The leakage on lateral pipelines would not be a little in volume. The assumed and indicated leakages in the table include such generated leakage on lateral pipelines branching off the distribution pipes.

Table 3.1-13 Assumed Breakdown for Current NRW

Category		Current Situation
Production (MG/d)		3.69
Total NRW (MG/d)		1.78
	NRW Ratio for total base	48%
a	NRW difficult to eliminate (5% of total NRW)	0.09
b	Meter malfunction (5% of total NRW)	0.09
c	Leakage on pipelines (MG/d)	1.60
	Impact of AC (6 inches or more)	81%
	Impact of other pipes	19%
	Leakage on AC pipes (6 inches or more) (MG/d)	1.3
	Leakage on other pipes (MG/d)	0.3

Source: JICA Survey Team

(6) Demand Forecast

1) Assumed NRW Reduction according to Pipe Replacement and NRW Reduction Schedule

The larger diameter AC pipes could be a main cause for the high NRW. The schedule for NRW reduction should be planned along with leakage reduction in the pipelines.

The Team attempted to calculate the amount of NRW that can be reduced by replacement of the larger diameter AC pipes (6inches or more). The calculation was done under the following assumptions:

- The simulation is done under current consumption conditions. In other words, the simulation would show the NRW if replacement was done immediately.
- The replacement is scheduled to be completed in 6 years for total of 32.4km pipes (average 5.5km per year). It is proposed to reduce NRW to 33% or less in 2020 (33% in 2020 is the target of ADB recommendation). It is estimated that NRW ratio will become 32% when 68% of larger diameter are replaced (4th year).
- Water production is able to be reduced by the reduced leakage on pipeline. According to the reduction of production, it was assumed that volume of “NRW difficult to eliminate” and “Meter malfunction” will be also reduced even if the generation ratios are unchanged.
- The estimation shows that the NRW will be reduced to 20% if all larger diameter pipes are replaced as presented in Table 3.1-14.

Table 3.1-14 Assumed NRW Reduction by Pipe Replacement (Current Consumption Base)

Rate to Replace Larger AC Pipes (6 inches or more) Total 32.5km / Water Production / NRW	Current	2017	2018	2019	2020	2021	2022
	Current	1st year	2nd year	3rd year	4th year	5th year	6th year
		5.5km	11.1km	16.6km	22.1km	27.6km	32.5km
Production (MG/d)	3.69	3.47	3.25	3.03	2.81	2.59	2.39
Total NRW (MG/d)	1.78	1.56	1.34	1.12	0.90	0.68	0.48
NRW Ratio for total base	**48%**	**45%**	**41%**	**37%**	**32%**	**26%**	**20%**
a NRW difficult to eliminate (5% of total NRW)	0.09	0.08	0.07	0.06	0.05	0.03	0.02
b Meter malfunction (5% of total NRW)	0.09	0.08	0.07	0.06	0.05	0.03	0.02
c Leakage on pipelines	1.60	1.38	1.16	0.94	0.72	0.50	0.30
Impact of AC pipes (6inches or more)	81%	78%	74%	68%	58%	40%	0%
Impact of other pipes	19%	22%	26%	32%	42%	60%	100%
Leakage on AC pipes (6inches or more)	1.3	1.08	0.86	0.64	0.42	0.20	0.00
Leakage on other pipes	0.3	0.3	0.3	0.3	0.3	0.3	0.3

Source: JICA Survey Team

2) Demand Plan and Schedule for NRW Reduction until 2020

Pipe replacement is able to be commenced in the end of 2015 or the beginning of 2016. Therefore, some of the replacement effects on NRW ratio may appear in (may not appear before) 2017. To have 33% or less NRW ratio in 2020 and to have the effects of pipe replacement from 2017, the Team simulated the water production, consumption and NRW as shown in Table 3.1-15. With the replacement of the larger diameter AC pipes (6 inches or more) at around 5.5km per year rate, PPUC could reduce the water production to 3.09MG/d on average.

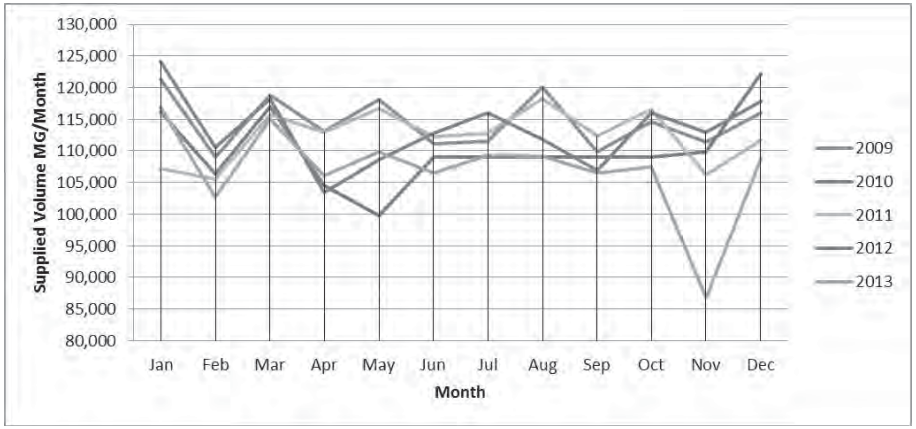
Table 3.1-15 Demand Plan until 2020

Category	2013	2014	2015	2016	2017	2018	2019	2020
Population	14,126	14,050	13,975	13,900	13,826	13,754	13,682	13,610
Foreign visitors per day	1,151	1,233	1,319	1,413	1,512	1,619	1,733	1,856
Equivalent population	15,277	15,283	15,294	15,313	15,338	15,373	15,415	15,466
Domestic Consumption								
Unit consumption (G/capita/d)	68.0	68.0	68.0	68.0	68.0	68.0	68.0	68.0
Domestic consumption (MG/d)	0.96	0.96	0.95	0.95	0.94	0.94	0.93	0.93
Non-Domestic Consumption (Gov)								
Consumption (G/capita/d)	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09
Annual increase ratio		0%	0%	0%	0%	0%	0%	0%
Non-Domestic Consumption (Com)								
Flat rate consumption (MG/d)	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Annual increase ratio		3.4%	3.4%	3.4%	3.4%	3.4%	3.4%	3.4%
Metered consumption (MG/d)	0.85	0.88	0.91	0.94	0.97	1	1.03	1.07
Annual increase ratio		3.4%	3.4%	3.4%	3.4%	3.4%	3.4%	3.4%
Total Commercial consumption (MG/d)	0.86	0.89	0.92	0.95	0.98	1.01	1.04	1.08
Grand Total for Consumption (MG/d)	1.91	1.94	1.96	1.99	2.01	2.04	2.06	2.10
NRW								
NRW (MG/d)	1.78	1.79	1.81	1.70	1.64	1.42	1.21	0.99
NRW ratio %	48%	48%	48%	46%	**45%**	**41%**	**37%**	**32%**
Production (MG/d)	3.69	3.73	3.77	3.69	3.65	3.46	3.27	3.09
Reference								
Production (G/capita/d)	261	265	270	265	264	252	239	227
Production (G/equivalent population/d)	242	244	247	241	238	225	212	200

Source: JICA Survey Team

(7) Daily Maximum Production

As mentioned in the previous section, the daily average demand will be reduced to 3.09 MG/day in 2020. However, it is not a practical design capacity for the facilities since the water demand fluctuates throughout the year. Figure 3.1-3 shows the fluctuation for the recent 5 years. In general, the peak demand is recorded in December and / or January, which have relatively more foreign visitors and less rainfall.



Remark: In November 2013, very low production was recorded due to leakage accident at KB Channel.

Data Source: Daily report of KAWTP, PPUC

Figure 3.1-3 Current Fluctuation of Water Production

Table 3.1-16 shows the average and maximum daily productions in the recent 5 years. According to the data, the production (demand) of the peak day is around 1.07 times of the average. It is, therefore, necessary to design water treatment and transmission facilities (including service tanks) with the 1.07 times of average demand. In short, the design daily maximum demand should be 3.31 MG/day. "3.31MG/day" is not, however, a practical designing figure of the facilities for Koror - Airai water supply system. Since the actual daily maximum water flow will decrease after improvement projects, the facilities' design for the beginning phase should be based on the current maximum flow (4MG/day).

Table 3.1-16 Load Factor for the Recent 5 Years

Item	2009	2010	2011	2012	2013	Ave
Average MG/day	3.77	3.62	3.69	3.71	3.58	3.67
Maximum MG/day	4.02	3.88	3.86	3.94	4.03	3.94
Load Factor	1.07	1.07	1.05	1.06	1.10	1.07
Ave / Max	94%	93%	96%	94%	89%	93%

Remark: Data for exceptional month, which is November 2013, are excluded from the above analysis.

Data Source: KAWTP, PPUC

3.1.3 Conditions and Issues on Water Sources

(1) Water Balance

Using rainfall data, the Team calculates the water balance. The result of the calculation shows that the ratio of groundwater recharge against annual precipitation is 23.3%, and ratio of direct runoff against annual precipitation is 46.7%.

It is estimated that 46.7% of the rainfall can be available as surface water, and that 23.3 % of the rainfall can be used as groundwater.

Table 3.1-17 Water Balance Analysis

	Item	Estimate (mm/year)	Ratio against annual precipitation (%)	Note
(1)	Annual precipitation	3,734[1)]	100	Long term average of rainfall by observation[1)]
(2)=(1) x70%	Surface water discharge	2,614	70.0	Average of runoff of surface water is estimated as 70% of annual precipitation.[2)]
(3) =(1)-(2)	Evapotranspiration	1,120	30.0	30% correspond to the observed result of evapotranspiration in Guam and Yap which have similar climate condition with the Survey area. So, the above estimation seems reasonable.
(4) =(2)/3	Base Flow (Groundwater recharge)	871	23.3	Base flow (=groundwater recharge) was estimated as one third [3)] of precipitation surface water discharge of 2,614mm.
(5) =(2)-(4)	Direct runoff of surface water	1,743	46.7	Direct runoff = total runoff-groundwater recharge

Source:
1) NOAA's National Climatic Data Center (NCDC)
2) Water Resources Report, by John William Porter, "Preparing Babeldaob Water Supply Project (2009)" and "Comprehensive Groundwater Protection Strategy (1996)"
3) There is no detailed daily discharge data that shows ratio between runoff and base flow. So the ratio of runoff and base flow was temporarily assumed considering of Japanese case.

(2) Drought Situation and Climate Change (El Nino)

The Team focuses on a three-month's precipitation in dry season, February to April, for study because of the data of intake water amount are not available during drought periods.

The monthly average rainfall from February to April is 8.97 inches (229mm). The monthly average rainfall recorded for February - April in 1983, 1998, 1992 are less than 40% of the 50 years average. These are categorized as severe drought years (Refer to Figure 3.1-4 and Table 3.1-20).

According to the formula shown below, 10.2MG/day of water is usually available even if in February-April. It is sufficient for the production of KAWTP (Refer the result of calculation shown below).

1) Possible amount of intake water per day
= Monthly average rainfall × 0.7 × (1-1/3) × Catchment Area / 30days
= 8.97 inches / month × 0.7 × (1-1/3) × 10.7 km^2 / 30days
= 10.2MG / day

The precipitation requirement is calculated based on the water demand in 2020, 3.3MG/day (12,491 m^3/day).

In order to secure 3.3MG/day, which is the planned daily maximum water production, the monthly rainfall is required to be 2.96 inches/month (Refer the result of calculation shown below, and Table 3.1-18 for Calculation Conditions).

2) Possible amount of intake water per day
=Monthly average rainfall × 0.7 × (1-1/3) × Catchment Area / 30days
3.3MG/day = Monthly average rainfal×0.7 × (1-1/3) ×10.7km^2 / 30days
→ Monthly average rainfall = 2.96inches / month

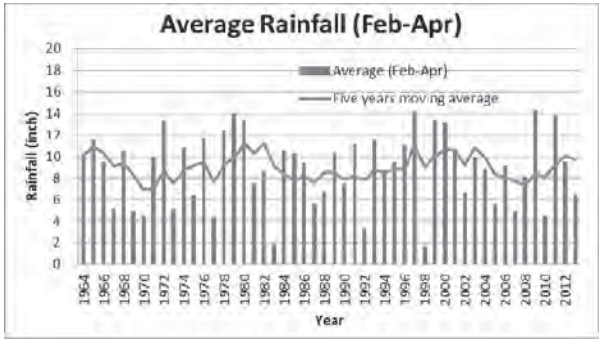
Result of the calculations shown above, the drought had happened twice during 30 years, in particular 1983 and 1998. The drought is defined as a year in which February to April's average precipitation is less than 2.96inches/month (75mm/month), which is the required precipitation for water demand in 2020, 3.3 MG/day (12,491 m^3/day). The frequency of drought situation satisfies the standard reliability of water utilization in Japan, once a decade. In addition, the El Niño effect was observed in the duration of the drought situation. So if the occurrence frequency of El Niño increase, the risk of the drought situation might also increase.

Concentrating only on February rainfall of the last 50 years, the number of cases with less than 2.96 inches/month reaches seven (7). It is, therefore, necessary to pay efforts for appropriate storage of rainwater.

Table 3.1-18 Calculation Method of Possible Amount of Intake Water

Item	Calculation conditions
Possible amount of intake water	①Volume of runoff of surface water：70% of Rainfall ②Base Flow：1/3 of Volume of runoff of surface water Available volume for intake ＝①－②
Catchment Area	Ngerikiil Intake Pump Station (Ngerikiil IPS)＝8.5km^2 Ngerimel Dam ＝2.2 km^2
Monthly average rainfall	9 inches / Month (228.6mm/month) =Monthly average rainfall from February to April
Calculating formula	Possible amount of intake water per day =Monthly average rainfall×0.7×(1-1/3) ×Catchment Area / 30days

Source: JICA Survey Team



Source: NOAA's National Climatic Data Center (NCDC)

Figure 3.1-4 Monthly Average Rainfall (February-April)

Table 3.1-19 Period of El Niño

No.	Period
1	1963/Jun – 1964/Jan
2	1965/May – 1966/Feb
3	1968/Sep – 1970/Feb
4	1972/May – 1973/Mar
5	1976/Jun – 1977/Mar
6	1982/Aug –1983/Aug
7	1986/Sep – 1988/Jan
8	1991/Apr – 1992/Jul
9	1997/Apr – 1998/May
10	2002/Jun – 2003/Feb
11	2009/Jun – 2010/Mar

Source: Japan Meteorological Agency

Table 3.1-20 Monthly Average Rainfall (February-April)

YEAR	FEB-APR Average rainfall (inch/month)	Rank
1964	10.18	
1965	11.58	
1966	9.53	
1967	5.19	10
1968	10.56	
1969	4.96	7
1970	4.61	6
1971	10.03	
1972	13.30	
1973	5.16	9
1974	10.86	
1975	6.50	
1976	11.80	
1977	4.46	4
1978	12.49	
1979	14.04	
1980	13.45	
1981	7.50	
1982	8.72	
1983	1.82	2
1984	10.54	
1985	10.36	
1986	9.47	
1987	5.59	
1988	6.74	
1989	10.46	
1990	7.52	
1991	11.17	
1992	3.36	3
1993	11.54	
1994	8.77	
1995	9.52	
1996	11.09	
1997	14.22	
1998	1.69	1
1999	13.46	
2000	13.17	
2001	10.78	
2002	6.71	
2003	9.98	
2004	8.92	
2005	5.61	
2006	9.17	
2007	4.99	8
2008	8.20	
2009	14.29	
2010	4.56	5
2011	13.85	
2012	9.54	
2013	6.54	
Total	448.57	
Ave.	8.97	

Source: NOAA's National Climatic Data Center (NCDC)

(3) Issue

For usual cases, the current water source is enough to supply the water at 4MG/d. The frequency of draught influencing the water intake is twice per 30 years. Moreover, it is possible to reduce water requirement through reduction of leakage and NRW. Additional / alternative water resources development is not, therefore, very urgent. The new development of water resources should be

examined and planed for middle - long term basis, considering the reduction results and/or reduction schedule of NRW.

If the frequency of El Nino increases, the drought frequency might be also higher than the current one. In such case, examinations for countermeasures should be undertaken against water shortages. As countermeasures, 1) Increasing storage capacity of rainwater and 2) Development of additional water resources such as well field are recommended.

3.1.4 Conditions and Issues on Koror - Airai Water Treatment Plant

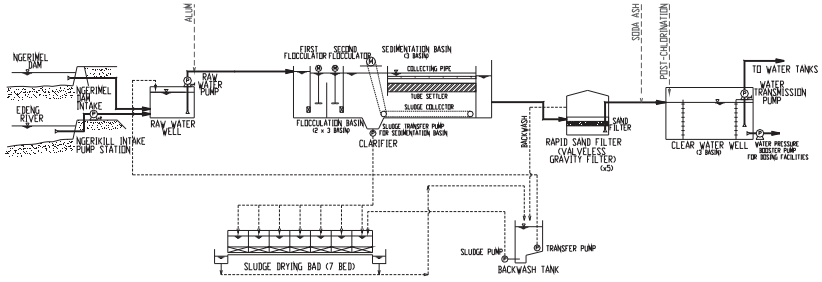
(1) Main Equipment

Koror - Airai Water Treatment Plant (KAWTP) was originally constructed in the 1970s with 3 rapid sand filters (valve-less gravity filters). It was, then, expanded to be 5 filters in the 1990s to 2000. Although KAWTP is old, it has a production capacity of 4 MG/day. The main components of KAWTP are shown in Table 3.1-21.

Table 3.1-21 Main Components of KAWTP

No	Name	Component
1	Water Treatment Facility	Raw water well, Raw water pumps, Clarifier (Flocculation basins, Sedimentation basins), Rapid sand filters, Chemical feeding facilities, Sludge drying beds, Clear water well
2	Water Transmission Facility	Water transmission pump facility
3	Laboratory	Analytical equipment for water analysis
4	Operation Control Facility	Control panel, Monitoring panel, Flow meter
5	Power Receiving and Transforming Facility	Power receiving equipment, Transformer
6	Emergency Generator	Diesel generator
7	Building	Administration building, Warehouse

Source: JICA Survey Team



Source: JICA Survey Team

Figure 3.1-5 Schematic Process of KAWTP

1) Raw Water Well and Raw Water Pump

There are 2 sources of water for KAWTP, which are Ngerikiil Intake Pump Station (Ngerikiil IPS) and Ngerimel Dam. The water from the sources is conveyed separately by pipelines to raw water well of KAWTP. The flow from Ngerikiil IPS is kept continuously. The raw water flow from Ngerimel Dam is controlled / regulated according to the demand by an inlet valve at Raw Water Well.

Raw water is transferred to the clarifier by raw water pumps. The main specification of raw water pump is as shown in Table 3.1-22. Currently, 1 pump (No. 3) has been removed due to trouble and stored in the warehouse. Three raw water pumps have been operated according to the necessary flow as shown in Table 3.1-23.

It is recommended to replace the pumps and to install the flow meters to manage intake volumes.

Table 3.1-22 Main Specification of Raw Water Pump

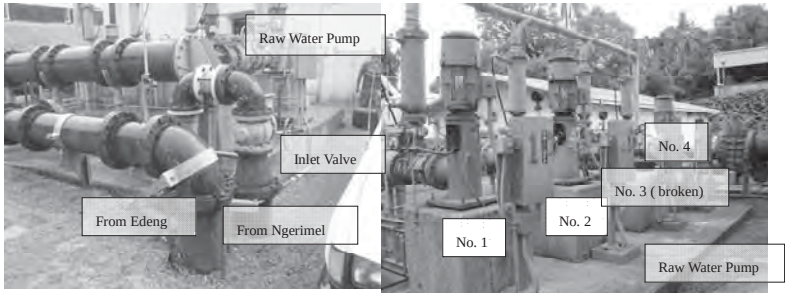
Pump Type	Vertical centrifugal pump
Number of Pump	4 (2 for regular, 1 for spare operations and 1 in broken)
Discharge Quantity	1,080G/min (per 1 unit)
Pumping Head	44 feet
Output of Main Motor	20 kW

Source: JICA Survey Team

Table 3.1-23 Operation Modes of Raw Water Pump

Required Flow	Pump Operation
4.0MG/day	3-always on
3.9MG/day	2-always on, 1-auto by float switch
2.7MG/day	2-always on, 1-off

Source: JICA Survey Team



Source: JICA Survey Team

Figure 3.1-6 Raw Water Well and Raw Water Pump

2) Mixing Basin

There is no mixing basin in KAWTP for coagulant. Currently, dissolved alum-sulphate is injected just behind the Raw Water Pumps. Then, the mixed water is delivered to the receiving well of

clarifier. The distance from the injection point to the receiving well, which is around 170 ft., is so long that the flocculation may be harmed. Coagulant shall be mixed rapidly just before the clarifier for effective flocculation. Therefore, the installation of mixing basin in front of the clarifier is recommended. Then the injection point shall be replaced by this mixing basin.

3) Clarifier

The clarifier consists of flocculation basins and sedimentation basins.

The flocculation basins are placed before the sedimentation basins. Mechanical system is applied for flocculation. As it is required to be tapered flocculation according to the growth of flocs, 2 kinds of flocculator are installed. The rotating speed of the flocculators is 45 and 20 rpm respectively. The main specification of flocculation basins is as shown in Table 3.1-24.

Table 3.1-24 Main Specification of Flocculation Basins

Type	Mechanical mixing horizontal flocculator
Size	1st basin: $15ft^{W}x15ft^{L}x10.3ft^{Dep}$x3 basins (lines); Up flow 2nd basin: $15ft^{W}x15ft^{L}x10.3ft^{Dep}$x3 basins (lines); Down flow
Capacity	104,000 G (total of 6 basins)
Number	6 basins (2 rows x 3 lines)

Source: JICA Survey Team

A Sedimentation Basin is installed in order to remove large size floc by sedimentation and to reduce the load of the following filtration basin. The main specification of the sedimentation basin is as shown in Table 3.1-25. Three basins (width: 14.5ft per basin) are installed in consideration of cleaning, inspection and repair. Sludge collector is also equipped in each basin.

Table 3.1-25 Main Specification of Sedimentation Basin

Type	Up flow sedimentation basin with tube settler
Size	$15ft^{W}$ x $45ft^{L}$ x $3ft^{Dep}$×3 basins(lines)
Capacity	154,800G (total of 3 basins)
Number	3 basins (1 row x 3 lines)

Source: JICA Survey Team

Source: JICA Survey Team

[left] Flocculation Basins, [right] Sedimentation Basins

Figure 3.1-7 Clarifier

The dislodging from clarifier is usually held 3 times for about 10 minutes per day per basin. The tube settlers are cleaned usually once per month per basin. The condition of tube settler before and after cleaning is as shown in the following photos. As a few of the small flocs carry over to the

outlet pipe, periodic cleaning of clarifier is recommended.

Source: JICA Survey Team

[left] before cleaning, [center] just after cleaning, [right] 1 day after cleaning

Figure 3.1-8 Condition of Tube Settler

4) Rapid Sand Filter

There are 5 units of valve-less gravity filters. The main specification of rapid sand filter is as shown in Table 3.1-26.

Table 3.1-26 Main Specification of Rapid Sand Filter

Filtering Type	Rapid sand filter with valve-less gravity filter system
Backwashing method	Automatic backwashing by siphon
Shape	Circular
Size of filter	$22ft^{Dia}$ x $24Inch^{H}$ /filter
Number	5 filters

Source: JICA Survey Team

Backwashing of sand filter is usually conducted almost once every other day per filter manually for about 20 minutes, in spite of automatic backwash system by siphon. Outflowed sands are sometimes observed at clear water well. Cracks are, therefore, suspected at the bottoms of the filters.

The Valve-Less Gravity Filter was devised originally for the cool climate where water temperature is low, such as North America and Europe. It is, therefore, supposed to be unsuitable for the hot climate where water temperature is high, such as Palau.

As described above, it is recommended that rapid sand filters be renewed.

Source: JICA Survey Team

[left] As built Drawing in 1990s by WWO, [center] No.3 Filter, [right] Backwashing

Figure 3.1-9 Rapid Sand Filter

5) Chemical Dozing Facilities

KAWTP has chemical dosing facilities which feed calcium hypochlorite, aluminum sulphate (alum), powdered active carbon (PAC) and soda ash (Na_2CO_3) as sterilizer and coagulant, respectively.

Currently, only calcium hypochlorite, alum and soda ash are fed by 3 chemical dosing facilities. One chemical dosing facility has been out of order. Calcium hypochlorite is fed to clear water well.

According to the As Built Drawing of the 1990s, injection points of PAC and coagulant substances (alum and soda) were designed just after the Raw Water Pumps. Currently, only dissolved alum is injected just after the Raw Water Pumps. The PAC has not been fed injected, and the soda ash has been fed just in front of clear water well as shown in Figure 3.1-5. It is unknown why soda ash isn not fed before clarifier as pH conditioner. It is recommended that soda ash shall be fed at an appropriate point and in an appropriate amount based on examined pH value.

Since the chemical dosing facilities are deteriorated, renewal is recommended.

Source: JICA Survey Team

[left] Chemical Dosing Facilities, [center] Dosing Facility (Alum), [right] Dosing Facility (Calcium Hypochlorite)

Figure 3.1-10 Chemical Dosing Facility

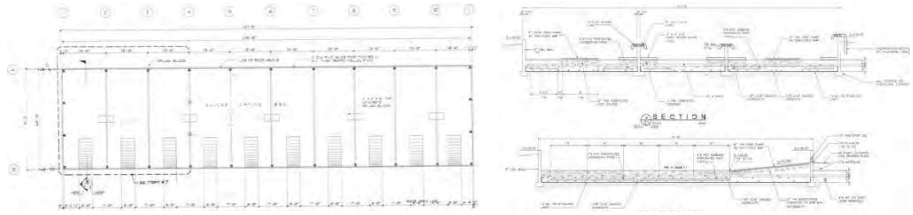
6) Sludge Drying Bed

There are 7 beds for sludge drying with roof. The main specification of sludge drying bed is as shown in Table 3.1-27.

Table 3.1-27 Main Specification of Sludge Drying Bed

Shape	Rectangular
Size	$60ft^W$ x $24ft^L$ /bed
Number	7beds

Source: JICA Survey Team



Source: As Built Drawing in 1990s by WWO; 7 beds had been constructed as built.

Figure 3.1-11 Sludge Drying Bed

The sludge from clarifier is discharged to the sludge drying bed by gravity. The sludge from backwash of rapid sand filters is discharged to the sludge drying bed by sludge pumps in the backwash tank. However, sludge pumps have not been operated.

Sludge is dried up for 1 month in case of dry season, and for 2 months in case of rainy season.

Sometimes discharged sludge from clarifier overflows from the sludge drying bed to the natural stream as shown in the following photos. It is recommended to be held appropriate operation for sludge drying bed.

Source: JICA Survey Team

[left] Just discharged, [center] Dried up, [right] Overflow of sludge

Figure 3.1-12 Sludge Drying Bed

7) Clear Water Well

The original Clear Water Well for treated water transfer pumps in Airai P/S was built in the 1970s. The capacity is estimated at about 72,655G (275m^3) with the dimensions of 32ft-4inches (9.855m) width, 38ft (11.6m) length and 8ft (2.4m) depth approximately. The Clear Water Well is in concrete structure and was constructed without reinforcement; therefore, a fairly large amount of leakage is anticipated.

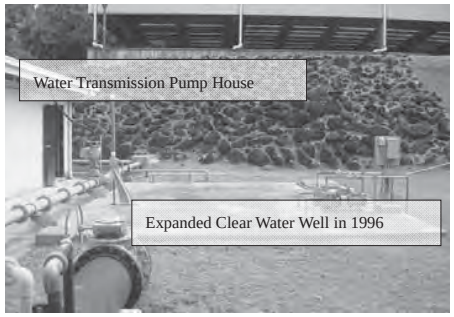
It is also found that ground water penetrates into the decrepit well from outside when the water level in the well is lower. It is considerable that treated water is not only leaked, but also contaminated.

Source: JICA Survey Team
Original Clear Water Well constructed in 1970s
Inflow from Filter

Original Clear Water Well
Ground water penetrates into the decrepit well from outside when water level in the well is lower.

Figure 3.1-13 Clear Water Well

In 1996, an additional Clear Water Well was constructed adjacent to the original Clear Water Well. The capacity is estimated at 20,600G (78m^3) with the dimensions of 18ft (5.4m) width, 20ft (6m) length and 8ft (2.4m) depth approximately.



Source: JICA Survey Team

Figure 3.1-14 Expanded Clear Water Well

Although the Clear Water Well was expanded in 1996, its volume was small and the decrepit original Clear Water Well is used continuously.

Therefore, it is necessary to construct an additional clear water well or improve the existing clear water well.

8) Water Transmission Pump

Treated water is transferred to one Service Tank (Airai Service Tank) in Airai and 3 Service Tanks (Ngermid Service Tank, Ngerkesewaol Service Tank and Arakabesang Service Tank) in Koror through 4 units of Water Transmission pumps, each with 1050G/min discharge capacity and 100HP as shown in Table 3.1-28. Currently, two or three pumps are operated and one is for stand-by based on the following operation system, in principle:

- From 24:00 to 5:00am: 2 units operation
- From 5:00am to 24:00: 3 units operation

The water transmission volume varies from 2.5 MG/day to 3.8 MG/day according to the record of transmission volume on July 16, 2014 (refer to Table 3.1-29).

Table 3.1-28 Main Specification of Water Transmission Pump

Pump Type	Vertical centrifugal pump
Number of Pump	4 (3 for regular, 1 for spare operations)
Discharge Quantity	1,050G/min (per 1 unit)
Horse Power	100 HP

Source: JICA Survey Team

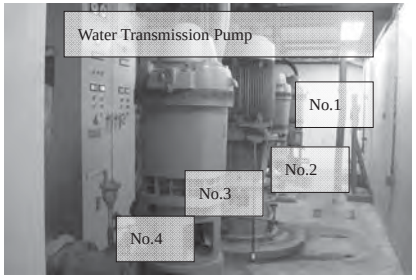
Table 3.1-29 Pump Operation of Water Transmission Pump

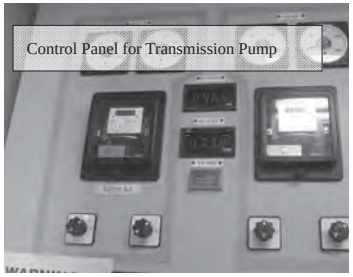
Flow	Pump Operation
Approx. 2.5MG/day	From 24:00 to 5:00am: 2 units operation
Approx. 3.8MG/day	From 5:00am to 24:00: 3 units operation

Source: JICA Survey Team

PPUC is planning to replace No.1 and No.2 Transmission pumps shown in Figure 3.1-15 with 2 sets of new pumps (capacity: 1,400G/min, Head: 293ft) by the end of December, 2014 by the program loan of ADB. The existing Control Panel will be modified in conjunction with the replacement of pumps.

Accordingly, new Transmission pumps will be able to send the treated water of 4 MG/day.





Source: JICA Survey Team

Figure 3.1-15 Water Transmission Pump

9) Laboratory Equipment

Laboratory for water quality analysis is necessary to check the change in raw water quality and safety of treated water. The laboratory has been installed in the administration building. Only the items listed in Table 3.1-30 have been examined using overage equipment every hour on daily basis.

These overage equipment have never been maintained and calibrated since procured. Automatic turbidity meter on the wall has been out of order.

Jar test is usually conducted every 6 hours on daily basis to calculate the feeding ratio of alum as

coagulant, currently.

It is recommended that more kinds of water quality such as pH shall be examined and new equipment be procured. And it is recommended to conduct the capacity building for the management of the water treatment system.

Table 3.1-30 Current Water Quality Analysis in KAWTP

Item	Test Method	Sampling Point
Physical Analysis		
Turbidity	Turbidity meter	(1)Raw water, (2)Before Filter, (3)After filter, (4) Clear Water Well
Chemical Analysis		
Chlorine	Chlorine ion meter	(1) Clear Water Well

Source: JICA Survey Team

Source: JICA Survey Team

[left] Turbidity meter (left), Chlorine ion meter(right), [center] Automatic Turbidity meter (out of order), [right] Jar Test

Figure 3.1-16 Equipment for Water Quality Test

10) Power Receiving Equipment

It has been more than 15 years since the installation of the transformer. PPUC shall, therefore, take into consideration the replacement the equipment in the medium or long terms plan.

It is noted that the electric pole which is wooden and old should be replaced as soon as possible.

Source: JICA Survey Team

Figure 3.1-17 Power Receiving Equipment

11) Emergency Generator

The Emergency Generator was installed in 1996 with the following specifications:

Rating	985 kVA, 750 kw Power factor: 0.8 Frequency: 60Hz
Generator Data	3 phase , 6 wire Generator; 480 Volts, 1128 AMPs Excitation; 36 Volts, 7.5 AMPs

Since no serious issues are found in the Emergency Generator and numbers of times of electric power failure are decreasing after the completion of Aimeliik Power Plant on June, 2014, the existing generator will be enough for KAWTP. However, the periodical maintenance is necessary.

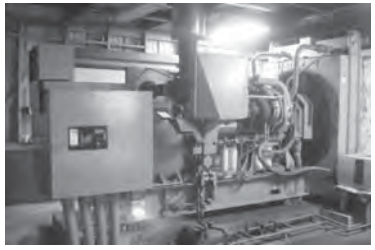


Figure 3.1-18 Emergency Generator

(2) Result of Water Quality Analysis

The water quality examination was conducted with equipment owned by Team, at KAWTP during the field survey. The analyzed items are turbidity, ammonium nitrogen, nitrate nitrogen, and E-coli at 4 sampling points. As the result presented in Table 3.1-31 shows, the analyzed value of turbidity after injection of chlorine is slightly higher than that of before injection of chlorine. As shown in Table 3.1-32, there is a difference on the analyzed values for turbidity between PPUC's turbidity meters and the Team's one. The accuracy improvement of the PPUC's turbidity meter is necessary for the safety of treated water.

Table 3.1-31 Result of Water Quality Analysis

Sampling point	Turbidity (NTU)	Ammonium nitrogen (ppm)	Nitrate nitrogen (ppm)	E-coli
Raw Water	8.8	< 0.2	< 0.2	None
Before Filter	6.5	< 0.2	< 0.2	None
After Filter	0.9	< 0.2	< 0.2	None
Clear Water Well	1.1	< 0.2	< 0.2	None

Source: JICA Survey Team

Table 3.1-32 Result of Water Quality Analysis

Sampling point	Turbidity (NTU)	
	PPUC owned tubidimeter (Hach 2100P Portable Tubidimeter)	Team owned tubidimeter (Dkk-Toa TB-31 Portable Tubidimeter)
Bottled Mineral Water	0.54	0.1
Raw Water	16.70	22.3
Before Filter	13.50	17.9
Clear Water Well	3.04	2.8

Source: JICA Survey Team

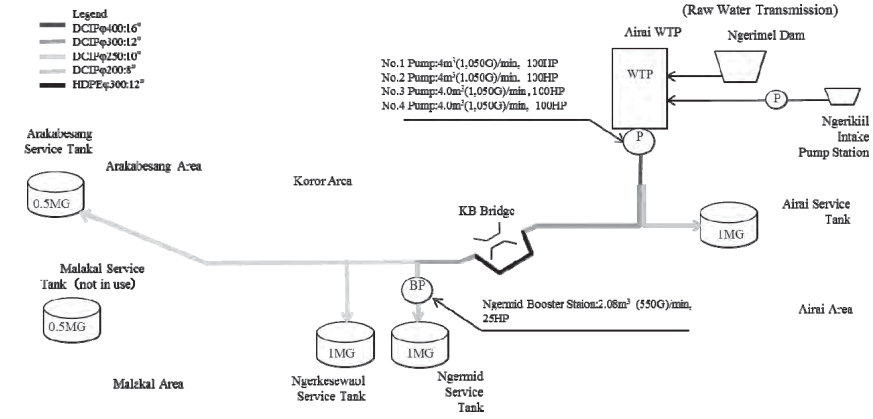
3.1.5 Conditions and Issues on Water Transmission and Distribution Reservoirs

(1) Conditions of Water Transmission system

1) Current Water Transmission system from Airai Pump Station

The treated Water for Koror and Airai area is transmitted from Airai Pump Station (P/S) of KAWTP through one transmission pipeline (Dia. 400mm: 16inches). This line branches to Airai Service Tank by a transmission pipe (Dia.200mm: 8inches). Then, the main pipeline (Dia. 300mm: inches) delivers the water to Koror . The Transmission pipe for Koror area is currently installed at the bottom of KB Channel and connected to 3 Service Tanks (Ngermid Service Tank, Ngerkesewaol Service Tank and Arakabesang Service Tank). Although there is Malakal Service Tank, it has never been used since it was built in the 1970s.

The current Water Transmission System is shown in Figure 3.1-19.



Source: JICA Survey Team

Figure 3.1-19 Current Koror and Airai Water Transmission System

2) Operation of Supply Water Volume

The supplied water volume from Airai P/S is recorded by a flowmeter which was installed in 1992 through a Japan's Grant Aid Project (the Previous Project). The numbers of Transmission Pumps are four with a capacity of 1,050G/min/pump. Currently two or three pumps are usually operated.

- From 24:00 to 5:00am: 2 units operation
- From 5:00am to 24:00: 3 units operation

The water transmission volume varies from 105,680G/h to 158,520G/h approximately according to the record of transmission volume in July 2014.

The following three shifts are applied for daily operation:

- From 8:00 to 16:00
- From 16:00 to 24:00
- From 24:00 to 8:00

3) Adoption of Remote Monitoring System

A Remote Monitoring System was installed at each Service Tank (Airai, Ngermid, Ngerkesewaol and Arakabesang) taking into consideration further development in SCADA (supervisory control and data acquisition) in the future. The system was installed in June 2014, and the water level in each Service Tank is monitored every 30 minutes at the PPUC Head Office, WWO and Airai P/S. The warning notice is also sent to the Manager of WWO and the Operator in KAWTP when the water level is high in each Service Tank. The operation of pumps in Airai P/S will be adjusted according to the instruction of the Manager of WWO and the Operator in KAWTP.

4) Ngermid Booster Pump for Ngermid Service Tank

The Booster Pump has been replaced with new one (capacity: 550G/min) in June 2014. It is automatically operated according to the water level of Ngermid Service Tank. And it is also covered by the remote monitoring system.

5) Plan of replacement of Transmission Pumps in Airai P/S

PPUC will replace two sets of transmission pumps with new ones (capacity: 1,400G/min, Head: 293ft) by the end of December 2014. The new Transmission pumps can transmit 4 MG/day of water.

(2) Issue of Water Transmission system

The existing transmission pipeline (dia. 16inches to 8inches) was installed in 1993 by a Japan's Grant Aid Project (the Previous Project). Target year of the Previous Project was year 2000 and the design water supply was 2.1 MG/day. On the other hand, the water demand is estimated at 3.3MG/day in 2020 and 4MG/day for the current maximum flow. The design capacity of the existing transmission main is insufficient for the forecast water demand in 2020 and the current level of water production. Countermeasures such as additional transmission main are, therefore, necessary.

(3) Conditions of water transmission to Malakal area

There is no water transmission pipeline exclusively for Malakal Service Tank, and the water was supplied to Malakal area through Ngerkesewaol Service Tank.

Ngerkesewaol water distribution zone suffers from low and unstable water distribution pressure because of large covering area and significant increase of water demand due to foreign visitors and economic growth. Especially, it is expected that the water demand increase in Malakal area since the area has been designated as a new development area by the Koror State Government.

For the above reason, Malakal area shall be separated from the Ngerkesewaol water distribution zone and a new water transmission pipeline for Malakal Service Tank is necessary.

(4) Conditions of Service Tank

1) Current conditions of Service Tank

Five steel tanks (Airai, Ngermid, Ngerkesewaol, Arakabesang and Malakal Service Tank) were built in the 1970s. The surface of all tanks is in a very bad condition, and the paint peeled off in many places and there are serious rust and damages in the rib, baseplate and anchor bolts. The thickness of the steel wall was measured by Ultrasonic Thickness measuring equipment from the outside of tanks directly. The measurement was taken at 5 points of the periphery of the tank at the heights of 30cm and 80cm - 100cm. The situation of the measuring works is show on Figure 3.1-20. The results of thickness measurement are shown in Table 3.1-33.

2) Issue of Water Service Tank

Since the specifications or As-built drawings are scattered and none of them are available, the original thickness is not known. The good surface of the wall appears after pretreatment such as removal of paint and polishing with sandpaper in order to measure the thickness. However, there are serious rust and damages in the rib, baseplate and anchor bolts. If service tanks continue to serve without any maintenance, the tanks will decay before long.

It is necessary to repaint the surface of the tanks after applying sand blast on the surface.

Ngermid Service Tank

Arakabesang Service Tank

Pretreatment before measurement at Malakal Service Tank

Source: JICA Survey Team

Figure 3.1-20 Measurement of steel plate thickness of Service Tank

Table 3.1-33 Result of steel plate thickness of Service Tank

Service Tank	Capacity	Dimension (m)	Result of thickness (mm)			Conditions of outsides by visual inspection
			At 30cm (1ft)above ground (5places)	At 80cm (2ft-7.5in.)- 1m(3ft-3.4in.) above ground (5places)	Minimum thickness	
Airai Service Tank	1MG ($3,785m^3$)	D=20.14 H=12.878	14.19, 13.55, 14.75, 13.73, 14.09	14.13, 13.57, 14.70, 13.86, 14.14	13.55 (0.533in.)	Paint application is relatively in a good condition. No leakage is found.
Ngermid Service Tank	1MG ($3,785m^3$)	D=20.14 H-12.878	11.66, 10.81, 11.08, 11.29, 11.43	11.79, 11.66, 11.38, 11.39, 11.61	10.81 (0.426in.)	Outside surface is in a very bad condition. Rust and damage in rib, baseplate and anchor bolts are serious. No leakage is found.
Ngerkesoaol Service Tank	1MG ($3,785m^3$)	D=22.56 H=10.445	NA, 10.05, NA, 10.20, 9.69	9.63, 10.20, 9.96, 10.25, 9.83	9.63 (0.379in.)	Outside surface is in a very bad condition. Rust and damage in rib, baseplate and anchor bolts are serious. No leakage is found.
Arakabesang Service Tank	0.5MG ($1,893m^3$)	D=20.14 H=6.77	9.88, 9.57, 9.56, 9.63, 9.61	9.97, 9.68, 9.67, 9.66, 9.61	9.57 (0.377in.)	Since interior and exterior painting were done in 1992 by a Japan's Grant Aid project, conditions of rust are relatively good. However, some exterior places rusted due to lack of maintenance. No leakage is found.
Malakal Service Tank	0.5MG ($1,893m^3$)	D=20.14 H=6.77	9.73, 9.74, 9.65, 9.88, 9.61	9.67, 9.60, 9.47, 9.97, 9.80	9.60 (0.378in.)	Malakal Service Tank has never been used since establishment in 1970s. Outside surface is in a very bad condition. Rust and damage in rib, baseplate and anchor bolts are serious. Leakage is not clear.

Source: JICA Survey Team

(5) Conditions of Surging Tank

Two units of steel surging tank (No.1 and No.2) were installed at high ground levels on the way of Transmission pipeline in 1992 by the Previous Project in order to avoid the water hammer generating troubles to the Transmission pumps.

The surging tanks have not been maintained properly since they have been installed. Therefore, they have rust on the surfaces. Especially, No.1 tank is in a serious condition due to overflow caused by breakdown of float valve. The float valve shall be fixed and the surface of the tanks and steel structures shall be painted.

Source: JICA Survey Team

Surging Tank No.1(in front of Airai View Hotel)

Rusted due to overflow caused by breakdown of float valve. Slight amount of water flows out from the overflow pipe. No maintenance since built in1992.

Surging Tank No.2

Good conditions comparing with No.1, however no maintenance since built in 1992. Rusted on the baseplate of tank.

Figure 3.1-21 Surging Tank No.1 and No.2

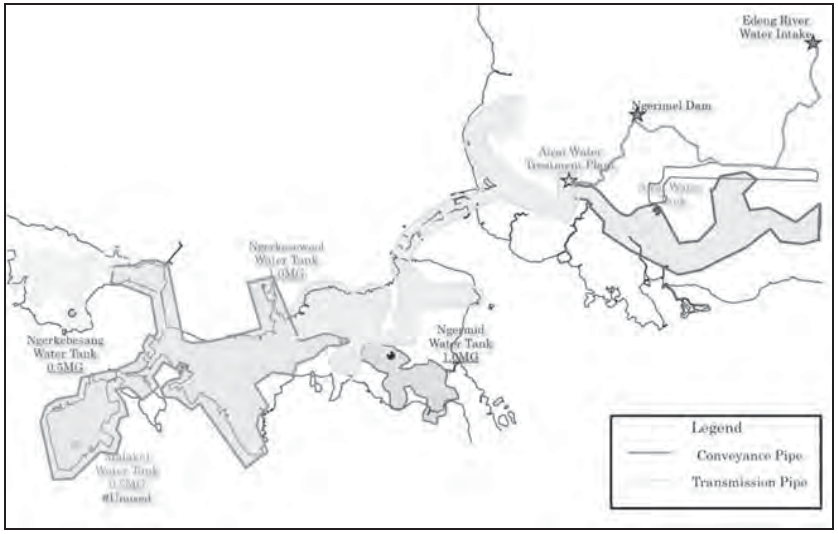
3.1.6 Conditions and Issues of Water Distribution Networks

(1) Current water distribution network

1) Water distribution system

Current water distribution system is comprised of 5 water distribution zones, Airai, Ngermid, Ngerkesewaol, Arakabesang and direct distribution zone from KAWTP. Currently, water in Malakal zone is distributed through Ngerkesewaol Service Tank. Except for direct distribution zone from KAWTP, water is distributed by gravity. The current situation of the water distribution zones is shown in Figure 3.1-22

The amount of water is enough. However, since Ngerkesewaol distribution zone is large, the water is not supplied to Malakal at the time of the accident for water transmission / distribution such as leakage.



Source: JICA Survey Team, based on PPUC information

Figure 3.1-22 The water distribution system diagram (water distribution block) of current situation

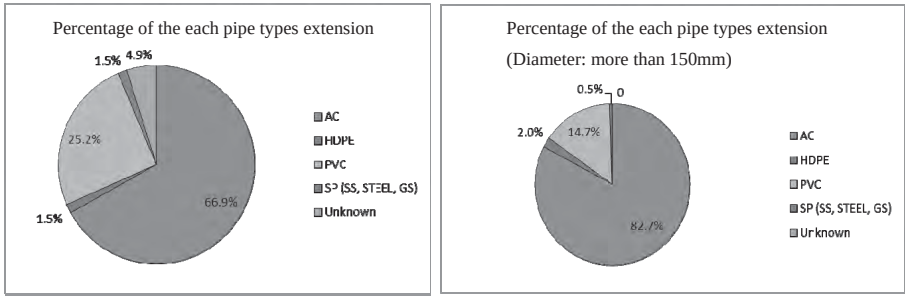
2) Distribution Pipelines

The total length of distribution pipeline that has been installed from 1940 to 2002 is approximately 53.5 km. The oldest pipe is over 74 years old, and 70% of the distribution pipelines are constructed by asbestos cement (AC) pipes and about 25% by PVC pipes. The share of these two pipe types is 95% of the total. AC pipe that is brittle and contains carcinogens asbestos is utilized for about 83% of the principal water distribution lines where pipe diameter is 150 mm or more (approximately 39 km).

Table 3.1-34 Pipe Length by Type, Diameter and Water Distribution Zone

Water Distribution District	Water Service Tank	AC					HDPE	PVC				SP (SS, Steel, GS)			Other	Total
		φ300	φ200	φ150	φ100	φ50	φ300	φ150	φ100	φ80	φ50	φ150	φ100	φ50	(unknown)	
direct from KAWTP	Airai water pump well	5,023.4	534.7	414.7	0.0	0.0	786.4	1,014.1	806.2	0.0	810.8	0.0	0.0	322.1	1,555.6	11,268
Airai	Airai	0.0	1,694.7	1,564.2	0.0	0.0	0.0	2,722.6	0.0	1,196.7	1,135.3	0.0	0.0	0.0	715.3	9,029
Ngermid	Ngermid	0.0	1,305.5	0.0	0.0	0.0	0.0	0.0	662.7	0.0	814.9	0.0	0.0	0.0	0.0	2,783
Ngerkesoaol Exclusion: Malakal	Ngerkesoaol	2,240.0	13,013.4	2,925.0	2,758.8	256.2	0.0	0.0	0.0	0.0	594.7	135.0	0.0	0.0	208.8	22,132
Arakabesang	Arakagesang	0.0	1,544.2	142.5	305.7	0.0	0.0	2,047.7	237.0	0.0	0.0	0.0	183.5	74.6	0.0	4,535
Malakal	Malakal (inactive)	0.0	1,765.1	281.9	58.8	0.0	0.0	0.0	365.8	0.0	1,100.0	73.1	0.0	0.0	143.2	3,788
Total [m]		7,263	19,858	5,328	3,123	256	786	5,784	2,072	1,197	4,456	208	184	397	2,623	53,535
Pipe type total [m]		35,829					786	13,509				788			2,623	53,535
Percentage of the entire		66.9%					1.5%	25.2%				1.5%			4.9%	100.0%
Diameter: more than 150mm		32,449			–	–	786	5,784	–	–	–	208	–	–	–	39,228
Percentage of the entire		82.7%			–	–	2.0%	14.7%	–	–	–	0.5%	–	–	–	100.0%

Source: Tabulated from pipe network diagram of PPUC



Source: Tabulated from pipe network diagram of PPUC

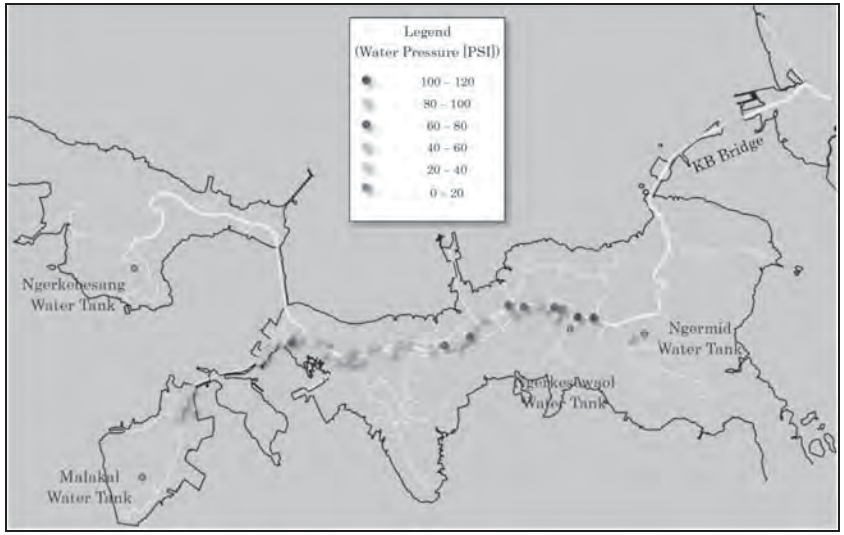
Figure 3.1-23 Percentage by Pipe types

(2) Water Pressure in Distribution Zones

PPUC conducted a series of water pressure surveys (measuring with faucet) at 56 points on the main roads in the center of Koror, from May 6 to May 20, 2014. The water pressure distribution map is shown in Figure 3.1-24.

The target minimum water pressure is 20 PSI (0.14MPa) in the water distribution network. As a result, the minimum pressure is recorded at 12 PSI (0.08MPa) and the maximum at 118 PSI (0.81MPa). The result shows that water pressure distribution is not appropriate for stable water supply.

According to PPUC, there is low pressure zone in Ngerbeched area which is slightly elevated in Ngerkesewaol water distribution zone.



Source: JICA Survey Team, based on PPUC information

Figure 3.1-24 Water Supply Pressure Distribution Map

(3) Water Leakage Record

According to PPUC's "Trouble Call Reports", 731 troubles such as water leakage, muddy water and water outage were reported from February 2, 2013 to April 18, 2014 (during one year and two months). In this report, 585 of the reported cases (80% of total troubles) were water leakage troubles; 37 cases (6.3% of all leakage) out of the 585 were leakages between water distribution branch and water meter, which is categorized as NRW and to be maintained by PPUC. The other leakages are under the responsibility of the customers although the number of cases is huge.

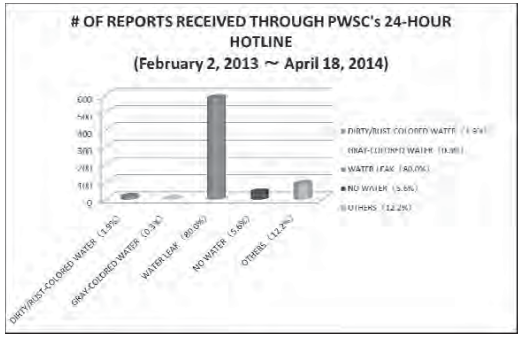
The breakdown of the 37 leakages is shown in Table 3.1-35.

Table 3.1-35 Leakage Location Found in February 2013 - April 2014

Leakage location	Number of Cases	[%]	Remarks
Starting point of water service feeder pipe from distribution pipe	0	0	-
Water service feeder pipe before water meter	23	62.2	Including two illegal connections.
Water meter	14	37.8	Including gate valve.
Total	**37**	**100**	**-**

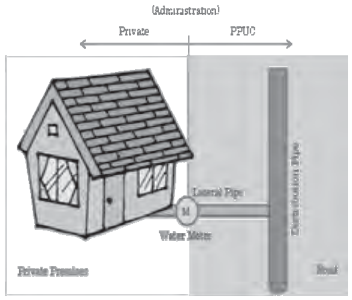
Source: Trouble Call Report of PPUC

The frequency of each trouble type is shown in Figure 3.1-25. The responsibility demarcation is shown in Figure 3.1-26.



