CHAPTER 9 COST ESTIMATION

9.1 Cost Estimation

The calculation concerning the cost estimation needed to execute the water supply facilities construction of 6 District Towns in the master plan was done by the under mentioned calculation policy. In this calculation, the construction cost was divided into direct and indirect construction cost and the indirect construction cost was calculated by totalling the temporary works cost and the field cost. The equipment cost and the labour cost were classified into the direct construction cost. Technological cost was included in the temporary works cost with the transportation packing cost and the safety management cost.

1) Cost Estimation

The cost estimation of the water supply systems at 6 District Towns in the master plan is shown in Table-9.1 below. The execution time of cost estimation is December 2000. The exchange rate is 1Kina=Aus$0.5955, 1 Aus$=¥58.6 and 1Kina=¥34.9. Moreover, neither domestic tax nor other collection of taxes, the value added tax, etc. of PNG are included in this estimation.

Table-9.1 Cost Estimation of 6 District Town Water Supply Systems

Study Area	Construction Cost (Kina)			
	Stage-Ⅰ	Stage-Ⅱ	Stage-Ⅲ	Total
1) Bereina	1,495,600	891,700	617,600	Kina 3,004,900
2) Kupiano	3,457,100	2,704,800	3,307,100	Kina 9,469,000
3) Kwikila	1,565,600	1,325,300	735,500	Kina 3,626,400
4) Finschhafen	1,985,400	1,585,800	2,282,100	Kina 5,853,300
5) Mutzing	823,500	519,900	-	Kina 1,343,400
6) Oro Bay	2,119,700	2,740,400	1,315,000	Kina 6,175,100

Stage-Ⅰ:2001～2005、Stage-Ⅱ:2006～2010、Stage-Ⅲ:2011～2015

2) Land Procurement Cost and Compensation

There is a historical background peculiar to this country for the land problem of Papua New Guinea. For instance, the case with the existence of two or more landowners of the same land is not rare. The confirmation and acquisition of the facilities construction sites are difficult. In the selection of the facilities construction site for this plan, State Land (public property) is a precondition of the candidate. Customary Land (private property) is off the subject. Therefore, neither the land procurement cost nor the compensation for the facilities construction

site is included in this estimation of above-mentioned.

3) Operation and Maintenance Costs

Basically, the income from water service charges becomes the only fund for the operation and maintenance of the water supply system. It is difficult to formally start the collection of water charges immediately after the completion of the water supply system. Therefore, a fixed charge will be collected during the shift period until the metered charge collection system is formally established. In the calculation of the operation and maintenance cost, the details were divided into five items including the power expense and personnel expenses as shown in Table-9.2 and 9.3.

Table-9.2 Operation and Maintenance Expense for District Town Water Supply

Power Expense	A standby diesel engine generator is used if necessary though solar power generation is used in Bereina. In Kwikila and Mutzing, the electric power expense is paid according to the tariff of ELCOM.
Personnel Expense	One operator (staff of PNGWB Grade 7) is permanently stationed and an assistant (Grade 4) is employed locally. Personnel expenses of the operator and the assistant are covered by the water service charge.
Chlorination Expense	Bleaching powder is used for chlorination. The Local side bears the cost though the powder is procured by Regional Office. Regional Office's procurement enables the reduction of expenditure.
Maintenance Expense	Major repairs are done by Regional Office. Daily checks and small repairs are done locally.
Office Expense	The procurements such as furniture, office equipments are done through Regional Office The cost of procurement is a load on the local side. The business is managed by minimum equipment necessary for the moment.

Table-9.3 Operation and Maintenance Costs for 6 District Town Water Supply

Site	Operation, Management & Maintenance Cost (Kina)		
	Stage-Ⅰ	Stage-Ⅱ	Stage-Ⅲ
1) Bereina	4,946	5,082	5,231
2) Kupiano	4,444	4,497	4,599
3) Kwikila	4,746	4,813	4,909
4) Finschhafen	4,890	4,982	5,076
5) Mutzing	4,733	4,838	4,948
6) Oro Bay	4,352	4,387	4,441
Total	28,111	28,599	29,204

Stage-Ⅰ:2001～2005、Stage-Ⅱ:2006～2010、Stage-Ⅲ:2011～2015

9.2 Financial Plan

The Study Team conferred with PNGWB and explained concerning details of the master plan. As a result of the conference, the Study Team obtained enough understanding and the agreement of the PNGWB about the examination process and the result. The PNGWB was required to continue the examination of the embodiment of water supply services in District Towns where water supply facilities improvement by Pilot Project is not done based on this Study.

