CHAPTER 13 OPERATION AND MAINTENANCE

13.1 Operation and Maintenance of Water Supply Systems

PNG Waterboard (PNGWB) is currently operating water supply and wastewater treatment plants in 11 Provincial Towns. It is planned that PNGWB will operate the plants in all of the Provincial Towns though National Capital District (NCD), Goroka and Arswa are not included in the future. The PNGWB has much experience in running water supply plants in urban areas, and has a number of properly educated and trained staff. The PNGWB in Lae District can be an example to show its capacity where the operators are operating and maintaining the plant in 3 shifts, 24 hours a day.

On the other hand, the PNGWB does not have experience in supplying water to rural areas. In the Pilot Project Areas, the staffs of the Department of Works (DOW) have operated the existing facilities, and there are not many operators properly trained. Therefore, it is expected that the ways of operation and maintenance in these Pilot Project Areas will be the proper models of rural water supplies for PNGWB.

The water supply systems in Bereina and Kwikila are managed under the Southern Regional Office of Customer Services Division, while that of Mutzing is under the Northern Regional Office as shown in Fig.-13.1

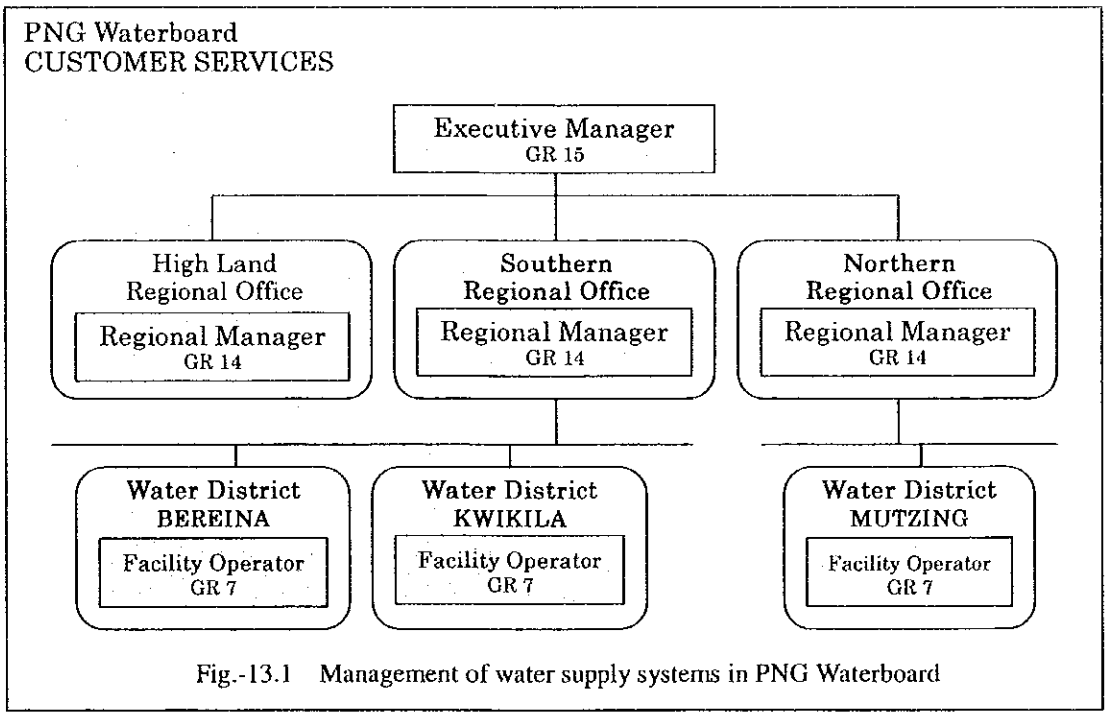


Fig.-13.1 Management of water supply systems in PNG Waterboard

As operators of these water supply systems, PNGWB staff that are Grade 7 or have the same abilities will be appointed. Moreover, a local assistant will be employed in each Water District to conduct the daily operations.

The following points are important for the daily O&M.

1) Continuous training and education to the operators
2) Technical supports from the Regional Offices of PNGWB in the event of breakdowns and renovations of the systems
3) Co-operations from the Provincial and Local Level Governments regarding the campaigns for the consumers in order for them to use the systems properly

Continuous training and education to the operators can not only improve their abilities but also encourage their motivations and responsibilities for their duties. Immediate actions from the PNGWB in case of breakdowns and renovations can make the consumers trust the systems, which encourage them to pay the water tariffs, and thus lead to more reliable systems. To encourage proper uses of the systems and avoid the thefts and vandalism, the campaigns are necessary with the co-operation of the Provincial and the Local Level Governments.

13.2 O&M Manuals

The PNGWB is currently using its O&M manual. However, these manuals are originally prepared for urban water supplies, and not necessarily suitable for rural water supplies. Therefore, "Operation & Maintenance Manuals for Water Supply System" were newly composed for each of the Pilot Project Areas. The following four points were considered when the new O&M manuals were composed.

1) To describe the structures and the specifications of the water supply systems clearly;
2) To describe the routine works using check lists;
3) To make the manuals easy to understand;
4) And to make the manuals a model for the other sites.

The outlines of the O&M manuals prepared by the Study Team for the Pilot Project are shown as follows.

JAPAN INTERNATIONAL COOPERATION AGENCY
THE PAPUA NEW GUINEA WATERBOARD

THE STUDY ON GROUNDWATER DEVELOPMENT
FOR WATER SUPPLY SYSTEMS
IN PAPUA NEW GUINEA

OPERATION & MAINTENANCE MANUAL FOR WATER SUPPLY SYSTEM

— KWIKILA —

July 2001

JAPAN TECHNO Co.,Ltd.
TOKYO JAPAN

CONTENTS

1. Introduction

This "Operation and Maintenance Manual for Water Supply System" describes for the Facility Operators how to operate and maintain water supply facilities continuously in Kwikila.

The Facility Operator has several important roles with regard to the water supply service. The main tasks of the Facility Operator are as follows;

1. To operate the facilities properly.
2. To patrol and inspect the facilities daily and weekly.
3. To write the operation daily, which consists of operation data, etc.
4. To report to the Regional Office, weekly and/or monthly.
5. To correspond with Regional Office in case of trouble.

The sustainability of the water supply facilities depends on the Facility Operator's tasks as listed above. Therefore it is expected that this manual be referred to by Facility Operators at all times.

THE STUDY ON GRANDWATER DEVEROPMENT
FOR WATER SUPPLY SYSTEMS
IN PAPUA NEW GUINEA

JAPAN INTERNATIONAL COOPERATION AGENCY
JICA STUDY TEAM
JAPAN TECHNO Co., Ltd

2. Outline of the Water Supply System

The Water Supply System constructed in this pilot project is comprises of five facilities as follows.