Source: Trouble Call Report of PPUC

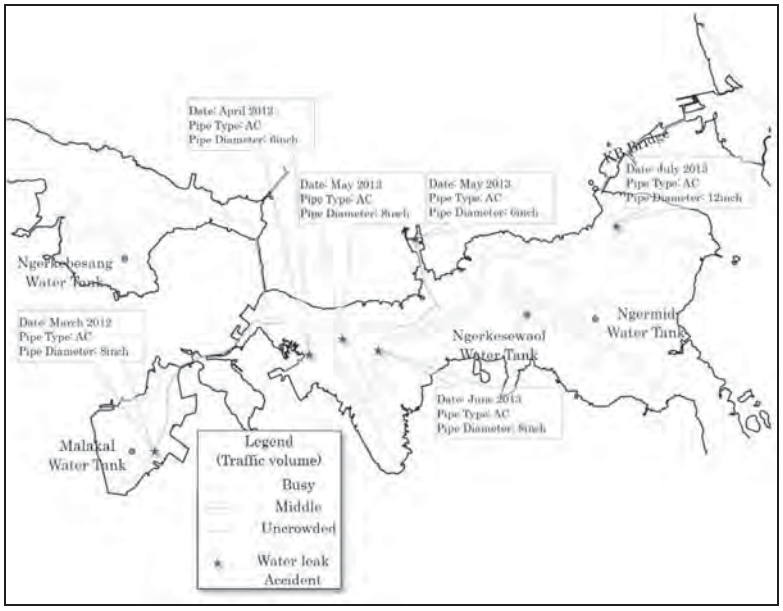
Figure 3.1-25 Number of each troubles



Source: JICA Survey Team , based on PPUC information

Figure 3.1-26 Concept of PPUC's maintenance area

Seven water leakage accidents occurred on principal water distribution lines in the recent two years, and six out of the seven were caused by asbestos pipe. The leakage locations in the water distribution main are shown in Figure 3.1-27. The remaining one case happened at Koror - Airai Channel (KB Channel) in the under- sea pipeline.



Source: JICA Survey Team, based on PPUC information

Figure 3.1-27 Leakage Location on Water Distribution Lines

(4) Summary of the issues

- There is direct distribution zone from KAWTP; transmission line and distribution line are not separated.
- Since Ngerkesewaol water distribution zone is large, the water is not supplied to Malakal at the time of the incident.
- 70% of the distribution pipelines are constructed by asbestos cement pipes; they are fragile and a major cause of water leakage.
- There is low pressure zone in Ngerbeched area in Ngerkesewaol water distribution zone.

3.1.7 Conditions and Issues of Small Scale Water Supply Systems in Babeldaob

(1) Current Condition of Facilities of Small Scale Water Supply Systems

There are 16 small scale water supply systems in Babeldaob Island, of which water sources are surface water in 14 systems and groundwater in 3 systems. According to PPUC, surface water is used as water sources prior to groundwater if enough surface water is located near the communities. If not, groundwater will be used as water sources. Four small water supply systems as listed in Table 3.1-36 were investigated in this Survey to know the current condition and issues for future improvement

Table 3.1-36 Small water supply systems in Survey area

State	Name of system	Population to be supplied	Type of water sources
Aimeliik State	Mongami small scale water supply system	28 household and school	Surface water
	Ngchemiangel small scale water supply system	80 household and electric power generation site	Surface water
Ngarchelong State	Mengellang small scale water supply system	100 families	Surface water
Ngiwal State	Ngiwal small scale water supply system	96 household and school	Groundwater

Source: JICA Survey Team

(2) Problems and Issues

Water quality is examined for the three small scale water supply systems in Table 3.1-37 after water treatment (filtering raw water and disinfection with chlorination). In the field survey, it seems that the efficiency of the filtering is not well enough. In addition to this, effect of backwash as well as disinfection also seems not to be enough.

On the other hand, water supply in Ngiwal area uses groundwater. The groundwater is advantageous because of the following:

- Water quality of groundwater is better than that of surface water. It is not necessary to use chemical sedimentation and rapid sand filters.
- Water supply of groundwater is advantageous in drought season.

There is a hydrological difference between Ngiwil and the other three areas that use surface water. The river discharge is poor in Ngiwal area due to small river basins. It is a reason why the groundwater is utilized in Ngiwal area.

(3) Result of Water Quality Analysis

The water quality analysis was conducted at three small scale water supply systems during the field survey. The analyzed items are turbidity, ammona, nitrate, and E-coli. As a result shown in Table 3.1-36, the improvement of the water treatment systems is necessary for some of the water supply systems. It is recommended that the PPUC conduct water quality analysis for all small systems and study the countermeasures.

Table 3.1-37 Result of Water Quality Analysis

State	Name of system	Turbidity (NTU)	Ammonium nitrogen (ppm)	Nitrate nitrogen (ppm)	E-coli
Aimeliik State	Mongami small scale water supply system	3.1	< 0.2	< 0.2	None
	Ngchemiangel small scale water supply system	10.2	0.2	< 0.2	None
Ngarchelong State	Mengellang small scale water supply system	1.4	< 0.2	< 0.2	Small quantity

Source: JICA Survey Team

3.1.8 Other Relevant Issues for Water Supply

(1) Plan of Water Pipelines along KB Bridge

There are currently two water pipelines laid undersea at the bottom of Koror - Airai Channel (KB

Channel). One of those lines is the water transmission main to the direction of Koror from KAWTP and the other one is for water distribution for north - east of Koror. Those lines are planned to be attached to KB Bridge.

In October 2013, a leakage was found in the mentioned distribution line (16 inches in diameter). The repair of the leakage took one and half months. During the period of survey and repair, the water supply was regulated / suspended. Since then, PPUC have commenced concrete procedures to replace the two pipelines with bridge-attached pipes. In July 2014, it was in evaluation stage for proposal of tenderers. The new pipeline will be completed in March 2015 if all goes smoothly. The schedule is managed currently as follows:

Request for Proposal	March 2014
Opening of Tenders	21 May 2014
Specification	2 pipelines (12 inches) in ductile cast iron pipe (DCIP) to be attached to KB Bridge. The pipeline should be earthquake resistant.
Number of Tenderers	Two companies applied.
Stage in Tendering	Under evaluation of technical proposal.
Next Procedures	Selection of the successful tenderer (including approval) will be in August - September 2014.
Contract	September 2014
Completion of works	March 2015

(2) Utilization of New Pipeline Attached to KB Bridge

PPUC is now planning to utilize the new pipelines to be attached to KB Bridge for the same purposes of current ones, i.e. one is for transmission and the other is for distribution.

The Team examined the current situation and reviewed the exiting drawings of the networks. According to the examination, the Team noticed the following:

1) The capacity of transmission main is insufficient for the forecast water demand in 2020 and the current level of water production as described in Section 3.1.5 and 3.3.2. Therefore, an additional transmission main is necessary.

2) Direct water distribution zone exiting on the both sides of the KB Channel should be modified to be distributed from Ngermid or Airai Service Tank as described in Section 3.3.3. The existing distribution line crossing KB Channel will be, accordingly, unnecessary.

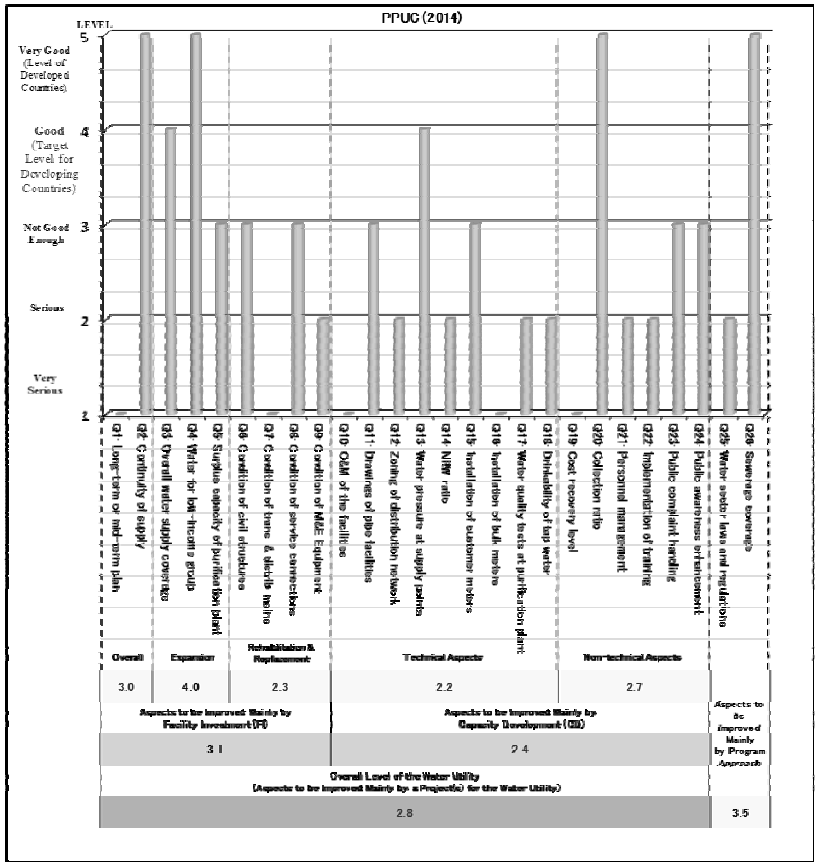
In this background, the following utilization is valuable for the new bridge-attached pipe:

- Changing the purpose of the new bridge-attached distribution line to transmission.
- Utilizing it the new distribution line as a part of the additional transmission main for distribution zones in Koror zones.

3.1.9 Summary of Capacity Assessment

The Team evaluated the business performance of PPUC according to JICA's tool. Result sheets are attached in the Appendix. Figure 3.1-28 shows the summary of capacity assessment. It is noted that

the scores for Q2-Q4 which are related for coverage and production capacity are higher. On the other hand, ones for Q6-Q9 which are for maintenance performance are low. It may be explained by the lack of middle - long terms plans for facilities improvement / rehabilitations. PPUC rehabilitated the water supply facilities through US assistance in the end of 1990s. After then, the population as well as water demand has decreased. PPUC, therefore, has not faced requirements for new investment on major facilities for the recent 15 years. It may be one of the reasons for weak awareness of PPUC on the scheduled investment and rehabilitation in stock management.



Source: JICA Survey Team

Figure 3.1-28 Summary of Capacity Assessment on PPUC Water Supply

As for the finance, the ratio for cost recovery is very low at 38%. In spite of higher tariff collection ratio, the income for water supply and sewerage is low and PPUC requires subsidies from GoP and / or development partners.

To improve the finance conditions, the improvement of efficiency, especially reduction of NRW, should be noted. The current cost for water transmission is assumed at USD600/MG as shown in Table 3.1-38. If NRW was reduced by 0.5MG/d, PPUC could reduce the water production by 182.50MG/y and could save the electricity cost for water transmission by USD109,500.00-. If it was reduced by 1.0MG/d, 365.00MG/y of water and USD219,000.00- of cost would be reduced as well. It is a good example that the efficiency improvement will contribute to improvement of financial capacity.

Table 3.1-38 Estimation of Water Transmission Cost

a	b	c =a / b	d	e	f	g = c x d x e x f	h	i = g x h	j = i / 365 / a	
Production (MG/d)	Pump Flow (MG/d /pump)	Ave No. of pump (pumps/d)	Motor (kW/ Pump)	Hrs (h/d)	Days (days/ year)	Electricity (kWh/y)	Elect. Tariff (USD/ kWh)	Elect. Charge (USD/y)	Cost / MG	
									USD/MG	USD/m^3
3.69	1.51	2.44	89	24	365	1,902,322	0.427	812,291	603.10	0.16

Remark: Motor power is calculated from water flow and pumping head.
Source: JICA Survey Team

3.2 Short and Medium Terms Target for Water Supply Development

The following are recommended to be improved in short - medium terms (5 - 10 years) for further development of water supply toward safer and more stable system.

3.2.1 Water Demand

The current average and maximum water demands are 3.69 MG/day and 4.00 MG/day, respectively. The surface water potential of the catchment area of KAWTP is estimated at 10.00 MG/day The mentioned potential is enough for KAWTP for the current level of water supply. The water availability, however, decreases in draught periods. The availability would be 1.9 - 3.7 MG/day, assuming the draught levels experienced in 1983, 1992 and 1998. This is why PPUC needs to provide alternative / additional water resources.

On the other hand, Koror - Airai water supply system has a large scale of NRW. The necessity of additional / alternative water resources should be assessed by taking into account the expected reduction of demand, including NRW. PPUC should reduce the demand to 3.1 MG/day for average and 3.3 MG/day for daily maximum for 2020. It should be a base to plan the water supply business in the short term.

Considering the population decrease trend in the last 10 years, PPUC should be careful not to plan / design over-scale facilities. For middle term water demand target, the Team recommends verifying the water demand as well as the number of population and foreign visitors and the progress of demand reduction activities at 3 - 5 years interval.

Accordingly, the following are recommended for targets:

Short term target: To reduce the average water production (demand) to 3.1 MG/day, and the maximum to 3.3 MG/day.

Middle term target: To be determined along with the progress in water demand reduction activity.

3.2.2 Capacity of Water Source

Along with the reduction of water demand, the required capacity for water resources also decrease to a level of 3.3 MG/day. Additional / alternative water resources should be examined in parallel with verification of progress and results of leakage reduction.

The current water sources are enough for normal situation in water supply and rainfall. As for the countermeasures for drought, the groundwater, which is relatively easier to secure, is recommended. The groundwater resources should be secured to cover the demand in the drought year.

To plan the additional / alternative water source, the frequency of drought year and its rainfall are points to be discussed. According to the Japanese guidelines for water facilities design, the probability of drought occurrence in 10 years should be considered for designing facility's capacity. The Team recommends following this guideline to design the capacity of new well facilities.

The water shortage frequency that is below 3.3 MG/day at sources would be twice per 30 years. It is a less frequent than "once per 10 years".

Accordingly, the following are recommended as targets:

Short term target:	To maintain the stability for the current level of intake volume (4.00 MG/day), through repairing the existing sources' facilities.
Middle term target:	To determine necessary capacity to be added, considering reduction activity for water demand and To have water sources' capacity for possible droughts at 10 - 15 years frequency, through alternative / additional water resources or improvement of the current sources facilities.

3.2.3 Reduction of NRW

The current NRW is in a level of 1.78 MG/day. NRW ratio is calculated as 48%. Although it is difficult to grasp the breakdowns of NRW, it is assumed that the share of leakage is large, considering a large volume of consumption and rare illegal connections. As for the leakage, old AC pipelines, especially larger diameter pipes (6 inches or more), are assumed to be highly contributing (assumed at 83%) to the leakage volume.

The Team conducted a provisional calculation for NRW reduction along with the replacement of the larger diameter AC pipes. The calculation indicated that the NRW ratio would be 20% if all larger diameter pipes were replaced. Since the length of the larger diameter AC pipes reach approximately 32.5km, it is difficult to replace them immediately. If the pipes are replaced at 5.5km per year rate, NRW will be reduced to 32% in 2020 and 20% in 2022, according to the provisional calculation.

Accordingly, the following are recommended as targets:

Short term target:	To reduce NRW ratio to 32%.
Middle term target:	To reduce NRW ratio to 20%.

3.2.4 Stable Water Transmission and Distribution

It is essential to have enough facilities and system to supply water for a level of 4.0 MG/day in current demand and 3.3 MG/day in planned demand for short term.

To maintain stable water supply, the following current transmission and distribution system

problems have to be solved:

(1) The current capacity for transmission main reached the limit of service capacity.

(2) Ngerkesewaol water distribution zone suffers from low and unstable water distribution pressure due to large covering area.

(3) Malakal, which belongs to Ngerkesewaol zone, suffers from water shortage in case of water availability, transmission and distribution incidents.

Accordingly, the following are recommended as targets:

Short term target:	To have transmission main capacity for 4.0MG/day water production. To secure sufficient distribution pressure (20PSI) in Ngerkesewaol water distribution zone, including Malakal.
Middle term target:	To be determined along the demand reduction.

3.2.5 Assurance for Water Quality

KAWTP was originally constructed in the 1970s. Although it was expanded in the late 1990s, many facilities and devices are deteriorated. Moreover, there is no system for periodical monitoring of water quality in the distribution networks. It is, however, observed that PPUC currently treats the water to an acceptable water quality in turbidity.

It is the time to make a plan for overall rehabilitation as well as for water quality monitoring / assurance system. World Health Organization (WHO) recommends formulating "Water Safety Plan" to water supply entities. PPUC should prepare the "Water Safety Plan" according to related guidelines in the middle - long term basis. In the short term, a team should be established with the provision of equipment for daily water quality monitoring and management.

Accordingly, the following are recommended as targets:

Short term target:	To secure water quality, which is assured by increased management parameters for treatment process and distribution, such as E-coli, bacteria, residual choline, pH, temperature.
Middle term target:	To have improved treatment facilities for efficiency and stability for water quality, through rehabilitation of KAWTP.

3.3 Recommendation for Urgent Action Plan

The Team recommends the following as urgent actions to be commenced immediately:

3.3.1 Meter Installation

PPUC commenced a meter installation / replacement project in April 2014. It should be promptly completed to eliminate flat rate customers. It is strongly recommended to prioritize Koror and Airai

in the meter installation to eliminate frat rate customers from the region. Metering all customers will be synchronized with the other urgent actions for management of NRW.

3.3.2 Strengthening Transmission Main

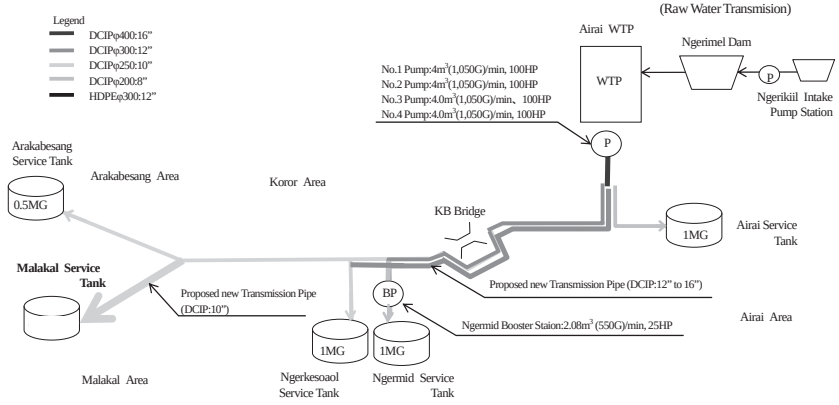
As mentioned in Section 3.1.5, the capacity of the existing water transmission main is not sufficient to transmit the required volume. To overcome the problem, there are options shown in Table 3.3-1. Among the options, the Team recommends option-3 since the required energy is the least.

Table 3.3-1 Options for Strengthening Transmission Main

Option	Counter Measures	Advantage	Disadvantage	Required Energy	Recommendation Priority
Option-1	Replace transmission pumps for higher pumping head.	No additional pipeline and no pump station are necessary.	Pressure in the transmission main becomes too high.	The highest.	3rd
Option-2	Construct booster station on the existing transmission main.	No additional pipeline is required.	A booster station is necessary.	Higher.	2nd
Option-3	Install additional pipeline for transmission up to Ngerkesoaol Service Tank	No additional pumps and no modification of pumps are necessary.	Additional pipeline is required.	The lowest.	1st

Source: JICA Survey Team

Adopting Option-3, an additional transmission main is necessary. Figure 3.3-1 is a preliminary plan to lay additional pipeline (Dia. 12 to 16 inches) from Airai P/S to Ngerkesewaol Service Tank. To cross the KB Channel, it is recommended to utilize the planned bridge-attached pipeline, which is under tendering procedures. The design of the bridge-attached pipeline and the new transmission main should be integrated.



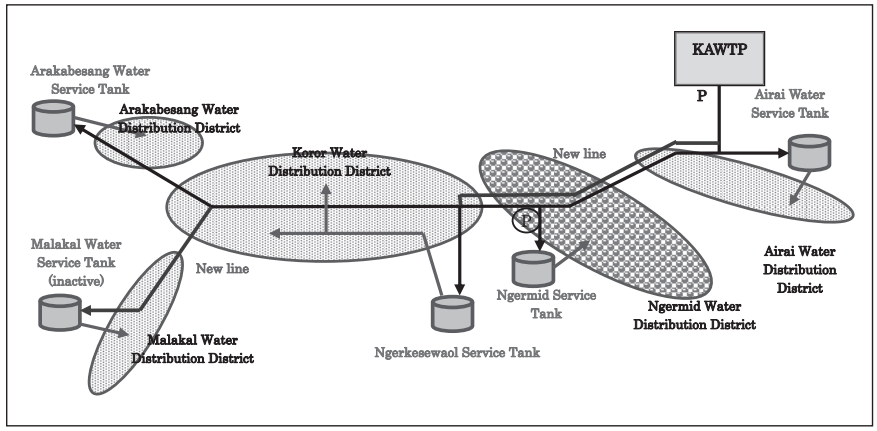
Source: JICA Survey Team

Figure 3.3-1 Improvement for Koror and Airai Water Transmission System

3.3.3 Modification of Distribution Zones

To eliminate low water pressure zone in Ngerbeched area and to ensure stability of the water supply of Malakal area, it is recommended to separate the Malakal area from Ngerkesewaol water distribution zone. For this purpose, renewal of Malakal tank and an exclusive transmission main are necessary. Accordingly, re-arrangement of distribution zones should be undertaken together with the establishment of Malakal zone, described in the next clause.

In parallel, to ensure the stability of water supply and adequate balance of water distribution, the current zoning should be reviewed. If the additional transmission main, which is described in the previous Section, is realized, new zoning shown in Figure 3.3-2 is recommended. Along the mentioned rehabilitation, district flow meters should be installed at tanks for distribution flow management.



Source: JICA Survey Team

Figure 3.3-2 Proposed water transmission and distribution system

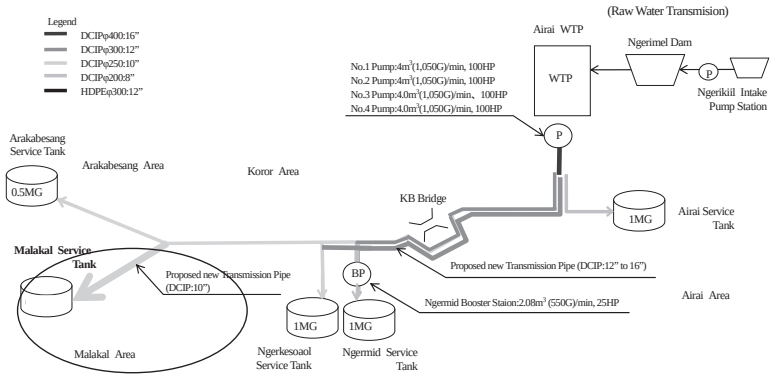
3.3.4 Establishment of Malakal Zone and Transmission Main to Malakal Tank

(1) Improvement of Malakal Water Supply System

1) Installation of Water Transmission Pipeline to Malakal Service Tank

Since Malakal area has been designated as a new development area for the establishment by the Koror State Government, improving water supply is prioritized. The area, however, suffers from water pressure shortage during transmission / distribution incidents since the area is located at far from Ngerkesoaol Service Tank.

For the above reasons, the reinstating the Malakal Service Tank and the construction of a new water transmission pipeline (DCIP, dia. 10 inches), which is used exclusively to transfer water to the Malakal Service Tank, are necessary as shown in Figure 3.3-3.



Source: JICA Survey Team

Figure 3.3-3 Improvement for Koror and Airai Water Transmission System

There are Minato Bashi and the causeway on the route for the new transmission main to Malakal Service Tank.

a) Minato Bashi

The existing sewer line is installed at west side of the Minato Bashi. The two existing water distribution pipelines (Dia. 4 inches, two pipes) are installed at east side (Long Island side) as shown in Figure 3.3-4. The new water transmission main is also recommended to be installed at east side (Long Island side) of the Minato Bashi.

Source: JICA Survey Team

Minato Bashi (West side) : Existing sewer

Minato Bashi (East side: Long Island side) : Existing water pipeline (dia.4" x 2 lines)

New one Water Transmission Pipeline (dia. 10") will be installed additionally

Figure 3.3-4 Existing Utilities at Minato Bashi

Source: JICA Survey Team

Malakal causeway (West side)

Walkway is maintained as a path for walk and jogging

Malakal causeway (East side: Long Island side)

New Transmission Pipeline will be installed underneath 4" thick concrete walkway or curbstone, or on the riprap with concrete encasement

Figure 3.3-5 Malakal Causeway

b) Malakal causeway

West side walkway should be maintained as a path for walking and jogging. The new water transmission main should be, therefore, installed at the following locations in east side (Long Island side):

- Underneath 4 inches thick concrete walkway
- Underneath curbstone
- On the riprap with concrete encasement

The locations will be decided by a further study based on the As-Built Drawing of the causeway and discussion with Bureau of Public Works.

(2) Malakal Service Tank

The existing Malakal Service Tank has never been used since it was built in the1970s. As the result of survey, there are serious rusts and damages not only in rib, baseplate and anchor bolts but also on the roof and wall. Moreover, it is difficult to assure the strength of the existing tank.

Therefore, reconstruction of the tank is recommended after demolishing the existing tank.

The access road to the tank is not so steep. Therefore, heavy construction equipment is able to approach the tank site.

Source: JICA Survey Team

Figure 3.3-6 Access road to Malakal Service Tank

As for the structure and shape of the tank, the following two options are considered:

1) Steel Circular Tank same as the existing Tank; periodical painting works are inevitable.

2) Rectangular Reinforced Concrete Tank; maintenance is easier.

The maintenance works including the periodical painting for the steel structures such as the existing Service Tanks and Surging Tanks are inevitable to prevent rusting; however it was found in this survey that those maintenance works have never been done.

Therefore, the rectangular reinforced concrete tank with easy maintenance, which is used in the water facility in the communities on Babeldaob, is recommendable. The view of the rectangular reinforced concrete tank is shown in Figure 3.3-7 as a sample.

(3) The procedure for dismantling the existing Malakal Service Tank

The following procedure will be taken when the existing Malakal Service Tank is to be dismantled:

1) The scrap metals generated by the Government property shall be dealt with, according to the law promulgated by the Palau Environmental Quality Protection Board (EQPB), Law No.1-58 (Chapter 2401-31).

2) A division of Solid Waste Management Office of the Bureau of Public Works (BPW) under the Ministry of Public Infrastructure Industries & Commerce is in charge of any waste disposal.

3) PPUC will clear the site and secure the land for implementation of the new Malakal Service Tank as mentioned in the Minutes of Discussions on the Preparatory Survey for this Project dated 27 June 2014.

4) PPUC will apply the following procedure for dismantling the steel tank:

- PPUC will auction the steel tank to the interested buyers and the successful buyer will dismantle the tank and store the scrap metals in his/her own storage area.
- The successful buyer will sell the scrap to overseas metal manufacturer.

Source: JICA Survey Team

Figure 3.3-7 Rectangular Reinforced Concrete Tank (sample)

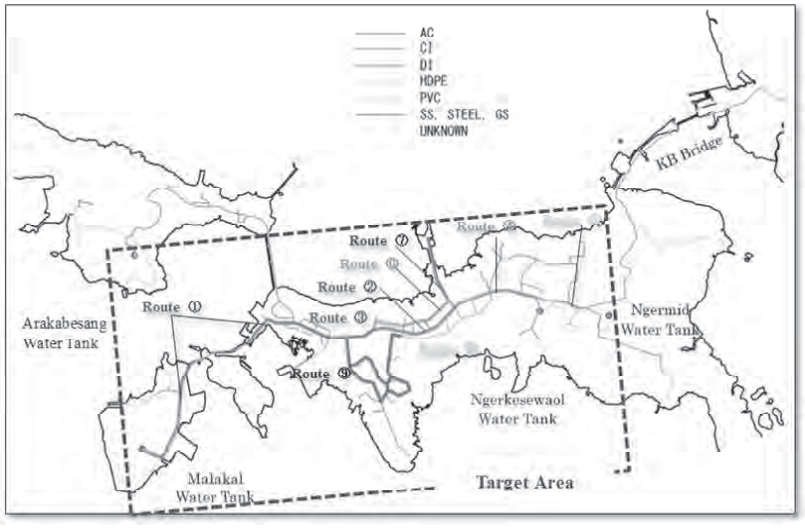
3.3.5 Replacement of Major Distribution Lines

As mentioned in Section 3.1.9, reduction of NRW is strongly required for PPUC to improve the business efficiency. Since the NRW is supposed to be mainly caused by the leakage, the reduction of NRW will contribute to the reduction of energy for water treatment and transmission.

Accordingly, the reduction of water leakage as well as strengthening the distribution pipelines is required to be commenced promptly through replacing AC pipes. This works should be scheduled and started according to priority. The schedule should be arranged according to budget distribution for the coming 10 years.

Since some of water leakages are found at lateral connections, reduction of this kind of leakage should be also managed by PPUC, especially ones before meters. Replacement of lateral connections should be conducted in parallel with the distribution line replacement.

As for the urgent parts to be replaced, the Team recommends the routes shown in Figure 3.3-8. Total length of the recommended lines is around 13km.



Source: JICA Survey Team

Figure 3.3-8 Recommended Route for Urgent Replacement for Old Distribution Pipes

AP-6-51

3.3.6 Soft Approach

The following are recommended as soft approaches for capacity development:

(1) Management for Water Flow and Pressure

To improve and establish the appropriate operation modes for KAWTP and service reservoir, management system of data for flow and pressure should be improved. The improvement includes the installation of bulk meter for water flow and several fixed water pressure gauges. Along the improvement of data recording system, PPUC will be able to grasp the demand by region and by hours and formulate appropriate modes for operation. Moreover, continuous monitoring will contribute to prompt actions against leakages and/or other accidents.

(2) Leak Detection

PPUC has one set of ground microphone and correlator for leak detection. Only one staff-member can operate the mentioned equipment, but only for the ground microphone. The current number of staff-members and equipment is not sufficient for scheduled detection of leakage. It is necessary to establish a team for leak management together with provision of training, equipment and management system.

3.3.7 Priority for Urgent Action Plans

The Team recommends the priority for the urgent action plans as shown in Table 3.3-2.

Table 3.3-2 Priority for Urgent Action Plans

Priority	Plan	Note
Priority-1	Meter Installation	Meter is the basic tool for management of water distribution. PPUC has been conducting this action since April 2014. It should be completed promptly.
Priority-2	Strengthening Transmission Main	The capacity of the existing transmission main has been insufficient. It is placed in a risky condition for the sudden stoppage of water transmission. This action should be conducted as soon as possible.
Priority-3	Modification of Distribution Zones	There are low pressure areas and a direct distribution zone where the flow / pressure control is difficult. Since such troubles appear on the network, this should be conducted as a higher component.
	Establishment of Malakal Zone and Transmission Main to Malakal Tank	Establishment of Malakal Distribution Zone is indispensable for the re-arrangement / modification of distribution zones for Koror - Airai. It should be a part of the action for modification of distribution zones.
	Management for Water Flow and Pressure (Soft Approach)	Along with the facilities construction / re-arrangement, management system should be established for management of water distribution and NRW.
	Leak Detection (Soft Approach)	Staff members and equipment for leak detection are not enough for NRW management of the existing distribution networks. It is recommended to promote leak detection skills along with the improvement of water distribution management.
Priority-4	Replacement of Major Distribution Lines	To promote efficiency for water supply, the reduction of NRW / leakage is prioritized actions. As the first step, the major pipelines (13km) are recommended to be replaced.

Source: JICA Survey Team

3.4 Recommendation for Short / Medium Action Plan

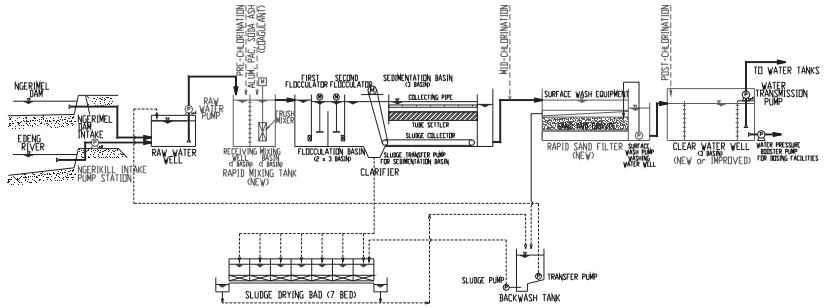
The Team recommends the following as actions to be conducted within 5 - 10 years (short - medium terms) :

3.4.1 Rehabilitation of Koror - Airai Water Treatment Plant (KAWTP)

As aforementioned, KAWTP needs the following:

- Rehabilitation of water quality management system, including facilities / equipment / technical training.
- Rehabilitation of chemical injection system, including flash mixer system of coagulant.
- Rehabilitation of sand filters.
- Rehabilitation of Clear water well.
- Replacement of raw water pumps.
- Installation of raw water flow meters.
- Improvement of operation procedures through constant production.

Concept for modification of treatment process is shown in Figure 3.4-1.



Source: JICA Survey Team

Figure 3.4-1 Concept for Modified Process of KAWTP

Those inputs are recommended to be conducted through a package project after securing the adjacent land as shown in Figure 3.4-2. The rehabilitation project should be conducted in parallel with the operation of the existing plant, in order not to suspend the water supply. Since the scope is wider than a rehabilitation, PPUC should have another option to reconstruct KAWTP in a middle - long term schedule, if the acquisition of land with enough space is possible in the adjacent area.

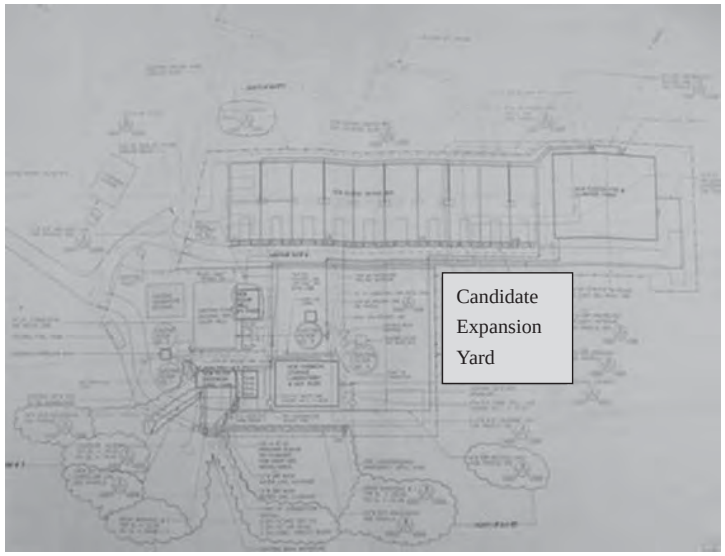


Figure 3.4-2 Candidate of Facilities Expansion Yard

The Team recommends the following for improvement:

(1) Water Quality Management System

Parameter to be managed should be at least for

- Temperature,
- pH,
- Turbidity,
- Residual chlorine and
- E-coli and bacteria.

It is not necessary to be automatic. Manual equipment might be better for periodical maintenance and repair. Along the equipment introduction, sufficient training for equipment utilization and maintenance should be provided for the water quality management team to be established.

(2) Chemical Injection System

All chemical injection system as well as modification / adjustment of injection points should be rehabilitated. Especially for coagulant (alum-sulphate), facilities modification is recommended to have a flush mixer before flocculation.

(3) Rehabilitation of Sand Filter

Current system (valve-less gravity system) is good in automatic operation. It is, however, difficult to control the filter-washing manually through observation of filtration velocity, sand condition, water quality, etc. Moreover, automatic filter is not necessary since operators are deployed for 24 hours at KAWTP.

(4) Rehabilitation of Clear Water Well.

Since the existing clear well has deteriorated, it should be rehabilitated. The Clear water well should have the capacity for more than 1 hour storage. Currently, it is difficult to secure enough space for rehabilitation. It is therefore recommended conducting the rehabilitation in parallel of sand filter's one.

(5) Replacement of Raw Water Pumps and Flow Meters

The existing raw water pumps have deteriorated. It is recommended replacing the pumps at the rehabilitation time. In order to manage the production volume, raw water flow meters should be installed together with the rehabilitation of raw water pumping system.

(6) Improvement of Operation Procedures

Water Treatment Plant should be usually operated for constant production. It is necessary to keep water quality management easier. If Airai Well Field is commenced, integrated operation with the wells is also necessary. To do so, training though trials and manual preparation (standard operational procedures) should be conducted.

3.4.2 Improvement of Ngerimel Dam

Ngerimel Dam has not been dredged since its establishment. Dredging would be an effective work to secure more water in the dam. The dredging work is costly. It is, however, a good option for raw

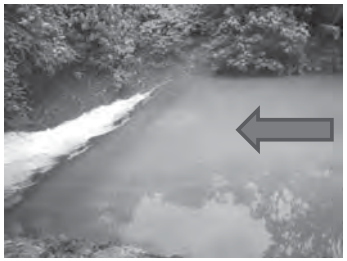
water conveyance in operation cost since the water can be conveyed by gravity. In parallel, the broken maintenance bridge should be repaired.

3.4.3 Improvement of Ngerikiil Intake Pump Station

(1) Concept of Improvement for Weir and Intake

1) Current Condition

The river water level has been stabilized at Ngerikiil Intake Pump Station (Ngerikiil IPS) site, by the construction of a weir at 200m downstream from the pump station.



Source: JICA Survey Team

Diversion Weir Intake

Figure 3.4-3 Condition of Ngerikiil Intake Pump Station

2) Improvement

During drought period, water intake becomes difficult. It is necessary to stabilize the water level for drought period. Height modification of the weir is effective for the stabilization.

In addition, some countermeasures are necessary to prevent leaves and dust. For this reason, rehabilitation of intake is recommended. Moreover, screen should be installed before intake.

(2) Concept of Improvement for Intake Pump

1) Conditions of intake pumps

There are three raw water intake pumps installed in the 1970s. Conditions of them are as follows:

No.1 pump: Good condition.

No.2 pump: It is difficult to reach Maximum efficiency due to water leakage by decrepit mechanical seal.

No.3 pump: Out of order due to decrepitness. Currently, pump is dismantled.

2) Conditions of Generator

A generator was designed to operate 2 pumps originally. However, currently the generator can

operate one pump only due to deterioration and overheating.

3) Concept of improvement for Intake Pump and Generator

At lease, two new pumps should be introduced. The two new pumps should be utilized for operation. The exiting pump (one pump in good conditions) should be utilized as stand-by pump.

The numbers of times of electric power failures are decreasing after the completion of Aimeliik Power Plant in June, 2014. However, the replacement of the generator is necessary for emergency cases.

Source: JICA Survey Team

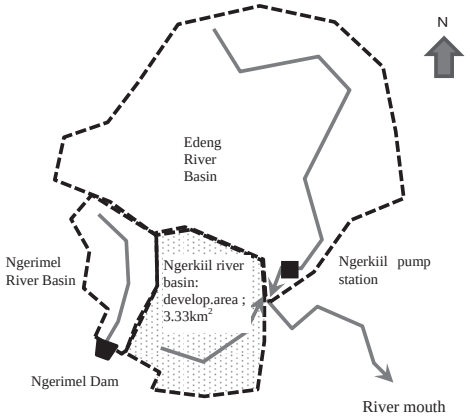
Raw water pump station Raw Water Intake facilities

Figure 3.4-4 Current conditions of raw water pump

3.4.4 Establishment of Airai Well Field

(1) Area for new groundwater development

The location of the area for the new groundwater development and the other related river basin is shown in Figure 3.4-5. The area of the new groundwater development is located within Ngerkiil River Basin. Water is taken from Edeng River in Ngerkiil Pumping Station. The river basin of the new groundwater development joins Edeng River in the downstream area of the pumping station. The Ngerimel River basin, where Ngerimel Dam is constructed, is located in the west of Ngerkiil River Basin. The basin area of the proposed groundwater development is 3.33km^2, with distance of 1.9km between the area and the nearest coast.



Source: JICA Survey Team

Figure 3.4-5 Areas for New Groundwater Development and Related River Basin

More than 10 boreholes have been dug in the area for new groundwater development since 1985 to study groundwater development capacity. ADB recently proposed groundwater development in this area where the existing boreholes are located along the stream line. The summary of the previous study is shown below:

- Average depth of boreholes: around 30m
- Natural groundwater level of boreholes: less than 5m below the ground
- Yield of boreholes: 100–350m^3/day
- Draw-down of groundwater level of boreholes by pumping: around 20m
- Transmissivity of boreholes: 12m^2/day (rough estimate)

(2) Long term groundwater development potential

Based on a long term water balance analysis, natural groundwater recharge of the area was estimated 871mm/year. Generally speaking, there is no formula showing direct relationship between natural groundwater recharge and safe yield of individual borehole. In this survey, it is assumed that the amount of natural groundwater recharge of the target area (See Figure 3.4-5, 3.33km^2) is the same as the maximum amount of safe yield of boreholes in the area.

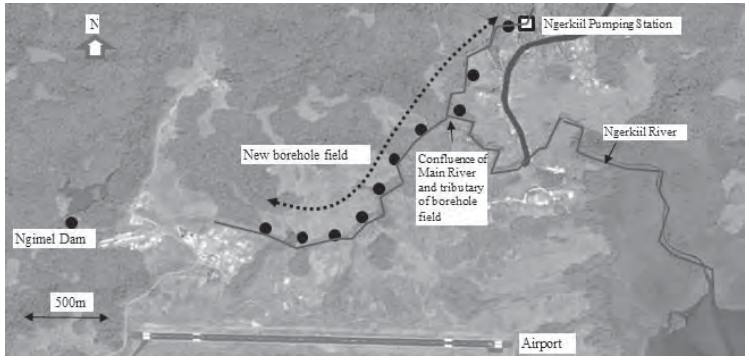
3,330,000m^2×0.87m/year=2,897,100m^3/year=7,940m^3/day

In practice, an amount of groundwater of 7,940m^3/day can be developed because influence area by the pumping may not cover the entire target area. However, groundwater development of 4,000m^3/day, which is required to be developed in the target area according to ADB Report in 2009, would be possible.

(3) Amount of groundwater to be developed

Maximum amount of groundwater to be developed is theoretically estimated based on the groundwater recharge. However, actual amount of groundwater to be developed is estimated based

on the arrangement of borehole distribution and permeability/thickness of aquifer. A borehole distribution plan (draft) is shown in Figure 3.4-6. Ten (10) boreholes in total are proposed in the area along the stream, and one borehole is planned in near the Ngerimel dam. Altitude of the top of the borehole is 10 to 20m above the sea level, and the borehole depth is 50m each. Total amount of yield from 11 boreholes is 4,000m^3/day under the assumption that yield of one borehole is 350m^3/day.



Source: JICA Survey Team, based on The Office of Automated land and Resource Information System (PALARIS), Ministry of Resources and Development

Figure 3.4-6 Borehole Distribution Plan (draft)

Based on the borehole distribution plan of Figure 3.4-6, the relationship between yield of borehole and draw-down of groundwater level can be estimated under the assumption of permeability and thickness of aquifer. This relation will allow formulation of detailed plan for borehole field construction. In this survey the maximum draw-down of groundwater level was estimated tentatively at 25m below the ground with average dynamic groundwater level of 15m below the ground in case where total amount of 4,000m^3/day is pumped form borehole field shown in Figure 3.4-5 under assumption of aquifer transmissivity of 12m^2/day.

(4) Water conveyance route from borehole field to stage tank

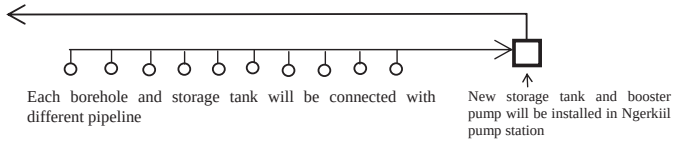
There are two plans for water conveyance routes from the borehole field to KAWTP (See Figure 3.4-7 and 3.4-8). The options for water conveyance route should be compared carefully in next steps for feasibility study or basic design stages.

Route-1: Groundwater will be conveyed from the borehole field to Ngerikiil Pump Station, from which groundwater will be again conveyed along the existing pipeline to KAWTP.

Advantage: The exiting Ngerikiil Pump Station and conveyance pipeline can be utilized. Investment cost will be the least under the conditions that 1) the groundwater will be mixed with the surface water and 2) the in-taken water will be treated at KAWTP.
Disadvantage: The groundwater of wells will be mixed with the surface water and the mixed water should be treated in KAWTP. The good quality of groundwater will not be utilized efficiently. In order to utilize the good groundwater quality, additional and exclusive conveyance pipeline is necessary. Necessary investment for the additional pipeline will be much larger than ones of Route-1.

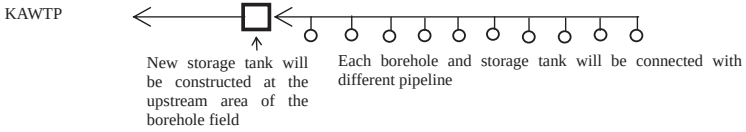
Route-2: New pipeline will be constructed from the borehole field to KAWTP directly.

Advantage: The groundwater can be conveyed to a clear water well in KAWTP. The water may be able to be transmitted through chlorination without filter and chemical sedimentation.
Disadvantage: Construction of new pump station and conveyance pipeline is necessary.



Source: JICA Survey Team

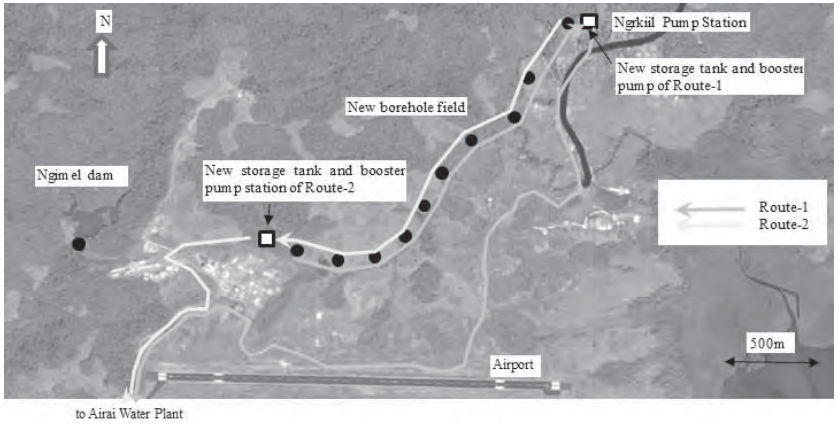
Figure 3.4-7 Route-1 (draft)



Source: JICA Survey Team

Figure 3.4-8 Route-2 (draft)

Capacity of submersible pump for borehole is less efficient than that of the other type pumps with large capacity. Therefore, it is proposed that new water storage tank should be constructed near borehole field to collect groundwater from boreholes, and the collected water will be sent to KAWTP from the storage tank. It is more efficient than to send groundwater directly from each borehole to KAWTP.



Source: JICA Survey Team, based on The Office of Automated land and Resource Information System (PALARIS), Ministry of Resources and Development

Figure 3.4-9 Water Conveyance Route (Draft)

(5) Problem

- More than 10 boreholes have been drilled in the area since 1985. Most of the pumping test data have been, however, already lost. As a result, there are few data on permeability of aquifer in the target area. Pumping test will be implemented for detailed analysis on aquifer capacity.

In ADB Study in 2009, water sampling was taken from No.5 borehole, which is one of the targets for pumping test of this Survey. And water quality analysis was implemented using the samples. According to the result of the analysis, concentration of iron (Fe), manganese (Mn) and fluorine (Fl) is less than WHO Guideline. Concentration of NO_3 and SO_4, which is an indicator of groundwater contamination, is also less than the Guideline. On the other hand, concentration of arsenic (As) showed a little bit high value of 0.03mg/L (WHO Guideline is 0.05 mg/L). Arsenic concentration should be checked again though it satisfied WHO Guideline so far.

Accordingly, more detail survey and investigation are recommended before the well development.

3.4.5 Painting the Existing Tanks

The existing four service tanks should be repainted to keep durability.

3.4.6 Improvement of Small Scale Water Supply Systems in Babeldaob

Based on the result of the survey on small water supply system, it is proposed that water source be changed from surface water to groundwater in Babeldaob Island. Groundwater does not need complicated filter operation for water supply, which will lead to improvement of water quality of small water supply. The matters below should be taken into account when surface water is replaced with groundwater for water sources.

- Drilling boreholes near the current water treatment plant is proposed. Except for type of water source, the current water supply system can be used as it is.
- Considering altitude of the current water treatment plant where boreholes are planned to be newly drilled, borehole's depth of 50m will be enough to pump up required amount of groundwater. There is low possibility of sea water intrusion into the boreholes because the distance between the boreholes and the coast is more than 300m.
- Aquifer consists of tuff breccia. Water demand for the area is as small as less than 90 household demand and ground water can be secured from the aquifer. Two boreholes (one for additional use) are enough for the demand of each site.

On the other hand, groundwater has disadvantages mentioned below, and measures against them should be proposed.

- Drilling of boreholes needs drilling rigs and drillers who operate them, both of which currently do not exist in Palau.
- It is not easy to formulate borehole drilling plan because the yield of borehole is different from place to place. Geological survey and test drilling are necessary to locate optimum drilling point beforehand.

3.4.7 Replacement of Remained AC Pipelines

The Team recommended replacing 13km of major AC pipelines in Section 3.3.5 for an urgent action. Since the total length of major AC pipelines (Dia. 6 inches or more) is 32.5km, 19.5km will be remained even if the urgent action is undertaken by PPUC. The 19.5km should be replaced in steps and finished before 2022 to reduce NRW ratio up to 20%.

3.4.8 Soft Approach

The following are recommended as soft approaches for capacity development:

(1) Improvement of Water Quality Monitoring System

Water quality should be assured not only at KAWTP but also in distribution pipelines. Water quality monitoring system should be, therefore, expanded to cover the distribution pipelines. In the distribution pipelines, the residual chlorine should be, at least, monitored periodically. The organization deployment as well as equipment provision and training for monitoring should be conducted for the development.

(2) Establishment of Well Management Section

If well field is introduced in Airai State, KAWTP should be operated in integrated way with the wells. Training for operation is necessary for supervisors and operators of both KAWTP and the wells. To maintain the wells appropriately, monitoring system for groundwater should be included in the training.

3.4.9 Priority for Short / Medium Terms Action Plans

The Team recommends the priority for the urgent action plans as shown in Table 3.4-1.

Table 3.4-1 Priority for Short / Medium Action Plans

Priority	Plan	Note
Priority-1	Small Scale Water Supply Systems in Babeldaob	Since the issues are related to water quality, this is one of urgent actions. It is, however, not placed in urgent actions due to investment efficiency of the action. It is recommended commencing the action soon and complete within short term.
Priority-2	Painting the Existing Tanks	This action is not so difficult and costly. As one of periodical maintenances, it should be conducted promptly.
Priority-3	Rehabilitation of Koror - Airai Water Treatment Plant (KAWTP)	Including necessary land acquisition, a plan for rehabilitation should be formulated within a few years. After then, the rehabilitation works should be undertaken in short term.
	Improvement of Water Quality Monitoring System (Soft Approach)	Water quality monitoring system should be established, considering water safety plan. It includes skill trainings, equipment provision and formulation of a permanent team.
Priority-4	Improvement of Ngerikiil Intake Pump Station	As the exiting pumps and auxiliary equipment are deteriorated. A risk for sudden stoppage will be increased according to ages. It is recommended to conduct this action earlier in short term.
Priority-5	Improvement of Ngerimel Dam	As priority for water resources development is less, it should be managed within medium term. It is, however, recommended to be undertaken before development of Airal well field.
Priority-6	Establishment of Airai Well Field	It is less prioritized than the Improvement of Ngerimel Dam. Study for this component should be undertaken along with monitoring the NRW reduction.
	Establishment of Well Management Section (Soft Approach)	Once well field developed, a management section is necessary. Along with the facilities construction, PPUC should formulate a permanent team with enough technical trainings and equipment.
Priority-7	Replacement of Remained AC Pipelines	The major AC pipes are planned to be replaced within 6 years (8 years if adding preparation period). It should be managed within short / medium terms.

Source: JICA Survey Team

CHAPTER 4 Development Framework for Sewerage

4.1 Introduction

The basic assessment of the sewerage system described in Chapter 4 of the Sector Development Framework was compiled based on the information collected by the field survey conducted from June 23 to July 18 2014 by Ms. Hiroko KAMATA, Senior Advisor to JICA and the comments to the draft from PPUC and ADB received in October 2014. The response to the comments from PPUC and ADB were attached as the Appendix to the Sector Development Framework.

Developments since last October are not incorporated in this chapter, and the views expressed in this chapter are those of the author and do not necessarily represent the official positions of JICA. This chapter is expected to be used as a reference for PPUC for further development of sewerage sector in Palau.

4.2 Organization

4.2.1 Environmental Quality Protection Board (EQPB)

(1) Acts and Regulations[1]

In 1981, the Republic of Palau enacted an "Environmental Quality Protection Act," Title 24 of the Palau National Code Annotated (Title 24 PNCA), to ensure greater protection of the unique and aesthetically beautiful environment while promoting sustainable economic and social development that would achieve the desired financial goals of the people of the Republic. The Act created an Environmental Quality Protection Board (EQPB), a semi-autonomous agency of the executive branch of the government of the Republic, to be tasked and responsible for the protection and proper conservation of quality of the environment and its resources so that sound and sustainable economic and social development proceeds in a manner that will not jeopardize Palau's future possibilities or opportunities.