As the capital for which the PNGWB can use, there is the government capital such as Provinces Development Fund and the support from AusAID, which declared the support for the water supply sector in the future. The consideration of the Grant aid scheme of Japan is needed large-scale water supply systems. It is necessary also to consider the support such as "Development Partners Programme" from JICA for the small-scale one, because PNGWB expects support from Japan.

CHAPTER 10 EVALUATION OF ECONOMY, FINANCE, SOCIAL AND ENVIRONMENT

10.1 Financial and Economic Evaluation

In the Study Area of 6 District Towns where concrete water supply facilities plans were prepared, these plans are evaluated financially and economically. Concerning financial evaluation, the estimated cost of construction in the water supply improvement plan and operation & maintenance cost of facilities are counted as the entire cost. Based on the assumption that Grant funding is provided for the construction of the facilities at the 1st Stage of the master plan, amounts of this Grant, the water rate collected from water supply system operation is handled as the entire benefit. The entire benefit and cost were compared. Due to comparably small number of users and low level of water rate (same as Provincial Town's) the benefit for the water supply systems at 6 District Towns are absolutely not enough. B/C ratio in 15 years (up to the design year 2015) for financial evaluation shows the figures, i.e. Bereina 0.06, Kwikila 0.14, Mutzing 0.21, Kupiano 0.06, Finschhafen 0.13, Oro Bay 0.03.

On the other hand, in the economic evaluation, obtaining reliable quantitative data of the benefit is very difficult in this case. However, the current governments budget spent for operation & maintenance of the unreliable water supply systems, the operator's salary, medical care cost for the cases of water related diseases, the cost of "unable to work" during the sickness and the cost of water fetching estimated in terms of "unable to work" during the water fetching work are listed. And these costs were turned into the benefits for the case of "with the Project" is done in order to have the quantitative figure of the benefits. As the cost for the above economic evaluation, similar to the case of financial evaluation, the construction cost of the facilities and operation & management cost are included. Additionally saved subsidies of the government are counted as the benefit. As a result of economic evaluation for 15 years up to the target year indicated more positive at 6 District Towns, i.e. Bereina 0.91, Kwikila 1.57, Mutzing 2.18, Kupiano 1.87, Finschhafen 1.62, Oro Bay 1.43 (please refer to the Data Book, 2. Economy, Finance, Institution and Legal Framework).

All of the water supply systems of 6 District Towns have difficult conditions financially, but as the economic evaluation indicates the benefits of the water supply improvement are significant. It is assumed that this confirms importance of the Project in aspect of social development. Therefore, under the Pilot Project the subsidies from Provincial Government and Local Level Government are discussed and recommended to MOU and MOA by the concerned agencies.

10.2 Social Impact

It cannot be said that water supply services give a negative impact on society. Yet, in promoting water supply services in District Towns by PNGWB, the sole worry is that if the services are provided only for formal residents, benefits will be devoted to only people with social or economic advantage. Considering that water is the most fundamental and indispensable resource for living, it will be a big problem if such services bring benefits only to those already advantaged.

Meanwhile, a positive effect is that people will get stable, safe and sufficient supplies with ease, so that the living environment and sanitation is improved. In villages like Kupiano and Oro Bay, since water sources are far from villages, villagers spend a lot of time carrying water. Thus, water supply services will bring a prominent effect to improving the life of women.

In addition, circumstances at medical institutions entail some wards or delivery rooms being closed in some clinics assumedly because of water shortages. And at Study Areas where the water supply is not stable, clinics cannot fully function. In light of this situation, improvement of water services will bring about a better medical environment. Moreover, it is said that educational institutions such as high schools or vocational schools at the surveyed sites are closed annually because of water shortages. Therefore, improvement to the water situation may also bring about a better educational environment. These factors should not only have a positive effect on the Study Areas of the water services, but also peripheral villages indirectly.

10.3 Environmental Consideration

This Study concerns the groundwater development for water supply systems. When we implement the water supply project we should consider the environmental factors namely construction phase for water supply system and operation phase for water supply system.

1) Water Supply System Construction Phase

   The construction works for water supply system consist of borehole, intake facilities, distribution and supply facilities. However, there are no serious construction works such as topographic changes and earth reforming at the eight Study Areas. Therefore, it is considered there are no environmental impact factors during the construction phase.

2) Water Supply System Operation Phase

Considering operation phase for water supply we should consider the two environmental impact factors namely natural environment and pollution. Therefore, groundwater pumping might be the impact factor for water supply system as follows.

a. Decline in groundwater level: There are no other boreholes, which might be influenced by the operation of this groundwater pumping for District Town water supply.
b. Saline water intrusion: The aquifers of Daru and Finshhafen consist of coral reef limestone. Therefore, groundwater drawdown should be minimized to avoid saline water intrusion.
c. Land subsidence: There is no serious problem due to the thin clay layers in the Study Areas.