(1)	Pump Station	1 Station
(2)	Rising Main Pipeline	1 System
(3)	Water Storage Tank	Ground Tanks 60 m^3 ×2
(4)	Distribution Pipeline	1 System
(5)	Public Faucet	1 Unit

In addition to these new facilities mentioned above, there is an existing pipeline reticulation and water storage tanks in Kwikila.

The pump station consists of three portions (Well facility, Pump house and Power souses). Water storage tanks are located in water supply areas as follows.

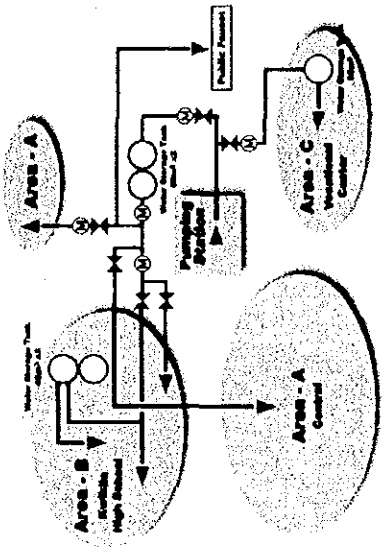
3. Water Supply Area

There are three water supply areas (A)Central, (B)Kwikila High School, (C)Vocational Center in Kwikila. Each area has a water storage tank.

Water Supply Area		Water Storage Tank
Area-A	Central	Ground Tanks 60m^3 ×2
Area-B	Kwikila High School	Ground Tanks 45m^3 ×2
Area-C	Vocational Center	Ground Tank 45m^3

A gate valve is located on a distribution pipeline for each water supply area. These gate valves will enable the control of distribution to these areas.

OPERATION & MAINTENANCE MANUAL FOR WATER SUPPLY FACILITY

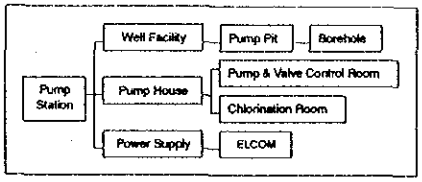


THE STUDY ON GRANDWATER DEVELOPMENT FOR WATER SUPPLY SYSTEMS IN PAPUA NEW GUINEA | SITE : KWIKILA | Figure - 1 | Water Supply Areas

OPERATION & MAINTENANCE MANUAL FOR WATER SUPPLY FACILITY

4. Pump Station

The pump station in Kwikila consists of three portions (a) Well facility, (b) Pump house, (c) Power supply as follows.



The Specification of Well Facility

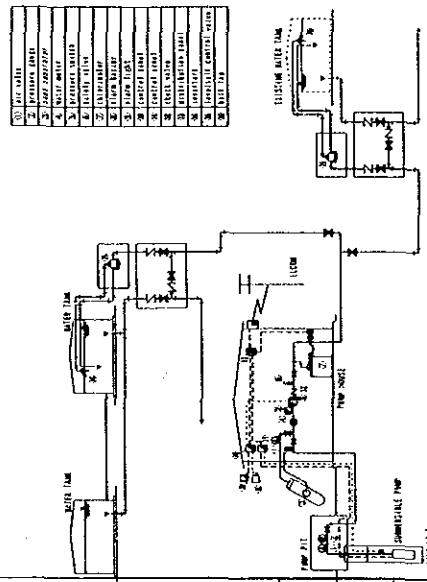
Borehole	Dia. = 150 mm (inside 143 mm), Depth = 31m	
Screen	Depth = 5.1 ~ 11.1 m & 23.1 ~ 29.1 m	
Pump	Submersible Pump	; AC3 φ 400V, 200L/min×65m
	Riser Pipe	; GSP 3" (outside 89mm)
	Pump Installation depth	; 20 m

5. Pump House

The pump house separated into two rooms "Pump control room" and the "Chlorination room". The pump control panel has been installed in the pump control room. The gate valves, sand separator, safety valve, check valve and water mater have been installed along the pipe in this room.

The chlorination room is for the chlorinator. The pipeline from the borehole reaches this room through the pump control room. Solution chlorine injection will be done by the injection pump in this room before the water goes up to water storage tank.

OPERATION & MAINTENANCE MANUAL FOR WATER SUPPLY FACILITY

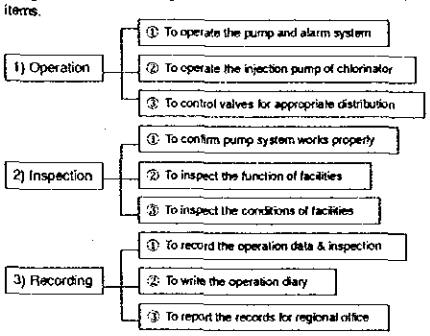


THE STUDY ON GRANDWATER DEVELOPMENT FOR WATER SUPPLY SYSTEMS IN PAPUA NEW GUINEA | SITE : KWIKILA | Figure - 2 | Flow Diagram

OPERATION & MAINTENANCE MANUAL FOR WATER SUPPLY FACILITY

6. Management

The management role to be done by the Facility Operator is categorized into three categories and each one is divided into three items.



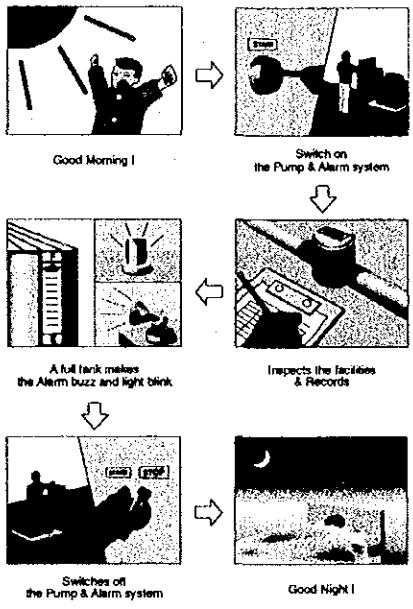
7. Daily Operation

The Facility Operator's daily work begins by switching on the pump, and his work continues from morning to evening as follows:

1. Switch on the pump and alarm system
2. Check & confirm the system if it is working properly
3. Adjust the chlorinator and valves where necessary.
4. Write the operation dates on record.
5. Inspect the function and conditions of facilities.
6. Switch off the pump and alarm system
7. *Write the operation diary.*

OPERATION & MAINTENANCE MANUAL FOR WATER SUPPLY FACILITY

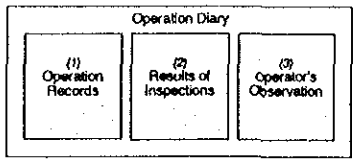
8. One Working day for the Facility Operator



OPERATION & MAINTENANCE MANUAL FOR WATER SUPPLY FACILITY

9. Operation Diary

The Facility Operator has an obligation to write the operation diary everyday. The operation diary includes operation records, result of inspections and the operator's observation.