Title 24 PNCA authorized the EQPB to promulgate and enforce regulations addressing the following topics:

(a) Earthmoving
(b) Marine and Fresh Water Quality
(c) Toilet and Wastewater Disposal Facilities
(d) Solid Waste Management
(e) Pesticides
(f) Public Water Supply Systems
(g) Environnemental Impact Statements
(h) Air Pollution Control
(i) Ozone Depleting Substance

(2) General [2]

Palau is well known throughout the world as having pristine blue waters, beautiful natural forests and unique cultural aesthetics. The Environmental Quality Protection Board provides environmental protection for the community through appropriate regulations *In order to protect Human Life and to ensure human health & safety. - Protect the "Land", Protect the "Water", Protect the "Air" –*

[1] EQPB Home Page
[2] EQPB Home Page

The board Member consists of 5 members as shown below.

Chairman	Benjamin Adelbai
Vice Chairman	Benjamin Yobech
Member	Mathias Erbai, Jack Meltel, Elia Yobech

In an effort to conserve Palau's natural treasures, the Palau EQPB works to ensure that projects involving earthmoving, waste and water quality are done in an environmentally sustainable manner. The EQPB office is composed of 7 departments comprised of 15 staff. These are Administrative and Supporting services, Education and Outreach Programs, Laboratory, Environmental Surveillance, Compliance, Solid Waste, Environmental Engineering, Legal Counsel and last but not least Hazmat, Pesticides, Pollution. The organization chart of EQPB is shown in Figure 4.2-1.

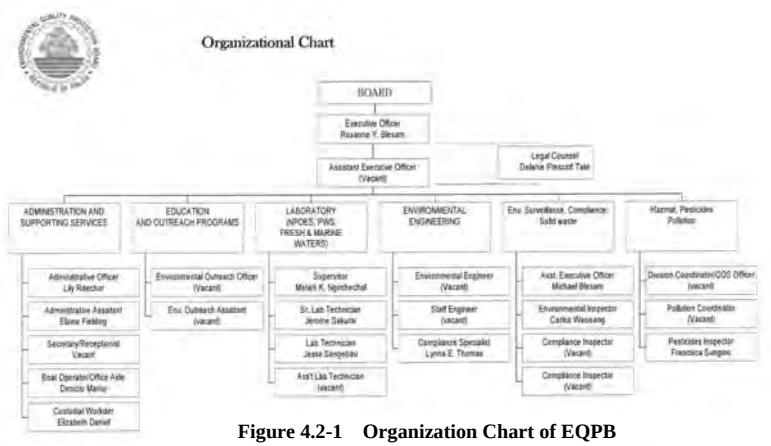


Figure 4.2-1 Organization Chart of EQPB

4.2.2 Palau Public Utilities Cooperation (PPUC)

(1) Organization of Sewerage Sector

Based on the Utilities Consolidation Act 2013, Palau Public Utilities Corporation, PPUC is now mandated to deliver electricity, water and sewerage services and the PPUC water and wastewater operations division has been established to manage and operate Palau s water and sewerage services. Figure 4.2-2 shows the organization chart of Water and Wastewater Operation in PPUC.

The staff number of sewerage sector is about 25 and it is very small in comparison to staff number of 90 in Water Sector.

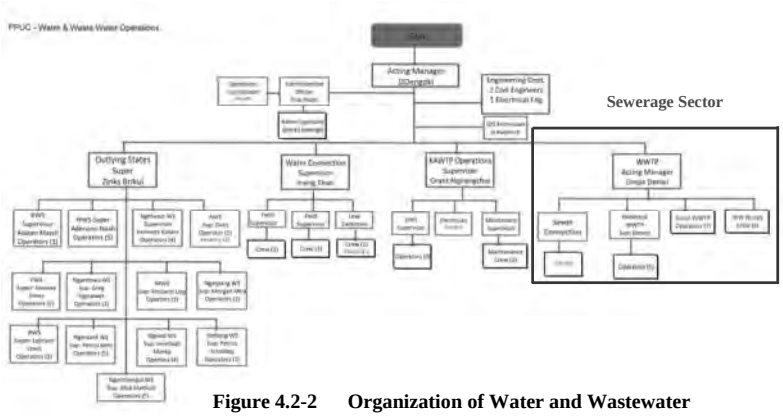


Figure 4.2-2 Organization of Water and Wastewater

(2) Finance Stability

The Water and Sewer Corporation Act 2010 and the Utilities Consolidation Act 2013 specify that tariffs must be set so that they recover all O&M costs, depreciation, and indebtedness, while in 2011 the government spent $3.8 million for water and sewerage services. For achieving the full recovery, by the end of FY 2015 the government aims to achieve the following targets (i) government subsidies reduced from 74 % (2011) to zero (ii) tariff collection efficiency improves from 92 % (2011) to 95 %, and (iii) nonrevenue treated water reduced from 43 % (2010) to 25 %.

The concept of tariff at present is (i) volumetric water and sewer tariffs for domestic and nondomestic connections, (ii) tariff increases to reduce an unsustainably too high level of per capita water consumption, (iii) Lifeline blocks to protect the poor and vulnerable are set below the cost of delivery. The present tariff system as shown in Table 4.2-1 is effective on 1. February, 2012. However, revision of new rate was postponed three times till now, namely, October 2013, January 2014, and July 2014 due to no approval of Board Members.

Table 4.2-1 Water and Wastewater Tariff System as of 2012.2.1

Category		Item		Water	Wastewater
Residential	Metered	Lifeline Rate	<18.927m^3/Month	$1.17/3.785m^3	$0.30/3.785m^3
			>18.927m^3/Month	$1.91/3.785m^3	
	Unmetered	Single Family Room /dwelling house		$15.00	$2.50
		Single Family Room /Airai-dwelling house		$12.50	
		Multi Family Dwelling/apartment		$15.00	$2.50
		Employee Barracks	1-10 Employee	$15.00	$2.50
			11-25 Employee	$35.00	$3.00
			26-50 Employee	$75.00	$4.00
			>51 Employees	$150.00	$5.00
Commercial	Metered			$1.91/3.785m^3	$1.70/3.785m^3
	Unmetered	Restaurant/Dining Facilities& Bars/Cocktail Lounge	1-25 Seats	$20.00	$2.50
			26-50 seats	$25.00	$3.00
			≧51	$40.00	$4.00
		Laundry/Laundromat	1-5 washes	$40.00	$4.00
			6-10 washes	$60.00	$6.00
			≧11 washes	$100.00	$10.00
		Hotel/Motel		$3.0/room	$3.0/room

Category		Item		Water	Wastewater
		Government Facilities/Other Unlisted Commercial Activities	1-25 Employees	$20.00	$2.50
			26-50 Employees	$25.00	$3.00
			51-100 Employees	$40.00	$4.00
			≧101 Employees	$60.00	$6.00
		Hospitals		$1.25/bed	$1.25/bed
		School/Colleges (non-boarding)	1-50 Students	$15.00	$1.50
			51-100 Students	$20.00	$2.00
			101-200 Students	$30.00	$5.00
			≧201 Students	$60.00	$7.50
		Boarding School/Colleges	1-50 Students	$35.00	$3.00
			51-100 Students	$70.00	$5.00
			101-200 Students	$140.00	$10.00
			≧201 Students	$250.00	$15.00
		Churches/Assembly Halls		$10.00	$1.50

Source: PPUC

The tariff and connection number in water/sewerage sector in March 2013 is shown in Figure 4.2-3, 4.2-4, respectively. It shows that both tariff and connection number in domestic sewerage sector is too low, and the weight of non-domestic revenue both in water and sewage is large.

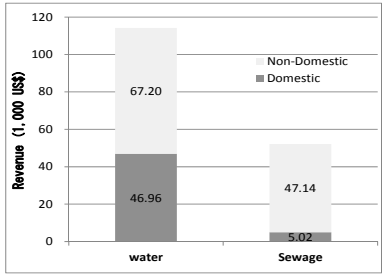


Figure 4.2-3 Revenue of Water and Sewage

Figure 4.2-5 shows the total amount of water and sewerage tariff is 17.4$/household/month. Base on "the Palau 2006 Household Income and Expenditure Survey"[3], average income in Koror State was 1,797$/household/month in 2006. Based on this monthly income, the ratio of total water and sewerage tariff to total income is 0.97%, which is too low in comparison with the international standard of 5 %.

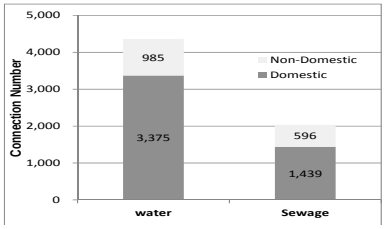


Figure 4.2-4 Connection Number of Water and Sewage

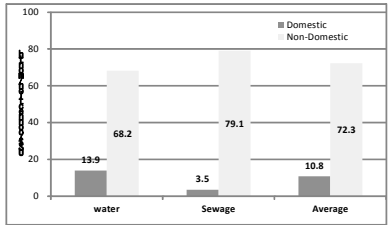


Figure 4.2-5 Revenue of Water and Sewage per connection

Water and sewer tariff are currently being adjusted in accordance with the tariff adjustments proposed under the Water Sector Improve Program to achieve full cost recovery by the end of fiscal year of 2015. Public hearing was conducted during the third week of September 2014 and was expected to become effective in the third week of October 2014.

However, the accident of leakage of water due to burst of distribution pipe at KB Bridge happened in October 2014 and it forced the systematic suspension and distribution of water

[3] http://palaugov.org/wp-content/uploads/2013/10/2006-Household-Income-Expenditure-Survey-Report.pdf

supply for more than one month. The president also declared that he could not agree to the tariff revision if water supply system will not be improved quantitatively and qualitatively.

Now, the Board Member of PPUC decided that the public hearing will be held in March 2015 and at the earliest, tariff system will be revised in April.

4.2.3 Ministry of Health (MOH)

(1) Outline

The Ministry of Health is the principal advisor on healthcare to the Government of Palau. It has a responsibility of ensuring that the physical, mental and social health of its citizens is always a priority.

The Ministry employs over 400 staff and incorporates the activities of (a) Administration, (b) Bureau of Clinical and Hospital Services, and (c) Bureau of Public Health.

The Ministry of Health shall take positive actions to (a) attain healthful environment, (b) promote health and social welfare, (c) protect family and health safety, (d) provide health care services throughout the Republic of Palau. Its main activities are:

i) Promotion and protection of public health through the provision of Primary and Preventative Health Services throughout Palau

ii) Provision of clinical medical services to the public through the operation and management of public medical facilities

(2) Division of Environmental Health

This division is under Bureau of Public Health and staff number is 15. The organization chart is shown in Figure 4.2-6. The services provided by this division are shown in Table 4.2-2.

With regard to the activity No.2, the staff visit and check the 10 items for all the houses/commercial facilities such as restaurant, hotel and so on, based on the check sheet as shown in Figure 4.2-7.

In case of some defect on site is found out, the staff issues the paper which instructs the correction point. Later, the staff visits the site again whether defect point has been corrected or not. In case of no correction, the staff can send the official letter to court, while it is very rare.

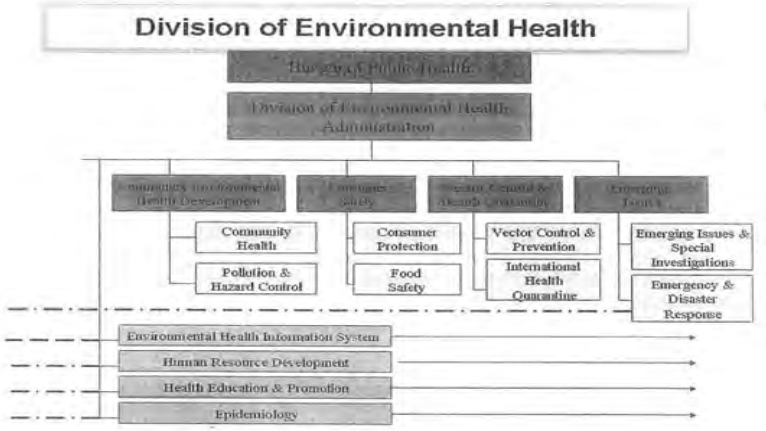
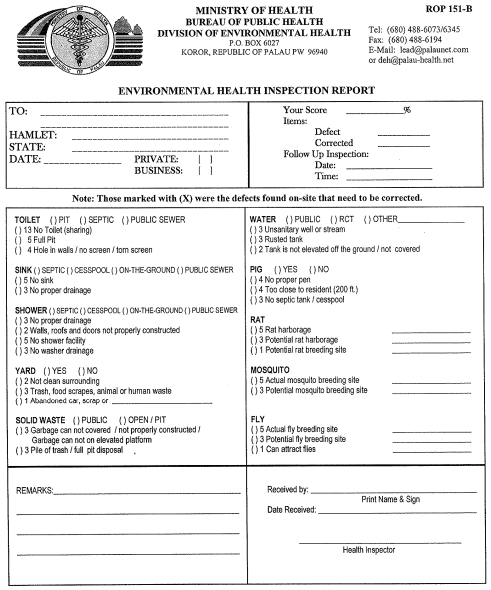


Figure 4.2-6 Organization Chart of Division of Environmental Health, MOH

Table 4.2-2 Service provided by DEH

No.	Name of Service	Content
1	Environmental Health Administration	. to navigate the Division in achieving its mission "to protect the health of all people by ensuring clean, safe and healthy living environment.
2	Community Environmental Heath Development	. to ensure improvement of overall health and safety of residents by addressing household and community-level environment health issues, identifying and controlling pollution and hazards, increasing health education and promotion activities, and facilitating community based project for health environment consisting of (a) community health and pollution, and (b) pollution and hazard control.
3	Consumer Safety	. to protect the health and safety of consumers by reducing risks and hazards in consumer products and/or service establishments . to reduce incidence and prevalence of food-borne disease and ensure that drinking water sources are safe in Palau.
4	Vector Control and Prevention & International Health Quarantine	. to reduce incidence and prevalence of vector-borne disease in Palau . to ensure enforcement International Health Regulations are enforced at all borders to reduce introductions of emerging & re-emerging diseases into Palau.
5	Emerging Issues	. to adequately respond to new emerging health issues as well as respond to daily emergencies, mass casualties and diseases in line with the Public Health Emergency Section
6	Environmental Health Information System	. to educate and promote environmental health in line with "Healthy people in Health Islands" vision.
7	Environmental Health Information System	. to manage environmental health data in relation to the overall MOH Health Information System
8	Epidemiology	. to manage and maintain reportable diseases and statistical analysis of outbreak information for environmental induced and environmentally related disease.
9	Human Resources Development	. to promote personal development and qualification toward the responsibility of Environmental Health



MINISTRY OF HEALTH
BUREAU OF PUBLIC HEALTH
DIVISION OF ENVIRONMENTAL HEALTH
P.O. BOX 6027
KOROR, REPUBLIC OF PALAU PW 96940

ROP 151-B

Tel: (680) 488-6073/6345
Fax: (680) 488-6194
E-Mail: lead@palaunet.com
or deh@palau-health.net

ENVIRONMENTAL HEALTH INSPECTION REPORT

TO: _____
HAMLET: _____
STATE: _____
DATE: _____ PRIVATE: [ ]
BUSINESS: [ ]

Your Score _____%
Items:
Defect _____
Corrected _____
Follow Up Inspection:
Date: _____
Time: _____

Note: Those marked with (X) were the defects found on-site that need to be corrected.

TOILET ( ) PIT ( ) SEPTIC ( ) PUBLIC SEWER
( ) 13 No Toilet (sharing)
( ) 5 Full Pit
( ) 4 Hole in walls / no screen / torn screen

SINK ( ) SEPTIC ( ) CESSPOOL ( ) ON-THE-GROUND ( ) PUBLIC SEWER
( ) 5 No sink
( ) 3 No proper drainage

SHOWER ( ) SEPTIC ( ) CESSPOOL ( ) ON-THE-GROUND ( ) PUBLIC SEWER
( ) 3 No proper drainage
( ) 2 Walls, roofs and doors not properly constructed
( ) 5 No shower facility
( ) 3 No washer drainage

YARD ( ) YES ( ) NO
( ) 2 Not clean surrounding
( ) 3 Trash, food scrapes, animal or human waste
( ) 1 Abandoned car, scrap or _____

SOLID WASTE ( ) PUBLIC ( ) OPEN / PIT
( ) 3 Garbage can not covered / not properly constructed / Garbage can not on elevated platform
( ) 3 Pile of trash / full pit disposal

WATER ( ) PUBLIC ( ) RCT ( ) OTHER_____
( ) 3 Unsanitary well or stream
( ) 3 Rusted tank
( ) 2 Tank is not elevated off the ground / not covered

PIG ( ) YES ( ) NO
( ) 4 No proper pen
( ) 4 Too close to resident (200 ft.)
( ) 3 No septic tank / cesspool

RAT
( ) 5 Rat harborage _____
( ) 3 Potential rat harborage _____
( ) 1 Potential rat breeding site _____

MOSQUITO
( ) 5 Actual mosquito breeding site _____
( ) 3 Potential mosquito breeding site _____

FLY
( ) 5 Actual fly breeding site _____
( ) 3 Potential fly breeding site _____
( ) 1 Can attract flies _____

REMARKS:_____

Received by: _____
Print Name & Sign
Date Received: _____

Health Inspector

Figure 4.2-7 Environmental Health Report by DEH

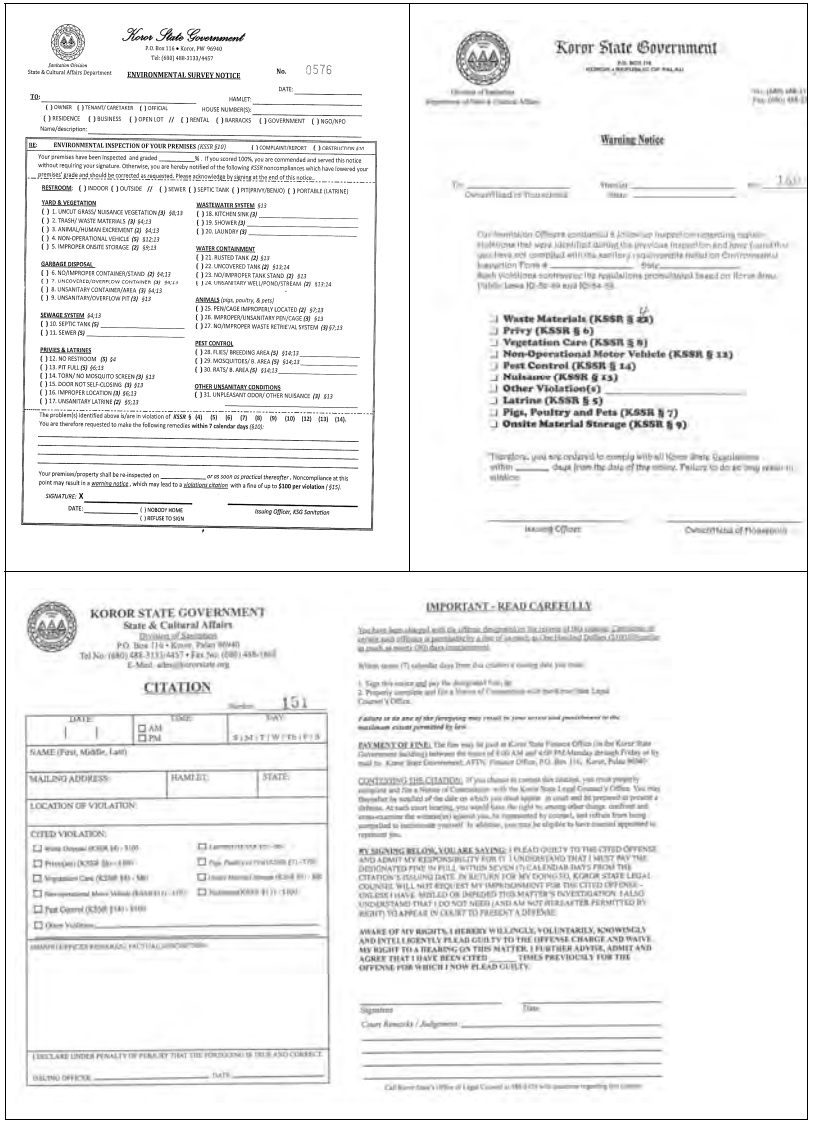
4.2.4 Koror State Government, State & Culture Department, Sanitation Department

The Sanitation Division in Koror State Government is under State & Culture Department and this division also survey and inspect every household/commercial facilities as shown in Figure 4.2-8. The division staff consists of 7, 1 manager plus 3 teams with 2 staff. 3 teams are engaged in on site job with survey, check, record, issue of warning notice if necessary. The time required for a series of work is 20-30 minutes/1 target building.

The difference between MOH and Koror State government is shown in Table 4.2-3.

Table 4.2-3 Difference between MOH and Koror State

Item	MOH	Koror State
Target Area	All Palau	Koror State
Purpose	Protection of disease	Beautification
Level of Inspector	Bachelor Degree at least	Graduate from High school
Target Building	Every household/commercial facility	Every household/commercial facility
Frequency	at least once/2 years In case of violating the regulation, 2-3 times/year depending the situation	3 times/year (November, March, July)
Case of violating the regulation	Issue notice and survey again, In case of no correction, MOH sends the letter to Court.	Issue warning notice and survey In case of no correction, issue of citation for payment of fine
Check Item	(1) Toilet (6) Water (2) Sink (7) Pig (3) Shower (8) Rat (4) Yard (9) Mosquito (5) Solid Waste (10) Fly	(1) Yard & vegetation (6) Water contamination (2) Garbage disposal (7) Animals (3) Sewerage system (8) Pest control (4) Privies & latrines (9) Other unsanitary (5) Wastewater system condition



Koror State Government
P.O. Box 116 • Koror, PW 96940
Tel: (680) 488-3133/4457

ENVIRONMENTAL SURVEY NOTICE No. 0576

Koror State Government

Warning Notice

- Waste Materials (KSSR § 23)
- Privy (KSSR § 6)
- Vegetation Care (KSSR § 8)
- Non-Operational Motor Vehicle (KSSR § 12)
- Pest Control (KSSR § 14)
- Nuisance (KSSR § 13)
- Other Violation(s) _____
- Latrine (KSSR § 5)
- Pigs, Poultry and Pets (KSSR § 7)
- Onsite Material Storage (KSSR § 9)

KOROR STATE GOVERNMENT
State & Cultural Affairs
Division of Sanitation
P.O. Box 116 • Koror, Palau 96940
Tel No. (680) 488-3133/4457 • Fax No. (680) 488-1860
E-Mail: admin@kororstate.org

CITATION

Number: 151

IMPORTANT - READ CAREFULLY

Figure 4.2-8 A series of Report by Koror State

4.3 Strategy for Sewerage Development

4.3.1 Government Policy and Strategy

In 2011, the Government integrated water and sewerage services into a single state-owned enterprise, the Palau Water and Sewer Corporation (PWSC), responsible for the delivery of water supply and sewerage services. The Utilities Consolidation Act 2013, aimed at optimizing efficiency in the management and delivery of power, water and sewerage services, consolidated the PWSC and the Palau Public Utilities Cooperation[4]. PPUC is now mandated to deliver electricity, water and sewerage services and the PPUC water and wastewater operations division has been established to manage and operate Palau's water and sewerage services. The creation of the PPUC Water and Wastewater Operations division and its development as a commercial enterprise is a first step toward possible private sector engagement in future.

4.3.2 Asian Development Bank

(1) Strategy[5]

Pacific Approach 2010-2014[6] now serves as the strategy for Palau, with details in the country operations business plan (COBP). ADB's approach to assisting the Pacific (The Pacific Approach) addresses challenges and opportunities common to ADB's Pacific developing member countries, and seeks to identify where and how regional approaches and common guidelines can be used to improve the effectiveness of development assistance.

The latest COBP[7] is for 2015-2017 and was approved on September 2014. The country operations business plan (COBP), 2015-2017 for Palau is consistent with the Pacific Approach, 2010-2014 and the Midterm Review of Strategy 2020 of the ADB. The COBP aligns with the government's Medium Term Development Strategy, 2009-2014 and the management action plan adopted by the government in 2013. Of the five priority areas, the diversification of the economy and investments in human resources and infrastructure, and private sector and public-private service provision, investment, and economic development guide the COBP. The COBP also supports the government priorities focusing on (i) improving public sector effectiveness, (ii) facilitating private sector development, (iii) delivering safe water and sanitation services, and (iv) improving connectivity.

(2) Project Records on going

Project records are listed by actual or planned approved date as shown in Table 4.3-1. They contain Project Data Sheets (summary information on projects or progress) as well as project and evaluation documents, business opportunities, and other project related information about proposed projects is tentative and indicative.

[4] Republic of Palau Public Law 9-4: The Utilities Consolidation Act 2013
[5] http://www.adb.org/countries/palau/strategy
[6] http://www.adb.org/sites/default/files/publication/27520/adb-pacific-approach-2010-2014.pdf
[7] http://www.adb.org/sites/default/files/institutional-document/148682/cobp-pal-2015-2017.pdf

Table 4.3-1 Project Record by ADB

Project Name	Types of Assistance	Approval Number	Approved Amount (1,000$)	Approval Date	Status
42439-013 Koror Airai Sanitation Project (http://www.adb.org/projects/42439-013/html)	Loan Loan	3060 3061	26,900 1,900	2013.1.19	Approved
44031-013 Water Sector Improvement Program (http://www.adb.org/projects/44031-013/html)	Loan Loan	2691 2692	12,600 3,473	2010.11.9	Closed 2014.4.2
42436-012 Implementation a Medium-Term Budget Framework (http://www.adb.org/projects/42436-012/main)	TA	7421	500	2009.12.8	Closed 2013.7.12
42439-012 Sanitation Sector Development Project (http://www.adb.org/projects/S/main)	TA	7382	700	2009.11.20	Closed 2012.9.29

(3) Project Record in Pipeline

In response to a request by PPUC, ADB is providing support as part of its overall assistance to the national government to review its public service, to be administered through the Ministry of Finance. ADB received endorsement to proceed with engagement of consultant from both PPUC and ultimately Ministry of Finance.

Objective and purpose is to support the government of Palau for strengthening its public administration systems to enable more responsive, efficient and accountable public service delivery. A project term is to be 6 months.

(a) to develop a revised human resource structure suitable for the newly merged entity;

(b) to develop a human resource development plan, including a framework for retention and succession to ensure continuity of the civil service; and

(c) to strengthen links between its human resources and financial management information systems.

4.4 Water Quality Regulation

4.4.1 Marine and Freshwater Quality Standard[8]

In EQPB Regulations Current as of January 8, 2013, "Chapter 2401-11 is Marine and Fresh Water Quality Regulations" Extract of this chapter is shown in Table 4.4-1.

[8] Palau EQPB Regulations, Groundwater standards are not included.

Table 4.4-1 Marine and Freshwater Quality Standards by EQPB Regulations Current as of January 8, 2013

Item	Sub-item
Water Use Classification	2401-11-05 Classification of Coastal Water Uses 2401-11-06 Classification of Fresh Water Uses 2401-11-07 Classification of Groundwater 2401-11-08 Classification of Groundwater Areas
Water Quality Standards	2401-11-09 Basic Criteria Applicable to All Waters 2401-11-10 Microbiological Standards 2401-11-11 pH Standards 2401-11-12 Nutrient Standards 2401-11-13 Dissolved Oxygen 2401-11-14 Total Dissolved Solids, Salinity, Currents 2401-11-15 Temperature 2401-11-16 Turbidity 2401-11-17 Radioactive Materials 2401-11-18 Oil and Petroleum Products 2401-11-19 Toxic Substances 2401-11-20 General Conditions
Water Quality Certification	2401-11-43 Groundwater Areas 2401-11-44 Permits/Licenses Subject to Certification 2401-11-45 Scope of Work 2401-11-46 Approval Criteria 2401-11-47 Conditioning of the Certification 2401-11-48 Contents of Certification 2401-11-49 Standard For Certification 2401-11-50 Certification Modification 2401-11-51 Contents of Application 2401-11-52 Notice and Hearing 2401-11-53 Waiver 2401-11-54 Effect of New Standards on Permitted Activity
Enforcement	2401-11-55 Enforcement

"Classification of Coastal Water Uses" in the Koror State is as an example shown in Table 4.4-2 and Figure 4.4-1.

Table 4.4-2 2401-11-05 Classification of Coastal Water Uses

Class	Definition	Koror State
AA	(1) The uses to be protected in this class of water are oceanographic research, the support and propagation of shellfish and other marine life, conservation of coral reefs and wilderness areas, compatible recreation and other aesthetic enjoyment. (2) It is the objective that this class of waters remain as near to their natural state as possible with an absolute minimum of pollution from any source. (3) To the extent possible, the wilderness character of such areas shall be protected. No point source discharge will be permitted in these waters, nor will destruction of reefs, aquatic habitants or other resources be permitted. (4) The classification of any water areas as Class AA shall not prelude other uses of such waters compatible with these objectives and in conformance with the standards applicable to them.	All areas (not otherwise classified)
A	(1) The uses to be protected in this class of waters are recreational (including fishing, swimming, bathing, and other water contact sports), aesthetic enjoyment, and the support and propagation of aquatic life. (2) It is the objective that in this class of waters, use for recreational purposes and aesthetic enjoyment shall not be limited in any way. (3) Class A waters shall be kept clean of any trash, solid materials and oil, and shall not act as receiving waters for any effluent which has not received the highest degree of treatment or control practicable under existing technological and economic conditions and shall be compatible with the standards established for this class.	(a) Meyuns, (b) Echang, (c) Cholebdechal (Oleblechol), (d) Ngiritang, (e) M-Dock (Singhatoba) Point, (f) Ngetmeduch, (g) Mechang
B	(1) The uses to be protected in this class of waters are small boat harbors, commercial and industrial shipping, bait fishing, compatible recreation, over-water commercial or residential structures for recreational or domestic use*, the support and propagation of aquatic life, and aesthetic enjoyment. (2) It is the objective for this class of waters that discharge of any pollutant be controlled to the maximum extent possible and that sewage and industrial effluent receive the highest degree of treatment practicable under existing technological and economic conditions, and shall be compatible with the standards established for this class. (3) The Class B designation should apply only to a limited area next to boat docking facilities. *No coastal areas with a coastal mangrove fringe greater than 50 feet in width shall be classified as Class B waters after the effective date of this amendment.** (4) The rest of the water area in such bay or harbor not falling within the area identified in the previous paragraph shall be Class A unless given some other specific designation.	(a) Malakal (Ngemelachel) Harbor, (b) M-Dock (Singhatoba) including S.E. of Ngerbeched Shore, (c) Kemangel Toachel, excluding T-Dock, (Ngerkemais), (d) Metukerademul to E. side of old Japanese Dock (Derromel), (e) Ngereksong, (f) Nikko (Iwayama) Bay from the Nikko pier to a shoreline boundary approximately 1200 feet N.W. of the Nikko pier and an additional 300 feet of offshore reef flat to the N.W. of the shoreline boundary, (g) Waters extending 200 m from the shoreline of Ngerur Island.

Summary of marine and freshwater quality standard based on the above-mentioned EQPB Regulations Current as of January 8, 2013, is shown in Table 4.4-3.

Table 4.2-3 Summary of Marine and Freshwater Quality Standards[9]

Parameter	Coastal Marine Waters			Freshwater	
	Class AA	Class A	Class B	Class 1	Class 2
Fecal Coliform	230/100ml 70/100ml[m]	400/100ml 200/100ml[m]	400/100ml 200/100ml[m]	230/100ml 70/100ml[m]	400/100ml 200/100ml[m]
Enterococci	60/100ml 33/100ml[gm]	60/100ml 33/100ml[gm]	-	-	-
Shellfish Areas		*	*		*
pH	7.7-8.5	7.7-8.5	7.7-8.5	6.5-8.5	6.5-8.5
Ratio N:P	11.1-27.1	11.1-27.1	6.1-18.1	<10% var.	<10% var.
Total P mg/l as P	<0.025	<0.025	<0.500	<0.2	<0.2
Total N mg/l as N	<0.4	<0.4	<0.8	<0.75	<0.5
DO (mg/l)	>6.0/75%	>5.0	>4.5	>6.0/75%	>5.0
Turbidity Units (NTU)	1	1	2	>5% above natural conditions	>10% above natural conditions
Salinity	<10% Change from natural isohaline conditions or outside the range of 29-35 ‰ or which would otherwise adversely affect the indigenous biota and natural sedimentary patterns.				
Temperature	<0.9% Change from natural condition				

m: Median total for 10 consecutive samples, gm: Geometric Mean for 5 samples in a 30 days period, var : variation from the natural conditions

*In areas where shellfish are harvested for human consumption, the micro-biological standards for Class AA and 1 Waters shall apply.

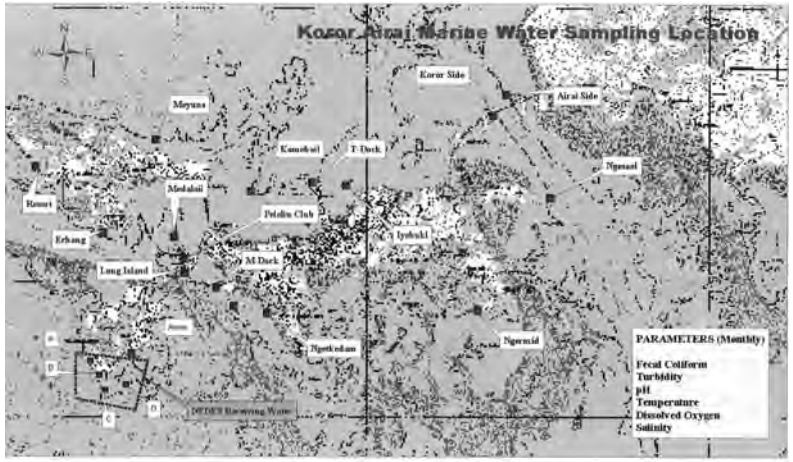


Figure 4.4-1 Koror Airai Marine Water Sampling Point

4.4.2 Monitoring Result by EQPB[10]

The monitoring result from 2010 to 2014 is shown in Figure 4.4-2 and 4.4-3 and Table 4.4-4. From these result in figures/table, the following issues are found.

(1) While EQPB wishes to monitor at least 6 parameters (pH, Temperature, Dissolved Oxygen, Salinity, turbidity, fecal-coliform) of marine water quality once a month, only two parameter consisting of turbidity and coliform was monitored 7 times/year in 2010, 3 times/year in 2011, 4 times/year in 2012, 5 times in 2013.

[9] Palau EQPB Regulations, Groundwater standards are not included.
[10] EQPB

(2) All the results of turbidity complied with the standard/

(3) All the result of fecal coliform exceeded the 400 MPN/100ml, which means that any data of fecal-coliform does not meet this standard.

(4) The monitoring frequency of pH, Temperature, Dissolved Oxygen, Salinity was less than that of turbidity and fecal-coliform.

(5) All the result of turbidity, pH met the standard. Only one result of DO did not comply with the regulation of more than 4.5 mg/l.

(6) Whether the result of temperature and salinity complied with the standards was not clear because there is no data of natural conditions.

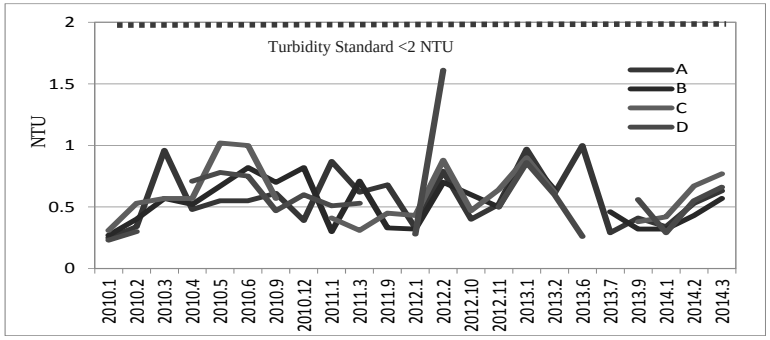


Figure 4.2-2 Turbidity trend at 5 points from 2010 to 2014

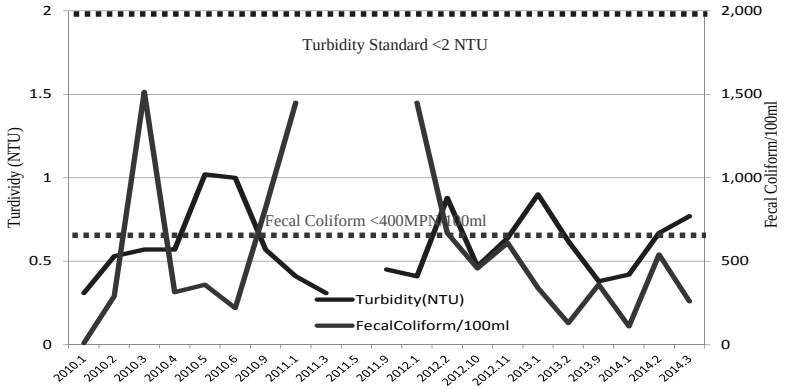


Figure 4.2-3 Turbidity and Fecal Coliform at point C from 2010 to 2014

Table 4.4-4 Result of Turbidity and Fecal Coliform from 2010-2014

Location	Sapling Date	Turbidity (NTU)	pH	Temperature (℃)	Dissolved Oxygen (mg/L)	Salinity	Floating Material
A	2010/5/17	0.55	8.30	30.00	5.20	34.10	none
	2010/6/15	0.55	8.30	30.50	5.10	33.90	none
	2010/9/23	0.61	7.90	30.90	5.40	33.40	none
	2010/12/28	0.39	8.20	33.00	5.80	33.20	none
	2011/9/13	0.68	7.60	30.20	5.80	30.30	none
B	2010/5/17	0.67	8.30	30.20	5.00	33.70	none
	2010/6/15	0.82	8.30	30.50	5.20	33.50	none
	2010/9/23	0.7	7.90	30.90	4.30	31.50	none
	2010/12/28	0.82	8.20	30.10	6.10	33.50	none
	2010/12/28	0.73	8.20	29.80	5.30	33.20	odor
	2011/9/13	0.33	7.60	30.00	6.40	31.50	none
C	2010/5/17	1.02	8.30	29.90	5.10	34.00	odor scum
	2010/6/15	1	8.30	30.50	5.10	33.70	odor
	2010/9/23	0.57	8.00	30.70	5.10	33.20	odor
	2011/9/13	0.45	7.60	29.90	6.10	31.50	none
	2011/9/13	0.37	7.60	29.90	6.10	31.60	none
D	2010/5/17	0.78	8.30	29.90	5.00	34.00	none
	2010/6/15	0.75	8.30	30.50	5.10	33.70	none
	2010/9/23	0.47	8.00	30.70	5.10	33.30	none
	2010/12/28	0.6	8.20	30.00	5.40	33.50	none

Value in yellow color violates the regulation.

4.4.3 Permission in Malakal STP

(1) Outline of Permission

Discharge of wastewater from the facilities shall be conducted in accordance with Palau National Code, Title 24, Chapter 1 and the Marine and Freshwater Quality Regulation, Chapter 2401-11, "2401-11-45 Permits/Licenses Subject to Certification" promulgated thereunder, and in a manner to protect the quality and beneficial uses of marine and fresh waters of Palau.

(A) Water quality certification must be provided by the Board prior to the issuance of any EQPB Permits or any permits required by Sections 402 and 404 of the United States Clean Water Act (33 U.S.C. Sections 1342 and 1344) and section 10 of the United States Rivers and Harbors Act, approved March 3, 1899, (33 U.S.C. 403).

(B) A Republic of Palau Foreign Investment Board license may also be required in order to receive water quality certification.

EQPB issues a Pollution Discharge Permit incorporating both the treatment standards and water quality standards of the EQPB Maine and Fresh Water Quality Regulations, Chapter 2401-11, for the particular receiving water use classification (Class B). The effluent of Malakal STP was considered to comply with these regulatory standards implemented as treatment based and water quality based effluent limitation within a mixing zone. (i.e, the discharge is from a submerged outfall with initial dilution.) So, on August 26, 2002, the permittee (Ministry of Resources and Development) submitted an application for an EQPB Pollutant Discharge Permit and NO. PEA-261-02 was issued by EQPB according to the following procedure in 2002. The administrative processing of an EQPB Pollutant discharge application consists of the following actions:

(a) Filing of a complete permit and certification application by the permittee;

(b) Comparison of the application with standards and criteria set forth in the stature and

regulations, and preparation of a draft Pollutant Discharge permit by EQPB staff; and

(c) Public notice of a draft Pollution Discharge permit by the EQPB and EQPB Board Meeting (s) to address public interests and concerns, and issuance of EQPB permit and certification.

The content of PEA-261-02 is shown in Table 4.4-5.

(2) Problems of Permission

(a) PEA-261-02 was issued by EQPB in 2002. However, it expired on September 31, 2007 and no permit any more from 2007.9. Strictly speaking, the operation of STP is illegal.

2401-11-55 Enforcement Any person in violation of any of the provisions of these regulations shall be subject to enforcement and court action under 24 PNC Sections 161 through 172, inclusive.

(b) Malakal STP has to report the water analysis of each parameter periodically based on the special condition. However, the laboratory of Malakal STP has no function of analyzing the water quality since October 2013.

Table 4.2-5 PEA-261-02 for Malakal STP

SPECIAL CONDITIONS:

A. EFFLUENT LIMITATIONS AND MONITORING REQUIREMENTS

1. During the period beginning with the effective date of this permit and lasting through the expiration date of this permit, the permittee is authorized to discharge treated wastewater from **Outfall 002** to receiving waters named Malakal Harbor. Such discharge shall be limited and monitored by the permittee as specified below:

Effluent Characteristic	Maximum Discharge Limitations (Unless Otherwise Noted)					Measurement Frequency	Sample Type
	Average Monthly (lbs/day)	Average Weekly (lbs/day)	Average Monthly	Average Weekly	Maximum Daily		
Flow	n/a	n/a	n/a	n/a	2.0 MGD	Continuous	Continuous
Biochemical Oxygen Demand (5-day) [1]	500	751	30 mg/L	45 mg/L	n/a	1 day/week	8 Hour Composite
Total Suspended Solids [1]	500	751	30 mg/L	45 mg/L	n/a	1 day/week	8 Hour Composite
Settleable Solids	n/a	n/a	1 ml/L	n/a	2 ml/L	1 day/week	Discrete

(1) Effluent limitations and monitoring requirements are based upon an average daily design flow of 2.0 MGD.

Both the influent and the effluent shall be monitored.

The arithmetic mean of the BOD_5 and TSS values, by concentration, for effluent samples collected over a calendar month shall not exceed 15 percent of the arithmetic mean, by concentration, for influent samples collected at approximately the same times during the same period.

Mass emission rate limitation is calculated using an average daily design flow of 2.0 MGD.

Effluent limitation is considered to be that achievable by the highest degree of treatment practicable under existing technological and economic conditions, and complies with the secondary treatment rule required by U.S. regulations.

Effluent Characteristic	Maximum Discharge Limitations (Unless Otherwise Noted)					Measurement Frequency	Sample Type
	Average Monthly (lbs/day)	Average Weekly (lbs/day)	Average Monthly	Average Weekly	Maximum Daily		
Oil and Grease	[2]		[2]		[2]	Quarterly [3]	Discrete
pH	pH variation shall be within 7.7 to 8.5 pH units					1 day/week	Discrete
Fecal Coliform			700 MPN/100 mL	n/a	1400 MPN/100 mL	Monthly	Discrete
Total Nitrogen	83		5 mg/L	n/a	10 mg/L (167 lbs/day)	Quarterly	24 hr Composite
Unionized Ammonia							
Total Phosphorus	83		5 mg/L	n/a	10 mg/L (167 lbs/day)	Quarterly	24 hr Composite
Priority Toxic Pollutants [4]	[2]		[2]	n/a	[2]	Oct 2004	24 hr Composite

(2) Monitoring and reporting required. No limitation set at this time.

(3) January - March; April - June; July - September; and October – December; Board may decrease measurement frequency if monitoring data shows no violation of effluent limitations.

(4) Priority toxic pollutants (excluding asbestos) are listed in 40 CFR 131.36(b)(1). The permittee shall collect *24 hour composite samples* for metals, 2,3,7,8-TCDD (dioxin), pesticides, base-neutral extractables, and acid-extractables. The permittee shall collect *discrete samples* for cyanide and volatile organics.

AP-6-65

4.4.4 Permission in Melekeok STP

While the permit was seemed to be issued to Bureau of Public Works, Ministry of Resources and Development on 05/24/04, there is no document of Permit in EQPB. So, it is difficult to know how about the condition of discharging the effluent to sea. Since it has already passed 10 years, the permit might be expired already as same as the case of Malakal STP.

4.5 Current Sanitation Status in Palau

4.5.1 Outline of Sanitation Status

Palau has an estimated population of 17,500 in 2012, with the majority of the population located on the island of Koror. Koror and Airai contain 80% of the Palau population. The only urban centres with a sewerage system and treatment works are in Koror and Melekeok States. All other population centres use onsite sanitation systems such as septic tanks or pit latrines.

Table 4.5-1 shows a sanitation situation in 2012 in Palau.

Table 4.5-1 State wise Sanitation Status in Palau (Palau Mini Census 2012)

State	Population (2012)	Sanitation Status				
		Public Sewer Pipe	Septic tank/Cesspool	Out house	Other means	Total
Koror	11,665	2,289	629	103	16	3,037
Airai	2,537		671	46	2	719
Peleliu	489		198	2		200
Ngaraard	453		113	49	1	163
Ngaremlengui	309		54	35		89
Melekeok	299	69	35	2	2	108
Ngchesar	287		88		1	89
Aimeliik	281		64	30		94
Ngarchelong	281		66	51		117

State	Population (2012)	Sanitation Status				
		Public Sewer Pipe	Septic tank/Cesspool	Out house	Other means	Total
Ngatpang	257		56	5	1	62
Ngiwal	226		64	16		80
Ngardmau	195		41	24	1	66
Angaur	130		18	32	2	52
Kayangel	76		14	27		41
Hatohobei	10			5		5
Sonsorol	6			3	1	4
Total	17,501	2,358	2,111	430	27	4,926

Source: 2012 Mini Census, Table 13

**Note: During the time of census enumeration, the characteristic of the dwelling "Access to Public Sewer" was observed by the enumerator thus these fields can be obtained regardless if the dwelling was occupied or vacant.*

4.5.2 Outline of Sewerage System

(1) Koror State

The sewage network in Koror State covers Koror, Malakal and Arakabesang islands and comprises 29.5 Km of gravity pipe, 13.2 Km of force (pumped) mains, 48 pump stations, and a sewage treatment plant (STP) located on the island of Malakal. For the most part, the commercial sector of the city is located at the crest of the ridge and the residential hamlets stretch down to the coast. Sewage is pumped up to the ridge and flows to the STP. The sewer network and STP have been operated more than 30 years, and STP along with some pump stations have been refurbished in the last 10 years, these have not been maintained or operated as designed. The low capacity of some parts of sewer sometimes causes overflows at the low-lying pump stations and subsequent discharge of effluent to the natural and built-up environment, including through people's homes, taro patches, and into the lagoon. The number of overflows increase due to network deteriorates. The problem is exacerbated by: (i) poor maintenance, (ii) inadequate emergency response capability, (iii) groundwater infiltration, and (iv) illegal storm-water connections.

(2) Melekeok State

The capital of Republic of Palau was transferred to Malekeok State, which is located in the center of Babeldaob Island in June, 2006. The sewerage system in the new capital was developed strongly by the assistance of the Republic of China. The population in the Melekeok State is about 300 residing along the eastern part of the coastal area.

(3) Other State

Only two States have sewerage system as above mentioned. Kasebelau in Airai State, adjacent to Koror, is growing new residential division responding to lack of available land for new housing in Koror State. Currently it has 300 homes; and this number is expected to double by 2036. The soil types and allotment sizes are unsuitable for septic tank, which frequently overflow discharging effluent through properties and into nearby water courses. So, this area is included in ADB project.

4.5.3 Koror-Malakal Sewerage System

(1) History of Koror-Malakal Sewerage System

The sewerage system started construction 1973 and gradually extended the service area. In 2002, the rehabilitation of the existing STP, followed by the refurbishing the PS each by each. The history of the sewerage system is shown in Table 4.5-2.

Table 4.5-2 History of Koror Sewerage System

Year	Collection System	PS	STP	Remarks
1973	Construction (1) started			
1974	Mitsui (JP) & Centra-Mills Company (Taiwan)		Construction started	
1977	Construction (1) completed		Construction completed.	
1978			Santa Fe (U.S) California	Domestic wastewater has been discharged from this outfall since early 1978.
1979	Construction (II)		1MGD	
1981	Construction (III)			
1985	Construction (IV)			
1986		A-7		
1988		37 stations		4,000 persons served.
1990				Roughly 52 % of house units use individual wastewater system, 62 % of all house in Koror used Flush toilet. About 14 % of Koror residential facilities contained septic tanks/cesspools. Roughly 39% of the homes in Koror used other types of individual wastewater disposal system.
1993				may have reduced the number of non-connected homes to about 30%.
1994		37 stations	Average dry flow 0.86 MGD	7,100 residents of Koror (68%)
1995			Maximum flow 1.120 MDG	
2000				3200 unit hook to system (80%)
2001		48 stations		
2002			Improvement start	
2004			Improvement completed ($3.6 M)	
2005			2 M$ in wet weather up to 5.3 MGD	
2006		48 stations		

Source: report of Mr.Takeshima, JICA SV,2011.3,

(2) Sewer System

The total length of sewer system is as shown in Table 4.5-3. It shows almost 30 % of total length is force main which is used for lifting up the sewage in lower level through PSs.

Table 4.5-3 Sewer Length of Sewer System

Item	Gravity (km)			Force Main (km)	Total (km)
	Main	Networ	Sub-tot		
Koror	3,675				
Malak	791				
Alaka	1,432				
Total (%)	5,898 (13.8)	23,633 (55.3)	29,531 (69.1)	13,206 (30.9)	42,737 (100.0)

Figure 4.5-1 Snake

At present, there is neither ledger whish shows the location/depth/pipe materials/slope, nor inspection tools for grasping the current situation and finding out the problems. In case of clogging of the sewer, staff tries to solve the problem by using “snake” as shown in Figure 4.5-1, while there is little record for this work. Figure 4.5-2 shows the Koror State Sewerage System.

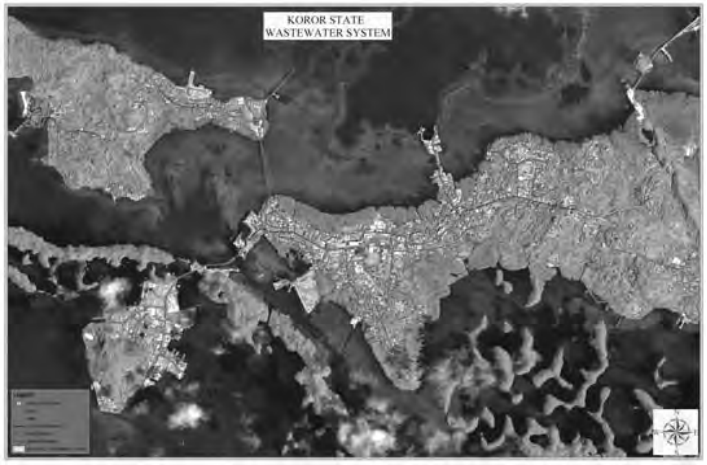


Figure 4.5-2 Sewerage System in Koror State

(3) Pumping Station (PS)

(a) Outline of PS

The part of service area does not drain into the central trunk sewer directly by gravity. The service area consists of many service sub-areas downhill from the main trunk sewer, and each one is served by a pump station which directly or indirectly lifts the sewage into the trunk sewer.

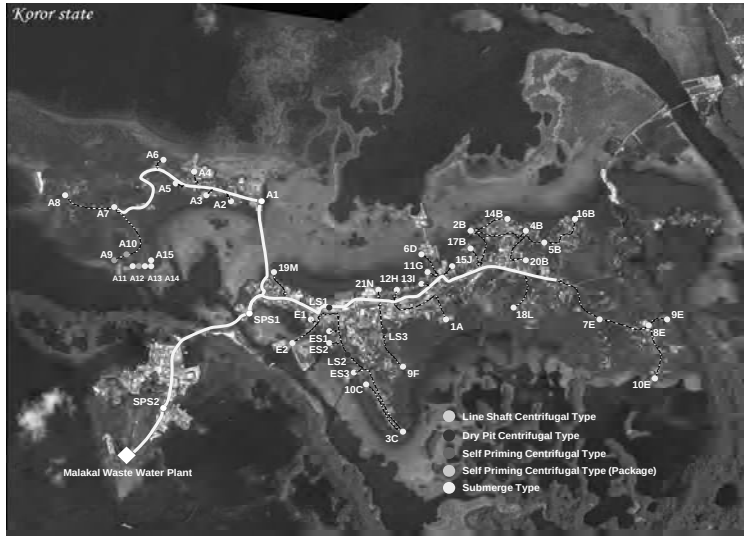


Figure 4.5-3 Pump System in Koror State (2004)

The division of the service area into sub-areas does not appear to have been planned, nor necessarily well executed. Rather, pump stations and collection networks appear to be a direct response to immediate housing development pressures. This means that there are far more pump stations than needed, resulting in greater operational complexity, cost, and risk of of breakdown.From 2006, some PSs were rehabilitated by the grant aid from the Republic of China. (The details are mentioned in 4.5.1.). Every day, the staff at Malakal STP patrol and check all the STP in order to find out an abnormality of the pump operation. However it is very difficult to get the amount of lifted sewage quantity due to an insufficient record of operation hour. While the current situation of PSs is better in comparison to that of sewer pipe, the main cause of trouble is frequent power failure due to sudden high voltage than expected. Since the generators are installed only in the major 5 PSs (SPS-1, SPS-2 A1, 2B, A7), the remaining PSs stop to transfer the sewage during power failure, resulting in the overflow from the PS. The layout of PS and tree of PSs in Koror (2004) and PS and Sewer System in Koror State is shown in Figure 4.5-3, 4.5-4, and 4.5-5, respectively.