CHAPTER 11 PILOT PROJECT

11.1 Selection of Pilot Project Areas

(1) Direction for Operation, Management and Maintenance (O, M & M) of District Town Water Supply and the Pilot Project

The direction for O, M & M of District Town water supply, which had been steered from the Phase-I Study in 2000, was proposed to PNGWB. Based on the results of Phase-I the objective and the status of the Pilot Project were explained to PNGWB and understood as follows.

a) Regarding water supply in the Provincial Towns in the entire country, the PNGWB has been making its effort to improve the facilities and to upgrade the services mainly utilizing funding of foreign aid. It is expected that all the Provincial Towns will have certain satisfactory level of services of water supply within the coming three to four years under management of PNGWB except Port Moresby, Goroka and Arawa where the services are not provided by PNGWB. On the other hand, water supply situation in rural areas is still very poor due to lack of water supply facilities or even though the facility is there the water supply is insufficient or stopped in most cases. It is assumed that improvement of water supply in rural areas is one of the important missions for PNGWB from now onward. In the rural areas District Towns are strongholds of public services and development in each District and improvement of water supply at District Towns must be highly prioritised.

b) Currently water supply services in District Towns are managed by Provincial Government. However, both capital investment and O, M & M for the District Town water supply are insufficient, and immediate remedies by governmental/public sectors are requested. It is judged that PNGWB is the most suitable organization to fulfil this task, while it is presumed that sustainable O, M & M by Provincial Government and/or Local Level Government is difficult.

c) Population of the District Town is small and the water supply business there will not be commercially viable. However, deficit to cover the recurrent cost other than the capital investment cost will not be a large amount. If provision of the subsidy to PNGWB by Provincial Government and Local Level Government to cover the deficit is set as the condition, PNGWB can serve for District Town water supply. Currently Provincial Government is bearing the financial burden to run the water supply in the District Town. If the service is improved and managed properly by PNGWB with affordable amount of subsidy, it is an advantage for Provincial Government.

d) With the above mentioned assumptions it is thought that establishing a model of water supply in District Towns must be meaningful for promotion of water supply improvement in

rural areas of PNG in the future. The decision was made to carry out the Pilot Project in areas where such a model can be experimented, among the Study Areas of Phase-I in 2000.

e) Selection of the area for implementation of the Pilot Project was done as follows. All eight Study Areas of this Study were evaluated on adequacy for the Pilot Project from the various viewpoints of water supply plan, O, M & M plan for the Pilot Project and applicability to similar water supply projects as model in future development, and so on. Concerning the water source, the test drilling was done during Phase-I of the Study in 2000 and potential of groundwater was confirmed in most of the Study Areas. Therefore, the utilization of these boreholes as production wells was considered as prerequisite condition for planning of the Pilot Project. Finally Bereina, Kwikila and Mutzing were selected as the areas of the Pilot Project that aimed at improving District Town water supply by rehabilitation and construction of the water supply facilities. Meanwhile other components of the Pilot Project were also decided. These are: i) introduction of the Water Vending Unit to service in the residential area of low-income group in Daru Town, ii) water quality and environmental survey in the area along Binaturi River which is the water source for Daru Provincial Town water supply, and iii) rural water supply project for installation of rainwater collection tank and, hand dug well with hand pump by community participation in the villages along Binaturi River.

f) Implementation of the Pilot Project contains various types of task such as rehabilitation and construction of the water supply facilities, formulation of O, M & M system, and community development in the water supply areas. Therefore, the appropriate work structure to meet the respective type of task is required and prepared accordingly.

The exchange of ideas with the PNGWB and other relevant organizations and discussions within the Study Team were reflected to the implementation of the Pilot Project, Phase-II in 2001.

(2) Conditions for Area Selection of Pilot Project

The following conditions are required for the area of the Pilot Project considering the position and the objective of the Pilot Study.

1) Feasibility of Sustainable Water Supply Service

There is very few water supply service of the District Town in PNG, which is being managed smoothly and sustainable. All six Study District Towns have issues and problems to be solved. Therefore, PNGWB has the policy to work on promotion of the District Town water supply service. However, due to difficulty to prepare planning, water supply facility construction and operation, maintenance and management, this has not yet been achieved until today.

It is important that the Pilot Project in this Study shows the achievement of the sustainable water supply service, and it will become an example of the successful practice of the District Town water supply service for PNGWB. Therefore, feasibility to be a sustainable water supply service is assumed to be the most essential requirement for the area selection for the Pilot Project. The water supply improvement plan of the Pilot Project area shall meet the following requirements. Among these requirements many of them are essential and some are supplementary. When all the essential requirements are satisfied in the plan of each District Town, that area becomes verified for the condition of "feasibility of sustainable water supply service".