The main items of operation records which operator has to pay attention are listed below. The operation record should be attached to monthly reports for the regional office.

1. Date / Operator's Name and Signature
2. Operation time
3. Water discharge and pressure
4. Water flow in each water supply area
5. Information of trouble and/or accident if it happen

The form of the operation record will be instructed for facility operator by the regional office but there is an example, which is comprises of the recommendable items in the appendix of this Operation and Maintenance Manual.

OPERATION & MAINTENANCE MANUAL FOR WATER SUPPLY FACILITY

10. Check List Items

Daily inspection and confirmation will be done by the Facility Operator. The main check list items are listed below. Weekly and/or monthly inspection will be held based on this list also.

Date: / /		Time:	Name:	Signature:	Y	N
(1) Pump House	1-1	Is the pump operating correctly ?			☐	☐
	1-2	Is the alarm system working correctly ?			☐	☐
	1-3	Is the chlorinator working correctly ?			☐	☐
	1-4	Is the pressure and flow sufficient ?			☐	☐
	1-5	Is the pipeline in the control room free from leakage ?			☐	☐
	1-6	Is the pump house being kept clean ?			☐	☐
	1-7	Are the doors and gate locked for security ?			☐	☐
(2) Water Storage Tanks	2-1	Is the level control valve working correctly ?			☐	☐
	2-2	Is the ball tap working correctly ?			☐	☐
	2-3	Does the water level indicator work correctly ?			☐	☐
	2-4	Are the tank and valves free from leakage ?			☐	☐
	2-5	Is the drain clear from sand or rubbish ?			☐	☐
(3) Pipeline and Valves	3-1	Is there any water leakage along the pipeline ?			☐	☐
	3-2	Are the water meter and valves working properly ?			☐	☐
	3-3	Is there any portion damaged by accident ?			☐	☐
(4) Public Faucet	4-1	Are the taps in good working order ?			☐	☐
	4-2	Are the water meter and valves working properly ?			☐	☐
	4-3	Is the meter box free from leakage ?			☐	☐
	4-4	Is the drain clear from sand or rubbish ?			☐	☐
	4-5	Is the Public faucet kept clean by the people ?			☐	☐
(5) Others	5-1	Is the facility environment in a satisfactory sanitary condition?			☐	☐
	5-2	Is the pipeline free from illegal connection ?			☐	☐

OPERATION & MAINTENANCE MANUAL FOR WATER SUPPLY FACILITY

11. Maintenance

Maintenance of the facilities forms the basis for the long team sustainability of the water supply system. Therefore it is important that the Facility Operator pays special attention to each facility and maintains the system. Important items of maintenance are listed below.

1. Submersible Pump
   The submersible pump shall be maintained according to the methods by which the manufacturer and/or supplier recommends. If there is a technical problem, the Operator should report to the Regional office after the confirmation of the actual condition.

2. Chlorination Pump
   The chlorination pump shall be maintained according to the methods by which the manufacturer and/or supplier recommends. The cleaning of the Chlorination Pump and surrounding shall be done once a week.

3. Water Storage Tank
   The cleaning of the Water Storage Tank and surrounding shall be done once a month.

4. Meter Box and Valve Box
   There are meters and valve boxes in the reticulation of the system. These facilities must be maintained properly also. The cleaning of these facilities and surrounding shall be done once a month.

5. Emergency Case
   In emergency cases where an accident or trouble occurs, the Facility Operator has to report to the Regional office immediately.

CHAPTER 14 TECHNOLOGY TRANSFER

14.1 Technology Transfer

One of the objectives in this Pilot Project is to transfer technologies in terms of the water supply system to the PNG side. The persons to whom the technologies are to be transferred are the counterparts of this Study in the Technical Services of PNG Waterbord (PNGWB) and the operators of the new water supply systems. Especially, for the counterparts from the PNGWB, the JICA Study Team paid attentions to let them become involved during the whole period of the construction works including the preparation. The summary of the technology transfer is described in Table-14.1 below.

Table-4.1 Contents of the Technology Transfer

Target Person	Contents of Technology Transfer	
Counterparts & Technical Services	Groundwater Development & Water Resource Planning	• Geophysical survey & selection of test drilling points • Pumping test & evaluation of groundwater potential • Volume of water production and water demand in water source planning • Selection of water intake facilities & pumps
	Designing of the Facilities	• How to formulate water supply plans • How to design water supply facilities
	Supervision of the Construction Works	• *How to supervise the progress of the construction works* • How to supervise the safety measures • Discussions with the relating agencies & co-ordination for land issues
	O&M	• How to operate, maintain and manage the systems
Operators	O&M	• How to operate the pumps and the chlorinator • How to carry out the daily checks of the system • How to record and report the daily data

14.2 Instructions for the Operations

Instructions will be given to the staffs and engineers of the Technical Services and the Customers Services, PNGWB as well as the operators at the Pilot Project sites. The instructions include how to operate and maintain the water supply systems.

The staffs and engineers from the Technical Services of the PNGWB have been involved in the

Study from the beginning, whereas the staffs from the Customer Services are also involved in the O & M after the completion of the Pilot Project construction works. It is necessary to explain the concepts of the water supply systems and instruction to the staffs of the Customer Services during the test operation.

The contents of instructions for the O & M are as follows.

① Outline of water supply systems and the water facilities
② How to operate and maintain the submersible motor pumps
③ How to operate and maintain the power sources, i.e. solar generating system, the generator and so on.
④ How to operate and maintain the alarms
⑤ How to operate and maintain the chlorinador
⑥ How to operate and maintain the sand-separator
⑦ How to adjust the valves

The O & M Manuals that were prepared by the Study Team counterpart should be effectively used for the training of the operators.

14.3 The seminar for Technology Transfer

The Study Team conducted the Seminars for Technology Transfer at Daru, Lae and Port Moresby in October 2001.