(b) Current Problem

The part of service area does not drain into the central trunk sewer directly by gravity. The service area consists of many service sub-areas downhill from the main trunk sewer, and each one is served by PS which directly or indirectly lifts the sewage into the trunk sewer. The division of the service area into sub-areas does not appear to have been planned, nor necessarily well executed. Rather, PSs and collection networks appear to be a direct response to immediate housing development pressures. This means that there are far more PSs than needed and so there is far greater operational complexity, cost, and risk of of breakdown. Consequently, the existing number of PSs became 48.

Although 12 PSs have repaired under Koror Sewer System Upgrade Project Phase IV supported by Republic of China, the condition of remaining PSs are still not good in operation based on ADB PAL TA-7382 Appendix H, as shown in Table 4.5-4. Furthermore, the generators are installed only in the major 5 PSs (SPS-1, SPS-2 A1, 2B, A7) and the remaining PSs stop to transfer the sewage in case of blackout, resulting in the overflow from the PS into near premises.

Table 4.5-4 Current Problem of Existing PSs

Number	Phenomena
A2	– This PS is located on private land behind a car repair yard. Overflows discharge directly through the car storage area and private property. – The pump control level does not appear to be correct especially for low water cut-off. – The noise associated with pump operation was reminiscent of failing bearings and/or the pump drawing air into the pump volute and discharge.
A4,A5	– Most wet well access covers shows signs of corrosion and does not provide adequate safety against unauthorized entry. – In addition, most wet wells shows degrees of fat and grease accumulation more than usually found in domestic sewerage systems with resultant odor problems.
A6	– Since construction of PS A6, the owners have modified the original dwelling and it almost sits up against PS. – Consequently, overflow discharge point is at the front door and the overflow path goes down the side of dwelling. – Household affects clutter PS wet well access and bloc entry to the control of panel.
19M	– This PS represents an extreme case of poor control over PS siting and construction near sewerage infrastructure. – The PS almost completely is surrounded by a car repair shop and associated dwellings and buildings leaving very restricted access to the pump station for repairs.

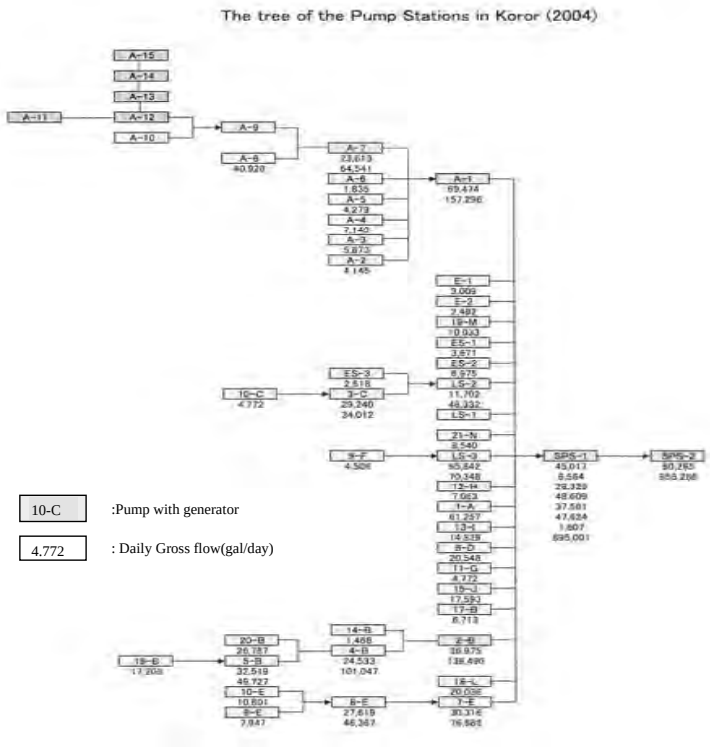


Figure 4.5-4 Tree of PS in Koror State (2004)

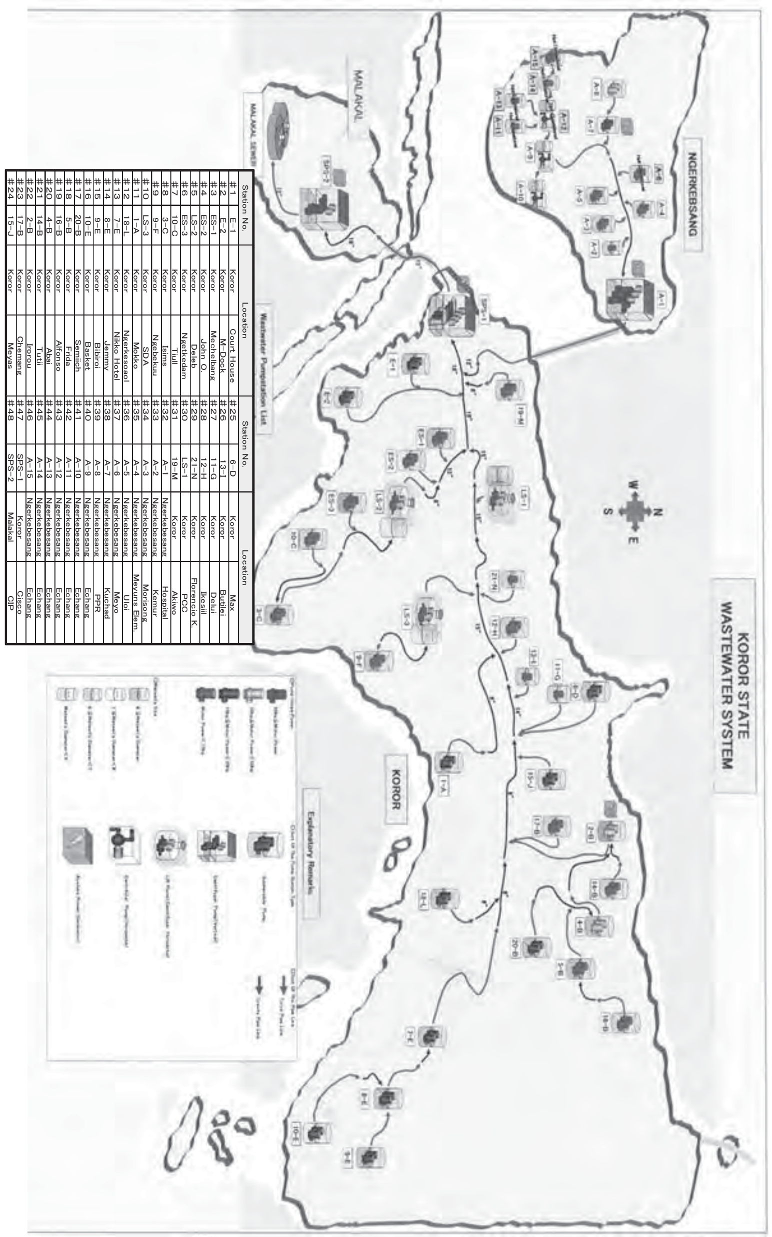


Figure 4.5-5 PS and Sewer System in Koror State

(4) Malakal Sewage Treatment Plant

(a) Outline of STP

The STP consisting of only two trickling filters started construction in 1974 and operation in 1977. During 2002-2004, rehabilitation was conducted by installing the circulated primary pond and two pieces of wet land system. Now, all the sewage through the PSs come to the primary pond, then is transferred to tricking filter, then discharged to the sea through two wet land system. In 2004, operation and maintenance manual were prepared by Winzler & Kelly. While it is said that the inflow amount to STP is 3,800 m^3/day by calculating operation hour of SPS-2, nobody knows the correct inflow amount because the flow meter in the STP has been out of order since 2007.

Although the design and planning is conducted by using the difference of the height of about 20 m, the effluent is not so good due to poor operation and maintenance. in order to improving the performance of STP, senior volunteer was dispatched who instructed the measurement of effluent quality to the staff of STP from 2011 to 2003. However, there is no analysis data since he has left to Japan in September 2013. So, it is impossible to check the water quality complies with the permission of EQPB.

The effluent is discharged through outfall pipe, buried beneath rip-rap and sand which reaches from the shore to the right hand corner of reef, into the sea classified as Class B receiving waters of Malakal Harbor of the Pacific Ocean, approximately 365 meters offshore at a depth of about 14m. The Malakal submerged outfall consists of two parts. The first part is a single 18" diameter cast/ductile iron pipe about 546 m long running from the effluent end of the chlorine contact chamber to an offshore point. The second part consist of two 6" diameter ductile iron diffuser pipes on the 18" pipe resting on the harbor bottom, approximately 24 m apart at depts. The layout and hydraulic profile of Malakal Sewage Treatment Plant is shown in Figure 4.5-6 and Figure 4.5-7, respectively. The structure of treatment facilities is shown in Figure 4.5-8, 4.5-9, and 4.5-10.

(b) Each Facility

The function of each facility is shown in Table 4.5-5.

Table 4.5-5 Function of Each Facility

Name	Description
Influent pump Station (SP2)	The end of the wastewater collection system consists of a lift station (SP2) which receives raw wastewater from the collection system. The raw water is pumped from the lift through a 12" force main to the primary pond. The force main splits before entering the primary pond and continues to two separate inlet points.
Primary Pond (Fig.4.13)	The incoming raw sewage is discharged into the primary pond through two submerged pipes. The primary pond is designed to retain about 10-20 days of solids and to reduce the oxygen demand of the wastewater. The primary pond contains three floating surface aerators that run in turn to supply supplemental oxygen to the pond. The wastewater flow leaves the pond via an outlet structure at the west end of the primary pond and flows to the primary distribution structure.
Trickling Filter (Fig.4.12)	The flow is split at the primary distribution structure before it continues to the secondary trickling filters (TF). The TFs provide the secondary treatment. The wastewater flows over two different length weirs contained in the primary distribution structure so that the split flow to each TF is proportional to the volume of filter media contained in the TF. Two TFs are connected in parallel and are both used to accomplish secondary treatment. The treated wastewater leaving TF A enters the lower chamber of TF B, from where all the secondarily treated wastewater flows to the wet lands cells for additional treatment and solids removal, or Recirculation Pump station.
Wetland Cells (Fig.4.14)	The secondarily treated wastewater that leaves the TFs, that does not get recirculated to the primary pond, continues to the wetland cells for additional treatment. There are two wetland cells in the treatment system, wetland cell A and cell B. Typically wastewater from the secondarily TF first flows into the wetland cell A through transfer structure #2 and out of wetland cell B through structure #3 to the effluent pump station. Solids that slough off the TF are removed in the wetlands.
Effluent Pump Station	Once the effluent has passed through both wetland cells it has been treated sufficiently enough for disposal. The effluent then flows into the effluent pump station from transfer structure #3. The

Name	Description
	effluent is discharged through the pump station via existing 18" pipe to an existing ocean outfall. The effluent can flow by gravity and through the ocean outfall under certain condition. However when the tide is high and flow exceeds 1MGD, the effluent pump is activated to pump the effluent Through ocean outfall.

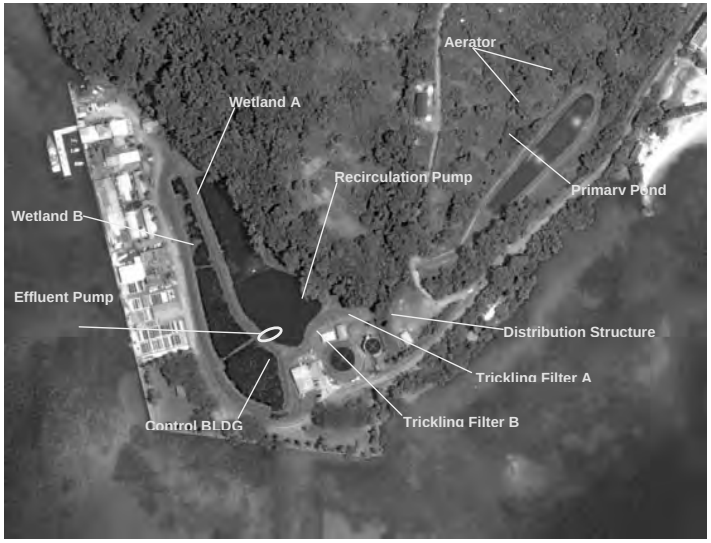


Figure 4.5-6 Layout of Malakal Sewage Treatment Plant

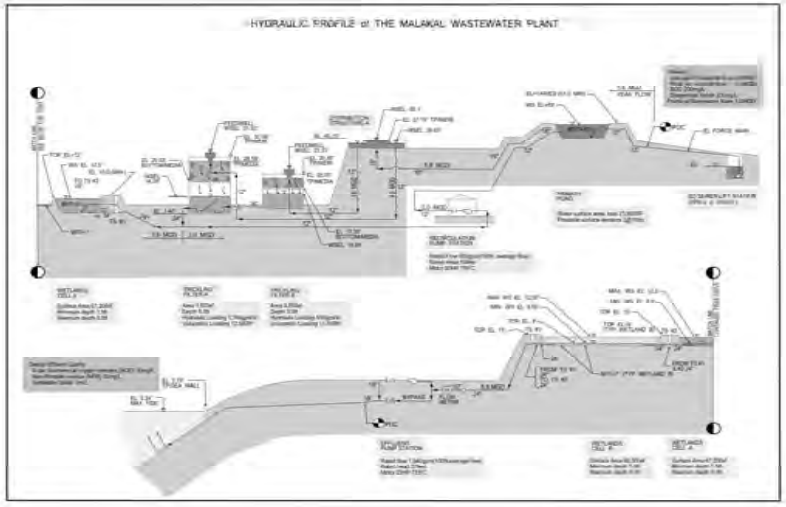


Figure 4.5-7 Hydraulic Profile of the Malakal Sewage

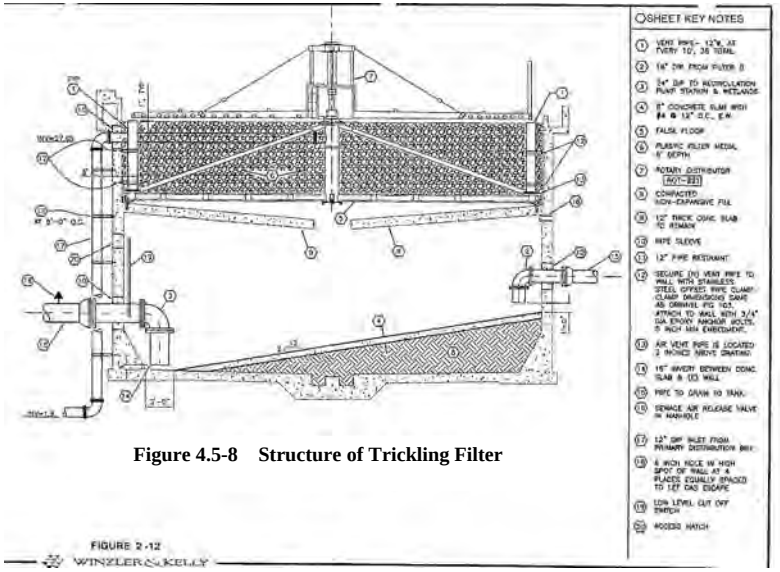


Figure 4.5-8 Structure of Trickling Filter

Figure 4.5-9 Structure of Primary Pond

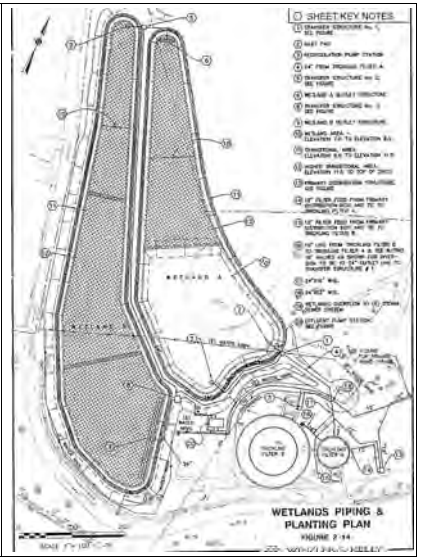


Figure 4.5-10 Structure of Wetland Cell

(c) Design Parameter (Please refer to Table 4.5-6)

Table 4.5-6 Design Parameter of existing Malakal Wastewater Treatment Plant

Item	Design Parameter		Design Value	
			Yard-Pound	MKS
Raw Wastewater Flows	Average dry weather flow		2.0 MGD	7,570 m^3/day
	Peak wet weather flow		5.6 MGD	21,200 m^3/day
Wastewater Loading	BOD		200 mg/l	
	Suspended Solid		200 mg/l	
Design Effluent Quality	BOD_5		30 mg/l	
	Non-filterable Residue (NFR)		30 mg/l	
	Settleable Solids		1 mg/l	
Primary Treatment Pond-1	Water Surface Area (total)		21,500 sf	1,997 m^2
	Floatable Surface Aerator		2 @10 HP	
	Estimated Solid Storage Life		10 years	
Secondary Tricking Filter-2	Filter A	Area	1,570 sf	145.86 m^2
		Depth	8 feet	2.44 m
		Hydraulic Loading	1,340 gpd/sf	54.60 m/day
		Volumetric Loading	12,560 ft^3	355.66 m^3
	Filter B	Area	3,850 sf	357.68 m^2
		Depth	3 feet	0.91 m
		Hydraulic Loading	500 gpd/sf	20.37 m/day
		Volumetric Loading	11,550 ft^3	327.06 m^3
Recirculation Pump	Rated Flow		800 gpm	3.03 m/min.
	Rated Head		50 feet	15.24 m
	Motor		20 HP TEFC	
Wetland Ponds-2	Number		2	
	Cell A	Surface Area	67,200 sf	6,243.08 m^2
		Minimum Depth	1.5 feet	0.46 m
		Maximum Depth	5.5 feet	1.68 m
	Cell B	Surface Area	69,300 sf	6,438.18 m^2
		Minimum Depth	1.5 feet	0.46 m
		Maximum Depth	5.5 feet	1.68 m
Effluent Pump Station	Rated Flow		1,940 gpm	7.34 m/min.
	Rated Head		37 feet	11.28 m
	Motor		25 HP TEFC	

(d) Effluent Water Quality

① Result between 1999.6-12 by Winzler & Kelly Consulting Engineers (Please refer to Table 4.5-7)

Table 4.5-7 Result of Water Quality at Malakal STP in 1999.6 to 12

Item	Parameter		unit	Average	Maximum	Minimum
Quantity	Influent		MGM	32.411	45.591	26.626
	Effluent		MGM	32.957	59.480	16.054
Quality	pH	Influent		7.8	7.9	7.6
		Effluent		7.1	7.3	7.0
	BOD	Influent	mg/l	222	360	130
		Effluent	mg/l	28	59	0
	Temperature	Influent	℃	16.6	18.9	13.7
		Effluent	℃	15.0	19.0	9.9
	Settleable Solids	Influent	mg/l	15.7	18.9	13.9
		Effluent	mg/l	0.0	0.0	0.0
	Total Ammonia	Influent	mg/l	29.8	38.1	16.0
		Effluent	mg/l	12.6	19.0	2.0
	Un-ionized NH_3	Influent	mg/l	0.74	1.17	0.27
		Effluent	mg/l	0.06	0.09	0.01
	Dissolved Oxygen	Effluent	mg/l	2.5	5.9	1.1

Item	Parameter		unit	Average	Maximum	Minimum
	NTU	Effluent		33.4	49.5	16.7
	Chlorine Residual	Effluent	mg/l	3.3	3.8	2.6

② Result between 2012.5-2012.9 by Senior Volunteer Mr.Takeshima (Please refer to Table 4.5-8)

Table 4.5-8 Result of Water Quality at Malakal STP in 2012.5-2012.9

Sampling			Measured Value				
Date	Point	Time	T (℃)	pH	DO (mg/l)	Transparency (cm)	BOD (mg/l)
2012.5.8	Inlet TF	8:20	31.6	6.96	0.4	18.0	68
	#1	8:26	31.2	7.28	4.2	15.8	42
	#3	8:34	31.2	7.15	0.9	24.6	28
2012.5.22	Inlet TF	8:47	30.0	6.98	1.4	16.2	35
	#1	9:00	29.8	7.42	5.5	18.2	30
	#3	8:55	29.3	7.12	0.4	17.0	15
2012.6.4	Inlet TF	9:36	30.0	6.86	2.4	15.6	45
	#1	9:50	29.8	7.43	5.3	25.0	23
	#3	9:45	29.8	7.08	0.7	>30.0	13
2012.6.18	Inlet TF						
	#1	8:30	29.2	7.31	5.7	20.4	39
	#3						
2012.7.11	Inlet TF	8:15	30.0	6.96	3.4	21.0	45
	#1	8:30	29.8	7.26	5.3	27.2	28
	#3	8:22	30.1	7.06	0.9	28.3	20
2012.7.18	Inlet TF	8:10	29.8	6.77	1.7	14.8	65
	#1	8:26	29.8	7.26	3.7	15.8	42
	#3	8:19	29.5	7.15	1.1	10.0	27
2012.7.30	Inlet TF	8:10	30.0	6.82	2.1	15.1	53
	#1	8:26	29.9	7.33	4.3	21.0	28
	#3	8:19	30.2	7.07	0.8	>30.0	13
2012.9.30	Inlet TF	13:45	30.6	6.85	1.4	17.6	70
	#1	13:57	31.0	7.32	4.2	15.8	39
	#3	13:52	31.2	7.09	0.7	20.2	23

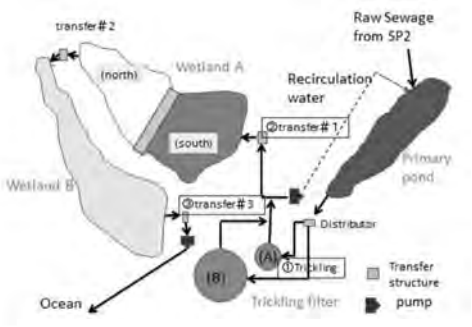


Figure 4.5-11 Sampling Point of Malakal STP

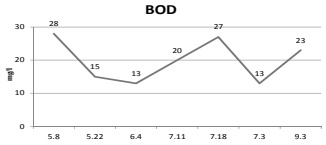


Figure 4.5-12 Effluent BOD in 2012

This water result shows the water quality at #1, #3, where the water quality has to comply with the regulation of EQPB, is less than 30 mg, which is the regulation issued by EQPB. Figure 4.5-12 shows the result of BOD_5 sampled at 3 points in Figure 4.5-11 and all these data

complied with the regulation of 30 mg/l. However, these data are old, and PPUC has to re-establish the function of the laboratory in Malakal STP as soon as possible to check and grasp the current situation of performance of STP. The picture of laboratory is shown in Figure 4.5-13.

Figure 4.5-13 Laboratory in Malakal STP

The staff number in the STP is 12, consisting of 1 acting manager, 2 electrical workers, 5 staff in charge of O&M of facilities including troubleshooting of pump/driving of special vehicle, 4 staff in charge of general works including mowing/cleaning. Working time is from 8:00 to 17:00 and no work at night). In turn, one person is in charge of catch emergency phone during off time.

(e) Current Problem

Current problem of Malakal STP is shown in Table 4.5-9. However, it is impossible to check whether effluent quality meets regulation or not because the laboratory in STP does not work since Autumn, in 2013.

Table 4.5-9 Current Problems in STP

Facilities	Phenomena
Inlet Works	. High level of putrefying fats and grease . No solid separation or handling mechanism /facility such as screen . Fence and gate are not lockable against unauthorized entry . Visible corrosion of metallic and concrete components
Trickling Filter	. It is hard to see the degree on biomass built up on the media and there was a high degree of putrescible matter on top of the media, resulting in poor quality of effluent from TF. . One of two trickling filter stops function due to malfunction of inlet pump.
Chlorine contact tank	. Chlorine contact tank did not appear to be in operation and in a serious state of disrepair.
Polishing pond 2 Launder	. Polishing pond 2 and 3 are overgrown and silted up. . The effluent appears to be very turbid and there is a high degree of fine floating materials close to the final launder (off take) from pond 2 to 3. . The effluent at the end of pond 3, prior to discharge does not appear to be consistent with the requirement for sensitive marine and associated coral reef environment.
Flow meter	. Flow meter before discharging effluent into marine has been out of order.
Pump for outfall	. The pump for out falling effluent from STP to marine has stopped operation.
Laboratory	. The laboratory stops function since JICA SV left to Japan in Autumn, 2013.

4.5.4 Melekeok Sewerage System

(1) Outline of Sewerage System

The sewage is transferred to STP via PSs. The sewerage system consists of 5.1 km of sewer line, 87 manhole, 8 PSs and sewage treatment plant as shown in Figure 4.5-14.

(2) Performance of STP

The STP was constructed in 2006 under the Palau National Capital Relocation Project (Phase III - Capital Sewer System Project) and serves both the National Capital and the town of Melekeok by donation by Republic of Taiwan and total investment cost is 2.4 M$.

The STP was constructed in 2006 under the Palau National Capital Relocation Project (Phase III - Capital Sewer System Project) and serves both the National Capital and the town of Melekeok by donating by Republic of Taiwan with total investment cost of 2.4 M$. The component of STP is shown in Table 4.5-10.

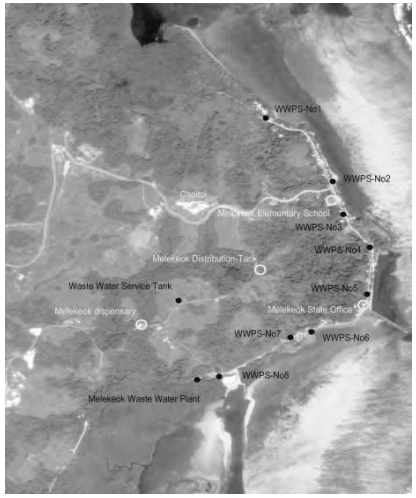


Table 4.5-10 Component of Melekeok STP

Process Unit	No.
Screening and grit removal unit	1
Equalization tank	1
Denitrification tank	2
Membrane tank with 250 m^2 ×0.4μ Membrane Bio Filter	2
Powdered activated carbon dosing	1
Permeate tank	4
Chemical tank with 250 l capacity for cleaning MF	1
UV disinfection	1
Sludge process with belt filter with polymer dosing and drying	1

The treatment process of STP is a sophisticated Membrane Bioreactor (MBR) STP which is fully automated. This system was installed and commissioned by Taiwan FREEAIR Environmental Engineering Co. Ltd. MBR system combine activated sludge treatment with a membrane liquid-solid separation process and the cost of building and operating a MBR is usually higher than conventional wastewater treatment. Furthermore, the membrane has to be cleaned with 10 % of sodium hydrate every day. The surface area of this STP is 390 m^2 and the effluent in the STP is lift up to the reservoir tank, then used for irrigation and other purpose. The dried sludge is also used

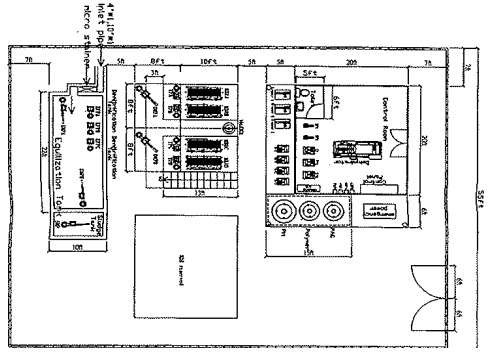


Figure 4.5-15 Layout of of Melekeok Sewage Treatment Plant

for agriculture. Figure 4.5-15 and 4.5-16 shows the layout and flow chart of this STP, respectively.

This capacity of this STP is estimated based upon a maximum design inflow (influent) rate of 39,000 gallon/day (148 m^3/day) of sewage per day, computed as follows:

1.5 × [(1000 capital office staff @ 10 gpd) + (100 village households × 4 people/household × 40gpd)]

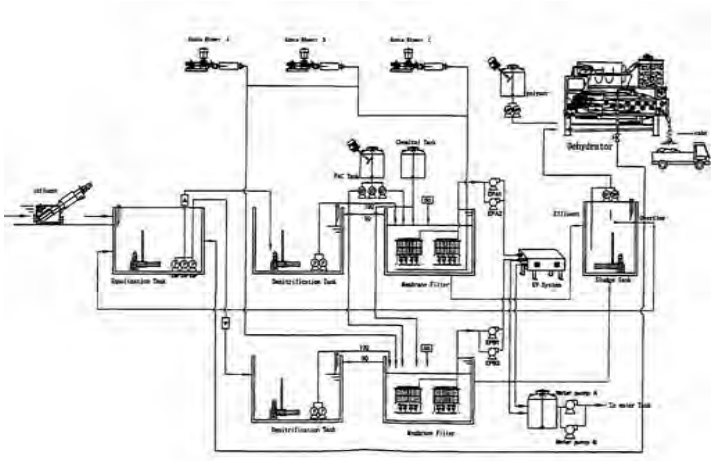


Figure 4.5-16 Flow Chart of Melekeok Sewage Treatment Plant

(3) Performance of STP

The inflow quantity is about 80 m^3/day according the daily report, while the design quantity is about 148 m^3/day. Water quality of Melekeok STP is shown in Table 4.5-11.

Table 4.5-11 Water Quantity and Quality at Melekeok STP in Aug-Sept., 2007

Item			unit	Average	Maximum	Minimum
Quantity	Influent		m^3/day	78.6	136.0	48
Quality	pH	Influent		7.0	7.1	6.9
		Effluent		7.0	7.1	6.9
	Turbidity	Influent	NTU	0.3	0.3	0.2
		Effluent	NTU	0.6	0.6	0.6
	COD	Influent	mg/l	91	110	72
	Temperature	Influent	℃	30	30	29
		Effluent	℃	30	30	29

(4) O&M Problem

Taiwan Free Air Environmental Engineer Company subcontracted for one year till October, 2008 with the contract amount of 27,000 US$. The contract item is operation and maintenance of sewer pipe and PS, STP and training the two local staff. Although Palau Government paid a huge contract fee, the daily operation report has gone with no water analysis survey after the contract has finalized, which resulted in the poor operation level. The MBR and UV system had not been operating for some months because the membranes were clogged. The plant is only

achieving an effluent quality typical of primary treatment with no disinfection. The cost to replace all 500 membranes has been previously estimated by others at $160,000.

The conclusion was shown as follows:

(a) MBR system is a sophisticated one, and a periodical and appropriate O&M, which requires a certain level of budget and skill, is indispensable.

(b) The selection of treatment process has to be carefully selected from the technical, financial, social point of view.

(5) Upgrading of Sewer System

The sewer system upgrading was conducted by funding through ROP-Economic Stimulus Package in Fiscal Year 2013. The project amount to $520,205

The project proceeded in April.5, 2013 with two components.

Package A: Procurement, supply and installation of damaged membrane filters and equipment

Package B: Two year operation and maintenance of the sewerage system after the all newly-installed equipment is completed.

4.5.5 Septic Tank

(1) General

With regard to “Toilet Facilities and Wastewater Disposal System Requirement”, EQPB established minimum standards governing design, construction, and operation of private toilet and septic tank seepage systems (EQPB Regulation, Chapter 2401-13). The permit is required for installation of a septic tank based on this regulation. While permitted by EQPB, the cumulative effect of multiple septic systems in some hamlets in Airai has resulted in poor septic system performance. Further sanitation planning should consider the cumulative effects of septic system for new residential development zones.

According to Table 4.5-10, there were 2,111 septic tank/cesspool including 629 in Koror State and 671 in Airai State in 2012. Figure 4.5-17 shows the sanitary system in Koror State.

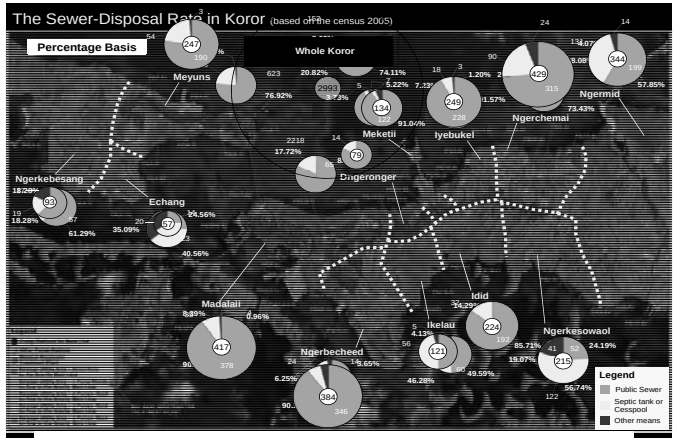


Figure 4.5-17 Sanitary System in Koror State

(2) Problem of Septic Tank

(a) Designing Stage

Figure 4.5-18 shows the typical layout of septic tank proposed by Koror State.

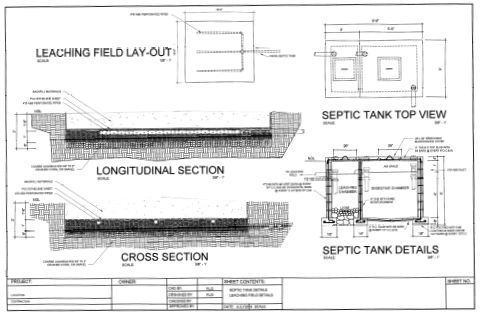


Figure 4.5-18 Typical Layout of Septic Tank

1) The size of capacity is decided based on the number of bed, which does not reflect the current situation.

2) The size of leaching field will be decided based on the leaching test, which is not realistic. However there is no statistical data for permeability/topographic data in each island. Absorption size depends on the quality of effluent, long term absorption rate of receiving soil, the capacity of soil and vegetation. So, absorption guideline has to reflect the current practice.

3) Any building has to install the septic tank with leaching field, whether it is residential house, commercial building, hotel or not. The leaching filed requires the huge area if the water consumption is big, which is not welcomed in case of constructing the commercial building. However, there is no exception in the guideline in EQPB. It is one option when EQPB issues the permission without leach area in case of effluent with good quality.

(b) O&M stage

Septic tank wastes (seepage) must be properly dislodged every 2 to 3 years to maintain their efficiency. While the volume of seepage is low in comparison to the volume of sewage in the sewerage system, the concentration of pollutants in seepage is much higher than domestic sewage. So, seepage has to to be treated properly by treatment plant.

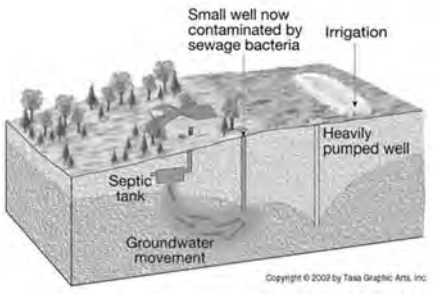


Figure 4.5-19 Contamination of Groundwater with Effluent from Septic

While almost all the houses connect to the public sewer line, some resident still use the septic tank, which requires the periodical desludging for proper O&M. However nobody knows how frequency the desludging services is provided to the resident because the service provider is very poor as shown below and these service providers dispose the seepage in a primary pond in Malakal STP with free of charge. So, there is no record/information of the quantity of seepage and service house number. Poor operation and maintenance causes not only the environmental deterioration but also the contamination of the groundwater. Figure 4.5-19 shows the schematic contamination of groundwater with effluent from septic tank.

The service provider for desludging in Palau is as shown below.

1) Only two individual persons with one vacuum cars provide desludging services based on call from residential and commercial property owner. The desludging service number is 10-15/month/each vehicle according to the interview survey. The service charge for desludging in one company is 50$/one trip in Koror State and 100 $/in one trip in Airai state, the other charge is 75-100 $/one trip depending on the distance from Malakal STP. Since one vacuum tank volume is 700-800 gallon (2.6-3.0 m^3)/tank, other is 500 gallon (1.9 m^3)/tank, it takes plural times to take the seepage from the commercial facilities such as hotels and so on.

2) In the Palau International airport in Airai State, the wastewater from the terminal building is at first discharged into the septic tank, and supernatant of septic tank is transferred to the holding tank by pump. Before PPUC had two vacuum tracks donated by Republic of China, however one is out of order. So only one vacuum track empties the holding tank and disposes it into Malakal STP with free of charge. Figure 4.5-20, 4.5-21, and 4.5-22 show the holding tank, cross section of septic tank and leaching field section.

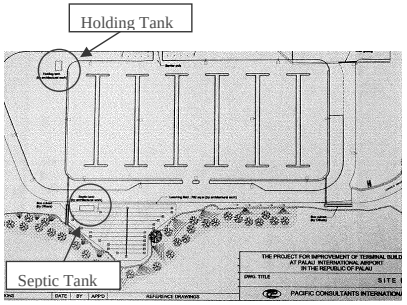


Figure 4.5-20 Layout of Septic/Holding Tank

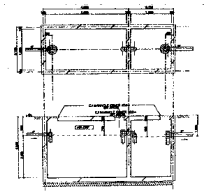


Figure 4.5-21 Cross Section of Septic Tank

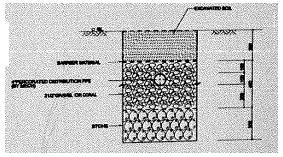


Figure 4.5-22 Leaching Field Section

3) The wastewater in each airplane is discharged into the special car which belongs to each airline, and also disposed into Malakal STP with free of charge.

4) Koror state also has provided the desludging service of private septic tank before; however, it stopped operation and now only dislodges public toilets in public parks.

4.6 On-going Project in the Sewerage Sector

4.6.1 Koror Sewer System Upgrade Project Phase IV[11]

(1) Outline of the Project

(a) Contractor: ESCO-TEC Company Ltd. (Taiwan)

(b) Contractor Amount: $705,160.00

(c) Date Advertised: 2013.3.29

[11] PPUC

(d) Original Bid Closing Date: 2013.5.13

(e) Revised Bid Closing Date: 2013.6.17

(f) Bid Opening Date: 2013.7.23

(g) Notice of Award: 2013.8.6

(h) Contractor's EQPB Application: 2013.9.9 (Permit Issued: 2014.1.13)

(i) Notice to Proceed: 2013.9.18

(j) Completion Date: 2014.5.29 (expected, as of 7.7.2014, it has not been completed yet.)

(2) Project Description

The Koror Sewer System started operation in mid 70's. Several Pump Stations were added in the system since then to augment its capacity to transport and manage the steadily increasing sewage load brought about by the continuous development and population increase of Koror. At the turn of millennium, ponding treatment system was retrofitted into the existing treatment system. Even though the ponding treatment system can accommodate or process more volume of raw sewage, the operation and maintenance of aging equipment on the system's collection and transmission remained a challenge to the government due to insufficient funds

In 2006, the government, with the Grant from the Republic of China (ROC) started the initial phase of the upgrading work on the sewer pump stations under the country's Economic Stimulus Package (ESP). Repair works were undertaken on ailing and less-performing pump stations. It was followed by similar works under Phase II in 2008 and Phase III in 2011. The total cost for all three (3) phases is $2.40 million.

Early 2013, with direct instructions from the President, the CIP Office conducted a thorough inspection on the Koror Sewer System for the purpose of identifying non-performing pump stations, which may be included on the Economic Stimulus Package (ESP) for FY-2013. The inspection was carried out in collaboration with the then BPW's Sewer Branch to the majority of the pump stations on the system including the Malakal primary pond.

As a result, the CIP Office determined the 24 sewer stations that needed priority attention including 7 spare pumps. A scope of work was developed for all of the above pumps. However, based on government estimates and a a working budget of $ 1 million including PWSC's tap into the same budget for other quick repairs on the sewer system, an addendum was issued to reduce the scope of works to 12 pump stations.

The main objective of the original scope of the project is to repair and or restore the full operational status of the 24 non-efficient pump stations including the provision of 7 spare pumps.

By Addendum No. 02 the original scope of work was subdivided into several packages with additional works including necessary for the proper operation of the pump stations; (see Addendum No. 02 of the Project). Table 4.6-1 shows content of each package.

Table 4.6-1 Content of Each Package

Package	Contents
A	- 12 pumps including the installation of one additional aerator pump and replacement of the 2 existing aerator pumps on the primary pond of the Malakal Sewer Treatment Plant - Supply of 10 waders with high water-proof boots and 10 pairs of long water-proof gloves for maintenance workers;
B and C	- 24 and Supply of spare Pumps:
D	- Repair/test/run/commissioning of 4 stand-by generator sets
E	- Construction/modification of two electrical la control pane housing
F	- Minor electrical, civil and mechanical repair of 10 pump stations, construction of enclosure fence and replacement wet well metal cover assembly, and provision of 10 float switch spares

However, due to funding restrictions, Addendum No. 02 was superseded by Addendum No. 03 which was developed for the final scope of the project. The final scope includes 13 pump stations including the primary pond and supply of waders as discussed above. Furthermore, Pump station A-7 was excluded in the Contract due to the urgent need to repair the pump station. The PWSC undertook the repair of A-7 (Arakabesang). The 12 target PS is as follows: 10-E, 9-E, 8-E, 2-B, 17-B, 13-I, A-9, A-10, A-1, 4-B, SPS-1, 6-D and 3 aerators at primary pond of Malakal STP.

Generally, the repair works on the pump stations including installation of new pumps, replacement of broken appurtenances, repair of pipe leaks, re-commissioning of standby power generator sets, construction of enclosure fences and panel housings, installation float switches and guides bars. And, as part of the scope of work, the contractor shall supply 10 waders and 10 pairs of hand gloves appropriate for maintenance work.

(3) Current Situation

While almost all the implementation has been finalized, it has not been handed over PPUC because some revision has to be conducted by ESCO-TEC Company. All the equipment by ESCO-TEC Company Ltd. shall have a warranty against against defects and workmanship for one year from the date of completion.

4.6.2 Koror-Airai Sanitation Project (KASP)[12]

(1) PPTA Implementing Consultants

GHD Head Office Level 7, 16 Marcus Clarke Street, Canberra ACT 2600, Australia	**GK2 Incorporated (civil & structural consulting engineers)** PO Box 8061, Koror, Palau, 96940
GHD Manila Office Level 2, 111 Paseo de Roxas, Legaspi Village 1229 Makati, Metro Manila, Philippines	**Melekau Environmental Consulting** 3rd Floor Surangel Building, Main Road, Koror, Palau, PO Box 6064, Koror, Palau, 96940
GHD Project Office c/o Capital Improvement Program, Malakal Rd, Malakal, Palau, PO Box 100, Koror, Palau 96940	

(2) Target Area

Koror and Airai (Kesabelau.Ked) are selected because these areas have high population and play a role of growth center.

(3) Design Criteria

(a) Population (Refer to Table 4.6-2)

[12] Sanitation Master Plan Report TA 7382 (PAL), Sanitation Development Feasibility Report TA 7382 (PAL)

Table 4.6-2 Population Projection

Area	2005 Population Census				2010	2015	2020	2025	2030	2036
	Total population	Person in household	House hold	Household Size						
Koror	12,676	11,884	2,958	3.97	12,500	12,750	13,000	13,200	13,350	13,500
Airai	2,732	1,999	651	3.78	3,400	3,950	4,500	5,000	5,500	6,000
Rest of Palau	4,508	4,299	1,135	3.63	4,760	4,480	4,340	4,330	4,380	4,600
Total Palau	19,907	18,182	4,744	3.86	20,660	21,180	21,840	22,530	23,230	24,100

(b) EP Loading for Various Development Type

EP loading for various development types (the numbers represent the number of EP/unit) is shown in Table 4.6-3.

Table 4.6-3 EP Loading for Various Development Type

	Category	Rate	Description
A	Domestic	1.0	360 l/EP/day
B	Hotels	2.5	Hotel guests tend to give rise to more sewage discharge than normal residents especially in tropical areas. This allows for an average of 1.25 EP/visitor and 2 persons/room.
C	Restaurants	6.0	Average 40 customs/day and 0.15 EP/customers
D	Commercial others	2.5	Average 25 customs/day and 0.10 EP/customers
E	School	0.15	0.15 EP/students
F	Institutional others	2.5	Average 25 persons/family and 0.10 EP/person
G	Churches & Places of Worship	10.0	Average attendance of 100 people and 0.10 EP/attendance

(c) Design Criteria (Refer to Table 4.6-4)

Table 4.6-4 Design Criteria

	Item		Unit	Value	
A	Water Consumption		l/capita/day	450	
B	Return Rate		%	80	
C	Groundwater infiltration		%	15	
	Wet weather infiltration/inflow		%	33	
D	Peak Factor	Dry weather		2.75	Peak dry weather flow/average dry weather flow
E		Wet weather		3.86	(1.33*(2.75+015)
F	Minimum Pipe Diameter		mm (ID)	150	
G	Minimum (self-cleaning) velocity		m/second	0.7	
H	Minimum slope			1/Diameter	
I	Minimum cover to pipe crown at house		mm	650	
J	Typical minimum depth to invert of		m	1.0	
K	Typical maximum depth to invert of		m	3.0	

(d) Collection System

1) Koror System

Outline of the Project in Koror State is shown in Table 4.6-5.

Table 4.6-5 Outline of the Project in Koror State

Component	Item	Size	Length (m)	depth (m)
Gravity sewer	New inceptor	ϕ525mm, HDPE	1,500	4.5
		ϕ450mm, HDPE	850	4.5
		ϕ375mm, HDPE	350	4.5
		ϕ300mm, HDPE	150	4.5
Force main*1	New pipe	ϕ450mm, HDPE	2,050	
		ϕ200mm, HDPE	500	
	Extension	ϕ250mm, HDPE	350	
Pumping Station (PS)	New construction*2	2 major PSs (1, A8)		
		2 minor PS		
	Improving	1 major PS*3 (2)		
		37 minor PSs*4		
Telemetry System*5	Supply and installation	39 existing minor PSs		
Toilet	New construction*6	3 Numbers		
	Rehabilitation*7	3 Numbers		
Sewage treatment plant	Malakal	24,000 EP	Inlet screens and grit removal, SBR, UV disinfection	

*1 including trench works, backfill, bridge crossing, site restoration, and traffic control
*2 inclusive excavation (sheet piling & ground water control), civil works including steel works and covers, pumps and pipework, electrical control building, electrical control panels and power supply, overflow treatment facility, and site-works including fencing and restoration
*3 including upgrading of pumps, pipework and fencing

*4 including upgrading of overflow arrangements, pump station covers, and fencing; and electrical control panels and power supply
*5 including central monitoring computer system and software
*6 shopping area, the Malakal recreation area, Koror tourist precinct
*7 Long Island Recreation Area, KB Bridge, T-Dock Recreational area

2) Airai System

Outline of the Project in Airai State is shown in Table 4.6-6.

Table 4.6-6 Outline of the Project in Airai State

Component	Item	Size	Length (m)	depth (m)
Gravity sewer	New sewer*1	ϕ 150 mm	6,000	1.5-2.5
Force main	New pipe	ϕ 150 mm, HDPE	260	
Pumping Station (PS)	Station B	2 Pumps	9 KW	
Sewage treatment plant	Airai	3,000 EP	including inlet Screen, girt removal, extended aeration nitrification/de-nitrification, UV disinfection, sludge drying (belt filter press) including access track and outfall pipeline nearby creek system	

*1 including trenching, bedding, pipe-laying, backfilling, installing house connections, decommissioning septic systems, and site restoration

(e) Selection of Treatment Process

The four types of secondary treatment considered by the designers for the Koror situation were shown in Table 4.6-7.

Table 4.6-7 Characteristics of Each Type of Treatment Process

Treatment Process	Description
Trickling filter (TF)	• Biological filters distribute waste water continuously over rock or plastic media on which an aerobic bio-film (layer of aerobic bacteria/organisms) is attached. • Treatment is achieved by the bacteria/organisms on the media consuming the biodegradable soluble organic contaminants in the wastewater.
Intermittent decant & extended aeration (IDEA)	• A form of activated sludge process: The reactor consists of one or more cells (usually two or more) and raw sewage is admitted continuously to all cells. • The wastewater in the tanks is subjected to fixed cycles of aeration, settling, and decanting. • Treatment is achieved by the bacteria/organisms in the reactor tank consuming the soluble organic contaminants in the wastewater
Sequencing batch reactor (SBR)	• A form of activated sludge process: The reactor consists of two or more cells and raw sewage is admitted to each cell in turn according to a preset sequence. • The wastewater in the tanks is subjected to fixed cycles of aeration, settling, and decanting. • Treatment is achieved by the bacteria/organisms in the reactor tank consuming the soluble organic contaminants in the wastewater.
Membrane bioreactor (MBR)	• Membrane bioreactors combine activated sludge treatment with a membrane liquid-solid separation process. • The membranes are typically immersed in the aeration tank; however, some applications utilize a separate membrane tank. • Treatment is achieved by the bacteria/organisms in the reactor tank consuming the soluble organic contaminants in the wastewater and any remaining material filtered out as it passes through the membrane media.

The main advantages and disadvantages of these technologies are summarised in Table 4.6-8 Comparison of Each Treatment Technologies.

Table 4.6-8 Comparison of Each Treatment Technologies

Issue	TF	IDEA	SBR	MBR
Capital Cost	Lowest	The IDEA and SBR plants tend to lie between the extremes represented by the Trickling Filter and Membrane Biological Reactor treatment plants.		Highest
Operating Cost	Lowest			Highest
Energy Requirement	Lowest			Highest
Land Requirement	Highest			Lowest
General effluent quality	Worst			Best
Buffer Capacity[13]	Worst			Best
Operational simplicity	Best			Worst

For simplicity and cost trickling filter treatment plants have a lot to commend them. However trickling filter plants:

- Are prone to producing lower quality effluent unless post filter clarifiers and/or tertiary filters are used
- Do not handle operational changes or abnormal conditions well with consequent loss of effluent quality
- Require more land than the other types of treatment processes
- Are prone to producing odours

At the other ends of the spectrum, membrane reactor treatment facilities overcome these difficulties and produce a very high effluent quality but at the cost of:

- Much higher capital and operating costs
- Greater operational complexity and maintenance requirements
- Inability to handle a wide range of flow conditions (i.e. wet weather)

Figure 4.6-1 Location Site of New STP

The Intermittent Decant Extended Aeration (IDEA) and Sequencing Batch Reactor (SBR) provide a balanced trade-off between these two ends of the treatment spectrum. These technologies can be made to produce high quality effluents (BOD_5 and TSS < 5 to 10 mg/L) but at the expense of their land and energy footprint requirements. For instance, in the case of the Malakal STP, initial calculations[14] of the reactor tank area needed were shown below.

- BOD_5 and TSS < 10 mg/L 2,900 m^2
- BOD_5 and TSS < 30 mg/L 1,800 m^2

The adopted effluent standard is practical and achievable and at the same time, these standards of 30 mg/L BOD_5 and 30 mg/L SS provides appropriate protection of marine waters while keeping the overall land footprint as small as possible as seen above. Land footprint requirements are an important consideration due to the limited access to suitable sites and the need to keep the existing plant in operation while the new plant is being constructed.

The designers considered that an IDEA or SBR plant producing a 30 mg/L BOD_5 and 30 mg/L SS effluent would provide the optimum balance of effluent quality, site area requirements,

[13] Buffer capacity: ability to maintain effluent quality during abnormal situations

[14] The calculations were very preliminary and would need to be refined by detailed treatment process modeling using BIOWIN software or similar. The areas given in the list are based on an operating volume of about 4.5 to 5.0 m.

operational simplicity, and cost for the Koror situation.

The location, layout and flow chart of Malakal New STP is shown in Figure 4.6-1, 4.6-2 and 4.6-3. The flow chart of Airai New STP is shown in Figure 4.6-4

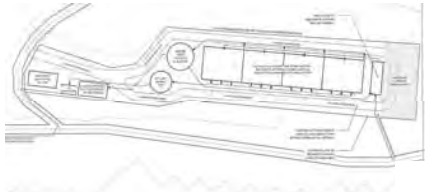


Figure 4.6-2 Layout of Malakal New STP

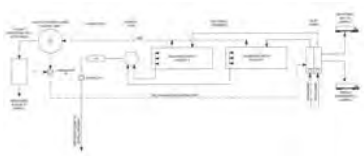


Figure 4.6-3 Flow Chart of Malakal New STP

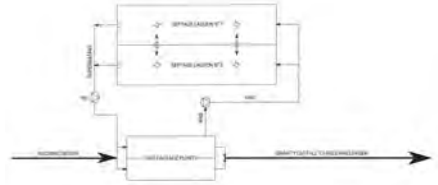


Figure 4.6-4 Flow Chart of Airai New

(f) Design Water quantity and Quality in Koror and Airai State

Table 4.6-9 shows design of quantity and quality in Malakal and Airai State.

Table 4.6-9 Design of Quantity and Quality in Koror and Airai State

Item		Koror	Airai
Population Equivalent		24,000	3,000
Treatment Process		SBR (Sequencing Batch Reactor) with nitrifying cycle to remove nitrogen	Extended aeration nitrification/denitrification
Main Facilities		Screening, Sludge dewater plant (belt press sludge dewatering), UV disinfection	UV disinfection outfall pipe to nearby creek and access road
Additional Work		Decommissioning and demolition of the existing sewage treatment plant, restoration of works site	
Average dry weather flow		8 MLD	1.0 MLD
Peak wet weather flow		23.0 (22.4) MLD	2.3
BOD	Influent	250	250
	Effluent	30	30
SS	Influent	300	300
	Effluent	30	30
T-N	Influent	60	300
	Effluent		10
TKN	Influent	30	
	Effluent	10	
T-P	Influent	12	300
	Effluent	10	10
Fecal Coliform		700 MPN/100ml	200 MPN/100ml
Defect liability period		This period for the plant and all associated equipment will be 60 months commencing at the operational acceptance of the plant.	

(g) Capacity of Each Facilities

Table 4.6-10 shows capacity of sewer and STP in Koror State.