1) Seminar at Daru, Apostolic Church Hall on October 4, 2001
2) Seminar at Lae, Conference Room of Lae International Hotel on October 9, 2001
3) Seminar at Port Moresby, Conference Room of Airways Hotel on October 16, 2001

The Seminar was aimed at introducing the results of the Study and facilitating technology transfer to the Papua New Guinean side concerning the respective technical fields covered by the Study. The locations of the Study Areas namely two Provincial Towns of Popondetta and Daru, and six District Towns of Bereina, Kupiano, Kwikila, Finschhafen, Mutzing and Oro Bay, and convenience to the participants to attend the Seminar from the respective Study Areas were considered. These Seminars were effective to realize exchange of ideas and to confirm mutual understandings of the Study. More than one hundred persons in total participated including the representatives of National Planning and Monitoring, PNGWB, Provincial Government, Local Level Government and the communities from the Binaturi Villages. The list of participants to the Seminars is shown in Data Book, Record of Seminar 2001.

14.4 Counterpart Training Programme

Two counterpart engineers from PNGWB joined the JICA's counterpart training programmes in Japan in April 2001 and August 2001, respectively. They had an intensive training programmes including groundwater development study, water supply master plan, design of water facility and discussion with operation and maintenance of several water supply plants, and deepened their integrated knowledge about water supply technologies in Japan.

CHAPTER 15 PROJECT EVALUATION

15.1 Environmental Evaluation

This Study involves groundwater development for water supply systems. Considering environmental points of view, the water supply project for District Towns is not a huge project to affect the environment seriously. However the water supply system should be sustainable operated and managed in long terms of 10 to 20 years. Therefore, the three items related to groundwater pumping as follows should be monitored.

1) The influence from existing boreholes on water level changes by the groundwater pumping
2) The saline water intrusions by groundwater pumping near the sea coast
3) The land subsidence by groundwater pumping for water supply system

On the other hand, considering District Town water supply there are no serious environmental affects by the implementation and operation of the Project. However, the stable water supplies to District Towns and surrounding villages are increasing wastewater in the areas, and therefore, environmental sanitation should be considered by the inhabitants themselves. This District Town water supply project including groundwater development can improve the situations in reducing the labour work of women and children in carrying water, increasing living standards due to steady and safe drinking water, and increasing economic activities in the Study Areas. This water supply project invites more positive benefits to the people.

15.2 Evaluation on Organization and Institution

Concerning water supply and sewerage services in the Provincial Towns, PNGWB has been making efforts to improve the service continuously. Financially PNGWB has a self-contained status and is making an appropriate profit while other CSAs are heavily depending on the governmental financial support. When the entire institution of PNGWB is focused, it is observed that more efficient service and more effective contact with the users are encouraged under the organization's strategy. In this Study, the Study Team recommended to PNGWB to promote the District Towns with new water supply systems as new Areas. The Pilot Project was implemented confirm the feasibility of the recommended policy. During implementation of the Pilot Project, the problems were verified and the applied organization & institution were evaluated. PNGWB hardly had this kind of experience to start up a brand new water supply system, and for the Technical Services Division that was in charge of this Study, implementation of this Pilot Project was a good opportunity to get valuable knowledge and experience. Especially the applied approach of holding open discussions

with the stakeholders such as the local governments and residents in the workshop during the planning stage and keeping frequent communications with the relevant agencies in the central government like DNPM and ORD is assumed effective when similar projects are implemented by PNGWB. It is considered that these knowledge & experience were absorbed within PNGWB. Renovation of the Customer Service Division is on-going as mentioned above, and function of the Regional Office and its head, the Regional Manager is expected to be effective. Among the sites of the Pilot Project, Mutzing is controlled by the Northern regional Office which is located within the PNGWB's Lae Water District Office, and on the other hand the Southern Regional Office which covers Bereina and Kwikila has not received the appointed Regional Manager yet. The Southern Regional Office is to be set up within the headquarters of PNGWB in Port Moresby and quick preparation is expected. The entire PNGWB's organization & institution has enough capacity to satisfy the basic demands on technical issues for operation, management and maintenance of water supply service. As a further development to reinforce the organization & institution, ceaseless efforts such as getting closer communications with the users, planning to achieve higher contentment of the users, familiarization of proper use of water supply system and payment for water among the users, etc. are required. Necessary action like an appointment of staff in charge of this function within the Customer Service Division is suggested.

15.3 Technological Evaluation concerning Water Supply Facility

1) Technological Evaluation

Construction of the new water supply facilities of the Pilot Project was completed in July 2001, and the facilities were handed over to PNGWB. Although the new water supply facilities improved water supply services in the target sites, not only new constructions but also the tasks of PNG side for effective usage of existing facilities were included in the Pilot Project. The tasks of PNG side consist of the renovations of existing distribution pipelines, house connections and new installation of house connections according to the requests from the residents.

These facilities are operated well although it is still in the period of trial run prior to the start of official water supply services under the User Pay Policy. The situation of new water supply facility in the Pilot Project in October 2001 is shown in Table-15.1 to 15.4 below.

Table-15.1 Situation of Water Supply Facilities in Bereina

Items		Situation of the Operation
Integrated Evaluation		Excellent
1	Solar Generating System and Diesel Engine Generator	The solar generating system is operating well. A more efficient operation of water supply system could be done and operating hour of the standby generator which is sometimes used can be reduced by the accumulation of data concerning the tendency in water consumption,
2	Chlorination	Operating well
3	Pipeline & Tap	Operating well. A minor adjustment of the valves and renewal of the existing distribution pipes & taps are necessary.
4	Elevated Tank	Operating well
5	Public Faucet	Operating well. It is judged that continuous education and awareness campaign to villagers concerning the maintenance such as cleaning etc. are necessary because many unclean public faucets are observed.

Table-15.2 Situation of Water Supply Facilities in Kwikila

Items		Situation of the Operation
Integrated Evaluation		Excellent
1	ELCOM Power Line	Operating well
2	Chlorination	Operating well
3	Pipeline & Tap	Operating well. However a more appropriate water supply is possible by the adjustment of the valves and water consumption in each water supply area based on data concerning the tendency in actual water consumption. Existing distribution pipeline and taps should be renovated.
4	Elevated Tank	Operating well
5	Public Faucet	Operating well. Daily cleaning is not sufficient. It is judged that continuous education and awareness campaign to villagers concerning the maintenance such as cleaning are necessary.

Table-15.3 Situation of Water Supply Facilities in Mutzing

Items		Situation of the Operation
Integrated Evaluation		Excellent
1	ELCOM Power Line	Operating well
2	Chlorination	Operating well
3	Pipeline & Tap	Operating well. A more appropriate water supply is possible by adjusting the valves based on data concerning the tendency in actual water consumption, and water consumption in each water supply areas. Existing distribution pipes and an existing water faucet should be renovated.
4	Elevated Tank	Operating well
5	Public Faucet	Being well operated, and maintenance by the villagers is kept in good condition.