Table 4.6-10 Capacity of Each Facility in Malakal Sewerage System

Component	Unit	Capacity		Current dry weather performance		Future wet weather performance	
		dry	wet	Load	shortfall	Load	shortfall
Central (Koror) Trunk Sewer	l/s	46	70	37	0.80	66	0.94
	l/s	42	64	102	2.43	184	2.88
Sewage Pump Station (SPS-1)	l/s	168	336	172	1.02	310	0.92
SPS 1 Force Main	l/s	110	110	172	1.56	310	2.82
Malakal Trunk Sewer	l/s	77	103	200	2.60	365	3.54
Sewage Pump Station (SPS-2)	l/s	254	508	200	0.79	365	0.72
SPS 2 Force Main	l/s	165	165	200	1.21	365	2.21
Sewage Treatment Plant	MLD	4.36	4.36	5.90	1.35	8.56	1.96

(4) Output of the Project[15]

Output of the project is shown in Table 4.6-11.

Table 4.1-11 Output of the Project

No.	Item	Description	M$
1	Effective, efficient, & sustainable sewage collection system in Koror and Airai State	• The sewerage network in Koror will be rehabilitated and augmented to (a) minimize the frequency and severity of uncontrolled sewage overflows; (b) minimize the energy requirement to operate network (c) improve the operation of the network through real-time system monitoring; (d) enable rapid response to disruptions in sewerage services resulting from system failures • The sewerage network will be constructed at Kesebelau (Airai) connecting the residential and commercial dwellings to an STP	8.5
2	Sewage treatment and disposal meets Palau's environmental standards	• Sewage collected in the Koror and Airai sewerage networks will be treated at new STPs to be constructed in the Koror and Airai. • Effluent from the new STPs will meet Palau's environmental discharge quality standards. • The STP in Koror will be consolidated on a much smaller footprint further from the coast than the existing STP, protecting the infrastructure from future storm-surge damage and releasing land for tourism development. • The new STPs will be procured under design, build, and operate contract.	12.9
3	Safe and hygienic public toilet facilities in Koror State	• Six public toilet facilities will be refurbished or built in key locations in the major tourist precincts, which lack modern public toilet facilities for tourists and female residents. • PPUC will manage the existing and new facilities.	0.1
4	Effect project management	• The project management unit (PMU), supported by Project Implementation Assistance (PIA) consultants, will provide project design and supervision, monitoring, reporting, quality and cost control, and contract administration.	2.7
Sub-total			28.8
Contingencies			4.6
Total			28.8

Note: Amounts (M$) shown are exclusive of taxes and duties

Sewerage Service Area/Facilities in Koror State and Airai State is shown in Figure 4.6-5 and 4.6-6.

[15] Koror-Airai Sanitation Project, Project Implementation Assistance (PIA) Consultants, Terms of Reference

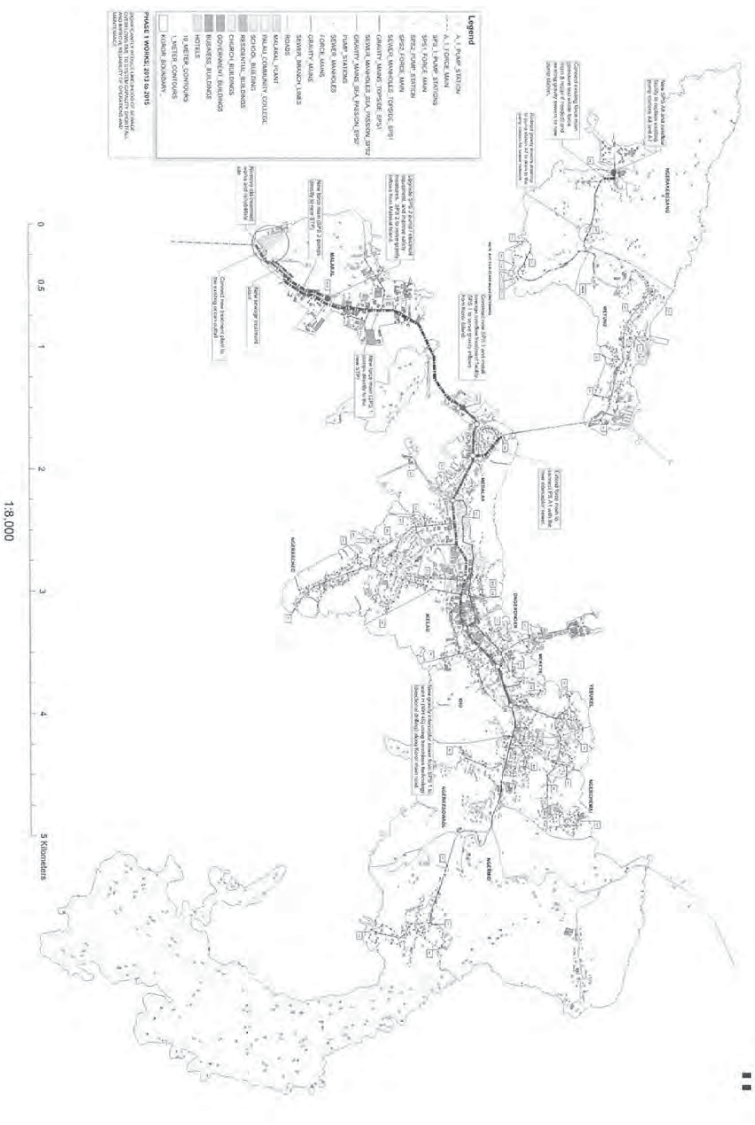


Figure 4.6-5 Sewerage Service Area/Facilities in Koror State

Figure 4.6-6 Sewerage Service Area/Facilities in Airai State

(5) Investment Cost

The project component will require the investment given in Table 4.6-12, 4.6-13, and 4.6-14. The estimated costs may vary depending outcome of further investigations such as, sewage flows, geotechnical and construction consideration, sewage treatment process.

Table 4.6-12 Investment Cost

No	Project Component	Description	Cost (US$)
1	Gravity Interceptor Sewer	• Directional drill gravity interception sewer along the Koror main road a) 1500 m DN525 (21 inch) b) 850 m DN450 (18 inch) c) 350 m DN375 (15 inch) • Directional drill 150 m of DN300 (12 inch) connecting sewers to join the existing main sewer to the new interception sewer and connect to existing sewer manholes at interception points • Adjust outlet arrangements in existing sewer manholes at the interception points to sectionalize the existing gravity carrier sewer	3,065,875
2	Major Pump Station Upgrade	• Construct new SPS 1 and overflow treatment facility • Upgrade existing pumping equipment and electrical control panel at SPS 2. Upgrade (where needed) pipework, steelwork, and electrical cabling • Construct new pump station SPS A8 to serve Arakebesang PPR area (replaces existing pump stations A7 and A8) including: decommission existing pump stations SPS A8 & SPS A7 and rehabilitate the area • Connect gravity sewers draining to pump station SPS A7 to the gravity sewer network draining to new pump station SPS A8 • Connect force main to new SPS A8 • Construct overflow retention and treatment facility	1,002,500

No	Project Component	Description	Cost (US$)
		• Site works including filling of proposed site and adjustment of existing stormwater drainage line and discharge point	
3	Major Force Main Upgrade	• Construct new force main for pump station SPS 2 and connect to new sewage treatment plant • Construct new force main for pump station SPS 1 and connect directly to new sewage treatment plant by: • Disconnecting force main from gravity sewer on Malakal • Constructing new force main along the causeway between Koror & Malakal and thence to the STP bypassing SPS 2 • Extend the existing force main for pump station A1 in Meyuns to connect directly to the new DN525 interception gravity sewer	1,890,000
4	Minor Pump Station Rehabilitation	• Rehabilitate pumps where needed including proper setting of switch levels • Rehabilitate control panels where needed to allow soft starting of pump motors and provide for automatic cycling of duty and standby pumps • Rehabilitate pump station covers and security where needed to prevent unauthorised entry • Rehabilitate pump station electrical control panel security measures to prevent unauthorised entry • Install subsurface overflow pipe to discharge to suitable area to minimize public nuisance and facilitate overflow cleanup	832,500
5	Sewage Treatment Plant	• On existing inlet primary pond site, construct a new advanced package treatment plant to achieve 30 ppm BOD and 30 ppm SS. • The new STP is to comprise (i) inlet mechanical screens and grit removal (ii) IDEA or SBR secondary treatment (iii) UV disinfection (iv) sludge dewatering using a belt filter press. • Decommission existing sewage treatment plant and primary inlet pond and rehabilitate both sites. • Connect the new sewage treatment plant to the existing treated sewage effluent ocean outfall	9,500,000
6	Public Toilet Facilities	• Rehabilitate and or construct public toilet facilities to serve the shopping area, the Malakal recreation area, and Koror Island tourist precinct • Rehabilitate and or construct public toilet facilities to serve Long Island recreation area, KB Bridge and T Dock recreation areas	97,500
7	Telemetry/Remote Monitoring	• Install a remote monitoring telemetry system to serve all pump stations and the sewage treatment plant including: • Installing wireless transmitters at each pump station and treatment plant • Upgrading equipment control panels to collect relevant alarms and signals • Supplying and installing a central computer based monitoring station	190,125
8	Kesebelau/Ked Sewerage System	• Construct a gravity collection sewer network and 2 minor pump stations for Kesebelau/Ked and connect dwellings to the network • Construct a package sewage treatment plant (minimum effluent quality to be 30mg/L of BOD_5 and 30 mg/L of SS) to serve the Kesebelau/Ked village, including a septage receiving station and a treated effluent outfall • Construct an access road to the sewage treatment plant and septage receiving station • Disconnect houses from the septic tank system and remediate the septic tanks and absorption areas	3,585,000
9	CCTV GPS Survey of Sewer Network	• Undertake a survey of existing sewer networks to determine the size, location, and level of collection sewers and force mains • Undertake a pilot CCTV inspection of critical sewers to determine condition hence future system rehabilitation needs	325,000
10	Unauthorized Inflow Investigation	• Undertake pilot sewer smoke and/or dye testing at strategic locations to identify unauthorised storm drainage connections to the sewer network • Disconnect unauthorized connections of storm drainage from the sewer network and redirect to appropriate location.	162,500

No	Project Component	Description	Cost (US$)
11	Sewage Flow Gauging	• Undertake a pilot sewer gauging program at strategic locations to determine: • Infiltration / Inflow component of sewage flows • Unit sewage flows from different types of development	162,500
12	Design and Supervision of Works	• Prepare a sewer network model and analyse overall system capacity and performance using both static flow and dynamic extended period analysis to determine: • Capacity shortfall hence ongoing sewer upgrade and rehabilitation program • Optimum system configuration to minimise energy requirements • Prepare engineering designs, technical specifications, and bid documents for the construction of proposed rehabilitation and upgrade works (Components 1 to 9) • Prepare Terms of Reference and bid documents for the activities aimed at supporting on-going system planning & improvement (Components 10 to 12) • Advise and assist with procurement of construction contractors and consultants required to undertake work for Components 1 to 12 • Implement / manage / supervise / administer works, goods, and services contracts in relation to Components 1 to 12.	2,061,108
13	OM of Malakal, Kesebelau/Ked, and Melekeok STPs	• Engage and train three local plant operators • Provide management support to the three plant operators • Oversee plant operations and day to day management of STP affairs • Provide emergency operational advice • Prepare monthly and annual operations performance reports • Monitor effluent quality and prepare EQPB compliance reports (3 years full-time and 2 years part-time O&M with spare parts)	1,468,750
	Capital Works and Budget[a)]		24,343,358
	Contingency	Physical (15%)[c)]	3,651,504
		Price [d)]	600,000
		Sub-total	4,252,000
	Interest and Service Charges [e)]		1,486,000
	Total Project Cost		30,082,000

a) Base cost at March 2012 prices.
b) Includes taxes and duties of $553 thousand.
c) Physical contingencies at 15% of base cost.
d) Price contingencies at 3.8% in 2013 and 2.5% p.a. thereafter for local costs; 0.3% in 2013 and 0.5% p.a. thereafter for foreign costs.
e) Financing charges during construction: 1% p.a. for ADB's Asian Development Fund (ADF) portion of loan and 1.53% p.a. for ADB's ordinary capital resources (OCR) [16] portion of loan; 0.15% commitment fee for undisbursed amount of loan.

Source: Consultant's Calculation

Table 4.6-13 Investment Cost by each resource (US$)

No.	Area	Item	Foreign	Local	Total	%
1	Koror	Gravity Interceptor Sewer	2,299,406	766,469	3,065,875	12.6
2		Major Pump Station Upgrade	601,500	401,000	1,002,500	4.1
3		Major Force Main Upgrade	1,134,000	756,000	1,890,000	7.8
4		Minor Pump Station Rehabilitation	333,000	499,500	832,500	3.4
5		Sewage Treatment Plant	7,125,000	2,375,000	9,500,000	39.0
6		Public Toilet Facilities	0	97,500	97,500	0.4
7		Telemetry/Remote Monitoring	95,063	95,053	190,125	0.8
9		CCTV GPS Survey of Sewer Network	325,000	0	325,000	14.7
10		Unauthorized Inflow Investigation	162,500	0	162,500	1.3
11		Sewage Flow Gauging	162,500	0	162,500	0.7
8	Airai	Kesebelau/Ked Sewerage System	2,151,000	1,434,000	3,585,000	0.7
12	Both	Design and Supervision of Works	1,545,831	515,277	2,061,108	8.5
13		OM of Malakal, Kesebelau/Ked, and Melekeok STPs	587,500	881,250	1,468,7505	6.0
	Total		16,522,200	7,821,049	24,343,249	100.0

[16] ADB indicative lending rate of 1.13% per annum as of 20 April 2012 for a 5-year fixed US$ swap rate loan under LIBOR-based loan facility plus spread of 0.40% per annum for loans contracted after 1 July 2011.

Table 4.6-14 Financing Plan

Sources		Amount $ ('000)	%
Asian Development Bank:	Asian Development Fund	1,980	7
	Ordinary Capital Resources	27,548	92
	Sub-total	29,529	98
Government of Palau		553	2
Total		30,082	100

(6) Project Implementation and Project Implementation Management Structure

A summary project implementation management structure is presented in Figure 4.6-7.

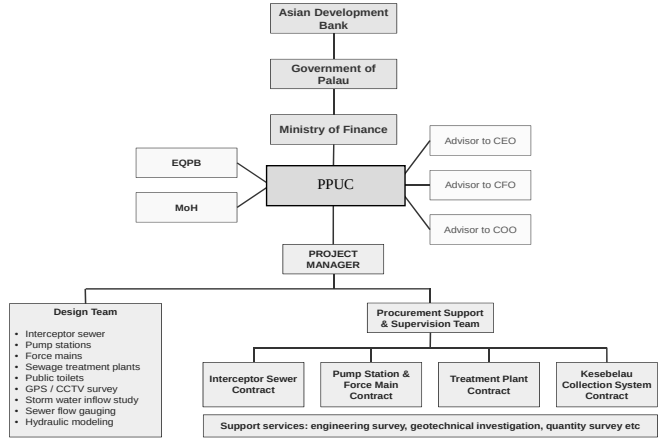


Figure 4.6-7 Project Implementation Management

The project is expected to take about 36 months to implement allowing for procurement as well as design and construction of the works as shown in Figure 4.6-8.

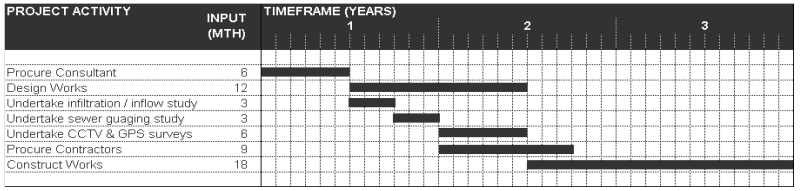


Figure 4.6-8 PPTA 7382 (PAL) Project Component Summary

(7) Current Stage for Implementation

Current stage of implementation as of 2014.9.3 is shown in Table 4.6-15.

Table 4.6-15 KASP Milestone and Action Matrix, 2014.6 – 2014.10

No.	Output/Activity	Action	By:	Target Date	Status
A	Loan and Project Agreements Executed	a) Loan and Project agreement finalized in readiness for signing	ADB (OGC)	2014.3.21	Completed.
		b) Loan and Project Agreements signed.	MOF ADB (OPR)	2014.3.27	Completed Loan signed on 2014.3.28.
		c) Signed Loan and Project agreements forwarded to OSEC for registration and filing	ADB (PO)	2014.3.28	Completed/ Signed loans forwarded to OSEC on 2014.3.28.
B	Loan declared effective	a) Legal opinion on the Loan Agreements and the Subsidiary Loan Agreement are finalized.	ADB (OAG) MOF	2014.3.24	Completed. 2014.3.27
		b) Legal opinion on the Project Agreement is finalized.	PPUC, ADB (OGC)	2014.3.24	Completed. 2014.3.25
		c) Subsidiary Loan Agreement is executed.	MOF, PPUC	2014.3.25	Completed. 2014.4.28
		d) Formal request to declare loans effective submitted to ADB (with Legal opinions on the Loan Agreements, Subsidiary Loan Agreement, and Project Agreement and supporting documentation attached) immediately following loan signing.	MOF	2014.3.27	Completed. 2014.4.30
		e) Loans declared effective.	ADB (OGC, PO, OIC, PAUS)	2014.3.28	Completed. 2014.5.8
C	Malakal Sewer system Design-Build Contract	a) Technical and performance specification and bid documents finalized.	PPUC ADB (PO)	2014.7.4	
		b) Invitation for bid published in Palau print media and on ADB website	PPUC ADB (PO)	2014.7.4 2014.7.21	
		c) Pre-Bid Conference		2014.8.6	
		d) Deadline for submission of bids	PPUC	2014.8 15 2014.9.3	
		e) Opening of Bids		2014.9.3	
		f) Bids evaluated and bid evaluation report (BER) submitted to PSC and ADB for endorsement	PSC ADB (PC)	2014.9 12	
		g) PSC and ADB endorse BER	PSC, ADB	2014.9.26	
		h) Award Contract	PPUC, ADB (PO), PSC	2014.9.29	
		i) Issue Notice to be Proceed	PPUC	2014.10.28	
		j) Implement contract	Contractor PPUC, PIA ADB (PO)	Commission all components by 2016.5.15	
D	PIA Consultants recruited	a) Terms of reference finalized	PPUC ADB (PO)	2014.3.21	
		b) Invitation for EOIs postsed on CMS	ADB (PO)	2014.3.28	
		c) Deadline for submission of EOIs	PPUC ADB (PO)	2014.4.26	
		d) Evaluate EOIs and prepare shortlist consultants	PMU ADB (PO)	2014.6.4	
		e) Issue RFP to short-listed consultants	PPUC, ADB (PO, OSFMD)	2014.6.9	
		f) Deadline for submission of proposals	ADB (OSFMD)	2014.7.14	
		g) Evaluation of technical proposals by CSC completed	PPUC, ADB (PO, OSFMD)	2014.7.15-8.11	
		h) Evaluation of financial proposals completed	ADB	2014.8.15	
		i) Contract negotiation with first-ranked consultants		2014.9.3-5	
		j) Contract signed		2014.9.13	
		k) PIA consultants commerce services		2014.10.6 (tentative)	
E	Imprest account established	a) Imprest account (s) opened.		2014.8.25	Established 2014.5
		b) WA for initial imprest account deposit submitted to ADB		2014.5.2	When required
		c) Funds deposit into imprest accounts		2014.5.16	When required

ADB: Asian Development Bank; CMS: Consultant Management System; EOI: Express of Interest, MOF: Ministry of finance; OGC: Office of the General Counsel; OIC PAUS: Office in charge Urban, Social development and Public Management Division; PIA: Project Implementation Assistance (Consultant); OPR: Office of the President; OSFMD: Operations Services and Financial Management Department; PO: Project Officer; PPUC: Palau Public Utilities

(8) Implementing Stage

Egis Eau is doing the implementation.

4.6.3 Procurement of Plant - Design, Supply and Installation of the Malakal Sewerage System (Single-Stage: One-Envelope)

(1) Issued on : July 21, 2014

(2) Invitation for Bids No. : PPUC-ADB-KASP-PAL42439

(3) ICB No. : PPUC-ADB-KASP-PAL42439

(4) Employer : Palau Public Utilities Corporation (PPUC)

(5) The main components of the work involve the following scope;

(a) Sewer network rehabilitation and expansion civil works at Malakal area and the Pump Stations SPS-1 and SPS-2 and other associated force main located near to the CIP Offices to the inlets of the existing Primary Treatment Pond;

(b) Construct new DN 450 (18 inch) pressure (force) main from SPS-1 to connect with the Primary Treatment Pond inlet works including; trench works, adjustment of causeway, backfill, bridge crossings, supply and installation of DN 450 (18 inch) PN12 HDPE pressure pipes, restoration of works site, traffic control, etc.;

(c) Construct new DN 200 (8 inch) pressure (force) main from SPS-2 to connect with the Primary Treatment Pond inlet works including; trench works, backfill, supply and installation of DN 200 (8 inch) HDPE pressure pipes, restoration of works site, traffic control, etc.;

(d) Construct new SPS-1 submersible pump station and overflow treatment facility;

- Excavation including sheet piling & ground water control;
- Civil works including steel works, covers, etc.;
- Pumps and pipework;
- Electrical control building;
- Electrical control panels and power supply;
- Overflow treatment facility;
- Siteworks including fencing and restoration;

(e) Upgrade of SPS-2 pump station;

- Pumps and pipework;
- Electrical control panels and power supply;

(f) Expansion and augmentation of the existing local sewerage system on Malakal to accommodate proposed tourism developments;

- Pumps and pipework;
- Lift Stations (if required);

(6) Current Situation as of 2014.9.10

Bid is evaluated and bid evaluation report (BER) has been submitted to PSC and ADB with statement of bid failure and recommendations for rebid or incorporation of works into main KASP project.

4.6.4 PIA Consultants

(1) Terms of Reference

An international consulting firm will be engaged over a period of 39 months to provide total 15 specialists who will comprise the PIA consulting team as outlined in the paragraph below. The consulting firm will be selected using quality- and cost- based selection procedure s in

accordance with ADB's guidelines on the Use of Consultants by the ADB and its Borrowers (April 2013, as modified from time to time) with a quality-cost ratio of 90:10. Table 4.6-16 shows Consultants Input Schedule (Person-months)

In addition, the consultancy will includes (i) topographic cadastral surveys required for design of the project works, (ii) architectural, structural design, and building services design as required, (iii) materials testing and investigation including geotechnical investigations and field and laboratory testing of soils, required for the design and quality control during construction.

Table 4.6-16 Consultants Input Schedule (Person-months)

	Position	Total	Year 1	Year 2	Year 3	Year 4
International Consultants	Team Leader – Project Management Engineer	36	11	11	11	3
	Sewerage Network Design Engineer	6	5	1		
	Sewage Treatment Process Engineer	3	2	1		
	Sewer Hydraulic Modeling Specialist	3	3			
	Environmental Specialist	3	2	1		
	Project/Sanitation Economist	1.5	1.5			
	Quality Surveyor /Valuer	3	3			
	Sub-total	55.5	27.5	14	11	3
National Consultants	Deputy Team Leader/Municipal Engineer	36	11	11	11	3
	Construction Supervision Engineer (Network)	24		12	12	
	Construction y Supervision Engineer (Treatment)	24		12	12	
	CAD Operator (×2, 6 months each)	12	9	3		
	GIS Specialist	6	6			
	Community Participation/Gender specialist	36	11	11	11	3
	Environment Specialist	9	3	3	3	
	Resettlement Specialist	6	3	2	1	
	Office Assistant/Accounting Officer	36	11	11	11	3
	Sub-total	189	54	65	61	9

Notes: Years indicated are relative to consultancy contract effective date.

(2) Scope of Works

Specific tasks of the PIA consultants will include, but not be limited to:

(a) Confirmation of the project scope and consultant inception activities

(b) Raise community awareness of sewerage services

(c) Project Output 1: Effective, efficient and sustainable sewage collection system in Koror and Airai

(d) Project Output 2: Sewage treatment and disposal meets Palau's environmental standard

(e) Project Output 3: Safe and hygienic public toilet facilities in Koror State are available.

(f) Project Output 4: Effective project management

(3) Current Situation as of 10.9.2014

With regard to recruiting PIA Consultants, Egis in France was awarded in early September as shown in Table 4.6-17.

Table 4.6-17 Result of recruiting PIA Consultants

ADB Member	Express of Interest	Request for Proposal	Issuance of Proposal
Singapore	1	1 ?	1
India	2		
Australia	2	2 GHD, Aurecon Group	1

ADB Member	Express of Interest	Request for Proposal		Issuance of Proposal
Pakistan	1			
Korea	3	1	YoowhinEngineering	
Bangladesh	1			
France	1	1	Egis.Co.	1
USA	2	1	Stanley Consultants	
Total	13	6		3

Since MP and FS were conducted GHD in Australia, Egis in France expresses to review and check the MP and FS at first. So, the content of project might be revised.

(4) Relationship between PIA and Contractor engaged in 4.5.3.

While PIA Consultants will responsible for the supervision and administration of such design-build contract (including review and endorsement of design, "shop" and construction drawings and specifications prepared by design –build contractors), the PIA consultants will not be responsible for the preparation of the detailed designs for sewer network rehabilitation and expansion components procured through design-build contract. However, the possibility of including the design in the main PIA Consultant contract is presently being considered.

4.6.5 Issues to be considered based on MP and FS prepared GHD

(1) Ratio of Peak Dry Weather Flow (PDWF) to Average Dry Weather Flow (ADWF)

In this project, the ratio of PDWF to ADWF is 2.75, and the design flow of Qd is PDWF+0.15 (infiltration of groundwater ratio) ×ADWF. While Qd is the basis of designing all the sewerage facilities in the sewage treatment plant, there is no explanation why the ratio of PDWF to ADWF is 2.75. In Japan, this ratio is usually less than 2.0 and 2.75 seems to be high. If this ratio is used for designing the facilities of STP, the size of each facility is also large, resulting in the increase of investment cost. Furthermore it might cause the poor operation because the treatment capacity is too big in comparison to the actual inflow.

This value is recommended by the GHD Feasibility Study for sewer system design and design purposes are somewhat contentious and ADB agrees that the issue requires further review during the detailed design phase. With respect to the GHD recommendation for a PDWF/ADWF ratio with 2.75, the Palau Pumping Station Report Volume 5 prepared by ASPA in 2006 recommends adoption of a PDWF/ADWF ratio in the range from 2.0 to 2.5. Hydrographic data captured in 2004 indicates PDWF/ADWF ratio ranging from 1.3 to 10.6 with the larger pump stations, Pumping Station A1 and Pumping Station 2B demonstrating PDWF/ADWF ratios ranging of 1.6 and 4.1 respectively.

(2) Consideration of Saving Energy of PS

As explained in 4.4.3 (3), the existing number of PS became 48 and the energy required for lift up sewage is also large. Figure 4.6-9 shows the present layout of PS in Iyebukel, Ngerchemai sub-areas, for example. The sewage generated in the catchment of PS 16B has lift up into the trunk sewer through 4 PSs (16B→5B→4B→2B). This system is very complicated and not efficient, resulting in the O&M and increase of PS. It is preferable to reduce the number of PSs in order to reduce energy cost and operate PS easily. The Koror-Airai Sanitation Master Plan (section 9.1) specifically recommends

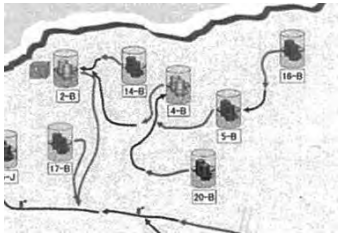


Figure 4.6-9 Example of Complicated PS

reconfiguring of the Koror Sewer Network to "significantly reduce the number of pump stations and connect pump stations to upgraded main gravity trunk sewer".

(3) Treatment Process

The FS shows that SBR (Sequencing Batch Reactor) with nitrifying cycle to remove nitrogen and extended aeration nitrification/denitrification treatment process is adopted in Malakal and Airai new STP, respectively. However, the following points should be considered in the detailed design stage.

(a) It is not clear why nitrification cycle has to be included while value of T-N of EQPB permit is not so strict and no specified treatment process seems to be required.

(b) FS shows only the flow chart of each treatment process as shown in Figure 4.6-2, 4.6-3, and 4.6-4. However, it is not clear why SBR was adopted in Malakal STP.

At present, there is no record of quantity of inflow and quality of influent/effluent due of no measurement of inflow and no work of laboratory at Malakal STP. So nobody knows whether the performance of this STP is good or not. If the problem of existing STP is caused by poor O&M, it can be solved by the improvement of O&M because the existing process uses the natural purification capacity well. Since there is little constraint of land space, there is no need to select the compact treatment process which requires the high consumption of electricity, high spare part/depreciation cost, and sophisticated skill in comparison of the existing treatment process. The treatment process has to be reviewed from the PPUC's financial, institutional, technical point of view.

(4) Promotion of Property Connection with External Plumbing and demolishing Septic Tank in New Sewerage Service Area

In the target area of Kesebelau/Ked Sewerage System in Airai, there are about 300 household which use the individual septic tank. After completion of this system, PPUC has to promote each house to demolish/remediate septic tank and connect the new sew line. Without this effort, no wastewater is discharged into the new STP. New department/division in charge of these activities has to be established for conducting this service. Figure 4.6-10 shows the scheme of property connection with external plumbing.

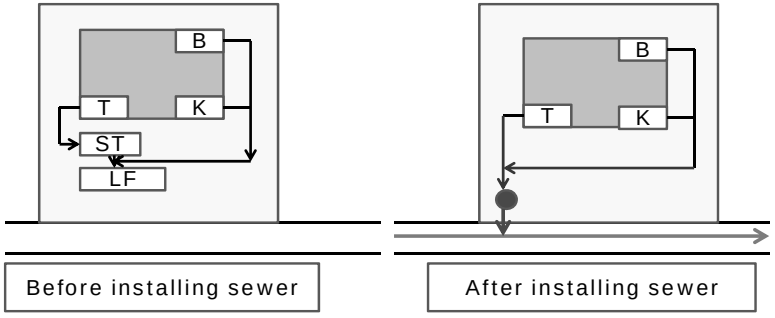


Figure 4.6-10 Promotion for connecting to sewer

4.7 Action Plan

4.7.1 Urgent Action Plan

(1) Re-preparation of Water Analysis System in Malakal STP

The water analysis system has to be prepared re-established for the following reasons. While the analysis equipment was donated by JICA based on the request of Senior Volunteer Mr.Fukazawa in 2012, the trainee who received the water analysis training from Mr.Fukazawa, has to train the analysis method to the new staff in Malakal STP.

(a) The result of quality analysis is utilized for grasping the current situation and getting the performance of STP. The performance of STP can be checked by taking sample at inlet and outlet of each facility and evaluating these data.

(b) It is the precondition of issuing the application form to EQPB as shown in 4.4.2.

(2) Acquisition of Permit from EQPB

As shown in 4.1.4. (5), PEA-261-02, the permit of Malakal STP, which was issued in September 2002 was expired on 30th in September 2007. However, the organization in charge of sewerage sector has not taken any action for this purpose since then. Since it takes more than three years for new STP to start operation, PPUC has to issue for applying the permission again as soon as possible after the water analysis system will be established.

(3) Enforcement of Supervising Staff in Malakal STP

At present, 12 staff is engaged in O&M work in Malakal STP. While some of the staff goes to PSs to grasp and check the current situation every day, the job-description of the rest staff is not clear.

At first, PPUC has to clear the job-description of each staff, prepare the manual of daily O&M. Then based on this manual, PPUC has to prepare the check sheet of the activity of each staff. So the activity of every staff can be grasped at the PPUC office.

4.7.2 Short/Medium Action Plan

(1) PPUC

(a) Rehabilitation of Malakal STP

1) Repair water measurement equipment

The quantity of inflow to STP is the most critical factor for O&M of STP. It is said that the STP is overloaded, nobody know it is correct or not. While the original design of STP is 2.0 MGD (7,570 m^3/day), the estimated quantity based on the SPS-2 working time is about 3,800 m^3/day, while this method is not so accurate. It means the STP capacity has a big room for future increasing inflow.

The Koror-Airai Sanitation Project Feasibility Study Appendix N reports an error in the design of ADWF for the trickling filters stated in the Winzler & Kelly Report (7.57 MLD or 2 MGD) as the trickling filter recirculation rate of 4.35 MLD is intended to be 100 % of ADWF. The Feasibility Study therefore concludes that the trickling filter design ADWF is about 4.1 MLD (see Appendix N Section 3.1.2) So, PPUC has to repair the water measurement equipment to grasp the current inflow for better O&M as soon as possible.

2) Repair of pumping for outfall of effluent

While EQPB permit shows the exact discharging point of effluent, the effluent cannot reach this point without driving force of PS. In order to prevent the effluent to be discharged in the near coastline, the pump for outfall of effluent has to be repaired soon.

In case of constructing new Malakal treatment plant at the site of the primary pond as recommended by the Koror-Airai Sanitation Master Plan, sufficient head is available to discharge the effluent by gravity and meet EQPB discharge consent requirement.

(b) Assignment of Staff in Charge of Sewer Maintenance

Based on the organization chart, there is no staff in charge of sewer maintenance. If resident call for overflowing sewage, the staff in Malakal STP is assigned to go to the resident, find the cause of trouble, and repair by "snake". While the total length of pipe line is 42,737 m consisting of gravity pipeline with 29,531 m and force main of 13,206 m, there is no specified division for O&M of sewer and it is impossible to analyze the cause of trouble due to no repair record. At first, staff in charge of sewer has to be assigned for smooth O&M of sewer and preparing ledger system.

(c) Asset Planning and Management in Malakal and Melekeok Sewerage System

PPUC has neither complete ledger system in sewer nor as-built drawing of treatment facilities/PS. Lack of asset information leads to poor planning and design outcome and also is indispensable for appropriate O&M of sewerage system and for statistical analysis of repair record based on the complaint from residents. In corporation with PALRIS (Palau Automated Land and Resources Information System) under Ministry of Public Infrastructure, Industries & Commerce has to be prepared as soon as possible.

PPUC has to develop the capacity for implementing asset planning and management consisting of O&M, asset upgrade, asset replacement, and services expansion etc.

(d) Establishment of Regulation for Discharging Industrial Wastewater to Sewer

At present there is no regulation for discharging the industrial wastewater to sewer. So any industrial water from the facilities including brewery, bakery, laundry, food processing factory, hospital, restaurant, fuel stand and so on, is discharged into the sewer with little/no treatment, resulting the deterioration of treatment function by high BOD, mineral oil, heavy metals or clogging of pipe by grease from restaurants. In order to protect the function of sewerage system, PPUC has to take action among two alternatives as shown in Table 4.7-1 and Figure 4.7-1.

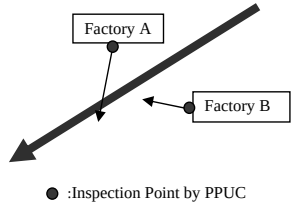


Figure 4.7-1 Scheme of Inflow from Factory

Table 4.7-1 Establishment of Regulation for Discharging Industrial Wastewater to Sewer

Alternative	Items to be considered
Establishment of regulation including following items	• Target activity/entity • Regulation per each parameter • Enforcement of regulation • Penalty in case of violating the regulation
Contract with each each entity about allowable discharge level of each parameter	• Target activity/entity • Allowable discharge level of each parameter • Enforcement of contract • Penalty in case of violating the contract

(e) Review of Sewerage Tariff Charging System

1) New Charge System for Seepage from Septic Tank

At this moment, the wastewater from the airplane and seepage from septic tank is discharged into the STP with free of charge. Since BOD concentration of the wastewater is too high in comparison with that of usual domestic sewage, PPUC has to establish the new service charge system and charge the new service fee as soon as possible in order to increase the income and protect the function of STP.

2) New Charge System for Rainwater Usage

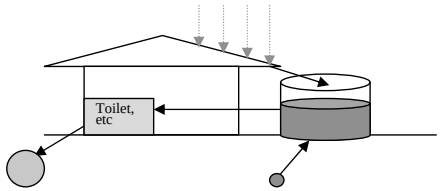


Figure 4.7-2 Water Usages and Discharge at Home

Some houses and apartment residents as shown in Figure 4.7-2 mainly use the water from the tank which collects the rainwater from roof. The water from PPUC also pours the tank supplementary in the drought seasons. Since the sewerage tariff is charged in proportional to the water consumption amount, the sewage volume is also small while a lot of wastewater from rain water is discharged into the sewer pipe. While PPUC has already installed the quality meter in some hotel, installation of meter or estimation of sewage inflow in consideration of rain water has to be estimated in order to charge the tariff based on the actual used wastewater.

(2) EQPB

(a) Empowerment of EQPB

EQPB is the only one monitoring organization which enforces the regulation/guideline to the relevant organization/person and has to a lot works for this purpose. However, EQPB has a shortage of human resources and budget. As shown in Table 4.7-2, the performance of EQPB is far from satisfactory. Although the organization chart shows the ideal one, there are some vacant seats. EQPB tried to recruit the staff by advertising in the new paper and other media, it is very difficult to recruit the qualified staff.

Table 4.7-2 EQPB Activity and Actual Situation

No	Activity to do	Actual situation
1	In case of violating regulation, the fine is charged based on the regulation.	The water of PPUC did not meet the standard of drinking water in three times, and EQPB charged the fine to PPUC. However, there is no payment of fine to EQPB till now.
2	Expiration of Permission from EQPB of two STPs	PPUC did not acquire the Pollution Discharge Permit from EQPB after expiration in September 2007. Malakal STP is running without permit. However there is no blame from EQPB.
3	Monitoring of the marine quality every month for at least 6 parameter	Due to shortage of chemical and equipment, only turbidity and E-coli is monitored several time/year, the frequency of remaining parameter is very few and often analysis work was outsourced.
4	Analysis and evaluation of the quality data above mentioned	The result of the data is only stored in the excel file with no analysis, evaluation of the trend or characteristics. Without such process, it is very difficult to take effective action to prevent deterioration of water quality in public water body.
5	Review of Guideline with regard to Septic tank	The guideline for installing the septic tank has to be reviewed by reflecting the current situation.
6	Grasp the current situation of O&M of septic tank	Nobody knows how much number of septic tanks is running and how about the annual desludging number/O&M situation. Poor O&M of septic tank might cause the contamination of groundwater, while nobody knows the current situation of groundwater contamination level.

Stronger enforcement powers should be considered for EQPB to effectively regulate the existing and future STP. The empowerment of EQPB will also be an external condition for improving the management system of PPUC. It is important that capability of monitoring and enforcing these regulations of EQPB keeps pace with improving sanitary infrastructure.

(b) Revision of the Septic Tank Standard

Since the septic tank will continuously be used from now on, the septic tank standard has to be revised because the reason as shown above. Furthermore, future sanitation planning should consider the cumulative effects of septic systems for new residential development zone.

EQPB has to review and strengthen septic tank codes/practices and strengthen enforcement with technical support from the relevant organization such as PPUC, DEH of MOH, and Koror State Government.

(c) Enforcement of proper O&M of Septic Tank

While almost all the houses connect to the public sewer line, some resident still use the septic tank, which requires the periodical desludging for proper O&M. However nobody knows how frequency the desludging services is provided to the resident because the service provider is tow private company and there is no data of disposal volume of seepage to STP. Poor operation and maintenance causes not only the environmental deterioration sues but also the contamination of the groundwater.

1) Confirmation of responsible organization in charge of enforcing the periodical desludging

2) Grasp of the current desludging frequency annually for each household

3) Check of groundwater analysis to survey the contamination by the septic tank

4) Increase of the number of service provider such as PPUC

4.8 Possible Project/Activity for Improving Sanitary Condition in Palau

4.8.1 Dispatch of Senior Volunteer to PPUC

From 2009 to 2013, JICA dispatched the three CVs for BPW as shown in Table 4.7-3. While their activities were appreciated by C/Ps, the performance contributed to little improvement of C/Ps due to low level of improving will from C/P sides.

Also it seems that the training on wastewater quality measurement carried out in 2011-2013 was not completed and equipment such as jars, chemicals, were missing or in short supply. Furthermore, the wastewater quality result are not still available for STP, especially BOD.

Table 4.7-3 List of SV in the Sewerage Sector

Term	Name of SV	Project	Counter Part
2008.7.28 – 2009.5.27	Mr.Higuchi Akira	Sewerage Facilities Maintenance	BPW, MRD
2009.3.23 – 2011.3.22	Mr.Takeshima Hidekazu	Sewerage Facilities Maintenance	BPW, MPIIC
2011.9.26 – 2013.9.25	Mr.Fukazawa Hitoshi	Water Quality Management at Malakal STP	BPW, MPIIC PWSC, PPUC

The duplication between ADB and JICA has to be avoided in consideration of progress of ADB Project. So the timing of dispatching SV to PPUC will be carefully considered through review and evaluation of the result/outcome of ADB project above mentioned. The expected activity is shown in Table 4.7-4. For the system, it would seem that some training on entry to confined spaces together with suitable safety equipment (gas detector, masks, harness, etc.) would be beneficial. Also training on methods of wastewater flow measurement could be beneficial in the long run. However, it will probably be necessary for KASP consultants to have their own independent flow and quality measurements carried out for the basis of design of the new STP.

Table 4.7-4 Probable Activity of SV

Category	Activity
Management	. to support preparing ledger system . to analysis repair record statistically and to propose effective/preventive O&M system
Technique	. to monitor, inspect sewer system and PS systematically . to indicate instruction on appropriate management and operation of the treatment process (existing and proposal)

4.8.2 Technical Cooperation (TC) for Revising Septic Tank Standard to EQPB

EQPB issued the following technical cooperation proposal for developing planning in August,2014. JICA also recommends this project due to following reasons;

- While the resources of water supply is now surface water, it is one alternative to use groundwater for financial and technical point of view. However the contamination through effluent from septic tanks progresses, it is impossible to used groundwater for water supply.

- Palau has a various kind of plan to construct the hotel and other facilities for tourist in islands and it is very preferable to revise the regulation as soon as possible.

(1) Background

Existing regulations and designs for on-site septic tank system (household) for areas with no access to public sewer system have been proven to be inadequately designed for the soil type of Palau. Regulation and designs for septic tank systems needs to be revised to suit the soil types in Palau. The overall mandate of Palau's environmental laws is to protect the integrity the marine, freshwater and groundwater to safeguard public health and environmental sustainability.

Hence the EQPB is seeking a technical support in sanitary engineering for short term loan from Japan to assist EQPB with alternative designs for safe and sanitary on-site wastewater treatment system.

In addition, Palau's Congress recently passed legislations to amend the Environmental Protection Act to include regulating water abstraction. This mandated the EQPB to promulgate water abstraction regulations. The challenge for the EQPB is to ensure that the water abstraction regulations development proceed in an enforceable manner so as not to deteriorate the environmental quality of Palau. Presently, the EQPB is unable to regulate water quantity because it lacks the necessity resources, including equipment, technical expertise, and manpower. The regulating of water abstractions would necessitate a hydrologist and additional equipment as well as training for staff.

(2) Outline of T/C

(a) Overall goal

The overall of this project is protection of environment through properly designed on-site wastewater treatment systems for households

(b) T/C Purpose

T/C purpose is to have properly designed on-site wastewater treatment systems for households as part of the EQPB regulations.

(c) Outputs

1) Alternative plans for on-site household septic systems developed and adopted by the Board

2) EQPB regulations revised to meet standards

3) Alternative designs used for new projects

4) Capacity of EQPB developed to implement new regulations

5) Developing a program for assessing stream and groundwater quantities

6) EQPB needs to quantify current users, finding out who is currently using what now. In addition, future uses must be planned for.

(d) T/C Site: Palau EQPB office and Babeldaob Island

(e) T/C Activity

1) Japanese sanitary engineering expert deployed at EQPB to review current designs used in Palau

2) Revision of EQPB standards with EQPB lawyer supported by Expert with Board approval

3) New designs made available to general public upon completion

4) Training conducted for EQPB staff and construction industry on new designs

5) Hydrological experts to provide guidance and recommendations

6) Purchase necessary equipment and get staff properly trained

(f) Input from the Recipient Government

1) Desk space at the EQPB office

2) Vehicle and fuel for transportation to field site

3) Support staff for field works and legal assistance for regulation revision

(g) Input from the Japanese Government

1) 1 expert in Sanitary Engineering and 1 Hydrologist to Palau, including travel expense

2) Equipment which to conduct hydrological survey testing as needed

(h) Implementation Schedule: 2015.7 ～ 2016.4

(i) Description of Implementation Agency

The EQPB has an annual budget of $400,000 and currently staffed with 14 people. The Compliance Section of the EQPB will be in charge of the T/C.

(j) Global Issue

The project will enhance the capacity of those involved in the water sanitation and management sector. There will be both man and woman trained and the entire population using such services will benefit the training as participants that are trained will be using skills learned to improve their sector.

4.8.3 Country Based Training "Capacity Enhancement for Water Sanitation Management"

(1) Background

In Micronesian three countries, only limited areas are provided with sewerage system and a large number of households still have pit latrines or other unhygienic excreta disposal system. Even the area covered by sewerage system, the system sometimes is not-functional and raw sewage is discharged outside. As a result, sea water, river water and groundwater are likely to be polluted and such poor control of water sanitation environment is considered to course environmental or human health problem.

On the other hand, the parameters that environmental protection agencies or water companies usually test are limited and they have almost no experience to test parameters about wastewater. In addition, it is required for relating agencies to enhance their capacity on water salinity management includes learning monitoring methods and ways of coping.

(2) Expected Output

. Management plan on Sewerage is developed in each state/atoll/county

. Participant's ability to implement the management plan on sewerage is enhanced.

. Necessary equipment to implement the management plan on Sewerage/Leachate is procured.

(3) Contents of the training

Schedule and contents of training in 2nd and 3rd year are shown in Table 4.8-1 and 4.8-2, respectively. Target trainee in Palau is from PPUC, EQPB, and relevant organizations.

Table 4.8-1 Schedule of Training

	Leachate	Sewerage
Development of Management Plan	1st year	2nd year
Learn how to implement the Management Plan	1st year	2nd Year
Onsite follow-up, Date Management	3rd Year	3rd Year

Table 4.8-2 Contents of Training

2nd year: Training in Japan on Sewerage	3rd year: Training on site
1) General remarks on proper water sanitation management in small island 2) General remarks on Sewage monitoring (parameter, target samples, standards) 3) Current status of sewer management in each agency (treatment, monitoring, equipment, human resources, budget, corporation by other donors, etc.) 4) Current issues on sewage management 5) Development of plan for sewage management which includes monitoring plan, standards, coping ways for abnormal level, action plan, necessary equipment, necessary human resources, budget, frequency, sampling target, etc. 6) Practice of sewage monitoring 7) Procurement for necessary equipment and budget	1) Feedback of monitoring results to strategy on Water Sanitation Management 2) Data sharing among related agencies 3) Follow up for data management, analysis, writing report 4) Follow up for implementing action plan

4.8.4 Dispatch of Senior Volunteer to DEH, MOH

As the role of this organization is shown in 4.1.3, DEH inspects the condition of each building in Palau from the view of protection disease. This recurrent cost is donated mainly from Center for Disease Control and Prevention (CDC) in USA and this is used biological test of food. Since 2006, DEH started to conduct the survey, and a lot of data is only saved in excel file in Computers and it is not statistically analyzed.

DEH strongly requires Senior Volunteer to survey and analyze this excel data statistically for proposing and conducting efficient policy and countermeasures for controlling disease.

Appendix-1 Comment on JICA Sector Development Framework October 2014-11-10

Comments on JICA Sector Development Framework October 2014-11-10

1. List of contents - Section 4.5.1 Korea Sewerage system upgrade – should be Koror⇒Revised
2. Section 4.5.2 for KASP indicates GHD as implementing the project – this should be revised to show that GHD were doing the PPTA and that Egis Eau are doing the implementation – scope to be added. ⇒Revised

In Table 4.35 KASP Milestone and Action Matrix,

Under D - PIA consultants recruited (page 52)

I) Contract Negotiated – 3rd-5th September

J) Contract Signed - 13th September 2014

k) PIA Consultants Commence Services – should be 6th October 2014

3. 4.5.3 Procurement of Plant - Design, Supply and Installation of the Malakal Sewerage System (Single-Stage: One-Envelope)

(6) Current Situation as of 2014.10.10

Bid is evaluated and bid evaluation report (BER) has been submitted to PSC and ADB with statement of bid failure and recommendations for rebid or incorporation of works into main KASP project – to be decided⇒Revised

(4) Relationship between PIA and Contractor engaged in 4.5.3. – at end of paragraph it should be added that "however the possibility of including the design in the main PIAC contract is presently being considered" ⇒Revised

4.7.1 last sentence – should refer to Table 4.40⇒No change

4. In Table 4.40, Technique⇒Revised

- The wording that indicates to instruct on appropriate treatment process – should be revised to indicate instruction on appropriate management and operation of the treatment processes (existing and proposed)
- For the systems it would seem that some training on entry to confined spaces – together with suitable safety equipment (gas detectors, masks, harness, etc) would be beneficial
- Also, it seems that the training on waste water quality measurement carried out in 2011 - 2013 was not completed – or possibly equipment / jars, chemicals, missing or in short supply? as still no waste water quality results are available for STP – particularly BOD.
- Also training on methods of waste water flow measurement could be beneficial in the long run. – However it will probably be necessary for KASP consultants to have their own independent flow and quality measurements carried out for the basis of design of the new STP

PALAU –WATER SECTOR ASSESSMENT- CHAPTER 4. revised by Kamata

Reference	Comment	Revision
Section 4.1.2. - Financial Stability	1. Mention should be made of the Utilities Consolidation Act (RRPL 9-4-1) 2014 which states "*All future rates shall be designed on the basis of full cost recovery*". 2. Water and sewer tariffs are currently being adjustment in accordance with the tariff adjustments proposed under the Water Sector Improve Program to achieve full cost recovery by the end of fiscal year 2015. Public hearing were conducted during the third week of September 2014 and are expected to become effective in the third week of October 2014.	1. revised 2. Revised
Section 4.2.2 - Asian Development Bank Strategy	The ADB country partnership strategy 2009-2013 is expired. In its stead, the Pacific Approach 2010-2014 now serves as the strategy for Palau, with details in the country operations business plan (COBP). The latest COBP is for 2015-2017 approved in September 2014. Both the Pacific Approach and the COBP are available on the ADB website. 4.2.2 (1) should be revised to reflect the above-mentioned documents	Revised
Section 4.2.2 - Project Records on going	A7421-PAL is also closed.	Revised
Section 4.2.2 - Project Record in Pipeline	It seems like this is referring to requested support to public administration being provided under TA8581-REG. The write up should reflect that in response to a request by PPUC, ADB is providing support as part of its overall assistance to the national government to review its public service, to be administered through the Ministry of Finance. The latter part of the para referring to approval by PPUC Board is outdated - we received endorsement to proceed with engagement of consultant from both PPUC and ultimately the Ministry of Finance. I also think this level of detailed information should not be part of a document of this nature especially as its an issue that is easily resolved,	Revised
Section 4.2.2 - Medium Term Development Strategy	The write up is straightforward and taken directly from the MTDS. We note that there is no reference made to the Management Action Plan, which the new administration adopted when it assumed office which was prepared aligned with the MTDS.	Deleted
Section 4.2.2 (4) - Overarching Strategies	The statement "*It seems that there are likely to be substantial potential savings from investing in gravity lines to shore-level mains around Koror island and connecting to Malakal; but such major options must be set in a longer strategy, with robust technical, economic and environmental appraisal*" is contrary to the recommendations of the Koro-Airai Sanitation Master Plan which assessed in depth a "shore-level" option as well as other options. The estimated cost of the "shore-level" solution is significantly higher than the recommended option of a centralized sewer system. The environmental impacts of the "shore-level" were also assessed and were found to substantial. Please refer to the Koror-Airai Sanitation Master Plan and the Koror-Airai Sanitation Project feasibility study documentation.	Deleted
Section 4.2.2 (5) - Final paragraph, final sentence.	Reference should be made to the Asian Development Bank loans amounting to US$28.8 million which were approved on 19 November 2013.	Deleted
Section 4.4.2, (4)	The surface aerators were removed from the primary pond at least 3 years ago and have not been	No change

Appendix-2 PALAU-WATER SECTOR ASSESSMENT CHAPTER 4

These pictures were taken at Malakal STP on 25th in June, 2014.

Reference	Comment	Revision
(b) Table 4.14 *Primary Pond*	reinstalled. Currently, the primary pond operates as a facultative pond. This information should be incorporated into the table.	because there are three surface aerators working.
Section 4.55 (1)	A suitable ratio of peak dry weather flow (PDWF) to average dry weather flow (ADWF) of 2.75 as recommended by the GHD Feasibility Study for sewer system design purposes is somewhat contentious and **ADB agrees that the issue requires further review during the detailed design phase**. With respect to the GHD recommendation for a PDWF / ADWF ratio of 2.75, the Palau Pump Station (PSP) Report Volume 5 prepared by ASPA in 2006 recommends adoption of a PWDF / ADWF ratio in the range from 2.0 to 2.5. Hydrographic data captured in 2004 indicates PDWF / ADWF ratios ranging from 1.3 to 10.6 with the larger pump stations, Pump Station A1 and Pump Station 2B demonstrating PDWF / ADWF ratios ranging of 1.6 and 4.1 respectively.	Revised
Section 4.55 (2)	The header to this section – "Little Consideration of Saving Energy of PS" is misleading and incorrect The Koror-Airai Sanitation Master Plan (Section 9.1) specifically recommends reconfiguring of the Koror sewer network to "*significantly reduce the number of pump stations and connect pump stations to upgraded main gravity trunk sewer*".	Revised
Section 4.55 (3)	The identification and evaluation of process options for the Malakal sewage treatment plant are presented in the Koror-Airai Sanitation Project Feasibility Study Appendix N: *Sewage Treatment Concepts*. The justification for the recommended processes - SBR or IDEA – are provided in the feasibility study.	No change because justification in FS is insufficient.
Section 4.6.2 1)	The average daily inflow estimate to the treatment plant of 3,800m^3/d as stated in the JICA sector assessment is based on pump run-times which is notoriously inaccurate (as the method assumes pumps operate as rated and pump run-time metering is accurate). The estimate also fails to account for losses from the system from overflows and exfiltration (which would be addressed when the sewer network is upgraded). The Koror-Airai Sanitation Project Feasibility Study Appendix N reports an error in the design ADWF for the trickling filters stated in the Winzler & Kelly Report (7.57MLD or 2MGD) as the trickling filter recirculation rate of 4.36MLD is intended to be 100% of ADWF. The Feasibility Study therefore concludes that the trickling filter design ADWF is about 4.10 MLD (see Koror-Airai Sanitation Project Feasibility Study Appendix N Section 3.1.2). Given the average daily inflow estimate to the treatment plant of 3,800m^3/d as stated in the JICA sector assessment <u>does not</u> leave "big room for future increasing flow", particularly given potential inaccuracies in the flow estimate as outlined above. ADB agrees that flow metering into and out of the Malakal sewage treatment plant should be priority.	ADB comment was addied.
Section 4.6.2 2)	ADB agrees that Malakal sewage treatment plant effluent pumps need to be repaired as a priority. However, if the new Malakal treatment plant is constructed at the site of the primary pond as recommended by the Koror-Airai Sanitation Master Plan, sufficient head is available to discharge the plant effluent by gravity and meet EQBP discharge consent requirements.	Revised

2. 基本ツール①～⑤と補助図表 – Basic Tool ①～⑤ and Supporting Figures and Tables

2.1 基本ツール①: 水道事業体の業務指標リスト – Basic Tool ①: List of Performance Indicators (LPI)

Info. Type	Category			Priority (優先度)	Reference No. of IBNET Indicator (IBI_), Other Indicator (OI_), IBNET Data (IBD_) and Other Data (OD_)	Name of Performance Indicator or Name of Data	Definition of Performance Indicator and its Equation for Calculation or Definition of Data		Answer										Score Calculation									
									Manual Input from IBNET or Other Record of Indicators				Auto-calculation of Indicators from Collected Data				Average				Scoring System		Score of Each Indicator Value (point)				Average Score for FI, Technical CD and Non-technical CD (points) (* is not average)			
	Large	Medium	Small						Koror-Airai	Utility B	Utility C	Utility D	Koror-Airai	Utility B	Utility C	Utility D	Koror-Airai	Utility B	Utility C	Utility D	Max. (100 points)	Min. (0 point)	Koror-Airai	Utility B	Utility C	Utility D	Koror-Airai	Utility B	Utility C	Utility D
Performance Indicators	Aspects to be Improved mainly by Facility Investment (FI)	Overall	Supply continuity	1st	IBI_15.1	Continuity of service (hours/day)	Average hours of service per day for water supply	=(IBD_61)					24	-	-	-	24	-	-	-	= 24 hours	≦4 hours	100	-	-	-	100	-	-	-
				2nd	IBI_15.2	Customers with discontinuous supply (%)	Percentage of customers with a water supply that is discontinuous during normal operation	=[(IBD_61a)/(IBD_40)]*100					0	-	-	-	0	-	-	-										
		Expansion	Service coverage	1st	IBI_1.1	Water coverage (%)*1	Population with access to water services (either with direct service connection or within reach of a public water point) as a percentage of the total population under utility's nominal responsibility	=[(IBD_40)/(IBD_30)]*100					100	-	-	-	100	-	-	-	≧90 %	≦ 30%	100	-	-	-					
				2nd	IBI_1.2	Water coverage - household connection (%)*1	Subset of IBI_1.1 for house connections	=[(IBD_40a)/(IBD_30)]*100					100	-	-	-	100	-	-	-										
			Affordability/ tariff	2nd	IBI_19.2	Annual water bill for a households consuming 6m^3 of water per month through a household or shared yard tap (excluding use of stand posts) (USD/year)	Cost in local currency to a household per month of 6m^3 water / Exchange rate with US$ * 12 months	=(IBD_C.4)/(IBD_6)*12					22.2	-	-	-	22.2	-	-	-										
				3rd	OI_1	Domestic water charge level (%)	Average domestic water charge per served population / National GNI per capita as a percentage	=[[(IBD_90a)/(IBD_40)/(IBD_6)]/(IBD_5)]*100					294.82	-	-	-	294.82	-	-	-										
				3rd	IBI_21.2	Ratio of industrial to residential water tariff -ratio)	The average charge (per m^3) to industrial customers compared to the average charge (per m^3) to residential customers	=[(IBD_90f)/(IBD_59b)]/[(IBD_90e)/(IBD_59a)]					1.6213	-	-	-	1.6213	-	-	-										
				3rd	IBI_22.2	Connection charge for water (% of GNI per capita)	(Lump sum cost for residential water connection per connection in LC / Exchange rate with US$) / National GNI per capita; expressed in percentage	=[[(IBD_147)/(IBD_6)]/(IBD_5)]*100					0.1521	-	-	-	0.1521	-	-	-										
			Water consumption	3rd	IBI_3.1	Water production (litres/person/day)	Total annual water supplied to the distribution system (including purchased water, if any) expressed per population served per day	=[(IBD_55)/(IBD_40)/365]*1000000					998.04	-	-	-	998.04	-	-	-										
				3rd	IBI_4.7	Residential consumption (litres/person/day)*2	The average residential water consumption per person per day	=[(IBD_59a)/(IBD_40)/365]*1000000					256.36	-	-	-	256.36	-	-	-										
				3rd	OI_2	Surplus purification capacity (%)	((Daily treatment capacity - Maximum daily treatment capacity) / Daily treatment capacity) as a percentage	=[[(OD_1)-(OD_2)]/(OD_1)]*100					0	-	-	-	0	-	-	-										
		Rehabilitation/replacement	Pipe network	3rd	IBI_9.1	Pipe breaks (breaks/km/year)*3	Total number of pipe breaks per year expressed per km of the water distribution network	=[(IBD_60)/(IBD_54)]					0	-	-	-	0	-	-	-										
	Aspects to be Improved mainly by Capacity Development (CD)	Technical Aspects	NRW*4	1st	IBI_6.1	Non revenue water (%)*4	Difference between water supplied and water sold (i.e. volume of water "lost") expressed as a percentage of net water supplied	=[((IBD_55)-(IBD_59))/(IBD_55)]*100					49	-	-	-	49	-	-	-	≦20 %	≧70%	42	-	-	-	42	*	-	-	-
				2nd	IBI_7.1	Metering level (%)	Total number of connections with operating meter / Total number of connections, expressed in percentage	=[(IBD_53)/(IBD_41)]*100					90.027	-	-	-	90.027	-	-	-										
				3rd	OI_3	Response to pipe breaks within 24 hours (%)	Annual percentage of pipe breaks responded to within 24 hours	=[(OD_3)/(OD_60)]*100					-	-	-	-	-	-	-	-										
				3rd	IBI_6.2	Non revenue water (m^3/km/ day)*4	Volume of water "lost" per km of water distribution network per day	=[((IBD_55)-(IBD_59))/(IBD_54)/365]*1000000					127.51	-	-	-	127.51	-	-	-										
				3rd	IBI_6.3	Non revenue water (m^3/conn/day)*4	Volume of water "lost" per water connection per day	=[((IBD_55)-(IBD_59))/(IBD_41)/365]*1000					1.8388	-	-	-	1.8388	-	-	-										
			Water quality	1st	IBI_15.3	Implementation of tests for residual chlorine at end users (%)	The number of tests carried out on samples taken from the distribution system, as a % of the number required by the standard that applies (note this may exceed 100%.) Operational samples, or any others that were not taken to check compliance with the standard, are excluded.	=[(IBD_64)/(IBD_63)]*100					-	-	-	-	-	-	-	-	≧95 %	≦80%	-	-	-	-				
				2nd	IBI_15.4	Passing of tests for residual chlorine at end users (%)	The percentage of samples tested for residual chlorine that pass the relevant standard	=[(IBD_65)/(IBD_64)]*100					-	-	-	-	-	-	-	-										
		Non-technical aspects	Financial performance	1st	IBI_23.2	Collection ratio - W&WW (%)*5	Cash income / Billed revenue as a percentage	=[(IBD_91)/(IBD_90)]*100					100	-	-	-	100	-	-	-	≧95 %	≦50 %	100	-	-	-	53	-	-	-
				1st	IBI_24.1	Operating ratio (billed revenue covering O&M cost excluding depreciation and financing charges) - W&WW (%)*6, *8	Total annual operational (billed) revenue / Total annual operating costs excluding depreciation and financing charges (interest and capital repayments) as a percentage	=[(IBD_90)/(IBD_94)]*100					38	-	-	-	38	-	-	-	≦130 %	≦60 %	0	-	-	-				
				2nd	IBI_11.3	Unit operational cost for water only (US$/m^3 water sold)*7	Annual water service operational expenses / Total annual volume sold (Annual operating expenses exclude depreciation, interest and debt service) in US$	=[(IBD_94a)/[(IBD_59)*1000000]/(IBD_6)					0	-	-	-	0	-	-	-										
				2nd	IBI_18.3	Average revenue for water only (US$/m^3 water sold)	Operating revenues (water only) / annual amount of water sold in US$	=(IBD_90c)/(IBD_6)/[(IBD_59)*1000000]					0	-	-	-	0	-	-	-										
				2nd	IBI_19.1	Percentage of total revenues - W&WW per service population (% of GNI per capita)	Total annual operating revenues per population served / National GNI per capita; expressed in percentage	=[[(IBD_90)/(IBD_6)]/[(IBD_5)*(IBD_40)*1000]]*100					1.2768	-	-	-	1.2768	-	-	-										
				3rd	OI_4	Operating ratio (billed revenue covering O&M cost excluding depreciation and financing charges) for water only (%)*6, *8	Annual operational (billed) revenues for water / Total annual operating costs for water excluding depreciation and financing charges (interest and capital repayments) as a percentage	=[(IBD_90c)/(IBD_94a)]*100					-	-	-	-	-	-	-	-										
				3rd	IBI_23.1	Collection period of accounts receivable - W&WW (days)	(Year-end accounts receivable / Total annual operating revenues) * 365	=[(IBD_120)/(IBD_90)]*365					81.535	-	-	-	81.535	-	-	-										
				3rd	OI_5	Current ratio - W&WW (%)*12	(Current assets / Current liabilities) as a percentage	=[(OD_4)/(OD_5)]*100					241.16	-	-	-	241.16	-	-	-										
				3rd	OI_6	Ratio of net worth to total capital - W&WW (%)*11	((Owned capital + Surplus) / Total of liabilities and capital)*100	=[[(OD_6)+(OD_7)]/[(OD_8)]*100					-	-	-	-	-	-	-	-										
				3rd	IBI_25.1	Debt service ratio (%) - W&WW*9	Cash income / Debt service as a percentage	=[[(IBD_91)/(IBD_114)]*100					-	-	-	-	-	-	-	-										
				3rd	OI_7	Ratio of fixed assets to equity capital - W&WW (%)*11	(Fixed assets / (Owned capital + Surplus)) as a percentage	=[(OD_9)/[(OD_6)+(OD_7)]]*100					-	-	-	-	-	-	-	-										
				3rd	OI_8	Turnover of fixed assets - W&WW (%)*11	(Operating income - Commissioned work income) / Fixed assets as a percentage	=[[(IBD_91)-(OD_10)]/(OD_9)]*100					-	-	-	-	-	-	-	-										
			Staff efficiency	1st	IBI_12.1	Number of staff working specifically for water (Number/ '000 water connections)*6	Total number of staff per thousand connections	=(IBD_36a)/(IBD_41)					12.938	-	-	-	12.938	-	-	-	≦5 staff	≧25 staff	60	-	-	-				
				2nd	IBI_14.1	Outsourced service costs - W&WW as percentage of total operational costs (%)*6	Total cost of services contracted out to the private sector, expressed as a percentage of total annual operational costs	=[(IBD_99)/(IBD_94)]*100					0	-	-	-	0	-	-	-										

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Appendix-3 Result of Capacity Assessment

Info. Type	Category			Priority (優先度)	Reference No. of IBNET Indicator (IBI_), Other Indicator (OI_), IBNET Data (IBD_) and Other Data (OD_)	Name of Performance Indicator or Name of Data	Definition of Performance Indicator and its Equation for Calculation or Definition of Data	Answer									Score Calculation		Score of Each Indicator Value (point)				Average Score for FI, Technical CD and Non-technical CD (points) (* is not average)			
								Manual Input from IBNET or Other Record of Indicators				Auto-calculation of Indicators from Collected Data				Average				Scoring System								
	Large	Medium	Small					Koror-Airai	Utility B	Utility C	Utility D	Koror-Airai	Utility B	Utility C	Utility D	Koror-Airai	Utility B	Utility C	Utility D	Max. (100 points)	Min. (0 point)	Koror-Airai	Utility B	Utility C	Utility D	Koror-Airai	Utility B	Utility C	Utility D
	Aspects to be Improved mainly by Capacity Development (CD)	Non-technical aspects	Financial performance/ tariff	1st	IBD_90	Total W & WW operating (billed) revenues (LC/year)	Total billing of water and wastewater services, connection fees, well abstraction fees, reconnection fees and other operational revenues including subsidies[**10], but excluding all taxes[**11] (shown in the utility's Profit and Loss statement (P/L))	1762528																			
				1st	IBD_91	Total W & WW (cash) income (LC/year)	Income actually received for water and wastewater services (shown in the utility's Profit and Loss statement (P/L))	1762528																			
				1st	IBD_94	Total W & WW operational expenses (LC/year)	Total operational expenses (W&WW) excluding depreciation and financing charges (interest and capital repayments) (shown in the utility's Profit and Loss statement (P/L))	4693439																			
				2nd	IBD_94a	Total operational expenses for water (LC/year)	Operating expenses excluding depreciation and financing charges (interest and capital repayments) for water supply services (usually shown in the utility's Profit and Loss statement (P/L))																			
				2nd	IBD_90c	Total operating (billed) revenues for water (LC/year)	Subset of IBD_90 for water services only (shown in the utility's Profit and Loss statement (P/L))																			
				3rd	IBD_120	Year end accounts receivable - W&WW (LC)	Total of all accounts receivable at year end including water billings, and all other outstanding invoices (shown in the utility's Balance Sheet (B/S))	393,721																			
				3rd	IBD_147	Connection charge - water (LC)	Lump sum cost for residential water connection per connection	15																			
				3rd	OD_4	Current assets - W&WW (LC)	Sum of cash, deposits, and bonds to be exchanged to cash within a year (shown in the utility's Balance Sheet (B/S))	2,487,599																			
				3rd	OD_5	Current liabilities - W&WW (LC)	Liabilities referring to short -term obligations to be redeemed within a year in normal transactions (shown in the utility's Balance Sheet (B/S))	1,031,513																			
				3rd	OD_6	Owned capital - W&WW (LC)	Sum of investments transferred when proper funds and fixed assets are acquired at the start of operation and surplus given through the acquisition of the fixed assets (shown in the utility's Balance Sheet (B/S))																			
				3rd	OD_7	Surplus - W&WW (LC)	Surplus given by subtracting capital from the water utility's net assets (shown in the utility's Balance Sheet (B/S))																			
				3rd	OD_8	Total of liabilities and capital - W&WW (LC)	Sum of liabilities and capital shown in balance sheets, which equals total capital (shown in the utility's Balance Sheet (B/S))																			
				3rd	IBD_114	Total debt service - W&WW (LC / year)	Total debt service costs (including interest and repayment of capital) (shown in the utility's Balance Sheet (B/S))																			
				3rd	OD_9	Fixed assets - W&WW (LC)	Fixed assets, which may be shown in Balance Sheet (B/S), referring to means held for long-term operation (more than one year), which equals the sum of tangible and intangible fixed assets, and investments																			
				3rd	OD_10	Commissioned work income (trust business revenues) - W&WW (LC/year)	Revenue given by constructing non-statutory waterworks facilities, for example, the introduction and repair of water supply equipment (shown in the utility's Profit and Loss statement (P/L))																			
			Staff efficiency/ training	1st	IBD_36a	Total number of staff - water (FTE)	Total number of staff working at the utility on water services expressed as Full Time Equivalent (FTE) staff number.	48																			
				2nd	IBD_99	Outsourced services costs - W&WW (LC / year)	Costs of all services within IBD_94 provided by private firms (shown in the utility's Profit and Loss statement (P/L))	0																			
				3rd	OD_11	Total number of training days (participants * training event duration) in the year - water (days/year)	Annual total number of training days per year (participants * training event duration) for staff working for water supply. Duration of half-day and one-class training can be counted as 0.5 day and 0.25 day respectively.																			
			Customer relations	3rd	OD_12	Number of customer complaints responded to within 10 days - water (Number/ year)	Annual number of customer complaints responded to within 10 days (solving the problem, taking an initial action in the field or explaining the procedure of solving the problem clearly to the customer).																			
				3rd	OD_13	Total number of customer complaints - water (Number/year)	Total annual number of customer complaints to the water utility	626																			
				3rd	OD_14	Number of water connections disconnected for more than 3 months (Number)	Number of water connections disconnected for more than 3 months. Possible reasons for being disconnected for more than 3 months include availability of alternative water sources, shortage of water distributed to the household or inability to pay, etc.																			
				3rd	OD_15	Total number of active and disconnected water connections (Number)	Total number of active and disconnected water connections																			
	Aspects to be Improved mainly by Program Approach	W&WW information	Service information	1st	IBD_70	Population served - sewer connection ('000 inhabitants)	Population under the utility's responsibility with sewerage services through house connections	12																			
				1st	IBD_30a	Total population in area of responsibility - wastewater ('000 inhabitants)	Total population under notional responsibility of the utility for sewerage, irrespective of whether they receive service	14																			

Info. Type	Category			Priority (優先度)	Reference No. of IBNET Indicator (IBI_), Other Indicator (OI_), IBNET Data (IBD_) and Other Data (OD_)	Name of Performance Indicator or Name of Data	Definition of Performance Indicator and its Equation for Calculation or Definition of Data		Answer										Score Calculation		Score of Each Indicator Value (point)				Average Score for FI, Technical CD and Non-technical CD (points) (* is not average)			
									Manual Input from IBNET or Other Record of Indicators				Auto-calculation of Indicators from Collected Data				Average				Scoring System								
	Large	Medium	Small						Koror-Airai	Utility B	Utility C	Utility D	Koror-Airai	Utility B	Utility C	Utility D	Koror-Airai	Utility B	Utility C	Utility D	Max. (100 points)	Min. (0 point)	Koror-Airai	Utility B	Utility C	Utility D	Koror-Airai	Utility B	Utility C	Utility D
			Training	3rd	OI_9	Average days of training for water staff (days/person)	Total number of training days (participants * training event duration) per the year for staff working for water supply / Total number of staff for water supply	=(OD_11)/(IBD_36a)					0	-	-	-	0	-	-	-									
			Customer relations	3rd	OI_10	Response to customers' complaints within 10 days for water only (%)	Annual percentage of customer complaints responded to within 10 days	=[(OD_12)/(OD_13)]*100					0	-	-	-	0	-	-	-									
				3rd	OI_11	Dormant connection ratio for water only (%)	Number of water connections disconnected for more than 3 months / Total number of active and disconnected water connections	=[(OD_14)/(OD_15)]*100					-	-	-	-	-	-	-	-									
	Aspects to be Improved mainly by Program Approach	W&WW information	Service coverage	1st	IBI_2.1	Sewerage coverage (%)[**1]	Population with sewerage services (direct service connection) as a percentage of the total population under utility's notional responsibility	=[(IBD_70)/(IBD_30a)]*100					85.71	-	-	-	85.71	-	-	-									
			Revenue	2nd	IBI_18.1	Average revenue - W&WW (US$/m3 water sold)	Total annual W&WW operating revenues / annual amount of water sold in US$	=(IBD_90)/(IBD_6)/[(IBD_59)*1000000)]					0.6753	-	-	-	0.6753	-	-	-									
Data for calculating the above Performance Indicators	Aspects to be Improved mainly by Facility Investment (FI)	Overall	Supply continuity	1st	IBD_61	Duration of water supply (hours/day)	Average hours of service per day (this indicator measures intermittent supply systems; interruptions due to unplanned failures or rehabilitation work should be excluded).		24																			
				2nd	IBD_61a	Number of customers receiving intermittent water supply ('000 inhabitants)	Percentage of residential customers who do not normally receive supply 24 hours per day		0																			
		Expansion	Service coverage	1st	IBD_40	Population served - water ('000 inhabitants)	Population under utility's responsibility with access to water through house connections, yard taps and public water points (either with direct service connection or within 200m of a stand post). Any population outside the utility's area of responsibility who are served (e.g. people who come from outside to the utility's water points) should be excluded.		14																			
				1st	IBD_30	Total population in area of responsibility - water ('000 inhabitants)	Total population under notional responsibility of the utility for water supply, irrespective of whether they receive service		14																			
				2nd	IBD_40a	Population served - direct water supply and shared taps ('000 inhabitants)	Population under responsibility of the utility with access to water through house connections and shared yard taps (where 2 or more houses share a private yard with a tap)		14																			
			Affordability/ tariff	2nd	IBD_C.4	Monthly water bill for a household consuming 6 m^3 of water per month through a household or shared yard tap (but excluding the use of stand posts) (LC/month)	Monthly water bill for a household consuming 6 m^3 of water per month through a household or shared yard tap		1.85																			
				2nd	IBD_6	Exchange rate (LC/US$)	Annual average exchange rate to the US dollar for the year to which the data apply		1																			
				2nd	IBD_5	GNI per capita (Atlas method) (US$/person /year)	Annual GNI per capita (Atlas method) for country for the year to which the data apply (Source: World Development Report, World Development Indicators Database, etc. of World Bank)		9860																			
				3rd	IBD_59a	Volume of water sold to residential customers (million m^3/year)	Total volume of water billed to residential customers		1.31																			
				3rd	IBD_50b	Volume of water sold to industrial & commercial customers (million m^3/year)	Total volume of water billed to industrial & commercial customers (excluding water to domestic customers, bulk water to other utilities and water to institutions)		1.3																			
				3rd	IBD_90e	Total billings for water to residential customers (LC/year)	Annual total amount billed in local currency for water to residential customers including fixed and volumetric charges		406975																			
				3rd	IBD_90f	Total billings for water to industrial & commercial customers (LC/year)	Annual total amount billed in local currency for water to industrial and commercial customers including fixed and volumetric charges		654810																			
			Water consumption	1st	IBD_55	Volume of water produced (million m^3/year)	Total volume of water produced for the service area, i.e. volume leaving treatment works operated by the utility and purchased treated water, if any.		5.1																			
				3rd	OD_1	Daily treatment capacity (million m^3/day)	Volume of water per day purified in the current purification plant (the capacity of failed or repaired facilities is excluded)		0.015																			
				3rd	OD_2	Maximum daily treatment capacity (million m^3/day)	Recorded maximum volume of water per day supplied in the corresponding plant in a year		0.015																			
		Technical aspects	Water quality	1st	IBD_63	Required number of tests of treated water for residual chlorine	The number of samples of potable water that are required by law/regulation to be taken from the distribution system to be tested for residual chlorine		0																			
				1st	IBD_64	Number of tests of treated water for residual chlorine carried out	The number of samples of potable water actually taken from the distribution system , that have been tested for residual chlorine		0																			
				2nd	IBD_65	Number of tests of treated water for residual chlorine that passed the relevant standard (Number/year)	The number of samples of potable water taken from the distribution system, that have been tested for residual chlorine and comply with the national standard		0																			
			Distribution network management	3rd	IBD_60	Number of water pipe breaks in the distribution network (Number/year)	Total number of water pipe breaks in the distribution network during the year. Failures that require repair of mains, connections, valves and fittings that are the utility's responsibility are included. Repairs from active leakage control are excluded.																					
				3rd	IBD_54	Length of water distribution network (km)	Total length of the distribution network (excluding transmission lines and service pipes)		53.5																			
				3rd	OD_3	Number of the water pipe breaks responded to within 24 hours (Number/year)	Total number of water pipe breaks responded to within 24 hours in the distribution network during the year. Failures that require repair of mains, connections, valves and fittings that are the utility's responsibility, are included. Repairs from active leakage control are excluded.		0																			
			NRW	1st	IBD_59	Volume of water sold (million m^3/year)	Total volume of water billed (metered and unmetered) irrespective of whether the bill is paid or not. Any unmetered volume must be estimated clearly from other information on the water users.		2.61																			
				1st	IBD_41	Number of water connections ('000)	Number of active water connections at year-end. All active connections should be counted – residential, non-residential etc - but inactive connections to vacant buildings should be excluded.		3.71																			
				2nd	IBD_53	Connections with an operating water meter ('000)	Total number of water connections with operating meter at year end		3.34																			

Abbreviations:
W = water service, WW = waste/water/sewerage service, NRW = Non Revenue Water, LC = Local Currency, FTE = Full Time Equivalent, B/C = Balance Sheet, P/L = Profit and Loss statement

Note on Indicators from IBNET:
**1: Coverage is a key development indicator. All coverage indicators (IBI_1.1, IBI_1.2, IBI_2.1) are impacted by whether the data on population and household size is up to date and accurate. The need to estimate the population served by public water points and/or the number of households per connection may affect the confidence that can be placed in the water coverage measure. Utilities are encouraged to provide a description of the implicit assumptions underlying their water and sewerage coverage estimates, including the number of people using public water points and household connections.
**2: The preferred water consumption indicator (IBI_4.7) is expressed in terms of litres/person/day. However there are data issues with the use of this indicator, namely 1) lack of accurate total consumption data (especially when metering is not universal) and 2) lack of up-to-date census data, or other relevant survey data, to determine household size, sharing of connections between households and number of households using public water points.
**3: The number of pipe breaks per km per year (IBI_9.1), relative to the scale of the system, is a measure of the ability of the pipe network to provide a service to customers. The rate of water pipe breaks can also be seen as an indicator of the general state of the network, although it also reflects operation and maintenance practices. It must be recognized, however, that highly aggregated reporting can hide the fact that sections of the network may be perpetually failing, whilst much of the remainder is in reasonable condition.
**4: Non Revenue Water represents water that has been produced and is "lost" before it reaches the customer (either through leaks, theft or through legal usage for which no payment is made). Part of this "lost" water can be retrieved by appropriate technical and managerial actions. It can then be used to meet currently unsatisfied demand (and hence increase revenues to the utility), or to defer future capital expenditures to provide additional supply (and hence reduce costs to the utility). The IWA distinguish between non revenue water (%) and unaccounted -for water, with the latter not including legal usage that is not paid for. There is a debate as to the most appropriate measure of non revenue water. A percentage approach (IBI_6.1) can make utilities with high levels of consumption, or compact networks, look to be better performing than those with low levels of consumption or extensive networks. To capture these different perspectives, the reporting of three measures of non revenue water (IBI_6.1, IBI_6.2 and IBI_6.3) has become the norm.
**5: Billing customers and getting paid are two different things. The effectiveness of the collections process is measured by IBI_23.2 while the NRW ratio is based on the amount of billed water and production.
**6: IBI_24.1 (&OI_4) and IBI_25.1 indicate whether revenues exceed operating costs and whether the utility's income enables it to service its debts.
**7: Unit operational costs (IBI_11.3) reflects the cost of providing water at the customer take off point.
**8: Utilities are often over staffed. IBI_12.1 provides insight into the impact of possible changes in future staff numbers. Indicator IBI_14.1 quantifies the degree to which outside (private) contractors are used to provide the utility service.
**9: According to the Japanese JWWA guidelines, Operating Ratio should be calculated including depreciation in the operational expenses; however, the IBNET's definition of Operating Ratio excludes depreciation from the operational expenses. Therefore, the indicator value of OI_4, which is based on IBNET's terminology, is higher than that calculated based on the definition of the Japanese JWWA Guidelines.
**10: Subsidies which can be included in the other operational revenues are external subsidies provided to the water utility for covering water charges and connection charge, partly or fully, for the people registered who are not able to pay due to financial difficulties.
**11: There are countries where special taxes related to water services are collected from residents, in addition to usual water charge and connection charge, for road cleaning, fire suppression etc.

Note on Financial Indicators from the JWWA Guidelines (OI00):
**12: OI_5 represents the ratio of the current assets to the current liabilities, that is, the capability to fulfill short-term obligations. The indicator value should be over 100 percent, otherwise a difficulty to pay daily expenses is indicated. If using this indicator to evaluate the paying capability, water utilities should check not only whether the value is small or large but also which of the current assets and liabilities is large or small.
**13: OI_6 represents the ratio of the owned capital to the total capital (liabilities plus capital), and is one of indices showing the soundness of finance. Water utilities should increase the indicator value to make their operation stable. Water utilities draw the most of their construction costs from external sources (loan capital), which decreases the indicator value. However, they should increase their own capital to ensure long-term stable operation.
**14: OI_7 shows how much owned capital is invested in the fixed assets. If the value is within 100 percent, it means that investments in the fixed assets are within the owned capital. If the value exceeds 100 percent, it means that loans are given for capital investment, which may cause problems in the repayment of the loans and interests. Water utilities rely on loan capital as a financial resource for most construction investment, which increases the indicator value.
**15: OI_8 represents the ratio of the operating income to the fixed assets, that is, how many times larger the operating income is than the fixed assets in a given period of time. The fixed assets turnover is very important, as drinking water supply services relate closely to facilities. If the indicator value is large, the facilities run effectively, but if small, excess investments may occur.

Category			Priority (優先度)	Question		Answer	
Large	Medium	Small					
		Guidelines	2nd	Q17-1: Are there any guidelines on each of following items? [Yes or No]	5) Operation and maintenance of water supply facilities	No	
			2nd	Q17-2: If Yes, are the guidelines effective and have the guidelines been followed by water utilities?	6) NRW reduction	No	
			2nd		7) Bulk water supply	No	
			2nd		8) Governance / management of water utility	No	
			2nd		9) Merger / clustering of utilities to improve efficiency (facility integration and/or office administration integration)	No	
			2nd		10) Environmental impact assessment	Yes	Managed by EQPB
		Integration	2nd	Q18: How well are existing policies, plans, laws, regulations and guidelines integrated without causing conflicts or operational difficulties in the water sector? [1. Not at all, 2. Not very well, 3. Fairly, 4. Well, 5. Very well]		4	
		Tariff	1st	Q19: Who has general oversight/control over utilities' minimum service levels and water charge levels? [1. Local, regional or national government department, 2. Independent board of stakeholders, 3. Independent service & price regulator, 4. Each utility, 5. Other]		1	
			2nd	Q20: Does the water supply act (law, regulations or their equivalent) in your country require water utilities to undertake 1) user-pays principle, 2) concept of full cost recovery, 3) independent accounting system; and to achieve an adequate level of water tariff? [1. None of the above, 2. One of the above, 3. Two of the above, 4. Three of the above]		1
		Poverty	1st	Q21: How well-defined are the policies on securing funding for poverty alleviation regarding water supply services, in terms of the arrangement or balance between 1) cross-subsidies based on water tariff structures in each water utility, 2) subsidies from local government, 3) subsidies from the water supply sector's supervisory national organization to each utility, and 4) direct subsidies from the organization specializing in poverty alleviation and/or public welfare to each water utility? [1. Not at all, 2. Not very well, 3. Fairly well, 4. Well, 5. Very well]		2	
			1st	Q22: What proportion of water supply service subsidies for poverty alleviation come from the water sector of the central government, compared to subsidies from other sectors of central government such as welfare sector and subsidies from local governments? [1. None, 2. A little, 3. Some, 4. A reasonable amount, 5. A large amount]		1	
			2nd	Q23: What proportion of water supply subsidies for poverty alleviation come from the other sectors/ministries of central government or other departments of local government, compared to subsidies from the sector/ministry or department of local government in charge of urban water supply? [1. None, 2. A little, 3. Some, 4. A reasonable amount, 5. A large amount]		1	
			2nd	Q24-1: Does the urban water sector prohibit water utilities from having free public taps? [Yes or No]		No	
			2nd		Q24-2: If No, are there any guidelines or clear instruction for the operation and maintenance of the public taps, to avoid wastage of water and use of free water by people other than the intended recipients? [Yes or No]	No	
		Water quality control	1st	Q25: How many water quality indicators are included in your country's water quality standards as enforceable parameters for water utilities? [1. None, 2. Few, 3. Less than ten, 4. Less than twenty, 5. More than twenty]		3	
			2nd	Q26: Is there any national laboratory for water quality testing which can support the establishment or revision of water quality standards for drinking water, including the selection of suitable test methods for each water quality indicator? [Yes or No]		No	
			2nd	Q27: Are there any environmental standards established to protect drinking water sources? [Yes or No]		No	
Soundness of inter-organizational operations in the sector	Governance/ management	Government	1st	Q28: Does the central government issue updated mandates clearly stating the roles and responsibilities of each organization in the sector, such as the ministry, regulator, utilities, etc? [1. No, 2. Yes, but only to some extent, 3. Yes]		3	
		Regulatory body	1st	Q29-1: Is there any regulator monitoring the compliance and performance of water utilities in your country? [Yes or No]		No	
			1st		Q29-2: Does the regulatory body have enough autonomy to control water utilities without being influenced by the politics of personal affairs, budgeting, tariff setting, etc.? [Yes or No]	No	
			1st	Q30: How well are the regulatory functions covering water utilities in the water sector working? [1. Not working at all, 2. Working a little, 3. Working to some extent, 4. Working well, 5. Working very well]		1	
			1st	Q31-1: Is the current performance of water utilities statistically understood using performance indicators? [1. No, 2. To some extent, 3. Yes]		1	
			1st		Q31-2: If 1. or 2., does the regulatory body prepare an annual report in which the performance of each water utility is assessed? [Yes or No]		
			2nd	Q32: Are minimum service levels clearly defined for different types/sizes of water utilities, and agreed with each water utility in writing in your country? [1. Not at all, 2. Defined to some extent but not agreed in writing, 3. Defined clearly but not agreed in writing, 4. Defined clearly and agreed in writing with major urban water utilities, 5. Defined clearly and agreed in writing with most or all the urban water utilities]		1	
			2nd	Q33: What aspects of water utilities are difficult to regulate?			
		Water utility	1st	Q34: In general, how much positive and negative influence does central government or local governments have over the appointment of top management in water utilities, regarding sustainable capacity development in the water utilities? [1. Strong influence, 2. Some influence, 3 Almost no influence or no influence]		1	
			1st	Q35: How well is the status of the General Manager defined regarding his/her term, conditions of conduct, and authority? [1. Not at all, 2. Not very well, 3. Fairly well, 4. Well, 5. Very well]		4	
			1st	Q36: Regarding the utilities in your country which belong to the central or local governments, do the General Managers of these utilities have independent authority for operation and maintenance of facilities (excluding tariff setting and long-term planning)? [1. Not at all, 2. Not very much, 3. Fairly good authority, 4. Good authority and 5. Total authority]		2	
			1st	Q37: In general, how much positive and negative influence do central government or local governments have over the appointment of staff in water utilities, regarding sustainable capacity development? [1. Strong influence, 2. Some influence, 3. Almost no influence or no influence]		2	
			2nd	Q38: What kinds of positive and negative influences do politicians have on water utilities in terms of even water distribution to different areas (e.g. different electoral districts)?		No	
			2nd	Q39: Are water tariffs kept significantly low under any political influence? [1. Yes - very low, 2. Yes - low, 3. No - not low]		1	
			2nd	Q40: How low are the salary and benefits in your water utility in comparison to those of similarly qualified persons in the corresponding private sector? [1. Less than a half that of the private sector, 2. More than 50% but less than 100% of the private sector, 3. Similar level to private sector, 4. Higher than private sector]		3	
			2nd	Q41: How well are performance based incentives (pay rises, promotions and bonuses based on individual performance) working in your utility? [1. Do not exist, 2. Exist but not working, 3. Working to some extent, 4. Working fairly well, 5. Working very well]		1	
	Funding	Investment	1st	Q42: How well are the central and local government procedures for helping water utilities access low-interest funds (including international funds) and subsidies for facility improvement working? [1. Not working at all, 2. Working a little, 3. Working to some extent, 4. Working well, 5. Working very well]		3	
			2nd	Q43: Does the urban water sector (i.e. supervisory organisations and water utilities) publish publicly accessible information, to help attract external investment from donors and the private sector (e.g. publication of annual reports and future plans on the internet)? [1. No public information, 2. Limited public information , 3. Moderate amount of public information, 4. Good level of public information, 5. Very good level of public information]		2
			2nd	Q44: Are the levels of total investment and/or total revenue in the sector monitored every year based on financial statements reported from each utility? [1. Not monitored at all, 2. Total investment is monitored but total revenue is not monitored, 3. Both total investment and total revenue are monitored]		3	
			2nd	Q45: How much has the overall investment in the urban water supply sector increased in the last five years? [1. Reduced significantly, 2. Reduced slightly, 3. Almost the same level, 4. Increased, 5. Increased greatly]		3	
			1st	Q46: Does the central government have procedures for providing subsidies or low-interest loans to utilities meeting certain conditions, for capital investment in water source development, and construction of purification plants and/or pipe networks? [1. No procedures, 2. There is an unclear procedure, 3. There is a clear procedure but it is not yet implemented, 4. There is a clear procedure and some implementation, 5. There is a clear procedure and significant implementation]		1

2.2 基本ツール②: セクター用チェックリスト – Basic Tool ②: Sector Checklist (SC)

Category			Priority (優先度)	Question		Answer	
Large	Medium	Small					
Current water supply conditions, etc.	Indicators from MDGs, etc.	Water coverage (WHO/ UNICEF JMP)	1st	Q1: What is the % of population using house connections (piped into dwelling, yard or plot) in your country as reported in the latest report of JMP of WHO/UNICEF?		Year of the Latest Survey: No report to WHO/UNICEF	**Around 90% for country. 100% for Koror-Airai.**
			2nd	Q2: What is the % of population using other improved drinking water sources (public tap/stand pipe, tube well/borehole, protected dug well, protected spring, rainwater collection) in your country as reported in the latest report of JMP of WHO/UNICEF?			**Around 90% for country. 100% for Koror-Airai.**
			2nd	Q3: What is the percentage improvement in the population using house connections (piped into dwelling, yard or plot) in your country since the baseline year reported in the latest report of JMP of WHO/UNICEF?		Year of the Baseline Survey:	**N/A**
		Improved sanitation coverage (WHO/ UNICEF JMP)	2nd	Q4: What is the % of population using improved sanitation facilities? (Flush or pour-flush to piped sewer system, septic tank or pit latrine; Ventilated improved pit latrine; Pit latrine with slab; Ecosan/Compositing toilet; and Mobiliets)		Year of the Latest Survey: No report to WHO/UNICEF 2012 Palau mini census	**Sewer: 75% of Koror. Septic tank and others: Airai and 25% of Koror**
		Poverty (The World Bank)	1st	Q5: What is the GNI per capita (Atlas method, US$/person/year) of your country in the latest World Development Report or World Development Indicators Database of the World Bank?		Year of the Latest Survey: WB Develop indicators 2014	**9860**
			1st	Q6: What is the % of population below $1 (PPP) per day (poverty ratio) in the latest World Development Report or World Development Indicators Database of the World Bank?		Year of the Latest Survey:	**N/A**
			2nd	Q7: What is the poverty gap ratio (%) at $1.25 per day, which shows depth of poverty, in the latest World Development Report or World Development Indicators Database of the World Bank?			**N/A**
		Corruption (Transparency International)	2nd	Q8: What is the rank of your country's corruption perception index reported in the latest Global Corruption Report of Transparency International, out of the total number of the countries assessed? (e.g. in the survey of 2009: Japan, China, Indonesia and Iraq were 18, 72, 126 and 178 out of 180 countries in the ranking).		Year of the Latest Survey:	
	Level of piped water supply services	Consistency	1st	Q9-1: Are there any significant differences in water supply service levels between water utilities with small served populations and water utilities with large served populations? [Yes or No]		**yes**	
			1st		Q9-2: If Yes, please describe the differences and their reasons.	**Maintenance of water treatment is difficult due to efficiency and scale.**	
		Continuity	1st	Q10: Is the demarcation of responsibility between urban water utilities and rural water suppliers clear, so that each urban water utility can calculate their current water coverage ratio based on the clear estimation of population under their responsibility? [Yes or No]		**No, PPUC covers whole Palau.**	
			2nd	Q11: How many cities/towns have continuous piped water supply in your country? [1. No cities/towns, 2. Some cities/towns, 3. Half of cities/towns , 4. Majority of cities/towns, 5. Almost all or all cities/towns]		**5. (All states except Sonsorol and Hatohobei States.)**	
		Chlorination	2nd	Q12: How well is the chlorination of piped water supply implemented by urban water utilities in your country? [1. Not implemented in most water utilities, 2. Not implemented in some utilities, 3. Mostly implemented but not appropriate at many utilities, 4. Mostly implemented but not appropriate at some utilities, 5. Implemented at all utilities and mostly appropriate]		**4**	
Availability and effectiveness of policies, national or regional plans, regulations and guidelines		Policy and plans	1st	Q13: Does the national policy include the following? 1) User-pays principle, 2) Concept of full cost recovery, and 3) Independent accounting system? [1. None of them, 2. Only one of them, 3. Two of them, 4. All of them]		**1**	
			1st	Q14: How many water utilities operate under their own independent (ring fenced) accounting system? [1. None, 2. Some, 3. Around half, 4. Most, 5. All]		**1**	
			1st	Q15-1: Are there any policies on each of following items at a national or regional level in the water sector? [Yes or No] Q15-2: If Yes, are the policies effectively incorporated into your country's national strategic plan or any other middle or long-term national plans? [Yes or No]	1) Expansion of water supply coverage	No.	
			1st		2) Minimum water service levels including drinking water quality and duration/amount of water supply	No	
			1st		3) NRW reduction and water saving	Yes	Palau national Master Development Plan 1995
			1st		4) Water supply to the urban poor	No	
			2nd		5) Water resource development	Yes	Palau national Master Development Plan 1995
			2nd		6) Merging of nearby utilities and clustering of small utilities to improve efficiency (facility integration, financial integration and/or services / office administration integration)	No	
			2nd		7) Human resource development for the sector	No	
		Law/ regulation	1st	Q16-1: Are there any laws/regulations on each of followings items? [Yes or No] Q16-2: If Yes, have the laws/regulations been effectively followed by water utilities? [Yes or No]	1) National water supply act or its equivalent (law, regulations)	No	
			1st		2) Regulations to encourage private sector involvement (Public Private Partnership (PPP), Public Sector Privatization (PSP), Private Finance Initiative (PFI), etc.)	No	
			1st		3) Licensing systems for contractors installing service connections to ensure construction quality control in order to reduce leakage	No	
			2nd		4) Local water supply by-law or ordinance	No	
			2nd		5) Regulations regarding water intake, including conventional rights to the use of natural water and restrictions on groundwater withdrawal to prevent land subsidence	No	
			2nd		6) Vocational qualifications / certification for utility staff (e.g. for construction supervision, operation of purification plant, water quality testing, accounting, computer programs)	No	
			1st		1) Water tariff setting	No	
			1st		2) Water quality standards	No	But, basically according to EPA standards
			1st		3) Authorized standards for materials and equipment for water utilities	No	But, basically according to AWWA standards
			2nd		4) Design of water supply facilities	No	

2.3 基本ツール③ 水道事業体の一般情報記入フォーム – Basic Tool ③: Utility General Form (UGF)

Category	Priority (優先度)	Question		Answer	
Basic information	1st	Q1: Utility name	1) Full name	Palau Public Utilities Corporation	
	1st		2) Acronym or abbreviated name	PPUC	
	1st	Q2: Head of water utility	1) Name	Kione J. Isechal	
	1st		2) Title	Chief Executive Officer	
	2nd	Q3: Contact person	1) Name	David Dengokl	
	2nd		2) Title	Manager of Water and Wastewater Operation	
	2nd		3) Email address	dave@ppuc.com	
	2nd		4) Telephone	488-8760	
	2nd		5) Fax		
	2nd		6) Mailing address	P.O.Box 1372, Koror, Palau 96940	
	2nd	Q4: In which year was your utility established?		2013	
	2nd	Q5: In which month does the fiscal year start in your utility?		October - September	
Utility type and responsibilities	1st	Q6: Does your utility provide the following services?	1) Piped water supply services [Yes or No]	Yes	
	1st		2) Wastewater services [Yes or No]	Yes	
	1st		3) Stormwater drainage [Yes or No]	No	
	1st		4) Solid waste services [Yes or No]	No	
	1st		5) Other, please specify.		
	1st	Q7: What type of utility is it?	1. National government water department (e.g. part of a ministry) - not ring fenced (i.e. financial information for water/wastewater functions is not reported separately from other government activities); 2. Local government water department (e.g. part of a municipality) - not ring fenced (see 1.); 3. National government water department (e.g. part of a ministry) - ring fenced (i.e. financial information for water/wastewater functions are reported separately from other government activities); 4. Local government water department (e.g. part of a municipality - ring fenced (see 3.); 5. Provider wholly owned by local or national government, operating under commercial law; 6. Jointly owned provider (Government and Private) operating under commercial law; 7. Not-for-profit provider operating under commercial law; 8. Privately owned provider operating under commercial law. Note: Generally, the further down the list, the higher the flexibility of management and necessity for governance of the utility.	5	
	1st	Q8: To what extent is the private sector involved in your utility? Please choose up to 3 from the following: [1. Not at all, 2. Service contract(s), 3. Management contract(s), 4-1. Affermage**1 lease contract(s), 4-2. Other lease contract(s), 5. Concession contract(s), 6. Build, (own,) operate & transfer (BOOT, BOT) contract(s), 7. Full private sector ownership and operation, 8. Other type of public private partnership (PPP) including amalgamation contract]. *Note:* **1 - Under an affermage contract, a private company is paid a fee (referred to as the "operator's water supply rate" or sometimes the "operator's tariff"), which is the price (usually expressed per m^3) for the volume of water produced and sold that the operator requires to cover all the costs of running the system. This price is the parameter that the bidders compete on. The operator's payment is calculated according to a formula set out in the affermage contract, which may contain factors designed to reward performance in certain areas. The operator collects revenue from consumers on behalf of the government according to the tariffs set by the state, retains the amount of their fee, and remits the difference to the government, who uses the balance to pay for investments made by the public authority.		1	
	1st				
	1st				
	2nd	Q9-1: Are there any fixed assets (water supply facilities, etc.) which your utility uses but does not own? [Yes or No]		No	
	2nd		Q9-2: If Yes, please specify these assets and their owners.		
	2nd		Q9-3: If Yes, is your utility responsible for including the depreciation of these fixed assets in your utility's financial statement or cost recovery calculations? Please describe how your utility handles and reports the depreciation costs of those fixed assets that are utilised by the utility but owned by others.		
	2nd	Q10-1: Is your utility responsible for the following aspects of water supply, and how does your utility implement them? Q10-2: If your answer is "3. No", which organization is responsible for these aspects?	1-1) Capital investment for water source development, including construction of intake and raw water transmission facilities [1. Yes, responsible and undertaken without external funding, 2. Yes, responsible but receive external funding , 3. No, not responsible]	2	
	2nd		1-2) Capital investment for major water supply facilities including purification plants, pump stations, treated water transmission and distribution trunk mains for major service area expansions, major rehabilitation, etc. [1. Yes, responsible undertaken without external funding, 2. Yes, responsible but receive external funding, 3. No, not responsible]	2	
	2nd		1-3) Capital investment for distribution branch mains and house connections for major service area expansions, major rehabilitation, etc. [1. Yes, responsible and undertaken without external funding, 2. Yes, responsible but receive external funding , 3. No, not responsible]	2	
	2nd		2-1) O&M for production for your utility [1. Yes, responsible and do not outsource it, 2. Yes, responsible but outsource it, 3. No, not responsible]	1	
	2nd		2-2) O&M for production for other utilities (bulk supply) [1. Yes, responsible and do not outsource it, 2. Yes, responsible but outsource it, 3. No, not responsible]	3	
	2nd		2-3) O&M of distribution systems other than pipe installation and replacement [1. Yes and do not outsource it, 2. Yes, but outsource it, 3. No]	1	

Category			Priority (優先度)	Question		Answer
Large	Medium	Small				
		Subsidy	2nd	Q47: Does the sector's supervisory organization have procedures for providing subsidies to small utilities to support mergers/clustering in order to improve their service quality and financial stability? [1. No procedures, 2. There is an unclear procedure, 3. There is a clear procedure but it is not yet implemented, 4. There is a clear procedure and some implementation, 5. There is a clear procedure and significant implementation]		1
			2nd	Q48: Is there an inter-ministerial agreement (or equivalent) to provide electricity subsidies to water utilities (whereby the water utility will be supported by the power supply ministry or its agencies)? [1. No such agreement 2. No, but some utilities get electricity at subsidized price, 3. Yes, but subsidies are not significant, 4. Yes, and subsidies are significant]		1
		Private sector	1st	Q49: Has the involvement of the private sector in the operation, maintenance and management of water utilities increased significantly in recent years in your country? [1. No increase or decrease, 2. Increased a little, 3. Moderate increase, 4. Large increase]		1
			2nd	Q50: How well are water utilities with more private sector involvement working, in comparison with water utilities with less private sector involvement? [1. Much worse, 2. Worse, 3. Similar, 4. Better, 5. Much better]		Difficult to answer.
			2nd	Q51: How much is private sector involvement in the management of water utilities expected to increase in your country? [1. No change expected, 2. Small increase expected, 3. Moderate increase expected, 4. large increase expected]		1
Training at national or regional level		Training centre, etc.	1st	Q52-1: Are there any organizations or independent training centres providing training to staff of multiple water utilities at a national or regional level? [Yes or No]		No
			1st		Q52-2: If Yes, please describe the name of main training centre/organization, training courses provided, which type of staff are offered training, and number of trainees.	
			2nd	Q52-3: If Yes, how much improvement is required for each of the following aspects of their training? [1. Huge improvement required, 2. Much improvement required, 3. Some improvement required, 4. A little improvement required, 5. No improvement required]	1-1) Suitability of the venue or building	
			2nd		1-2) Installed facilities, equipment and instruments for training	
			2nd		1-3) Adequate financing of O&M costs of training	
			2nd		2-1) Management capacity for organizing and handling training programs	
			2nd		2-2) Technical and/or communication capacity of the trainers	
			2nd		3-1) Recognition by the central government of the need for training of water utilities' staff; support from local government and regulatory bodies	
			2nd		3-2) Recognition of the need for training among the water utilities	
			2nd		4-1) Incentives for the staff working for the training centre (centre managers, trainers, etc.)	
			2nd		4-2) Incentives for participants from water utilities	
			2nd		4-3) Ease of undertaking training for participants (transportation, fee, timing, etc.)	
			2nd		5-1) Ensuring that programs and materials match policy, regulations, guidelines on water supply	
			2nd		5-2) Ensuring that programs and materials meet the needs of technical staff (e.g. engineers, technicians) in water utilities	
			2nd		5-3) Ensuring programs and materials meet the needs of administration and management staff (e.g. accountants, bill collectors, managers) in water utilities	
			2nd		5-4) Ensuring programs and materials are based on personnel evaluation in water utilities	
			2nd		5-5) Ensuring programs and materials are consistent with public/vocational qualification requirements and certifications	
			2nd		5-6) Ensuring programs and materials are consistent with current research	
			2nd	Q53: Are there any workshops or training centres at a national or regional level which can provide facilities, equipment and technical support to water utilities for the following aspects? [Yes or No]	1) Testing the accuracy of customer and bulk water meters	No
			2nd		2) Repair of mechanical or electrical equipment such as pumps	No
			2nd		3) Basic operation of different pumps and valves	No
			2nd		4) Basic installation of different pipes and fittings	No
			2nd		5) Training yard designed for practicing leakage detection	No
		Regulator	1st	Q54-1: Have there been any training programs carried out for the regulatory body inside or outside the country? [Yes or No]		No
			1st		Q54-2: If Yes, please describe the training programs.	
		Cooperative ties	2nd	Q55-1: Are there any large and/or advanced water utilities which provide training to other utilitie(s) having less capacity? [Yes or No]		No
			2nd		Q55-2: If Yes, please name the water utilities providing training, the training courses provided, which employees are targeted for training, and the number of trainees.	
			2nd	Q56-1: Are there any organizations or associations helping to coordinate communication between different national and local stakeholders in the water sector (e.g. between water utilities, consultants, contractors, suppliers, etc)? [Yes or No]		No
			2nd		Q56-2: If Yes, please name these organizations.	
			2nd	Q57-1: Are there any organizations conducting continuous research in the water sector? [Yes or No]		No
			2nd		Q57-2: If Yes, please name these organizations.	
			2nd	Q58-1: Are there any organizations (e.g. water industry associations, universities) which dispatch lecturers/trainers to water utilities? [Yes or No]		No
			2nd		Q58-2: If Yes, please name these organizations, the expertise of dispatched lectures/trainers, the target trainees, and the number of trainees.	
		Training for small contractors	2nd	Q59-1: Are there any training programs on construction quality control for small contractors who install service pipes, water meters and/or branch distribution pipes, etc. (in order to improve their work quality and reduce leakage etc)? [Yes or No]		No
			2nd		Q59-2: If Yes, please name the training centre/organization in charge, the type and scale of their training courses and approx. number of contractors receiving training each year.	
Other stakeholders		Beneficiaries	1st	Q60-1: Are there any reports containing socio-economic surveys regarding water supply in your country? [Yes or No]		No
			1st		Q60-2: If Yes, please provide information on the reports, such as title, year of survey and implementation organization.	
		Donors	1st	Q61: Is there a well functioning channel for coordination between national/regional governments and donors to discuss and allocate projects, etc? [1. No channel exists, 2. It exists but is not functioning well, 3. It exists and is functioning well]		3
			2nd	Q62: Which international donors are contributing significantly to your utility, and what roles do each of the contributing donors perform for your utility?		ADB and JICA for planning and investing
		Small suppliers, etc.	2nd	Q63: Does the water sector have good control over small/community water supply systems (initially or notionally developed for irrigation, etc.) and/or water vendors which cannot provide good quality drinking water, in order to prevent people from health problems or prevent licensed urban water utilities from losing their customers? [1. They are not controlled at all, 2. They are not controlled very well, 3. They are fairly well controlled, 4. They are well controlled, 5. They are very well controlled]		N/A
		Others	2nd	Q64-1: Are there any other significant stakeholders in the water sector besides the water utilities? [Yes or No]		No
			2nd		Q64-2: If Yes, who are they and what are their roles?	