Table-15.4 Situation of Water Supply Facilities in Daru and Binaturi

Items		Evaluation
1	Water Vending Unit	It is operating well. It is necessary for education and awareness on crime prevention continuously.
2	Dug Well	Although the activities for construction of dug wells with village participation is ongoing because of the influence of the rainy season, successful 6 bore wells with hand pumps are operating. On the other hand, only 3 dug wells are constructed. The construction work by the villagers was not easy under the condition where the groundwater level was high due to the rain.
3	Rainwater Collection	Operating well, 19 units completed

2) Installation of Water Meter &Rehabilitation of Existing Pipeline

The operation of water supply services is based on the User Pay Policy. Installation of water meters that is a part of the responsibilities of PNGWB has just began in the District Towns. This is to install a water meter in each House-Connection that is a branch from a main pipeline. As there are newly contracted users in these Areas, prompt action to realize new House-Connections including water meter and taps for new customers is also necessary and PNGWB is preparing this.

Rehabilitation of existing pipelines is planned as the responsibility of PNG side in order to minimize the amount of Unaccounted-for-Water (UFW) and improve the effective water ratio of water supply. Actually, parts of the existing pipelines are becoming deteriorated, and clogged due to scale and sand, and causing leakages at several points although major leakages have already been repaired by PNGWB.

The preparation of the above-mentioned works such as installation of water meters in House-Connections and the rehabilitation of existing pipelines is advanced by the PNGWB. For instance, it is reported that the number of installations of water meters in Mutzing are 60 units in the Station, 11 units in Mutzing Primary School, 21 units in Markham Valley High School and it becomes 92 units in total.

The procurement of materials for these works are going on and these works are expected to be completed by the end of October, 2001 in Mutzing. The works in Bereina and Kwikila are also under preparation by PNGWB. The outline of works to improve Unaccounted-for-Water (UFW) and effective water ratio is shown in Table-15.5 below.

Table-15.5 Installation of Water Meter &Rehabilitation of Existing Pipeline

(1) Works concerning Water Charge Collection by Metering	①Service Connection (New installation) From main supply pipe to water meter, Max. 25m length
	②House Connection and Tap (New installation) After water meter to yard tap or house tap
(2) Works concerning Improvements of UFW and an Effective Water Ratio on Water Supply	①Wash out of existing pipeline The scale and sand are washed out from existing pipeline
	②Repair and/or replacement of existing pipeline Repair of water leakage and replacement of damaged parts
	③Repair and/or replacement of House Connection and Tap Repair of taps and replacement of damaged parts

The works mentioned above to improve the rate of metered quantity of water and rate of effectiveness of water consumption are promoted by PNGWB. "House Connection and Tap (New installation) " and "Repair and/or Replacement of House Connection and Tap" are supported by PNGWB, although these works are the responsibility of Provincial Government and Local Level Government.

3) Situation of Operator's Activity

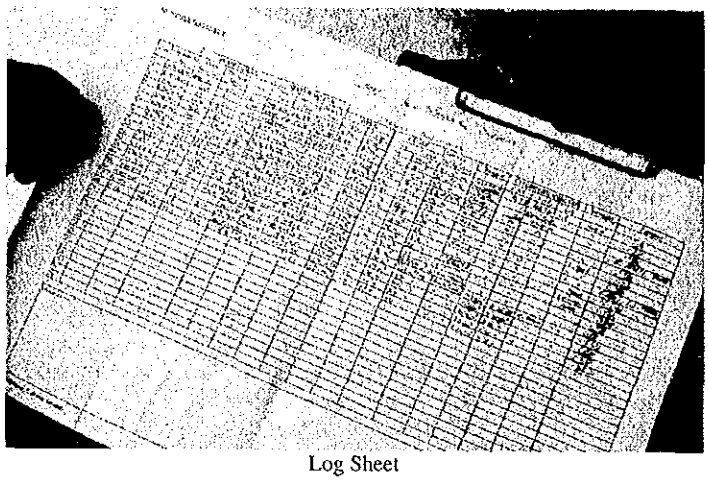
The installation of water meters and the rehabilitation of existing pipeline are progressing. Therefore, the operation of water supply facilities in the period before the start of official water supply services is on a trial run without water charge collection. This period provided good opportunity for On-the-Job Training (OJT) to facility operators to become familiar with the new facilities and their tasks. Facility operators received practical experience through the whole operators' tasks including pump operation, adjustment of valves, recording and reporting.

a) *Recording of Operation*

The operation diary and the Log sheet are filled up by the facility operator at each Site. The example of forms had been suggested in OM&M Manual by JICA Study Team, and PNGWB made forms for each site based on the suggestion.

The facility operator fills up this form to record supply hours, operation time, discharge and amount of water supply in each Area. The tendency and the characteristics of the water consumption in each water supply area will become clear gradually from the accumulation of these data. It is necessary to adjust the water supply hours and water-consumption based on these tendencies and characteristics.

Operator fills up log sheet



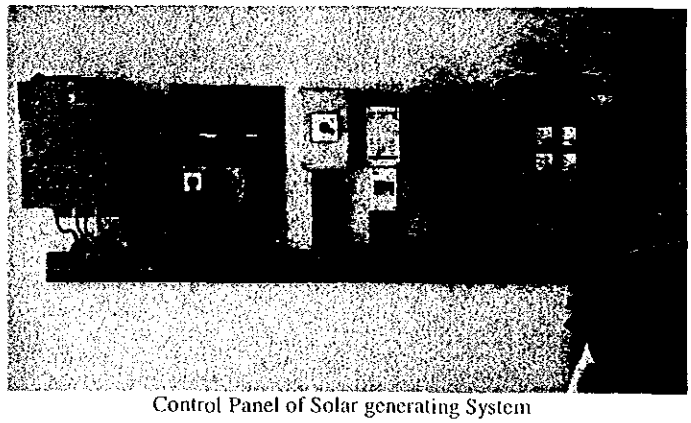
Log Sheet

At the start of official water supply services under the User Pay Policy, more efficient water supply service is expected by adjustments based on the information concerning the tendency and characteristics of the water consumption in each District Town water supply area. The operation diary and the Log Sheet are reported to the Regional Office.