2.4 基本ツール④: 水道事業体用基本チェックリスト – Basic Tool ④: Utility Basic Checklist (UBC)

(1) 本体部分 – Main Part

Category			Project Type (優先指標)	Priority (優先度)	Question (Reference No. of the same indicator if it is included in BT□: LPI)	Level					Answer (1 - 5)
						1: Very Serious	2: Serious	3: Not Good Enough	4: Good	5: Very Good	
Large	Medium	Small				This level reflects the conditions of water utilities which need all-round assistance in all fields.	This level reflects the conditions of water utilities which need broad assistance in many fields.	This level is reflects the conditions of water utilities which need partial assistance in some fields.	This level reflects the conditions which water utilities in developing countries should aim for in the foreseeable future.	This level reflects the conditions of water utilities in developed countries.	
Aspects to be improved mainly by Facility Investment (FI)	Overall		FI/CD	1st	Q1: Existence of long or mid-term plan for facility expansion, rehabilitation, etc.	Long or mid-term plan for facility expansion, rehabilitation, etc. does not exist at all.	Long or mid-term plan for facility expansion, rehabilitation, etc. exists but its target year has already passed.	Long or mid-term plan for facility expansion, rehabilitation, etc. exists but it has not been updated, although its target year has not yet passed.	Updated long or mid-term plan for facility expansion, rehabilitation, etc. exists but there are problems with its timely implementation.	Updated long or mid-term plan for facility expansion, rehabilitation, etc. exists and has encountered few or no problems in its implementation.	1
			FI/CD	1st	Q2: Continuity of supply	Mostly intermittent supply, averaging approx. every 4 days or less.	Mostly intermittent supply, averaging approx. every 1-3 days, with some served areas receiving continuous supply.	Intermittent supply and continuous supply are both common in the served areas.	Mostly continuous supply, but still there are some served areas with intermittent supply due to small utilities' inability to employ operators for 24 hours, high water demand during summer, etc.	Continuous supply in all served areas except for special cases such as serious drought.	5
			Average_Overall								3.0
	Expansion	Water supply service coverage	FI	1st	Q3: Overall water supply coverage (IB1_1.1)*1	Less than 50%	50-69%	70-84%	85-94%	95%-100%	4
			FI/CD	1st	Q4: Water supply coverage for low income groups	Majority of low income groups (including the urban poor) do not have piped water supply (including public taps/standpipes).	Around a half of low income groups (including the urban poor) do not have piped water supply (including public taps/standpipes).	Majority of low income groups (including the urban poor) have piped water supply (including public taps/standpipes).	Almost all the low income groups (including the urban poor) have piped water supply (including charged public taps/standpipes but excluding free public taps/stand pipes).	Almost all the low income groups have house connections.	5
		Purification plant	FI	1st	Q5: Surplus purification capacity OI_2)*2	Less than - 30%	Less than -10%	Less than 0%	0 - 5%	More than 5%	3
			Average_Expansion								4.0
	Rehabilitation/replacement	Conditions of facilities	FI	1st	Q6: Civil structures (such as basins and chambers in water purification plants)	Water leakage from civil structures is common, and some of these problems can only be solved by replacement rather than partial repair.	Water leakage from civil structures is common, but these problems can probably be solved by partial repair.	Water leakage from civil structures happens sometimes.	Water leakage from civil structures is rare.	Water leakage from civil structures almost never happens unless a strong earthquake hits, as regular assessments of facility strength are undertaken.	3
			FI	1st	Q7: Transmission and distribution mains*3	More than 75% of transmission and distribution mains are asbestos pipes, old cast iron pipes (excluding ductile cast iron) or old steel pipes, with rust significantly blocking flow.	50 - 75% of mains are asbestos pipes, old cast iron pipes (excluding ductile cast iron) or old steel pipes, with rust significantly blocking flow.	25 - 49% of mains are asbestos pipes, old cast iron pipes (excluding ductile cast iron) or old steel pipes, with rust significantly blocking flow.	10 - 24% of mains are asbestos pipes, old cast iron pipes (excluding ductile cast iron) or old steel pipes, with rust significantly blocking flow.	Less than 10% of mains are asbestos pipes, old cast iron pipes (excluding ductile cast iron) or old steel pipes, with rust significantly blocking flow.	1
			FI	1st	Q8: Service connections*4	95 - 100% of house connections are more than 25 years old.	80 - 94% of house connections are more than 25 years old.	60 - 79% of house connections are more than 25 years old.	40 - 59% of house connections are more than 25 years old.	0 - 39% of house connections are more than 25 years old.	3
			FI/CD	1st	Q9: Mechanical and electrical equipment*5	More than 30% of installed major mechanical and electrical equipment (such as pumps, electrical transformers and generators) are not operated due to serious failures.	10 -30% of installed major mechanical and electrical equipment (such as pumps, electrical transformers and generators) are not operated due to serious failures.	Less than 10% of installed major mechanical and electrical equipment (such as pumps, electrical transformers and generators) are not operated due to serious failures.	Most or all installed major mechanical and electrical equipment (such as pumps, electrical transformers and generators) are operated, however some or many operate with low performance or low efficiency.	Most or all installed major mechanical and electrical equipment (such as pumps, electrical transformers and generators) are operated. Most operate with appropriate performance and efficiency.	2
			Average_Rehabilitation/Replacement								2.3
	AVERAGE (FI)										3.1
Aspects to be improved mainly by Capacity Development (CD)		Overall	CD	1st	Q10: O&M of the facilities	Facilities do not have any O&M manuals.	Facilities have O&M manuals which are not effective, leading to O&M deficiencies.	Facilities have O&M manuals which are not effective, however the current O&M is adequate.	Facilities have effective O&M manuals, which are followed reasonably well.	Facilities have effective and comprehensive O&M manuals, which are followed strictly.	1
		Distribution network management	CD/FI	1st	Q11: Drawings of pipe facilities	Available paper drawings of existing transmission and distribution trunk mains are quite limited.	Paper drawings are available for most of the existing transmission and distribution trunk mains, but drawings for branch distribution mains are limited.	Small/Medium utilities: Paper drawings are available for most of the existing distribution mains including branch distribution mains. Large utilities: As above, and a grinitive GIS has been established for transmission mains, trunk distribution mains, etc.	Small/Medium utilities: Updated CAD files are available for most of the existing transmission and distribution mains. Large utilities: A GIS has been well-established and updated for management of transmission mains and distribution mains, with reasonable accuracy.	Small/Medium utilities: A map book of existing mains has been prepared for referencing and is periodically updated using CAD. Large utilities: A GIS has been well-established and updated for management of transmission, distribution mains, customer information, etc. with good accuracy.	3
			CD/FI	1st	Q12: Zoning of distribution network*6	Proper zoning of distribution areas and proper sub-zoning of networks in each distribution area, based on considerations of topology and/or different water sources, rarely exist or do not exist at all.	Proper zoning of distribution areas exists to some extent, but proper sub-zoning of networks in each distribution area rarely exists or does not exist at all.	Most distribution areas are properly zoned, but proper sub-zoning of networks in each distribution area is still limited.	All the distribution areas are properly zoned, and most distribution areas have proper sub-zoning in their distribution network.	All the distribution areas are properly zoned, and most distribution areas have proper sub-zoning in their distribution network. Multiple water sources, multiple lines of distribution trunk mains, and mutual connections between distribution areas and sub-zones are also considered for improving the stability of water supply.	2
			CD/FI	1st	Q13: Water pressure at customer meter points*7	At most or all points, pressure is not between 5-45m.	At approximately half of the points, pressure is not between 5-45m.	At approximately a quarter of the points, pressure is not between 10-45m.	At most points, usual pressure is between 10-45m but pressure drops significantly in the season of maximum water demand.	At most points, pressure is between 15-45m without significant pressure drop in the season of maximum water demand; or continuous and direct water supply with higher pressure to high buildings without using customer's receiving and elevated tanks has been introduced for water quality control.	4

Note:

***1: Overall water supply coverage = (Population served)/(Population within responsible area of the utility)*100 or (Number of households served)/(Number of households within responsible area of the utility)*100**
If responsible areas are not clearly understood, please assume the areas where the water utility will hold responsibility in the foreseeable future. The population served includes those who have direct water supply, yard taps and public taps/standpipes.
***2: Surplus purification capacity = ((Daily treatment capacity - Maximum daily treatment capacity) / Daily treatment capacity) * 100 (unit: %). The daily treatment capacity (m³/day) is the volume of water per day purified in the current purification plant. The capacity of failed facilities and those under repair facilities is excluded. The maximum daily treatment capacity (m³/day) is the recorded maximum volume of water per day supplied by the plant in a year.**
***3: An example of expected lifetime of water mains is 50 years.**
***4: Expected lifetime of house connections can be 25 years or more if using corrosion-resistant materials.**
***5: Examples of expected lifetime of mechanical/electrical equipment and instruments are 20 years and 15 years respectively.**
***6: Proper zoning and sub-zoning of distribution networks is a basic requirement for good pressure control, effective reduction of NRW, etc. The concept of zoning and sub-zoning is explained in *(2) Supporting Figures and Table*.**
***7: Conversion table for different units of pressure is shown in *(2) Supporting Figures and Table*.**
***8: NRW (Non-Revenue Water) ratio = (1-(Annual water charged)/(annual water produced))*100**
If all the bulk meters necessary for this calculation are not installed, estimation of this average NRW ratio can be carried out based on some data of NRW in some areas. The difference between NRW and UFW (Unaccounted for Water) is explained in *(2) Supporting Figures and Table*.
***9: Expected lifetime of customer meters is usually between 8 and 10 years, depending on their type and quality.**
***10: Recommended calibration intervals for bulk flow meters are 5 years for wheel/mechanical type and 1 year for electromagnetic and**

Category	Priority (優先度)	Question		Answer	
	2nd	organization is responsible for these aspects?	2-4) Small scale daily replacement/extension of distribution branch mains and installation/replacement of house connections [1. Yes, responsible and do not outsource it, 2. Yes, responsible but outsource it, 3. No, not responsible]	1	
	2nd		2-5) Leak detection and repair [1. Yes, responsible and do not outsource it, 2. Yes, responsible but outsource it, 3. No, not responsible]	1	
	2nd		3-1) Reading of customer meters [1. Yes, responsible and do not outsource it, 2. Yes, responsible but outsource it, 3. No, not responsible]	1	
	2nd		3-2) Billing & collection [1. Yes, responsible and do not outsource it, 2. Yes, responsible but outsource it, 3. No, not responsible]	1	
	2nd		4-1) If your utility is responsible for other work, please specify and describe how it is undertaken.		
	2nd	Q11-1: Has there been any sector/utility reform or significant change affecting your utility's institutional form, responsibility or organizational structure in recent years? [Yes or No]		Yes	
	2nd		Q11-2: If Yes, please describe the reform or significant changes and explain how your utility has been dealing with the transition.	WWO was operated by Government before. In 2013, it merged with PPUC, which was a public electricity power provider. Then, PPUC was renewed.	
Reports and databases	1st	Q12-1: Does your utility prepare an annual report? [Yes or No]		No	
	1st		Q12-2: If Yes, in which year was the latest annual report prepared?		
	1st	Q13-1: Does your utility have a Master Development Plan? [Yes or No]		No	
	1st		Q13-2: If Yes, when was it prepared?		
	1st		Q13-3: If Yes, what is the target year of the master plan?		
	1st	Q14: Are the following aspects of the water utility's operation computerized or automated?	1) Document management [Yes or No]	Yes	
	1st		2) Asset/facility management [Yes or No]	No	
	2nd		3) Pumping [Yes or No]	No	
	2nd		4) Treatment [Yes or No]	No	
	2nd		5) Billing/customer management [Yes or No]	Yes	
	2nd		6) Accounting [Yes or No]	Yes	
	2nd		7) Complaints management [Yes or No]	Yes	
	2nd		8) Personnel systems [Yes or No]	Yes	
	2nd		9) Other, please specify.		
Service area	1st	Q15-1: Which areas is the utility responsible for? [1. Only a principal city or town, 2. Multiple cities or towns, 3. Region, state or province, 4. Nation, 5. Other]		4	
	1st		Q15-2: If 2. Multiple cities or towns, how many cities or towns are under its responsibility?	2	
	1st		Q15-3: If 5. Other, please describe.		
	1st	Q16: What is the nature of the service areas? [1. Urban, 2. Semi-urban, 3. Rural, 4. Urban, semi-urban and rural, 5. Urban and semi-urban, 6. Semi-urban and rural]		4	
	1st	Q17: What is the population served with piped water supply ('000 inhabitants) (same as IBD_30 of LPI)		14	
	2nd	Q18: Size of present service areas (square km)			
	2nd	Q19: Number of piped water supply connections ('000 connections)	1) Domestic (households)	2.5	
	2nd		2) Non domestic (industrial, commercial, institutional, other)	0.84	
	2nd		3) Bulk water connections	0	
	2nd		4) Total (same as IBD_41 of LPI)	3.71	
	2nd	Q20: Please calculate the average population provided with piped water supply per town or city (= [Q17] / [Q15-2]) ('000 inhabitants/town or city)		7	
	2nd	Q21: Please calculate average household size of served population (= [Q17] / [Q19-1)]) (persons/domestic connection)		5	
Facilities	1st	Q22: Which of the following are sources of raw water?	1) Bulk water from another utility/company [Yes or No]	No	
	1st		2) Storage reservoir/impoundment, [Yes or No]	Yes	
	1st		3) Direct abstraction of river water [Yes or No]	Yes	
	1st		4) Groundwater and river bed water [Yes or No]	Yes	
	1st		5) Other, please specify		
	2nd	Q23-1: Which methods of treatment are used in your utility? [1. Disinfection but not filtration and flocculation, 2. Disinfection and filtration but not flocculation, 3. Disinfection, filtration and flocculation, 4. Other]		3	
	2nd		Q23-2: If "4. Other", please specify.		

(3) 結果グラフの自動作成 – Auto-Preparation of Result Graph

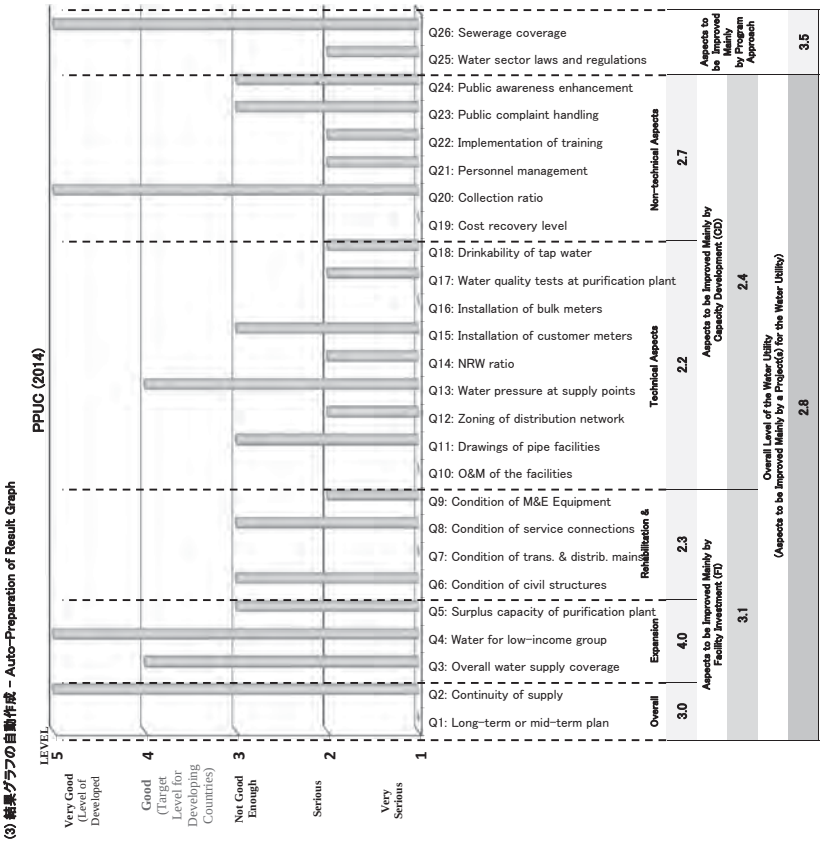

Figure: Results of the Capacity Assessment for OOOO Water Utility using Utility Basic Checklist (Basic Tool ④)

Category			Project Type (優先形態)	Priority (優先度)	Question (Reference No. of the same indicator if it is included in BT□: LPI)	Level					Answer (1 - 5)
Large	Medium	Small				1: Very Serious	2: Serious	3: Not Good Enough	4: Good	5: Very Good	
						This level reflects the conditions of water utilities which need all-round assistance in all fields.	This level reflects the conditions of water utilities which need broad assistance in many fields.	This level is reflects the conditions of water utilities which need partial assistance in some fields.	This level reflects the conditions which water utilities in developing countries should aim for in the foreseeable future.	This level reflects the conditions of water utilities in developed countries.	
Aspects to be improved mainly by Capacity Development (CD)	Technical aspects	NRW reduction	CD/FI	1st	Q14: NRW ratio (IBI_6.1)**8	More than 50%	36 - 50%	21 - 35%	10 - 20%	Less than 10%	2
			CD/FI	1st	Q15: Customer meters**9	There are no customer meters due to a flat-rate system, or the majority of existing customer meters are not functioning.	Functioning customer meters are supposed to be installed for every household, but more than 30% of them are missing or not working well.	Functioning customer meters are supposed to be installed for every household and replaced with new ones periodically, but more than 10% of them are missing or not working well.	Most households have well-functioning customer meters due to rigorous periodical meter exchange.	Almost all households have well-functioning customer meters with good accuracy.	3
			CD/FI	1st	Q16: Bulk meters**10	Bulk meters for accurate measurement of water production and basic control of distribution are not installed at most of the places where they should be; or most of the existing bulk meters do not work well due to lack of maintenance.	There are not enough functioning bulk meters installed at the places requiring them for accurate measurement of water production and basic control of distribution; and existing bulk meters are not well maintained.	There are enough functioning bulk meters for accurate measurement of water production and basic control of distribution, but not enough for calculating NRW ratio of each sub-zone (DMA) for effective NRW reduction. Majority of the existing bulk meters are well maintained.	There are enough functioning bulk meters installed for calculating NRW ratio of each sub-zone (DMA) for effective NRW reduction. Most of the existing bulk meters are well maintained, and important meter readings are recorded periodically.	There are enough functioning bulk meters installed (with good accuracy) for calculating NRW ratio of each sub-zone (DMA) for effective NRW reduction. All of the existing bulk meters are well maintained, and important meter readings are recorded periodically and analysed effectively.	1
		Water quality control	CD	1st	Q17: Water quality parameters tested at purification plants	Water quality testing is based on a visual observation of water cleanliness.	Water quality testing is based on periodical simple water quality tests for pH, turbidity, chlorine, etc., using handheld water quality testers or pack test kits. The treated water usually meets existing standards for the parameters tested.	Water quality testing is based on periodical laboratory water quality tests for micro-organisms such as coliforms, and general physical and chemical water quality parameters. The treated water usually meets existing standards for the parameters tested.	Water quality testing is based on continuous and daily water quality monitoring using appropriate water quality testing methods and well-maintained apparatus. The treated water usually meets existing standards for basic parameters selected with reference to the WHO guidelines, etc.	Water quality testing is based on continuous and daily water quality monitoring using appropriate water quality testing methods and well-maintained apparatus. The treated water almost always meets existing standards for comprehensive parameters selected in reference to the WHO guidelines, etc.	2
			CD	1st	Q18: Drinkability of tap water**11	In many areas, tap water does not meet water quality criteria for some key parameters (including residual chlorine) and it is not drinkable in some areas even after boiling.	In some areas, tap water does not meet water quality criteria for some key parameters (including residual chlorine), but it become drinkable after boiling in all areas.	In some areas, tap water does not meet water quality criteria for full list of parameters (including residual chlorine), but it become drinkable after boiling in all areas.	In all areas, tap water meets the criteria for the full list of parameters (including residual chlorine) with some exceptions (e.g. in the case of seasonal degradation of water source quality). It is usually drinkable directly from the tap with some risk of water quality degradation due to accidental stoppages of water supply, etc.	In all areas, tap water almost always meets all criteria for the full list of parameters (including residual chlorine), and it is almost always drinkable directly from tap without risk, as long as receiving tanks at end users do not contaminate the water.	2
		Average_Technical									2.2
	Non-technical aspects	Financial improvement	CD	1st	Q19: Cost recovery level (OI_4 is the same as IBI_24.1 if the utility provides water supply services only)**12	Only part of the O&M costs (excluding depreciation of water supply facilities) are covered by water charges. (OI_4 < 1)	All O&M costs (except for depreciation of water supply facilities) are fully covered by water charges. (OI_4 ≧ 1)	All O&M and depreciation costs are covered by water charges. (OI_12 ≧ 1, if not, check OI_14)	All O&M, depreciation and financial costs (interest & capital repayments) are covered by water charges. (1 ≦ OI_13 < 1.01, if not, check OI_15 and OI_16)	All O&M, depreciation and financial costs (interest and capital repayments), and costs for own-capital-funded expansion of facilities (to some extent) are covered by water charges. (OI_13 ≧ 1.01)	1
			CD	1st	Q20: Collection ratio (IBI_23.2)**13	Less than 60%	60-74%	75-89%	90-94%	More than 95%	5
		Organizational development	CD	1st	Q21: Effective personnel management rules and regulations including incentives **14	Working regulations and base salary systems are not clear.	Working regulations and base salary systems are clear, but there is no incentive scheme in place.	Working regulations and base salary systems are clear, but existing incentive schemes are ineffective.	Working regulations and base salary systems are clear, there are effective incentive schemes in place. Some critical rules on occupational health and safety are communicated to staff.	Working regulations and base salary systems are clear, and there are effective incentive schemes in place. Full set of regulations on occupational health and safety are communicated to staff.	2
			CD	1st	Q22: Implementation of training **15	Training is quite rare or not provided at all.	A limited number of training programs on some aspects are provided, however there are no incentives for staff to undertake training programs.	There are minimum levels of training required for important aspects, but incentives for staff to undertake training programs are limited.	An adequate number of training programs are provided on important aspects, including management and technical matters. There are enough incentives for staff to undertake training programs.	A wide range of training programs are available. The completion of these training programs is generally a condition of promotion.	2
		Public relations	CD	1st	Q23: Complaint handling	A procedure or information system for complaint handling has not been established, and complaints are currently dealt with on an ad-hoc basis.	A procedure or information system for complaint handling has been established, but there is a large backlog of unresolved complaints.	A procedure or information system for complaint handling has been established, but there are usually some complaints resolved.	An effective procedure and information system for complaint handling has been established, and data is recorded and analysed. There can however be a backlog of complaints in a particular season.	An effective procedure and information system for complaint handling has been established, and data is recorded and analysed. Even in peak complaints season, there is no backlog.	3
			CD	1st	Q24: Awareness-raising on NRW reduction, water saving, collection of water charges, etc. **16	No or minimal effective awareness-raising activities have been implemented.	A few effective awareness-raising activities have been implemented.	Several effective awareness-raising activities have been implemented.	Many effective awareness-raising activities have been implemented.	Many effective awareness-raising activities are being implemented continuously.	3
		Average_Non-technical									2.7
	AVERAGE (CD)										2.4
OVERALL AVERAGE (FI & CD)											2.8
Aspects to be improved mainly by Program Approach			CD/FI	1st	Q25: Laws and regulations covering the water sector**17	A water supply service act or its equivalent exists, but it does not require your utility to have an independent double-entry accounting system.	A water supply service act or its equivalent exists, and it requires your utility to have an independent double-entry accounting system.	Most of the required laws and regulations listed in note **17 have been established.	All of the required laws and regulations listed in note **17 are well established.		2
			FI	1st	Q26: Sewerage coverage (IBI_2.1)**18	0%	Less than 5%	Less than 30%	Less than 50%	More than 75%	5
Average_Program Approach											3.5

ultrasonic types. The size of district meter area (DMA) is recommended to be about 1000 - 3000 households.
**11: Key water quality parameters are assumed to be residual chlorine, turbidity, colour, odour, taste, toxic matter and coliform count. Coverage of testing parameters and standards for water quality criteria can refer to the WHO standards if country-specific water quality standards have not been established.
**12: This assessment should be based on financial statements. The supporting financial indicators for judging the level of cost recovery are shown in *(2) Supporting Figures and Table.*
**13: Billing customers and collecting revenue are two different things. The effectiveness of the collections process is measured by this indicator, while NRW ratio (Q14) is based on amount billed and water production. Collection ratio = (Collected revenue at the end of fiscal year)/(Annual amount billed)*100
**14: Personnel management rules and regulations include: 1) working regulations, 2) base salary system, 3) incentive schemes, and 4) occupational health and safety regulations.
**15: Training programs are required for engineers, technicians, administration staff, managers, etc.
**16: Public awareness can be enhanced through: 1) general public relations & publicity, 2) special promotional programs, 3) monitoring research, 4) painting/writing contests, 5) school education, etc.
**17: Laws and regulations include: 1) water supply service act, 2) independent "double-entry bookkeeping" accounting requirement for the water utility, 3) water supply service ordinances, 4) regulations related to water intake, including groundwater regulations, 5) labour standards act, 6) road traffic act, etc.
**18: It is assumed that sewerage development does not usually commence until GDP per capita reaches about US$3,000; and becomes full-scale at a GDP per capita of about US$5,000. It is highly possibility that sewerage is minimally developed in the countries and suburban cities where economic levels are low. It is recommended that the water utility explain the level of sanitary facility (toilet) coverage, particularly if it has answered the question on sewerage coverage as level 1(0%) or level 2 (5% or less).

Appendix-7

Result of Water Quality Analysis 1

to: YACHIYO ENGINEERING Co. Ltd.

Report Number 12201410200163-2
October 24, 2014

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Test Report

Project:Result of Water Quality Analysis for the Preparatory Survey on Water Supply System Improvement Project in the Republic of Palau

Analysis items	Test method	Quantitative limit(mg/L)	WHO Standard Value(mg/L)	Sampling point and date					
				KAWTP <Finished Water>		Edeng River <Raw Water>		Ngimel Dam <Raw Water>	
				October-4	October-9	October-4	October-9	October-4	October-9
Turbidity	Transmitted beam	0.2unit	5(2)unit	0.8	0.4	0.9	0.6	16	3.2
color	Transmitted beam	0.5unit	15(5)unit	3.9	2.8	8.4	8.5	28	15
Suspeded Solid	Gravimetric method	2	-	3	<2	2	<2	38	10
Dissolved Solid	Gravimetric method	50	1000(500)	69	67	60	<50	65	62
Alkalinity(pH8.3)	Titrimetry	2.0	-	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
Alkalinity(pH4.8)	Titrimetry	2.0	-	21	24	23	27	26	27
Chloride	Ion Chromatography	0.2	(200)	4.4	4.3	3.9	4.0	3.9	4.1
Sulfate	Ion Chromatography	2.0	250	11	11	<2.0	<2.0	<2.0	<2.0
Potassium	Atomic Adsorption Spectrophotometer	0.1	-	0.52	0.57	0.47	0.57	0.53	0.52
Calcium	Atomic Adsorption Spectrophotometer	1.0	-	4.6	5.0	4.2	5.1	6.6	6.1
Magnesium	Atomic Adsorption Spectrophotometer	1.0	-	2.3	2.9	2.7	3.2	2.3	2.7
Soluble Silicate	Absorptiometry	2.0	-	13	15	15	18.0	13	16
Total Hardness	Atomic Adsorption Spectrophotometer	1.0	(300)	20	23	21	25	24	25
Iron	Atomic Adsorption Spectrophotometer	0.01	(0.3)	0.02	0.02	0.16	0.18	0.18	0.19
Manganese	ICP-MS	0.005	0.5(0.05)	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Sodium	Atomic Adsorption Spectrophotometer	0.1	(200)	8.4	8.4	3.6	3.8	3.6	3.8
Arsenic	ICP-MS	0.001	0.01(0.01)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Selenium	ICP-MS	0.001	0.01(0.01)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Copper	ICP-MS	0.001	2(1.0)	0.001	0.002	<0.001	<0.001	0.009	<0.001
Cadmium	ICP-MS	0.0003	0.003(0.003)	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003
Chromium	ICP-MS	0.005	0.05	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Cyanide	Ion Chromatography	0.001	(0.01)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Lead	ICP-MS	0.001	0.01(0.01)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Mercury	Atomic Adsorption Spectrophotometer	0.00005	0.001(0.005)	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005
Boron	ICP-MS	0.02	0.3(1.0)	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Barium	ICP-MS	0.01	0.7	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Molybdenum	ICP-MS	0.001	0.07	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007
Nickel	ICP-MS	0.002	0.02	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
Aluminum	ICP-MS	0.02	(0.2)	0.17	0.18	0.12	0.06	0.28	0.09
Fluoride	Ion Chromatography	0.05	(0.8)	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Total Organic Carbon	Heated persulfate method	0.3	(3)	0.5	0.4	0.6	0.6	1.4	1.1
Total Nitrogen	Absorptiometry	0.2	-	<0.2	<0.2	<0.2	<0.2	0.3	<0.2
Nitrate Nitrogen	Ion Chromatography	0.02	-	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Nitrite Nitrogen	Ion Chromatography	0.004	(0.04)	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004
Total Phosphorus	Peroxodisulfate digestion method	0.05	-	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
E.Coli	MMO-MUG method	-	negative	negative	negative	positive	negative	positive	negative
Viable Bacteria	Standard plate count method	30cfu/mL	(100cfu/mL)	30以下(7)	30以下(7)	1.8×10^{3}	1.0×10^{2}	7.2×10^{2}	1.7×10^{2}

Note: ( ) Standard Methods for Examination of Water(2011)
Japan Water Works Association
cfu: colony forming unit

Tested by (signature) Yousuke Ito

Approved by (signature) Yousuke Sato

Edeng River: Place for intake point of Gerikiil Intake Station

AP-7-1

Appendix-8

Result of Water Quality Analysis 2

Republic of Palau
Environmental Quality Protection Board
P.O Box 8086
BUREAU OF PUBLIC WORKS B.DG.
KOROR, REPUBLIC OF PALAU 96940
TEL: 488-1639/3600 FAX: 488-2963
E-mail Address: eqpb@palaunet.com

Palau EQPB Water Quality Laboratory Test Results

For: Surangel & Sons Construction
JICA Preparatory Survey on Water Supply System Improvement Project

Koror-Airai Public Water Supply System Water Quality Survey Test Results

Location	Collection Date	Chlorne Residual (mg/L)	Turbicity (NTU)	Total Coliform per 100 ml water sample	*E. coli* per 100 ml water sample
Edeng River (Ngerikul Intake 1)	10/15/2014	-	3.32	>2400	180
Edeng River (Ngerikul Intake 2)	10/15/2014	-	3.30	>2400	250
Ngerimel Dam	10/15/2014	-	3.82	>2400	490
Ngerimel Dam (K/A WTP Combine)	10/15/2014	-	5.49	>2400	460
K/A WTP Wetwell (Raw water)	10/15/2014	-	4.20	>2400	440
K/A WTP Clarifier 1	10/15/2014	-	1.22	140	29
K/A WTP Clarifier 2	10/15/2014	-	1.04	58	21
K/A WTP Clarifier 3	10/15/2014	-	0.68	35	17
K/A WTP Lab (treated water)1	10/15/2014	0.88	0.51	0	0
K/A WTP Lab (treated water)2	10/15/2014	0.76	0.49	0	0
St. Joseph Church/Echang	10/16/2014	0.41	0.89	1	0
Cliffside Hotel/Ngerkebesang	10/16/2014	0.54	0.74	0	0
PNCC Station	10/16/2014	0.08	5.66	6	0
Meyuns Headstart/ Meyuns	10/16/2014	0.62	0.76	0	0
Oyaol Laundromat/Malakal	10/16/2014	0.52	1.01	0	0
Koror State Rangers	10/16/2014	0.48	1.68	0	0
PPUC WWO Office/Malakal	10/16/2014	0.36	0.67	0	0
Pier 7 Gas Station/Malakal	10/16/2014	0.69	0.88	0	0
GBH Elementary School/Ngerchemia	10/16/2014	0.31	1.02	0	0
Eddie's Laundromat/Ikelau	10/16/2014	0.39	0.48	0	0
Otong's Laundromat/Ngerbeched	10/16/2014	0.46	1.08	0	0
Kalau Gym/ Meyuns	10/16/2014	0.06	6.98	46	0

AP-8-1

Palau EQPB Water Quality Laboratory Test Results

Location	Collection Date	Chlorine Residual (mg/L)	Turbidity (NTU)	Total Coliform per 100 ml water sample	*E. coli* per 100 ml water sample
Remu Laundromat/Ngesaol	10/16/2014	0.32	0.70	0	0
Green Bay Hotel/Ngermid	10/16/2014	0.07	0.21	0	0
Ngermid Headstart/Ngermid	10/16/2014	0.07	0.46	0	0
Ngermid Dock Slipway/Ngermid	10/16/2014	0.06	0.94	0	0
Utekongel Laundromat/Ordomel	10/15/2014	0.15	3.66	0	0
Dave Dengokl Residence/Kesebelau	10/15/2014	0.22	0.42	0	0
NEMO Office/ Airport Road Ngerusar	10/15/2014	0.17	0.30	0	0
Japan Palau Friendship Bridge/Airai Side	10/15/2014	0.40	0.53	0	0

Weather: Clear
Sampler[A]: J. Sakurai
Analyst(s)[B]: J. Sengebau , A. Adelbai Jr.

Sampling Type: Grab

Analysis No.	Parameter	Method	Description
1	Residual Chlorine (Free)	[1]EPA 330.5	DPD Spectrometric
2	Turbidity	EPA 180.1	Nephelometric
3	Total Coliform	[2]SM9223-B	Colilert™ MMO-MUG
4	*Escherichia coli (E. coli)*	SM9223-B	Colilert™ MMO-MUG

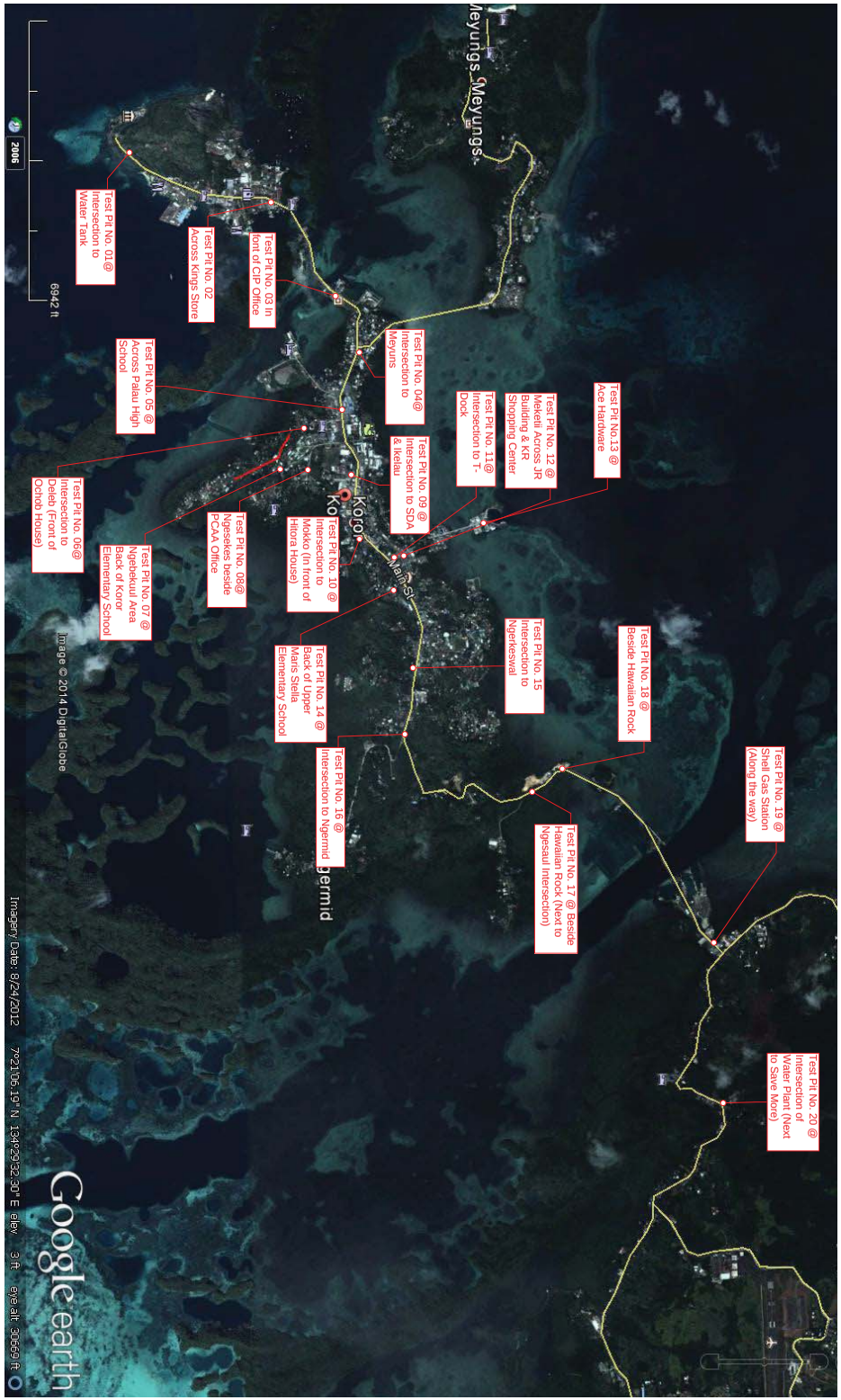
Reported by: _____ Date: 10/22/14
Metick K. Ngirchechol
Laboratory Supervisor

Methodology References
[1] US Environmental Protection Agency, Methods for Chemical analysis of Water and Wastes, EPA-600/4-79-020, Revised March 1983
[2] Standard Methods for Examination of Water and Wastewater, 20th Edition, APHA-AWWA-WPCF, 1992

[A]Sample collection is done in accordance with sampling instructions under USEPA FAS Water Quality Laboratory and Laboratory Technician Certification Program. Sampler is aware of sampling precautions outlined in [2]Standard Methods to maintain integrity of samples and prevent contamination.
[B]Analysts are certified under the USEPA FAS Water Quality Laboratory and Laboratory Technician Certification Program.

Appendix-9

Result of Test Pit Survey



AP-9-1

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Email: construction@surangel.com
www.construction.surangel.com

Category : Soil Condiction

Date: October 23,2014

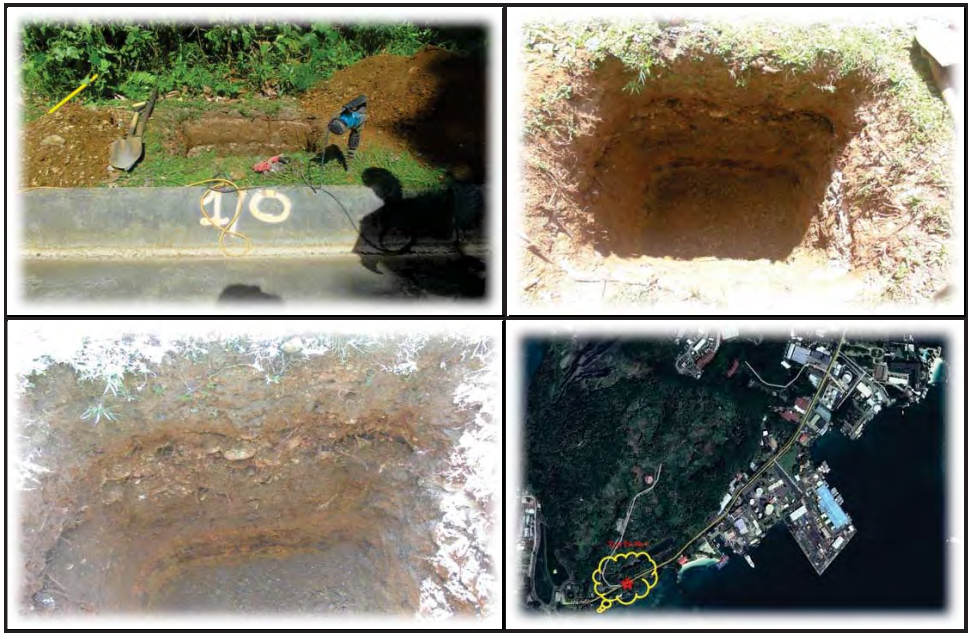
Location: Intersection to Malakal Water Tank

Sampler: Ebil Gailliard

Weather: Clear (Fair)

Sampling Method: Manual Excavation

Location/ Area	Test Pit No.	Type Of Soil	Thickness / Layer	Remarks
Intersection to Malakal	1	Topsoil	45 cm	
Tank		Coral	15 cm	
Malakal, Koror		Clay	60 cm	



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Category : Soil Condition

Date: October 23,2014

Location: Across Kings Store

Sampler: Ebil Gailliard

Weather: Clear (Fair)

Sampling Method: Manual Excavation

Location/ Area	Test Pit No.	Type Of Soil	Thickness / Layer	Remarks
Across Kings Store	2	Basecourse	15 cm	
Malakal, Koror		Clay	105 cm	

AP-9-2

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Category : Soil Condition

Date: October 22,2014

Location: Infront of CIP Office

Sampler: Ebil Gailliard

Weather: Clear (Fair)

Sampling Method: Manual Excavation

Location/ Area	Test Pit No.	Type Of Soil	Thickness / Layer	Remarks
Infront of CIP Office	3	Coral	120 cm	
Malakal, Koror				

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Category : Soil Condition

Date: October 22,2014

Location: Inter. to Meyuns Infront of Rainbow Mart

Sampler: Ebil Gailliard

Weather: Clear (Fair)

Sampling Method: Manual Excavation

Location/ Area	Test Pit No.	Type Of Soil	Thickness / Layer	Remarks
Infron of Rainbow Mart	4	Basecourse	100 cm	
Malakal, Koror		Coral	10 cm	
		Clay	10 cm	

AP-9-3

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Category : Soil Condition

Date: October 22,2014

Location: Infront of H.E Store

Sampler: Ebil Gailliard

Weather: Clear (Fair)

Sampling Method: Manual Excavation

Location/ Area	Test Pit No.	Type Of Soil	Thickness / Layer	Remarks
Infront of H.E Store	5	Basecourse	40 cm	
Malakal, Koror		Clay	80 cm	

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Category : Soil Condition

Date: October 22,2014

Location: Infront of Ochob House

Sampler: Ebil Gailliard

Weather: Clear (Fair)

Sampling Method: Manual Excavation

Location/ Area	Test Pit No.	Type Of Soil	Thickness / Layer	Remarks
Infront of Ochob House	6	Top soil	4 cm	
Ngerbeched, Koror		Basecourse	6 cm	
		Coral	40 cm	
		Clay	70 cm	




AP-9-4

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Category : Soil Condition

Date: October 21,2014

Location: Ngebekuu Area

Sampler: Ebil Gailliard

Weather: Clear (Fair)

Sampling Method: Manual Excavation

Location/ Area	Test Pit No.	Type Of Soil	Thickness / Layer	Remarks
Ngebekuu Area	7	Coral	35 cm	
Ngerbeched, Koror		Clay	95 cm	




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Category : Soil Condition

Date: October 21,2014

Location: Ngesekes Area

Sampler: Ebil Gailliard

Weather: Clear (Fair)

Sampling Method: Manual Excavation

Location/ Area	Test Pit No.	Type Of Soil	Thickness / Layer	Remarks
Ngesekes Area	8	Top Soil	10 cm	
Ngerbeched, Koror		Coral	30 cm	
		Clay	80 cm	

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Category : Soil Condition

Date: October 22,2014

Location: Intersection @ SDA Elemetary School

Sampler: Ebil Gailliard

Weather: Clear (Fair)

Sampling Method: Manual Excavation

Location/ Area	Test Pit No.	Type Of Soil	Thickness / Layer	Remarks
Inter. Of SDA	9	Clay	120 cm	**All Clay**
Ngerbeched, Koror				

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Category : Soil Condition

Date: October 20,2014

Location: Infront of Hitor House

Sampler: Ebil Gailliard

Weather: Clear (Fair)

Sampling Method: Manual Excavation

Location/ Area	Test Pit No.	Type Of Soil	Thickness / Layer	Remarks
Infront of Hitora House	10	Clay	120 cm	***All Clay***
Ikelau, Koror				

AP-9-6

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Category : Soil Investigation

Date: October 21,2014

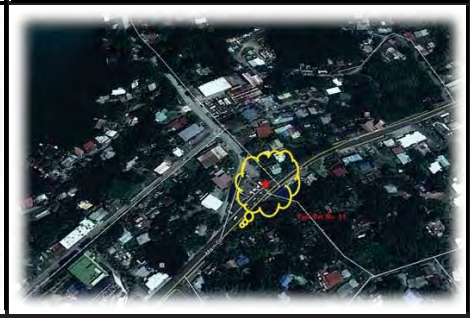
Location: Intersection @ Neco building going to T-Dock

Sampler: Ebil Gailliard

Weather: Clear (Fair)

Sampling Method: Manual Excavation

Location/ Area	Test Pit No.	Type Of Soil	Thickness / Layer	Remarks
NECO Building	11	Basecourse	100 cm	
Ikelau, Koror		Clay	10 cm	
		Coral	10 cm	



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Category : Soil Condition

Date: October 20,2014

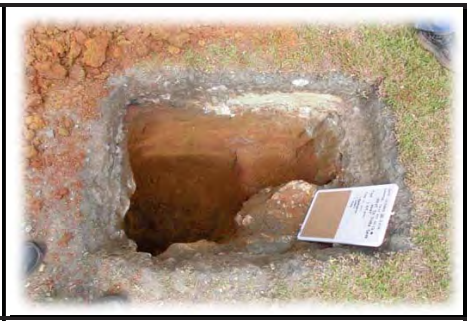
Location: Across Jr Building & KR Shopping Center

Sampler: Ebil Gailliard

Weather: Clear (Fair)

Sampling Method: Manual Excavation

Location/ Area	Test Pit No.	Type Of Soil	Thickness / Layer	Remarks
Across JR & KR Building	12	Bascourse	15 cm	
Ikelau, Koror		Coral	10 cm	
		Clay	95 cm	



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Category : Soil Condition

Date: October 20,2014

Location: Across Ace Hardware

Sampler: Ebil Gailliard

Weather: Clear (Fair)

Sampling Method: Manual Excavation

Location/ Area	Test Pit No.	Type Of Soil	Thickness / Layer	Remarks
Across Ace Hardware	13	Basecourse	35 cm	
Ikelau, Koror		Coral	85 cm	

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Category : Soil Condition

Date: October 19,2014

Location: Back at the upper Maris Stella school

Sampler: Ebil Gailliard

Weather: Clear (Fair)

Sampling Method: Manual Excavation

Location/ Area	Test Pit No.	Type Of Soil	Thickness / Layer	Remarks
Upper Maris Stella	14	Coral	20 cm	
Idid, Koror		Clay	100 cm	

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Category : Soil Condition

Date: October 19,2014

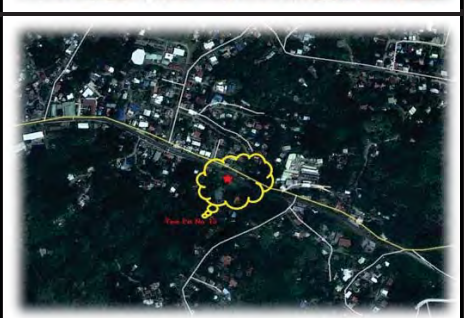
Location: Intersection of Ngekesewaul

Sampler: Ebil Gailliard

Weather: Clear (Fair)

Sampling Method: Manual Excavation

Location/ Area	Test Pit No.	Type Of Soil	Thickness / Layer	Remarks
Inter. of Ngekesewaul	15	Basecuorse	10 cm	
Ngerkeswaul, Koror		Clay	110 cm	



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Category : Soil Condition

Date: October 17,2014

Location: Intersection of Ngermid

Sampler: Ebil Gailliard

Weather: Clear (Fair)

Sampling Method: Manual Excavation

Location/ Area	Test Pit No.	Type Of Soil	Thickness / Layer	Remarks
Intersection of Ngermid	16	Basecourse	10 cm	
Ngerkeswaul, Koror		Rock	90 cm	
		Clay	20 cm	

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Category : Soil Condition

Date: October 17,2014

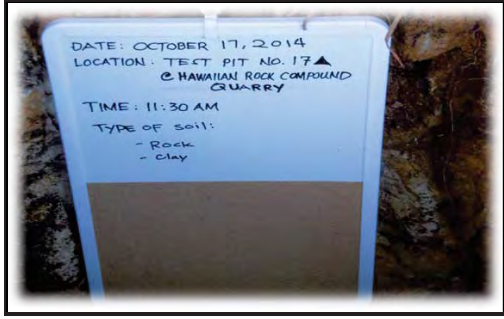
Location: Along Hawaiian Rock Quarry

Sampler: Ebil Gailliard

Weather: Clear (Fair)

Sampling Method: Manual Excavation

Location/ Area	Test Pit No.	Type Of Soil	Thickness / Layer	Remarks
Hawaiian Rock Quarry	17	Rock	100 cm	
Ngesaul, Koror		Clay	20 cm	



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Category : Soil Condition

Date: October 16,2014

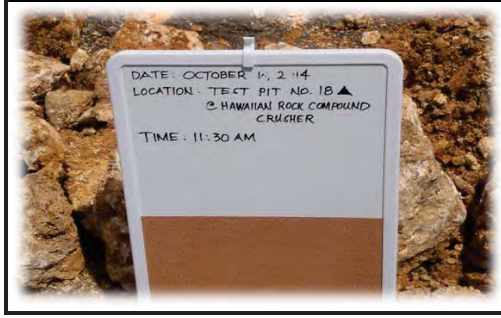
Location: Along Hawaiian Rock Quarry

Sampler: Ebil Gailliard

Weather: Clear (Fair)

Sampling Method: Manual Excavation

Location/ Area	Test Pit No.	Type Of Soil	Thickness / Layer	Remarks
Hawaiian Rock Quarry	18	Coral	15 cm	
Ngesaul,Koror		Rocks	105 cm	



AP-9-10

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Category : Soil Condition

Date: October 23,2014

Location: Along Shell Gas Station

Sampler: Ebil Gailliard

Weather: Clear (Fair)

Sampling Method: Manual Excavation

Location/ Area	Test Pit No.	Type Of Soil	Thickness / Layer	Remarks
Shell Gas Station	19	Basecourse	120 cm	
Airai				

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Category : Soil Condition

Date: October 23,2014

Location: Intersection to water plant

Sampler: Ebil Gailliard

Weather: Clear (Fair)

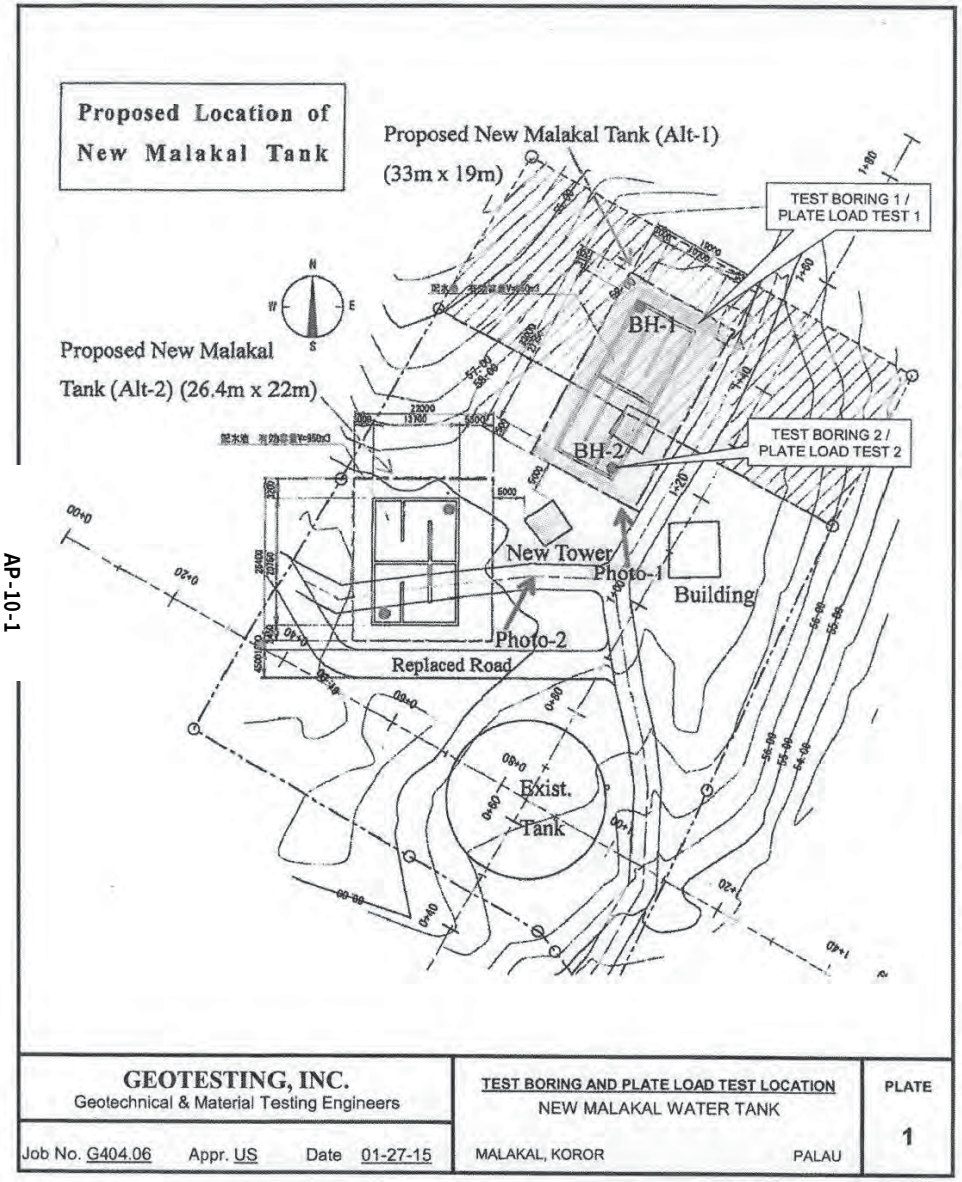
Sampling Method: Manual Excavation

Location/ Area	Test Pit No.	Type Of Soil	Thickness / Layer	Remarks
Inter. to water plant	20 a	Coral	60 m	Stopped do to Concrete Pipe
Ngesaul,Koror				**Relocation of Test Pit**
	20 b	Basecourse	15 cm	Final Test Pit Location
		Coral	105 cm	

AP-9-11

Appendix-10

Result of Soil Investigation



GEOTESTING, INC. Geotechnical & Material Testing Engineers	TEST BORING AND PLATE LOAD TEST LOCATION NEW MALAKAL WATER TANK	PLATE
Job No. G404.06 Appr. US Date 01-27-15	MALAKAL, KOROR PALAU	1

AP-10-1

PROJECT: NEW MALAKAL WATER TANK
Malakal, Koror, Palau

RESULTS OF PLATE LOAD TESTS

Plate Load Test No.	Yield Point load,		½ Yield Point load,		Settlement,
	psi	psf	psi	psf	Inches
PLT-1	36	5184	18	2592	0.080
PLT-2	35.5	5112	17.8	2563	0.175

LOG OF TEST BORING 1

Notes:
Relatively Undisturbed Sample
Disturbed/Bulk Sample
SPT = Standard Penetration Test based on 140 lb (63.5 kg) hammer free falling 30 in (76 cm.)/blow

DATE December 18, 2014
EQUIPMENT Mikun Drilling Rig
ELEVATION --

DEPTH (FT.)	DEPTH (M.)	DESCRIPTION	GRAPHIC LOG	SAMPLE TYPE	DRILL RATE (min/ft)	SPT (Blows/ft.)*	MOISTURE CONTENT, %	DRY DENSITY, lbs./cu.ft.	LABORATORY TESTS
0	0	MOTTLED RED-BLACK-YELLOW-BROWN-GREY CLAYEY SILT (MH) - stiff, moist							
	1					8	68.1	56	
5									
	2	medium at 7'				4	63.9	59	-200=92% LL= 56; PI= 3 Consol Gs=2.731
10	3								
		stiff at 12'				14	62.0	62	
15	4								
	5	(Refusal, no recovery, very hard, possibly encountered basalt				20/0"			
		(No free water encountered)							
		Note: Terminated at 16'-8", the drill rig cannot penetrate further down.							