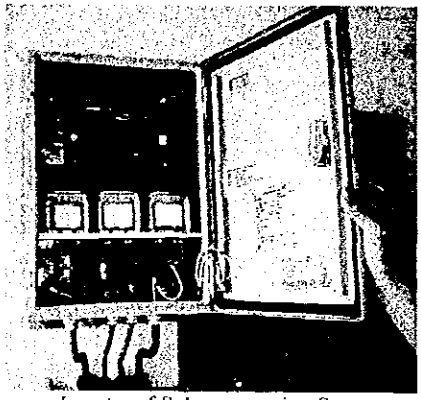
These concrete data as well as data on income and expenditure obtained from this Pilot Project will become valuable basic information on water supply management system when PNGWB develops the water supply service in other District Town in the future.

b) Control of Pump and Solar Generating System

The pumps and the solar generating system are driven smoothly by facility operators. Concerning the solar generating system, it is the first trial in PNGWB to be adapted into the water supply facility. It was a good opportunity to become familiar with the system including inter-change of solar generating system and standby diesel engine generator by actual operation during the period of the trial run. Even for the counterpart staff from PNGWB, it was quite new.



Control Panel of Solar generating System

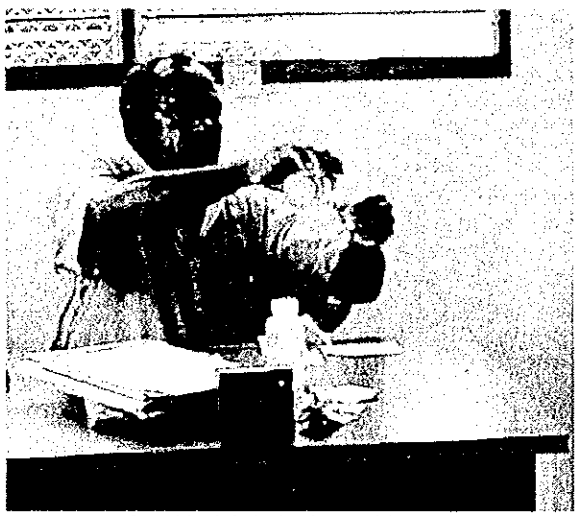


Inverter of Solar generating System

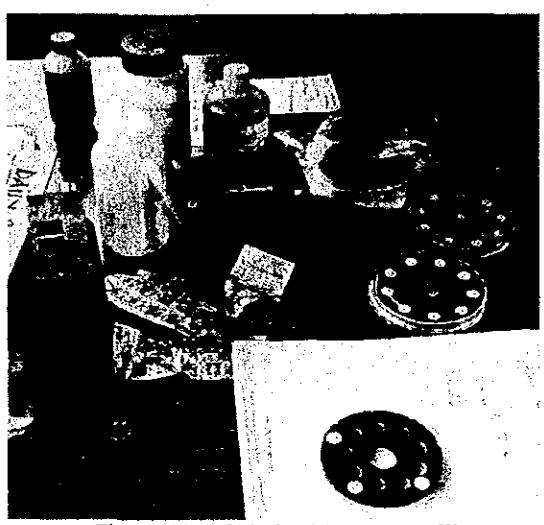
Control of the solar generating system installed in Bereina is automatic and touching the control panel is not necessary during usual operation. However, it is necessary to record not only the water consumption in each water supply area, but also the relation between insolation (or degree of sunshine), temperature, the amount of cloud and pump discharge during the actual operations. It is necessary to take tendencies of the parameters such as insolation into consideration in addition to the characteristic of the water consumption in each area for effective operation of the water supply system. The facility operator is accumulating this kind of record in Bereina.

c) Inspection of Residual Chlorine

In three sites (Bereina, Kwikila, and Mutzing), the water disinfections by chlorination is done, and the measurement of residual chlorine is one of the important tasks of the facility operator. The facility operator inspects the water sample every day with the residual chlorine measurement kit provided by PNGWB. The facility operator makes the chlorine solution by mixing bleaching powder (chlorine powder) and water. It is required to agitate the chlorine solution several times in a day, because the solution separates in the tank gradually, and the facility operator should pay attention on this point



Test of Residual Chlorine by Facility Operator



The Residual Chlorine Measurement Kit

The allowable range of residual chlorine is 0.1-1.0 mg/lit for WHO Standard and maximum limit is 0.7 mg/lit for PNGWB Standard. The installation of water meters and the rehabilitation of existing pipelines are progressing and the operation of water supply facilities during this period is on a trial basis. Facility operator should understand and consider the situation of the water supply system when he checks the residual chlorine. Support system from Regional Office that supervises each site has been already established. Sampling for the

water quality analysis will be carried out at the site by the personnel who are dispatched by the Regional Office, and regular water quality analyses will be done every month after the start of official water supply services.

d) Regular Reporting

The radio, which the Study Team used during the Study period, was handed over to PNGWB for setting up in Bereina and Kwikila where public communication means are not available. This radio equipment is expected to be used for daily reporting to the PNGWB headquarters in Port Moresby effectively.

15.4 Economic and Financial Evaluation

In this Study, rehabilitation, construction and extension of the water supply systems at 6 District Towns were considered. As it is described in Chapter 10, generally the revenue of this kind of small-scale water supply system is not enough to cover the operation cost, and the financial evaluation tends to be severe. All 6 District Towns showed negative the financial balance in 15 years of the target year. However, if the Provincial Government's subsidy is provided to PNGWB in the amount which is equivalent to the amount of their budget being spent for current water supply systems, the deficit made by the operation will be compensated to PNGWB and PNGWB and they will be able to sustain operation of water supply service in these District Towns. Regarding the fund for construction of the facilities, foreign Grant Aid and/or governmental Grant funding are prerequisite for capital investment at the 1st Stage of the master plan. In this case the funds for the investment after the 2nd Stage and the cost for replacement of facilities and equipment shall be secured from the ORD's rural development fund and/or the PNGWB's surplus made in their operation in Provincial Towns. The most serious problem is the fact that water supply service in more District Towns means heavier financial burden for PNGWB. Therefore, the extension of water supply service in District Towns shall have to be on a slow pace. If a system to allocate flexibly using the development fund for capital investment from the budget of the Central Government is established, the situation would change. However, currently the Central Government faces a severe financial condition and it seems difficult to expect such change immediately.

On the other hand, economic evaluation confirms that the economic benefit will exceed the cost if the water supply system is run properly. Moreover, it is assumed that improvement of water supply service will bring larger positive effects socially than the economic one. It is expected to contribute to development activities in the Area and favourable economic effect caused by this development would spread further.

15.5 Monitoring and Evaluation based on PDM

Several workshops for Project Cycle Management (PCM) have been held with the concerned persons since the first field survey, and resulting in forming Project Design Matrix (PDM) for the Pilot Project of groundwater development and rehabilitation and enhancement of existing water supply facilities in Kwikila, Bereina and Mutzing.

In the first place, the main objective to make PDM is to introduce PCM methodology and build mutual consensus for the Pilot Project, thus the utilization of PDM for the monitoring and evaluation is not necessary the intent. Due to above-mentioned background, existing PDM is not appropriate as it is for the monitoring and evaluation. In addition, the activities conducted by PNGWB have not yet been completed. Considering such situation, it is recommended that PNGWB itself will evaluate the Pilot Project later on.

The Tentative Framework for the Evaluation is recommended as follows;

When	From six (6) months to one year after starting the normal operation. It is estimated around from July 2002 to December 2002.	
Who	PNGWB	
What	Based on five (5) evaluation criteria	
	1) Relevance	The issue of privatization is considered to be the most influential factor.
	2) Effective	As for measuring the effectiveness of "Input", "Plan of Operation (Tentative Activity Plan)" will be referred. As for measuring the effectiveness of "Output" and "Project Purpose", the indicators in the PDM will be referred.
	3) Efficiency	The ratio of inputs to outputs for the Pilot Project will be compared with the ratio of other similar project.
	4) Impact	Unexpected positive and negative impact as the result of the Pilot Project will be inquired.
	5) Sustainability	The budgetary sustainability is thought to be the crucial part of the evaluation and actual disbursement from Province Governments based on the agreement between PNGWB and Province Governments will be an observable indication.
	Other Contributing or Interfering Factors	After reviewing above-mentioned five (5) criteria, it would be recommendable to inquiry other contributing or interfering factors again. Even when "Project Purpose" is accomplished well, it is not necessarily the fact that the activities conducted by the Project are real or direct cause of the positive change.
Where	In PNG	
How	Based on PDM and PO (Tentative Activity Plan)	

The main objective for making the PDM is to discuss the outline of the Pilot Project and establish the consensus for the Pilot Project between JICA Study Team and PNGWB. In addition, the

introduction of Project management by the PCM is another one as part of technology transfer activities. The PDM is thought not to be necessarily applicable for the monitoring and evaluation as it is, because the consideration to the part of activities conducted by PNGWB were not given adequately. It is thought that the limitation and shortfall of the PDM is clarified at the Technology Transfer Seminar in the third field survey.

The shortfall or careful points of the PDM are thought to be as follows;

1) Project Period

The period of established PDM is from February to October 2001, which is the end of the field survey period of JICA Study. When the PDM was made, the focal point was the period of JICA Pilot Project. However, it is thought that the completion of all the activities by October 2001 is not realistic. It will be required to readjust the appropriate timeframe after the third field survey.

Although tentative Plan of Operation (Tentative Activity Plan) has also been made based on the PDM, it has not yet been discussed in detail between JICA Study Team and PNGWB. The PNG WB was still inquiring the viable process for the Pilot Project including the required budget. If it is necessary to refer them for monitoring and evaluation, it will be necessary to review the tentative Plan of Operation and need certain consensus between JICA Study Team and PNGWB.

2) Monitoring and Evaluation

When the monitoring or evaluation is conducted for this Pilot Project, it is expected to apply five (5) indicators that are common in PCM method: Relevance, Effectiveness, Efficiency, Impact and Sustainability. However, it would be difficult to apply the above five (5) indicators at the end of present Project period.

As mentioned-above, it will be required to reconsider appropriate timeframe for the Pilot Project and fix the suitable time for the evaluation. In addition, there would not be appropriate staff who can use PCM Method for the monitoring and evaluation in PNGWB, and therefore it will be required to supply some kind of technical assistance for it.

3) Applicable Scope of Established PDM

The PDM is prepared for the Pilot Project in Kwikila, Bereina and Mutzing. Therefore, it does not include the Pilot Project in Daru and Binaturi of Western Province. In addition, it should be understood that it is designed for the Pilot Project and it is not intended to show the outline of this JICA Study generally.

Table-15.6 Project Design Matrix (PDM)

Project Title: The Study on Groundwater Development for Water Supply Systems in Papua New Guinea
Project Duration: April 2000 ~ October 2001 Target Area: Kwikila, Bereina, Mutzing
Target Group: Communities & Institutions in the target area Date of entry: March 3 2001 (Version: 1.0)

Narrative Summary	Objectively Verifiable Indicator	Means of Verification	Important Assumption
Overall Goal ☐ Living condition like health will be improved			
Project Purpose ☐ Safe, adequate quantitative, easy accessible and sustainable (including drought-resistant) water supply will be available to residents and institutions (users) ☐ Safe and convenient water is provided continuously	1-1. Water, of which quality satisfies the WHO standard, is supplied at the each water point (individual and public faucet) 1-2. The coliform contamination is to be improved at the individual faucet 1-3. The residuum of chlorination is maintained at the individual faucet 2. The amount of water consumption per capita is met to the planed level by the government 3. The operating hours is met to the demand 4. The water service level at the target area is became the same level as the NCD. 5. All pre-registered households and institutions is to be supplied properly	☐ The result of analysis conducted by JICA study team ☐ The result of severance by JICA study team and PNGWB ☐ The result of severance by PNGWB	☐ Provincial Government disburse subsidies according to "Minutes of Agreement" signed between Government and PNGWB
Output 1. Existing Water supply facilities are rehabilitated properly and improved 2. Management system for water supply service is established	1-1. The amount of water supply is increased 1-2. The rate of Unaccounted for Water (UFW) is decreased less than 26% (This figure is the average of PNGWB, in June 2000) 2-1. Required number of staffs, as following, is assigned: Manager, Operator, Revenue Collector 2-2. Revenue recovery rate increase as 0% to 9% 2-3. Each monthly report is submitted to Head Quarters	☐ The result of analysis conducted by JICA study team ☐ The result of severance by JICA study team and PNGWB ☐ The result of severance by PNGWB	☐ Pipelines are properly maintained and connected each household / institution's building to water meter by PNGWB ☐ Community based organization is established by Provincial Gov. and/or District Gov. ☐ There is no vandalism in the target area

Activity
1. Construction work for water supply facilities
1-1. Adequate quality of borehole is constructed
1-2. Procurement of required materials is done
1-3. Submersible motor pumps are installed
1-4. Adequate power supply system is installed
1-5. Water tanks which satisfied the necessity is installed
1-6. Chlorinator is fitted at the pump station
1-7. Main pipe line is repaired properly
2. Test Operation of water supply system is completed
3. JICA Study team hands over the constructed water supply system to PNGWB
4. Budget and logistic for Operation and Maintenance(O&M) is properly settled
4-1. Water meter is fitted at each household and/or building in target area
4-2. System of billing and collecting for revenue is established
4-3. Provincial Gov. and/or certain administrative agrees to arrange the subsidies for O&M in the target area
4-4. Investment plan in the near future is carried out
5. Human resources on management is assigned
5-1. Required number of staffs, as following, is assigned: Manager, Operator, Revenue Collector
5-2. Training of assigned staffs
6. Information technology is established
6-1. Reporting system from each site to HQ
6-2. Customer list and/or other related information is registered and used practical
6-3. Necessity of public relations including marketing is realized
7. Institutional management system is established
7-1. Regional office is established and starts its activity
7-2. District office at each project site is established and starts its activity
8. Customers register officially to the water service in target area
9. The Board of PNGWB approve to recommend this project as "Declaration of Water District" and also recommend as the same, to those ministers related to this project