GEOTESTING, INC.
Geotechnical & Material Testing Engineers

LOG OF TEST BORING 1
NEW MALAKAL WATER TANK
KOROR, PALAU

PLATE 2

Job No. G404.06 Date 12/23/14

AP-10-2

LOG OF TEST BORING 2

Notes:
Relatively Undisturbed Sample
Disturbed/Bulk Sample
SPT = Standard Penetration Test based on 140 lb (63.5 kg) hammer free falling 30 in (76 cm.)/blow

DATE December 18, 2014
EQUIPMENT Mikun Drilling Rig
ELEVATION --

DEPTH (FT.)	DEPTH (M.)	DESCRIPTION	GRAPHIC LOG	SAMPLE TYPE	DRILL RATE (min/ft)	SPT (Blows/ft.)*	MOISTURE CONTENT, %	DRY DENSITY, lbs./cu.ft.	LABORATORY TESTS
0	0	BROWN CLAYEY SILT (MH) - soft, moist, with grass on surface							
	1					29	50.9	66	Tx 1144 (175)
5									
	2	MOTTLED YELLOWISH BROWN-BROWN-BLACK DEEPLY WEATHERED TUFFACEOUS SILTSTONE - moderately hard				33	46.4	71	UC 3247
10	3	(No free water encountered)							
		Refusal, no recovery, hammer bounced during SPT sampling. Performed SPT at 10' after the drill rate was 1" over minutes.							
		Attempted to drill from 10' but drill rate was zero penetration over 4 minutes. Terminated the test boring at 10', the drill rig cannot drill further down.							

GEOTESTING, INC.
Geotechnical & Material Testing Engineers

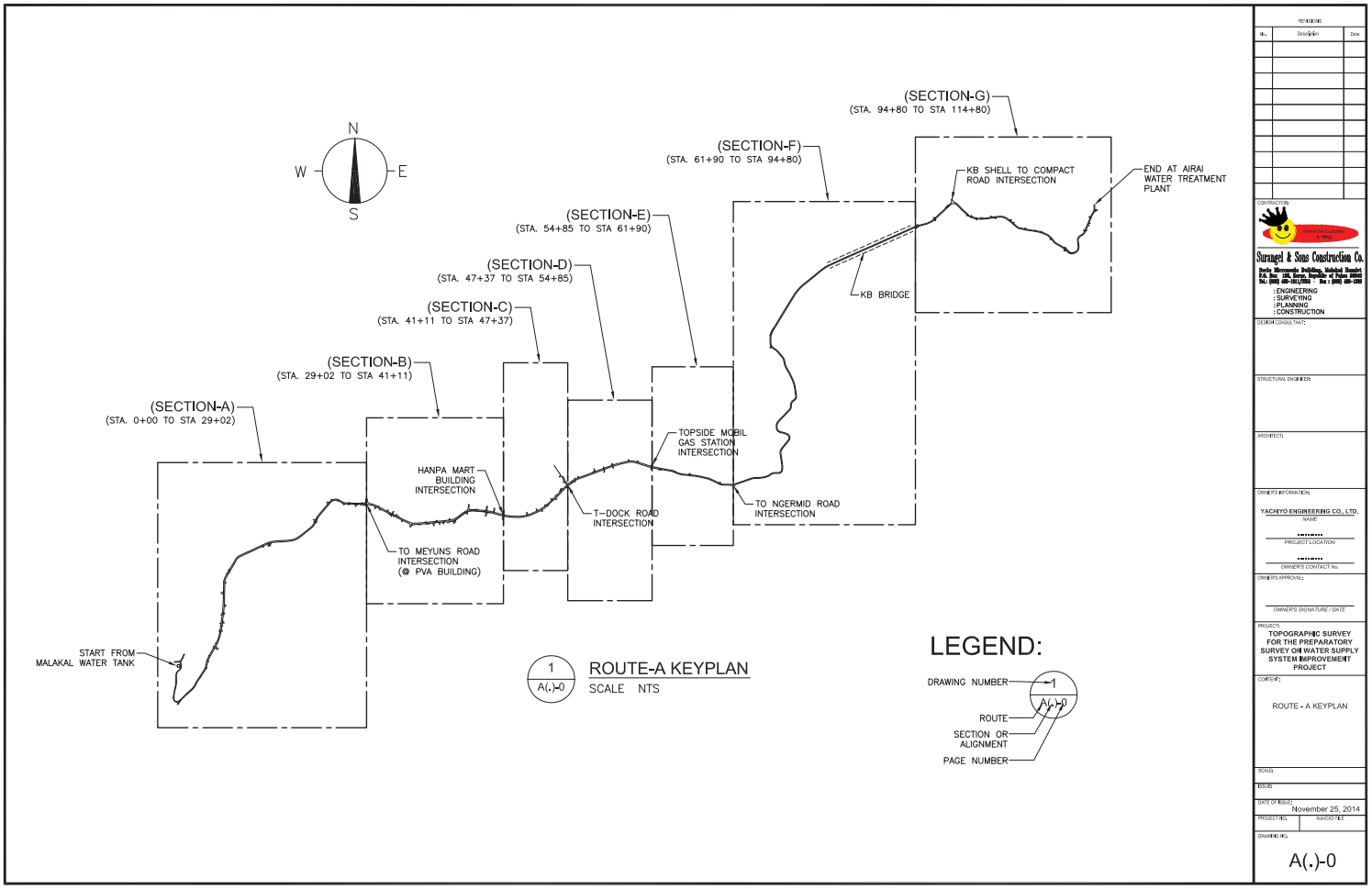
LOG OF TEST BORING 2
NEW MALAKAL WATER TANK
KOROR, PALAU

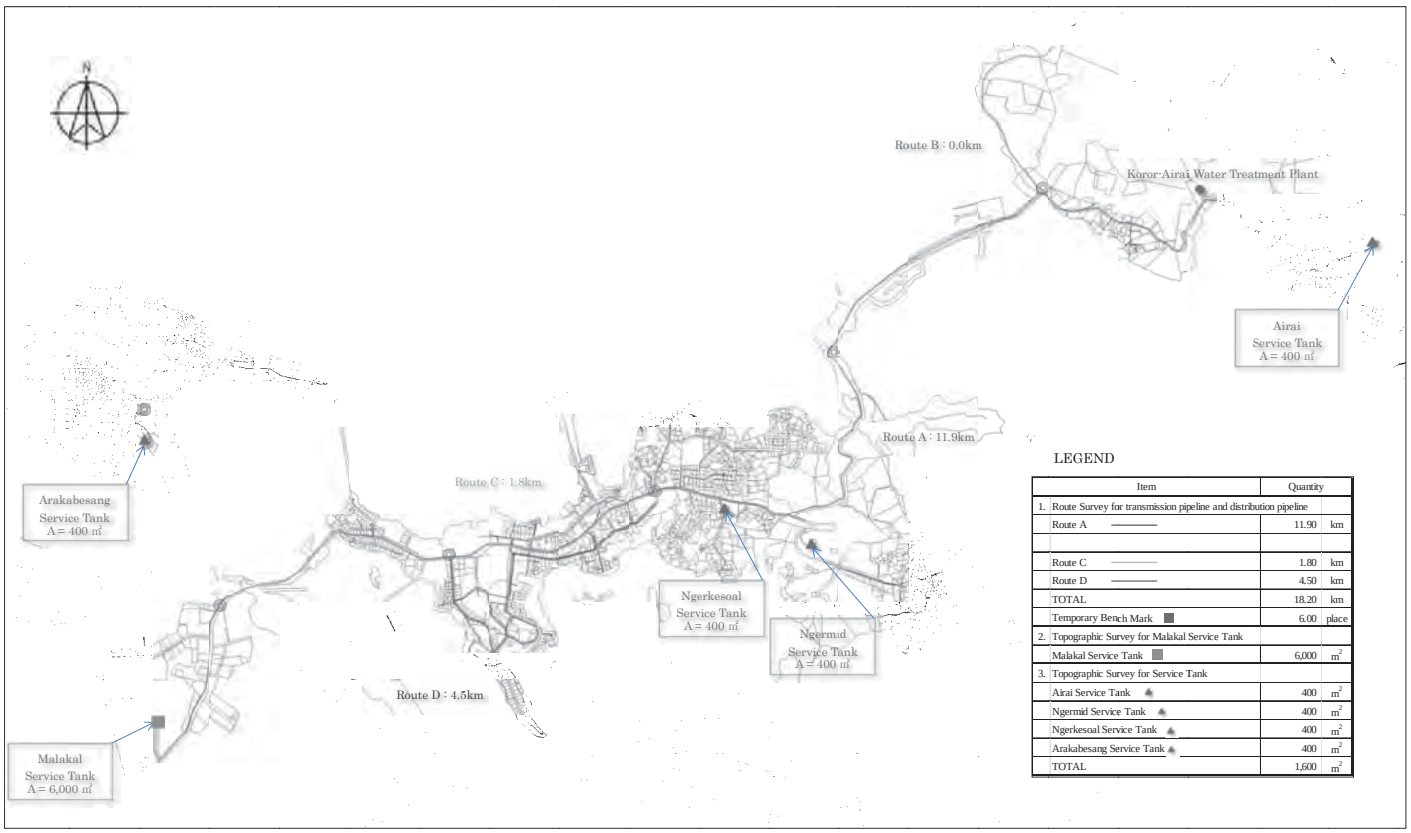
PLATE 3

Job No. G404.06 Date 12/23/14

Appendix-11

Result of Topographic Survey





	Item	Quantity	
1.	Route Survey for transmission pipeline and distribution pipeline		
	Route A	11.90	km
	Route C	1.80	km
	Route D	4.50	km
	TOTAL	18.20	km
	Temporary Bench Mark	6.00	place
2.	Topographic Survey for Malakal Service Tank		
	Malakal Service Tank	6,000	m^2
3.	Topographic Survey for Service Tank		
	Airai Service Tank	400	m^2
	Ngermid Service Tank	400	m^2
	Ngerkesoal Service Tank	400	m^2
	Arakabesang Service Tank	400	m^2
	TOTAL	1,600	m^2

Location Map for Route and Topographic Survey

Appendix-12

Result of Leak Detection

1. **Objective**

To grasp leakage condition of aged and deteriorated distribution water pipelines (AC pipes) under the main street and the road adjacent to main street in Koror State.

2. Outline of the leak detection

1) Name of survey

Leak Detection for the Preparatory Survey on the Water Supply System Improvement Project in the Republic of Palau

2) Survey Period

28 Sep, 2015 – 11 Oct, 2015

3) Survey Area

Center of Koror Island

4) Quantities

Targeted length for leak detection: 13km (8.08mi)
Length for preliminary inspection: 13km (8.08mi)
Sound listening survey (house to house): 196 houses
Sound listening survey (Road surface): 13km (8.08mi)

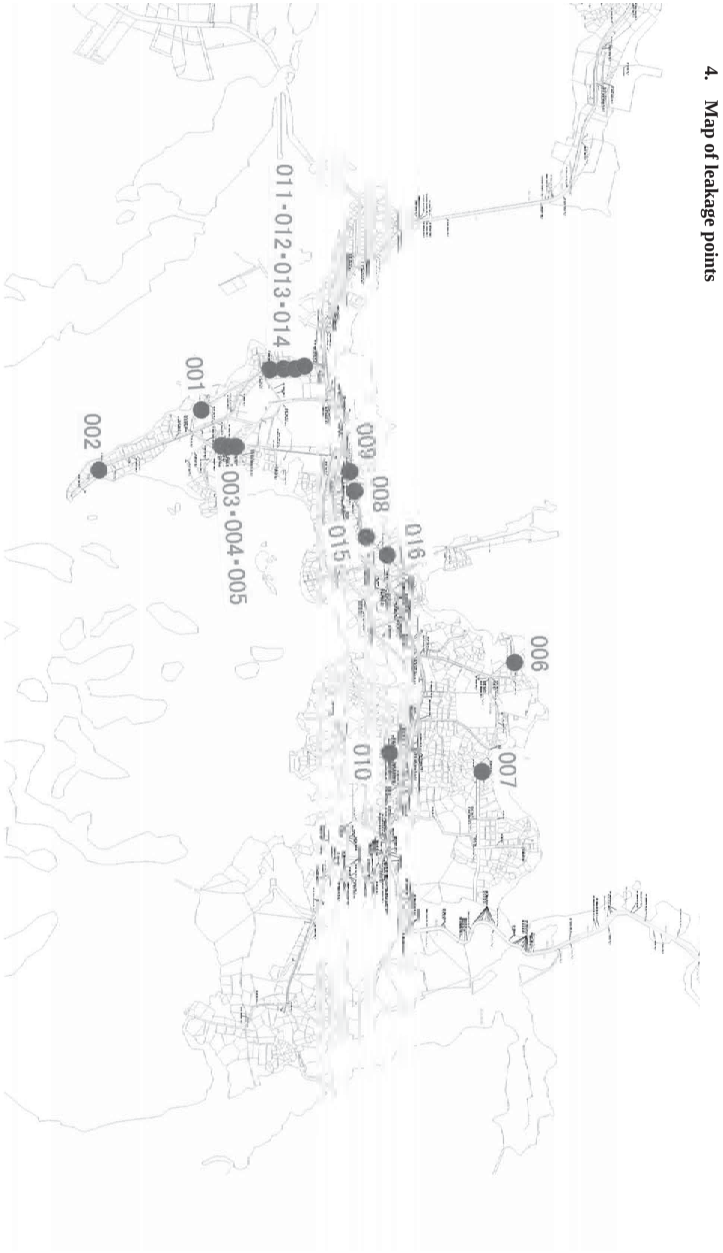
3. Result

Number of water leakage points: 16 points
Estimated volume of water leakage: 9.78m^3/h

List of Leakage points

No.	Leakage type	Pipe type	Pipe Diameter (mm)	Estimated leakage volume (m^3/h)	Leakage place	
					Public road	private property
001	Valve	PVC	25	1.00	○	
002	Valve	PVC	50	0.60	○	
003	Distribution pipe	AC	200	0.06	○	
004	Distribution pipe	AC	200	0.06	○	
Others	Distribution pipe	AC	200	0.06	○	
006	Fire hydrant	AC	100	0.30		○
007	Distribution pipe	AC	200	2.00	○	
008	Valve	PVC	13	0.30	○	
009	Distribution pipe	AC	200	0.10	○	
010	Lateral	PVC	13	0.10		○
011	Distribution pipe	AC	200	3.00	○	
012	Distribution pipe	AC	200	0.60	○	
013	Distribution pipe	AC	200	0.60	○	
014	Distribution pipe	AC	200	0.60	○	
015	Distribution pipe	AC	200	0.10	○	
016	Distribution pipe	AC	200	0.30	○	

4. Map of leakage points

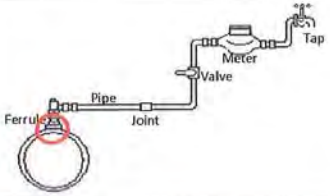


Leakage Record Sheet

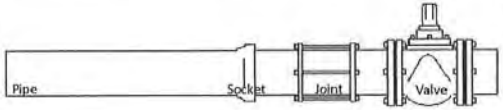
Leak. No 001

Date of survey:	30-Sep-14	Street	
House No,		GPS	N : 07° 20' 09.7" E : 134° 28' 25.6"
Main Pipe	1. CIP, 2. DCIP, 3. PVC, **4. ACP**, 5. Others	**Location**	1. Pipe, 2. Joint･Socket, 3. Ferrle , 4. Valve, 5. Meter, 6. Tap, 7. Reservoir Tank, 8. Others,
Diameter	200 mm	**Condition**	1. Hole, **2. Crack**, 3. Packing, 4. Loose Connection, 5. Over Flow, 6. Unknown, 7. Others ( )
Service Pipe	1. PEP, **2. PVC**, 3. GP, 4. Others ( )	**Cause**	1. Corrosion, **2** Deterioration (Aging), 3. Traffic Load, 4. Wrong Construction, 5. Less Adhesive, 6. Pressure Fluctuation, 7. Defective Valve , 8. Destruction, 9. Other Construction, 10. Unknown, 11. Others( )
Diameter	25 mm		
Depth	cm	**Surface**	**1.**Asphalt, 2.Concrete, 3.Gravel, 4.Grass, 5.Soil, 6.Others
Leakage Size	1. Large, **2. Middium**, 3. Small, 4. Drops, Estimated volume (1.0 m3/h)	Detected Method	1. Patrol, 2. Customer Informing, 3. Acoustic, **4.** Pinpoint,

Leak Point



Hole/Crack Size:(cm)



Location Map

Photo

Remarks:

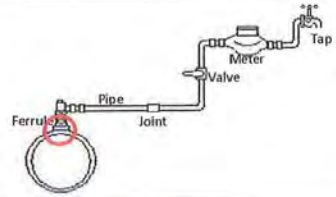
AP-12-2

Leakage Record Sheet

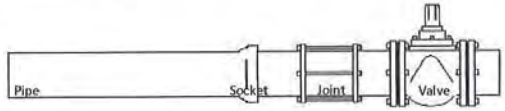
Leak. No 002

Date of survey:	30-Sep-14	Street	
House No,		GPS	N : 07° 19' 50.6" E : 134° 28' 38.6"
Main Pipe	1. CIP, 2. DCIP, 3. PVC, **4. ACP**, 5. Others	**Location**	1. Pipe, 2. Joint･Socket, 3. Ferrle , 4. Valve, 5. Meter, 6. Tap, 7. Reservoir Tank, 8. Others,
Diameter	200 mm	**Condition**	1. Hole, **2.** Crack, 3. Packing, 4. Loose Connection, 5. Over Flow, 6. Unknown, 7. Others ( )
Service Pipe	1. PEP, **2.** PVC, 3. GP, 4. Others ( )	**Cause**	1. Corrosion, **2.** Deterioration (Aging), 3. Traffic Load, 4. Wrong Construction, 5. Less Adhesive, 6. Pressure Fluctuation, 7. Defective Valve , 8. Destruction, 9. Other Construction, 10. Unknown, 11. Others( )
Diameter	50 mm		
Depth	cm	**Surface**	**1.**Asphalt, 2.Concrete, 3.Gravel, 4.Grass, 5.Soil, 6.Others
Leakage Size	1. Large, **2.** Middium, 3. Small, 4. Drops, Estimated volume (0.6 m3/h)	Detected Method	1. Patrol, 2. Customer Informing, 3. Acoustic, **4.** Pinpoint,

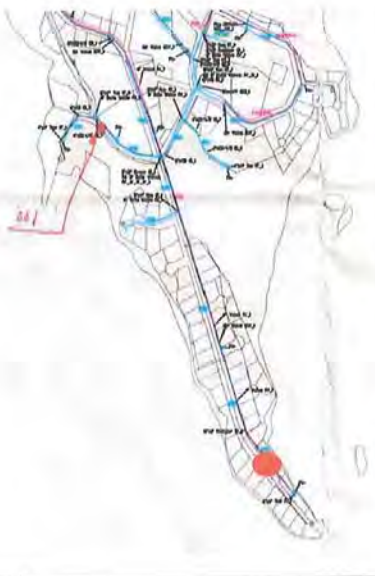
Leak Point



Hole/Crack Size:(cm)



Location Map



Photo

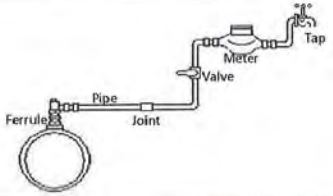
Remarks:

Leakage Record Sheet

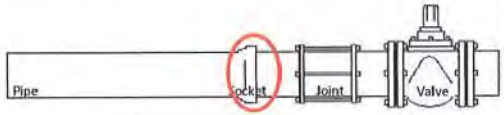
Leak. No 003

Date of survey:	1-Oct-14	Street	
House No,		GPS	N : 07° 20' 13.6" E : 134° 28' 32.9"
Main Pipe	1. CIP, 2. DCIP, 3. PVC, **4. ACP**, 5. Others	**Location**	1. Pipe, **2. Joint・Socket**, 3. Ferrle , 4. Valve, 5. Meter, 6. Tap, 7. Reservoir Tank, 8. Others,
Diameter	200 mm	**Condition**	1. Hole, 2. Crack, **3. Packing**, 4. Loose Connection, 5. Over Flow, 6. Unknown, 7. Others ( )
Service Pipe	1. PEP, 2. PVC, 3. GP, 4. Others ( )	**Cause**	1. Corrosion, **2. Deterioration (Aging)**, 3. Traffic Load, 4. Wrong Construction, 5. Less Adhesive, 6. Pressure Fluctuation, 7. Defective Valve , 8. Destruction, 9. Other Construction, 10. Unknown, 11. Others( )
Diameter	50 mm		
Depth	cm	**Surface**	**1.Asphalt**, 2.Concrete, 3.Gravel, 4.Grass, 5.Soil, 6.Others
Leakage Size	1. Large, 2. Middium, **3. Small**, 4. Drops, Estimated volume (0.06 m3/h)	Detected Method	1. Patrol, 2. Customer Informing, 3. Acoustic, **4. Pinpoint**,

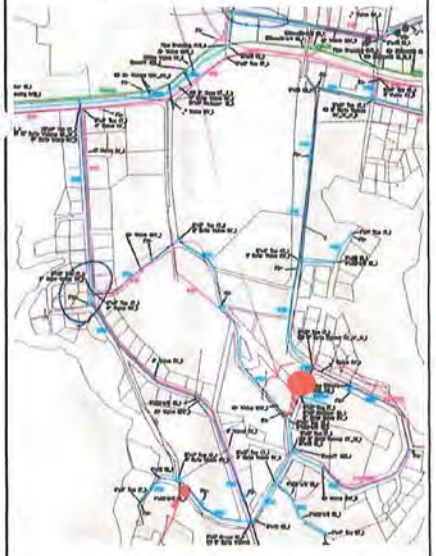
Leak Point



Hole/Crack Size:(cm)



Location Map



Photo

Remarks: Please confirm the boring investigation.

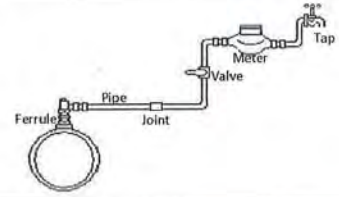
AP-12-3

Leakage Record Sheet

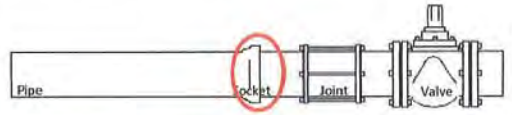
Leak. No 004

Date of survey:	1-Oct-14	Street	
House No,		GPS	N : 07° 20' 13.9" E : 134° 28' 32.9"
Main Pipe	1. CIP, 2. DCIP, 3. PVC, **4. ACP**, 5. Others	**Location**	1. Pipe, **2. Joint・Socket**, 3. Ferrle , 4. Valve, 5. Meter, 6. Tap, 7. Reservoir Tank, 8. Others,
Diameter	200 mm	**Condition**	1. Hole, 2. Crack, **3. Packing**, 4. Loose Connection, 5. Over Flow, 6. Unknown, 7. Others ( )
Service Pipe	1. PEP, 2. PVC, 3. GP, 4. Others ( )	**Cause**	1. Corrosion, **2. Deterioration (Aging)**, 3. Traffic Load, 4. Wrong Construction, 5. Less Adhesive, 6. Pressure Fluctuation, 7. Defective Valve , 8. Destruction, 9. Other Construction, 10. Unknown, 11. Others( )
Diameter	mm		
Depth	cm	**Surface**	**1.Asphalt**, 2.Concrete, 3.Gravel, 4.Grass, 5.Soil, 6.Others
Leakage Size	1. Large, 2. Middium, **3. Small**, 4. Drops, Estimated volume (0.06 m3/h)	Detected Method	1. Patrol, 2. Customer Informing, 3. Acoustic, **4. Pinpoint**,

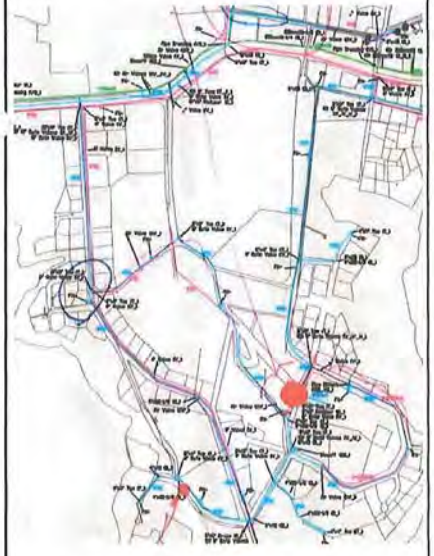
Leak Point



Hole/Crack Size:(cm)



Location Map



Photo

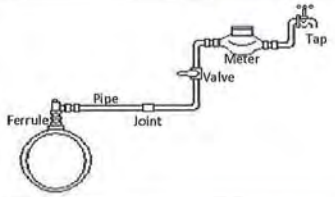
Remarks: Please confirm the boring investigation.

Leakage Record Sheet

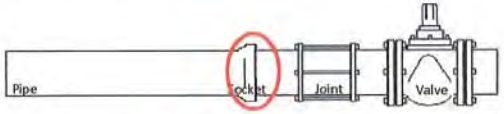
Leak. No 005

Date of survey:	1-Oct-14	Street	
House No,		GPS	N : 07° 20' 14.0" E : 134° 28' 32.9"
Main Pipe	1. CIP, 2. DCIP, 3. PVC, **4. ACP**, 5. Others	**Location**	1. Pipe, **2. Joint・Socket**, 3. Ferrle , 4. Valve, 5. Meter, 6. Tap, 7. Reservoir Tank, 8. Others,
Diameter	200 mm	**Condition**	1. Hole, 2. Crack, **3. Packing**, 4. Loose Connection, 5. Over Flow, 6. Unknown, 7. Others ( )
Service Pipe	1. PEP, 2. PVC, 3. GP, 4. Others ( )	**Cause**	1. Corrosion, **2. Deterioration (Aging)**, 3. Traffic Load, 4. Wrong Construction, 5. Less Adhesive, 6. Pressure Fluctuation, 7. Defective Valve , 8. Destruction, 9. Other Construction, 10. Unknown, 11. Others( )
Diameter	mm		
Depth	cm	**Surface**	**1.Asphalt**, 2.Concrete, 3.Gravel, 4.Grass, 5.Soil, 6.Others
Leakage Size	1. Large, 2. Middium, **3. Small**, 4. Drops, Estimated volume (0.06 m3/h)	Detected Method	1. Patrol, 2. Customer Informing, 3. Acoustic, **4. Pinpoint**,

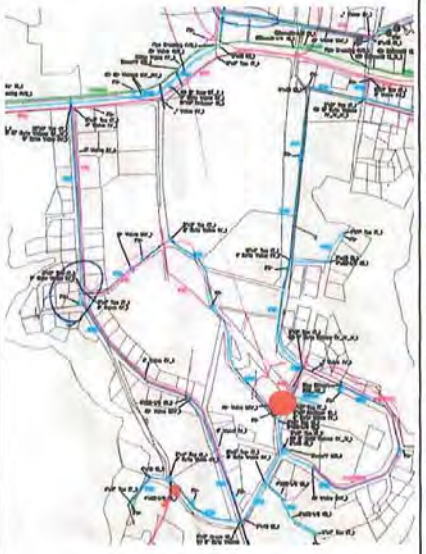
Leak Point



Hole/Crack Size:(cm)



Location Map



Photo

Remarks: Please confirm the boring investigation.

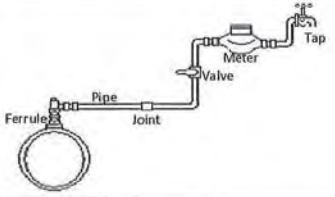
AP-12-4

Leakage Record Sheet

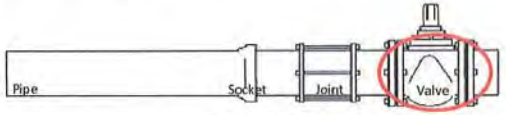
Leak. No 006

Date of survey:	2-Oct-14	Street	
House No,		GPS	N : 07° 21' 00.5" E : 134° 29' 08.0"
Main Pipe	1. CIP, 2. DCIP, 3. PVC, **4. ACP**, 5. Others	**Location**	1. Pipe, 2. Joint・Socket, 3. Ferrle , 4. Valve, 5. Meter, 6. Tap, 7. Reservoir Tank, 8. Others,
Diameter	100 mm	**Condition**	1. Hole, 2. Crack, 3. Packing, **4. Loose Connection**, 5. Over Flow, 6. Unknown, 7. Others ( )
Service Pipe	1. PEP, 2. PVC, 3. GP, 4. Others ( )	**Cause**	1. Corrosion, **2. Deterioration (Aging)**, 3. Traffic Load, 4. Wrong Construction, 5. Less Adhesive, 6. Pressure Fluctuation, 7. Defective Valve , 8. Destruction, 9. Other Construction, 10. Unknown, 11. Others( )
Diameter	mm		
Depth	cm	**Surface**	1.Asphalt, **2.Concrete**, 3.Gravel, 4.Grass, 5.Soil, 6.Others
Leakage Size	1. Large, 2. Middium, **3. Small**, 4. Drops, Estimated volume (0.3 m3/h)	Detected Method	1. Patrol, 2. Customer Informing, 3. Acoustic, **4. Pinpoint**,

Leak Point



Hole/Crack Size:(cm)



Location Map

Photo

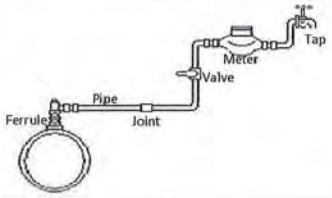
Remarks:

Leakage Record Sheet

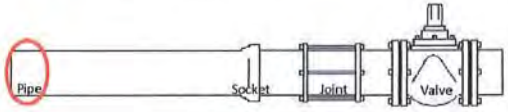
Leak. No 007

Date of survey:	3-Oct-14	Street	
House No,		GPS	N : 07° 20' 54.1" E : 134° 29' 26.5"
Main Pipe	1. CIP, 2. DCIP, 3. PVC, 4. ACP, 5. Others	**Location**	1. Pipe, 2. Joint·Socket, 3. Ferrle , 4. Valve, 5. Meter, 6. Tap, 7. Reservoir Tank, 8. Others,
Diameter	200 mm	**Condition**	1. Hole, 2. Crack, 3. Packing, 4. Loose Connection, 5. Over Flow, 6. Unknown, 7. Others ( )
Service Pipe	1. PEP, 2. PVC, 3. GP, 4. Others ( )	**Cause**	1. Corrosion, 2. Deterioration (Aging), 3. Traffic Load, 4. Wrong Construction, 5. Less Adhesive, 6. Pressure Fluctuation, 7. Defective Valve , 8. Destruction, 9. Other Construction, 10. Unknown, 11. Others( )
Diameter	mm		
Depth	cm	**Surface**	1.Asphalt, 2.Concrete, 3.Gravel, 4.Grass, 5.Soil, 6.Others
Leakage Size	1. Large, 2. Middium, 3. Small, 4. Drops, Estimated volume (2.0 m3/h)	Detected Method	1. Patrol, 2. Customer Informing, 3. Acoustic, 4. Pinpoint,

Leak Point



Hole/Crack Size:(cm)



Location Map

Photo

Remarks:

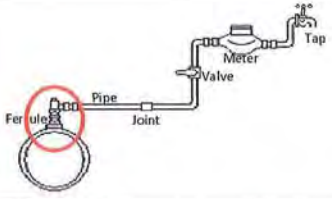
AP-12-5

Leakage Record Sheet

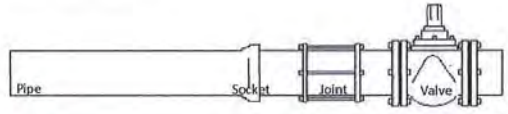
Leak. No 008

Date of survey:	6-Oct-14	Street	
House No,		GPS	N : 07° 20' 34.2" E : 134° 28' 38.9"
Main Pipe	1. CIP, 2. DCIP, 3. PVC, 4. ACP, 5. Others	**Location**	1. Pipe, 2. Joint·Socket, 3. Ferrle , 4. Valve, 5. Meter, 6. Tap, 7. Reservoir Tank, 8. Others,
Diameter	200 mm	**Condition**	1. Hole, 2. Crack, 3. Packing, 4. Loose Connection, 5. Over Flow, 6. Unknown, 7. Others ( )
Service Pipe	1. PEP, 2. PVC, 3. GP, 4. Others ( )	**Cause**	1. Corrosion, 2. Deterioration (Aging), 3. Traffic Load, 4. Wrong Construction, 5. Less Adhesive, 6. Pressure Fluctuation, 7. Defective Valve , 8. Destruction, 9. Other Construction, 10. Unknown, 11. Others( )
Diameter	mm		
Depth	cm	**Surface**	1.Asphalt, 2.Concrete, 3.Gravel, 4.Grass, 5.Soil, 6.Others
Leakage Size	1. Large, 2. Middium, 3. Small, 4. Drops, Estimated volume (0.3 m3/h)	Detected Method	1. Patrol, 2. Customer Informing, 3. Acoustic, 4. Pinpoint,

Leak Point



Hole/Crack Size:(cm)



Location Map

Photo

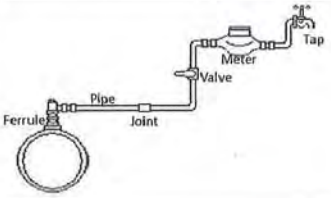
Remarks:

Leakage Record Sheet

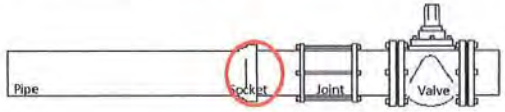
Leak. No 009

Date of survey:	6-Oct-14	Street	
House No,		GPS	N : 07° 20' 33.6" E : 134° 28' 37.6"
Main Pipe	1. CIP, 2. DCIP, 3. PVC, 4. ACP, 5. Others	**Location**	1. Pipe, 2. Joint・Socket, 3. Ferrle , 4. Valve, 5. Meter, 6. Tap, 7. Reservoir Tank, 8. Others,
Diameter	200 mm	**Condition**	1. Hole, 2. Crack, 3. Packing, 4. Loose Connection, 5. Over Flow, 6. Unknown, 7. Others ( )
Service Pipe	1. PEP, 2. PVC, 3. GP, 4. Others ( )	**Cause**	1. Corrosion, 2. Deterioration (Aging), 3. Traffic Load, 4. Wrong Construction, 5. Less Adhesive, 6. Pressure Fluctuation, 7. Defective Valve , 8. Destruction, 9. Other Construction, 10. Unknown, 11. Others( )
Diameter	mm		
Depth	cm	**Surface**	1.Asphalt, 2.Concrete, 3.Gravel, 4.Grass, 5.Soil, 6.Others
Leakage Size	1. Large, 2. Middium, 3. Small, 4. Drops, Estimated volume (0.1 m3/h)	Detected Method	1. Patrol, 2. Customer Informing, 3. Acoustic, 4. Pinpoint,

Leak Point



Hole/Crack Size:(cm)



Location Map

Photo

Remarks:

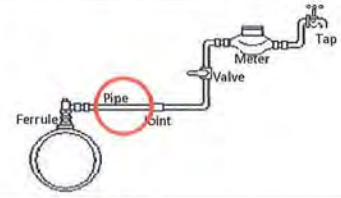
AP-12-6

Leakage Record Sheet

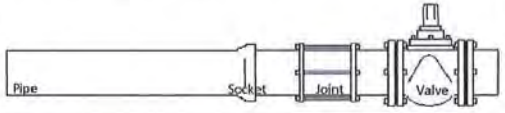
Leak. No 010

Date of survey:	6-Oct-14	Street	
House No,		GPS	N : 07° 20' 34.0" E : 134° 28' 38.0"
Main Pipe	1. CIP, 2. DCIP, 3. PVC, 4. ACP, 5. Others	**Location**	1. Pipe, 2. Joint・Socket, 3. Ferrle , 4. Valve, 5. Meter, 6. Tap, 7. Reservoir Tank, 8. Others,
Diameter	mm	**Condition**	1. Hole, 2. Crack, 3. Packing, 4. Loose Connection, 5. Over Flow, 6. Unknown, 7. Others ( )
Service Pipe	1. PEP, 2. PVC, 3. GP, 4. Others ( )	**Cause**	1. Corrosion, 2. Deterioration (Aging), 3. Traffic Load, 4. Wrong Construction, 5. Less Adhesive, 6. Pressure Fluctuation, 7. Defective Valve , 8. Destruction, 9. Other Construction, 10. Unknown, 11. Others( )
Diameter	13 mm		
Depth	cm	**Surface**	1.Asphalt, 2.Concrete, 3.Gravel, 4.Grass, 5.Soil, 6.Others
Leakage Size	1. Large, 2. Middium, 3. Small, 4. Drops, Estimated volume (0.1 m3/h)	Detected Method	1. Patrol, 2. Customer Informing, 3. Acoustic, 4. Pinpoint,

Leak Point



Hole/Crack Size:(cm)



Location Map

Photo

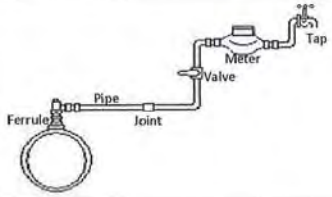
Remarks:

Leakage Record Sheet

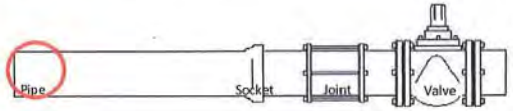
Leak. No 011

Date of survey:	8-Oct-14	Street	
House No,		GPS	N : 07° 20' 41.2" E : 134° 29' 23.9"
Main Pipe	1. CIP, 2. DCIP, 3. PVC, 4. ACP, 5. Others	**Location**	1. Pipe, 2. Joint･Socket, 3. Ferrle, 4. Valve, 5. Meter, 6. Tap, 7. Reservoir Tank, 8. Others,
Diameter	200 mm	**Condition**	1. Hole, 2. Crack, 3. Packing, 4. Loose Connection, 5. Over Flow, 6. Unknown, 7. Others ( )
Service Pipe	1. PEP, 2. PVC, 3. GP, 4. Others ( )	**Cause**	1. Corrosion, 2. Deterioration (Aging), 3. Traffic Load, 4. Wrong Construction, 5. Less Adhesive, 6. Pressure Fluctuation, 7. Defective Valve, 8. Destruction, 9. Other Construction, 10. Unknown, 11. Others( )
Diameter	mm		
Depth	cm	**Surface**	1.Asphalt, 2.Concrete, 3.Gravel, 4.Grass, 5.Soil, 6.Others
Leakage Size	1. Large, 2. Middium, 3. Small, 4. Drops, Estimated volume (3.0 m3/h)	Detected Method	1. Patrol, 2. Customer Informing, 3. Acoustic, 4. Pinpoint,

Leak Point



Hole/Crack Size:(cm)



Location Map

Photo

Remarks:

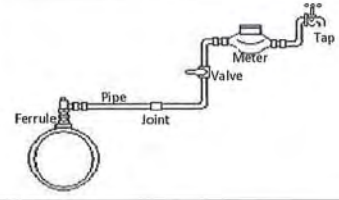
AP-12-7

Leakage Record Sheet

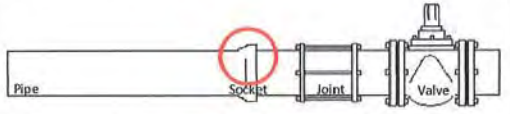
Leak. No 012

Date of survey:	9-Oct-14	Street	
House No,		GPS	N : 07° 20' 20.8" E : 134° 28' 20.0"
Main Pipe	1. CIP, 2. DCIP, 3. PVC, 4. ACP, 5. Others	**Location**	1. Pipe, 2. Joint･Socket, 3. Ferrle, 4. Valve, 5. Meter, 6. Tap, 7. Reservoir Tank, 8. Others,
Diameter	200 mm	**Condition**	1. Hole, 2. Crack, 3. Packing, 4. Loose Connection, 5. Over Flow, 6. Unknown, 7. Others ( )
Service Pipe	1. PEP, 2. PVC, 3. GP, 4. Others ( )	**Cause**	1. Corrosion, 2. Deterioration (Aging), 3. Traffic Load, 4. Wrong Construction, 5. Less Adhesive, 6. Pressure Fluctuation, 7. Defective Valve, 8. Destruction, 9. Other Construction, 10. Unknown, 11. Others( )
Diameter	mm		
Depth	cm	**Surface**	1.Asphalt, 2.Concrete, 3.Gravel, 4.Grass, 5.Soil, 6.Others
Leakage Size	1. Large, 2. Middium, 3. Small, 4. Drops, Estimated volume (0.6 m3/h)	Detected Method	1. Patrol, 2. Customer Informing, 3. Acoustic, 4. Pinpoint,

Leak Point



Hole/Crack Size:(cm)



Location Map

Photo

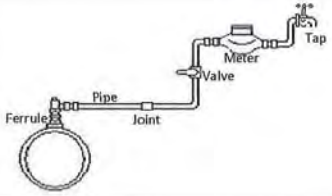
Remarks: Please confirm the boring investigation.

Leakage Record Sheet

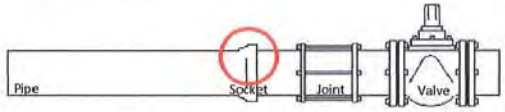
Leak. No 013

Date of survey:	9-Oct-14	Street	
House No,		GPS	N : 07° 20' 23.1" E : 134° 28' 19.8"
Main Pipe	1. CIP, 2. DCIP, 3. PVC, 4. ACP, 5. Others	**Location**	1. Pipe, 2. Joint·Socket, 3. Ferrle, 4. Valve, 5. Meter, 6. Tap, 7. Reservoir Tank, 8. Others,
Diameter	200 mm	**Condition**	1. Hole, 2. Crack, 3. Packing, 4. Loose Connection, 5. Over Flow, 6. Unknown, 7. Others ( )
Service Pipe	1. PEP, 2. PVC, 3. GP, 4. Others ( )	**Cause**	1. Corrosion, 2. Deterioration (Aging), 3. Traffic Load, 4. Wrong Construction, 5. Less Adhesive, 6. Pressure Fluctuation, 7. Defective Valve, 8. Destruction, 9. Other Construction, 10. Unknown, 11. Others( )
Diameter	mm		
Depth	cm	**Surface**	1.Asphal, 2.Concrete, 3.Gravel, 4.Grass, 5.Soil, 6.Others
Leakage Size	1. Large, 2. Middium, 3. Small, 4. Drops, Estimated volume (0.6 m3/h)	Detected Method	1. Patrol, 2. Customer Informing, 3. Acoustic, 4. Pinpoint,

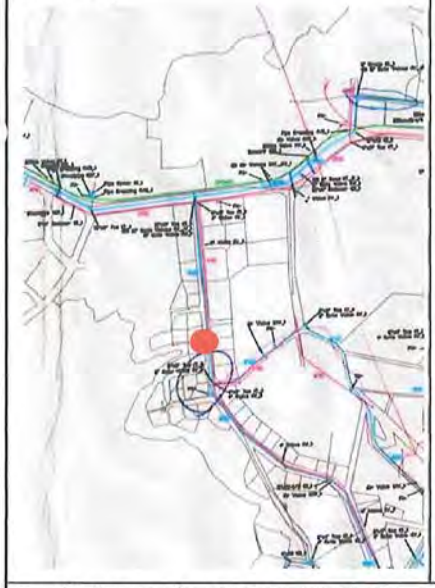
Leak Point



Hole/Crack Size:(cm)



Location Map



Photo

Remarks: Please confirm the boring investigation.

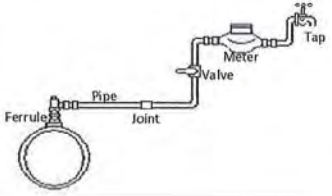
AP-12-8

Leakage Record Sheet

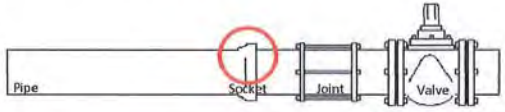
Leak. No 014

Date of survey:	9-Oct-14	Street	
House No,		GPS	N : 07° 20' 23.7" E : 134° 28' 19.9"
Main Pipe	1. CIP, 2. DCIP, 3. PVC, 4. ACP, 5. Others	**Location**	1. Pipe, 2. Joint·Socket, 3. Ferrle, 4. Valve, 5. Meter, 6. Tap, 7. Reservoir Tank, 8. Others,
Diameter	200 mm	**Condition**	1. Hole, 2. Crack, 3. Packing, 4. Loose Connection, 5. Over Flow, 6. Unknown, 7. Others ( )
Service Pipe	1. PEP, 2. PVC, 3. GP, 4. Others ( )	**Cause**	1. Corrosion, 2. Deterioration (Aging), 3. Traffic Load, 4. Wrong Construction, 5. Less Adhesive, 6. Pressure Fluctuation, 7. Defective Valve, 8. Destruction, 9. Other Construction, 10. Unknown, 11. Others( )
Diameter	mm		
Depth	cm	**Surface**	1.Asphal, 2.Concrete, 3.Gravel, 4.Grass, 5.Soil, 6.Others
Leakage Size	1. Large, 2. Middium, 3. Small, 4. Drops, Estimated volume (0.6 m3/h)	Detected Method	1. Patrol, 2. Customer Informing, 3. Acoustic, 4. Pinpoint,

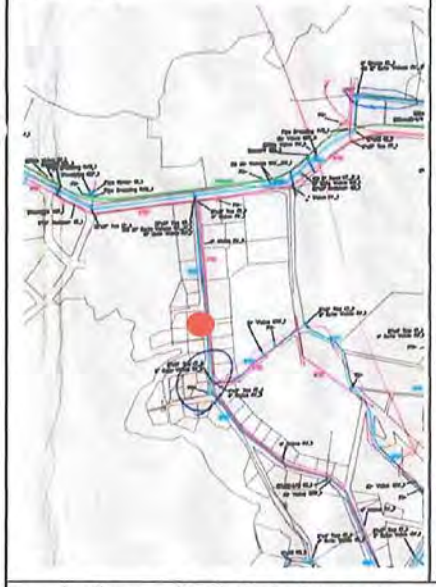
Leak Point



Hole/Crack Size:(cm)



Location Map



Photo

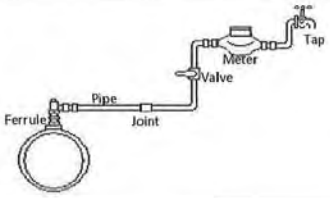
Remarks: Please confirm the boring investigation.

Leakage Record Sheet

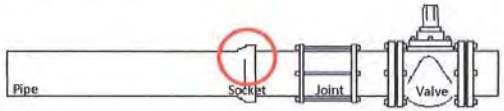
Leak. No 015

Date of survey:	9-Oct-14	Street	
House No,		GPS	N : 07° 20' 37.2" E : 134° 28' 48.0"
Main Pipe	1. CIP, 2. DCIP, 3. PVC, 4. ACP, 5. Others	**Location**	1. Pipe, 2. Joint·Socket, 3. Ferrle, 4. Valve, 5. Meter, 6. Tap, 7. Reservoir Tank, 8. Others,
Diameter	200 mm	**Condition**	1. Hole, 2. Crack, 3. Packing, 4. Loose Connection, 5. Over Flow, 6. Unknown, 7. Others ( )
Service Pipe	1. PEP, 2. PVC, 3. GP, 4. Others ( )	**Cause**	1. Corrosion, 2. Deterioration (Aging), 3. Traffic Load, 4. Wrong Construction, 5. Less Adhesive, 6. Pressure Fluctuation, 7. Defective Valve, 8. Destruction, 9. Other Construction, 10. Unknown, 11. Others( )
Diameter	mm		
Depth	cm	**Surface**	1.Asphal, 2.Concrete, 3.Gravel, 4.Grass, 5.Soil, 6.Others
Leakage Size	1. Large, 2. Middium, 3. Small, 4. Drops, Estimated volume (0.1 m3/h)	Detected Method	1. Patrol, 2. Customer Informing, 3. Acoustic, 4. Pinpoint,

Leak Point



Hole/Crack Size:(cm)



Location Map

Photo

Remarks: Please confirm the boring investigation.

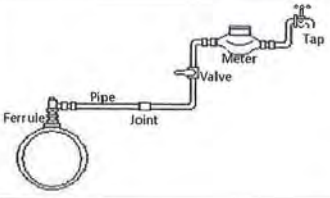
AP-12-9

Leakage Record Sheet

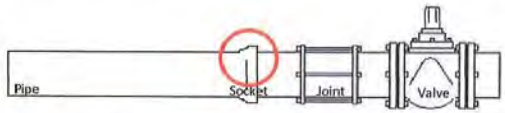
Leak. No 016

Date of survey:	9-Oct-14	Street	
House No,		GPS	N : 07° 20' 39.4" E : 134° 28' 50.1"
Main Pipe	1. CIP, 2. DCIP, 3. PVC, 4. ACP, 5. Others	**Location**	1. Pipe, 2. Joint·Socket, 3. Ferrle, 4. Valve, 5. Meter, 6. Tap, 7. Reservoir Tank, 8. Others,
Diameter	200 mm	**Condition**	1. Hole, 2. Crack, 3. Packing, 4. Loose Connection, 5. Over Flow, 6. Unknown, 7. Others ( )
Service Pipe	1. PEP, 2. PVC, 3. GP, 4. Others ( )	**Cause**	1. Corrosion, 2. Deterioration (Aging), 3. Traffic Load, 4. Wrong Construction, 5. Less Adhesive, 6. Pressure Fluctuation, 7. Defective Valve, 8. Destruction, 9. Other Construction, 10. Unknown, 11. Others( )
Diameter	mm		
Depth	cm	**Surface**	1.Asphal, 2.Concrete, 3.Gravel, 4.Grass, 5.Soil, 6.Others
Leakage Size	1. Large, 2. Middium, 3. Small, 4. Drops, Estimated volume (0.3 m3/h)	Detected Method	1. Patrol, 2. Customer Informing, 3. Acoustic, 4. Pinpoint,

Leak Point



Hole/Crack Size:(cm)



Location Map

Photo

Remarks: Please confirm the boring investigation.