Input

Japanese Side
Human resources:
Consultant team (11 consultants)
NGO (Community Organizer)
Project cost:
Rehabilitation costs for the existing water supply facilities (excludes the cost for piping to individual households)

PNG Water Board (PNGWB) Side
Human resources:
Counterpart staffs (engineer)
Project site staffs
Manager: 2
Operator: 3
Revenue Collector: 2

Land:
Sites for facilities to be constructed
Equipment
Water meters and it's installation cost

Local costs

Pre-Conditions
☐ The Provincial Gov. agrees to subsidize the deficit of Operation and Maintenance cost for the water supply systems

☐ PNGWB takes over a function of water supply service in each target area

CHAPTER 16 CONCLUSION AND RECOMMENDATIONS

16.1 Conclusion

Based on the series of technical discussions between the Study Team and the PNG Waterboard (PNGWB) the conclusions obtained from this Study are as follows.

(1) As the results of the first full-fledged Study on groundwater development in Papua New Guinea conducted in this Study, 6 boreholes out of 8 test boreholes were completed successfully as production wells. This indicates high potentials of groundwater development in the country.

(2) In the Pilot Project implemented at 4 sites of the Study Area, the existing water supply facilities were rehabilitated and new facilities were constructed, and the completed District Town water supply systems were handed over to PNGWB. Also the technology transfer on sustainable operation, management and maintenance of the water supply facilities was done through the Study, especially during the Pilot Project.

(3) Consideration and attention were paid to the poor and community participations were an important keyword in this Study, and therefore, the community development aspects were thoroughly examined throughout the Study. The rural people of developing countries, who used to be passive observers as recipients of the donor-funded projects, are now active players in the development with participatory approaches.

1) In particular, water supply services in the District Towns in Papua New Guinea has been provided free of charge as one of the community services obligation of the Government. However, due to financial constraints of the Government the water supply service in these Towns have been discontinued. Restoring the water supply services and re-establishing the operation, management and maintenance of water supply services based on the "User Pay Policy" are necessary to secure sustainable and healthy management.

2) For this purpose, understanding of the concept among the local stakeholders like Provincial and Local Level Governments and residents is essential. Several workshops using PCM methods to encourage their participation were held during the Study and the above-mentioned keywords were highlighted accordingly. The issues such as community based organisation, residents' willingness to pay for water, establishment of capable management of water supply services and subsidy from Provincial Government were existing in the present management system. These issues were discussed among the stakeholders during workshops and inter-agency meetings. The Study Team provided coordination and facilitation to seek solutions with managerial and financial viewpoint including organizational and institutional reinforcement.

16.2 Recommendations

Considering the above conclusions the following recommendations and suggestions can be made.

1) Utilization of the procedures used and lessons learned in this Study for groundwater development and water supply planning by the counterpart agency is expected for improvement of poor water supply coverage (around 30%) through upgrading of water supply in District Towns and rural villages. Based on the results of monitoring and evaluation to be executed by the PNG side for the completed Pilot Project, for Kupiano, Finschhafen and Oro Bay, which were excluded from the Pilot Project, a feasibility study should be carried out and a water supply improvement project needs to be implemented at the earliest possible.
2) For the sustainable operation, management and maintenance of the facilities constructed in the Pilot Project, additional guidance and support are required and dispatching short-term experts for this purpose are suggested. As the community-based activity through the NGOs is also necessary to promote operation, management and maintenance of public faucets, education on health and sanitation and capacity building of residents, introduction of the "Community Empowerment Programme" is a possible effective approach.
3) In the occasions of Workshops on operation & maintenance and Seminars for technology transfer the exchange of ideas and presentation of the cases were carried out in order to avoid duplication of the Project and to share the lessons learned with other organizations such as Governmental agencies, and NGOs that are working for water supply improvement. For the onward development, closer cooperation and coordination with the other organizations are required to be established.
4) It is strongly recommend that PNGWB takes more significant role in preparation of an action plan to catch up the national target which was set by Department of Health in their latest 10-Years Development Plan for 2000-2010 aiming at raising the present water supply coverage from 30% (2001) to 50% by 2010. For this target, preparation of a concrete and systematic plan for water supply improvement as well as groundwater development is essential and the required budget shall be secured. This plan shall contain the following:
   a) Concerning water supply services in District Towns, water supply for rural area PNGWB shall take leadership towards improvement of water supply services in the whole country. In the Pilot Project technical, social (community participation and sensitization), financial, economic (provision of subsidy) and legal measures for planning and implementation were introduced as a model of this kind of activity. Further extension of these activities for actual implementation of nation-wide water supply improvement programme is expected.
   b) In order to encourage water supply programs in rural towns and villages with it's on-going institutional reform, PNGWB shall proceed to set up a more efficient organization to promote new water supply systems on a non-commercial basis, with support from the

National, Provincial and Local Level Governments. This will also include the concept of cross-subsidization to support the less-financially viable rural water supply systems from surplus generated in the financially viable systems in Provincial Towns under the management of PNGWB.

c) Development of water supply system using groundwater as water source is recommended for District Towns with population of several thousands to ten thousands to minimize development and operation costs. But, consideration must be given to saltwater intrusion in case of coastal areas and small islands. For this development the training of experts to carry out the different tasks such as groundwater study like geophysical survey, preparation of development planning, drilling supervision, control of groundwater aquifer, water quality etc. is required urgently.

d) The PNGWB present approach shall be kept in cooperation with the Geological Survey of PNG, and their own staff shall be trained to raise the groundwater development experts who have water supply engineering background. The Geological Survey of PNG has experiences and history as the Governmental organization for groundwater development. However, it stopped its drilling activities due to depreciation and damages to drilling equipment and lack of funds for operation and maintenance.

e) Since the present technology level and capacity of equipment of the drilling contractors in the country will not be adequate when groundwater development is in earnest in a whole country, fostering competent drilling contractors is essential as well as training of the experts for geophysical survey, hydrogeology and drilling supervision.

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