Table-11.1 Condition of Pilot Project Area

Items			Conditions
① Water Supply Plan	Needs of Water Supply Improvement	Essential	Supply water to the area where needs of the water supply improvement are high, and able to get support from the local residents, the user, and the central & local governments.
	Political Priority	Supple-mentary	High political priority is given, and advantaged to get the support of the government.
② Water Source	Groundwater	Essential	Water source with good quality, sufficient volume and at convenient location for utilization as a water source.
③ Facility Plan	Appropriate Technology	Essential	Use an appropriate technology considering conditions of rural area and technical level of the contractors, etc. in PNG.
	Investment Cost	Essential	Relatively small investment cost including utilizing existing facility and availability of public electric power supply.
	Operation Cost	Essential	Low operation cost by means to minimize items such as power expense, level and number of the engaging staff, and consumable articles.
④ Operation, Maintenance & Management Plan	Population of Beneficiary	Supple-mentary	Due to larger beneficiary population more water users and increase of water charges are expected in principle.
	Cost Sharing	Essential	Users have firm willingness to pay and are ready to pay with certain sufficient economical condition such as the income etc.
	Heavy Users	Supple-mentary	Have some heavy water users like commercial and/or industrial customers within the water supply service area and increase of water charges are expected.
	Support by PNGWB	Essential	PNGWB has facilities such as the current offices of the Water District for supporting the District Town
	Appropriate Personnel	Essential	The human resources with adequate capability can be assigned continuously.
⑤ Applicability as Model	Possibility of Application	Essential	There is no case where the practice of the Pilot Project is not applicable since each site has very different characteristics from others. The practice of the Pilot Project is applicable to other District Town.
	Geographical Characteristic	Supple-mentary	Geographical conditions of the Pilot Projects represent the diversity of the conditions in PNG such as location at the south or the north side of the main island, on the coast, the highlands (or inland), and islands, etc. (All the Study Areas are in coastal strips except Mutzing which is inland.)
	Effect of Exhibition	Supple-mentary	Be effective area to have the visit of the locale as the model water supply service by wide parties concerned in PNG for their recognition.

2) Certainty of Proper Implementation of Pilot Project

It is necessary that the implementation of the Pilot Project be completed properly within the period of the Study in 2001. Therefore, it is necessary to consider certainty on the conditions such as the preparation for reception of the Pilot Project on the PNG side, the required

construction period, the natural conditions during the construction within the time framework of the Study in Phase-II. Moreover, the budget for the Pilot Project has a ceiling due to its background that it is implemented as part of this Development Study. The conditions of the certainty of proper implementation are as follows, and these conditions are all essential to execute the Pilot Project surely.

Table-11.2 Essential Conditions of Pilot Project

Items		Condition
① Readiness for Execution	Essential	No obstacle on the side of PNG (PNGWB, resident of the area, related government agencies) about the Pilot Project execution from December 2000 to July 2001.
② Construction Period	Essential	It is certain that the construction work for the water facility improvement is completed within the above-mentioned period.
③ Weather & Access	Essential	No obstacle in construction and transportation of equipment & material, etc. with consideration on weather and road condition while majority of the above-mentioned term of works corresponds in the rainy season.
④ Scale of Budget	Essential	An appropriate budget for the Pilot Project to execute as part of the Development Study.

(3) Selection and Evaluation of the Area for Pilot Project

1) Selection of the Area for Pilot Project

The decision for selection and evaluation of the area for Pilot Project among the 6 District Towns was given when the fulfilment of the conditions of the Pilot Project implementation which are described in the preceding explanation is confirmed by evaluation of the water supply master plan for each District Town.

First of all, with respect to the purpose of the Pilot Project, and each District Town is evaluated as to "feasibility of sustainable water supply service", and the candidate areas, as are narrowed. The condition on "Certainty of proper implementation as the Pilot Project" of the potential area is evaluated. When selecting, it is assumed that an area cannot to be a candidate when the "essential condition" is not fulfilled.

2) Evaluation of the Area for the Pilot Project

The prospective area for the Pilot Project was evaluated. The result of the evaluation of the area for Feasibility of Pilot Project considering Sustainable Water Supply Services is summarized in Table-11.3.

Table-11.3 Feasibility of Pilot Project Area

Evaluation Object			Bereina	Kupiano	Kwikila	Finsch hafen	Mutzing	Oro Bay
① Water Supply Plan	Needs of Water Supply Improvement	Essential	◎	◎	◎	○	○	◎
	Political Priority	Supple-mentary	○	○	○	○	◎	◎
② Water Source	Groundwater Potential	Essential	◎	△	◎	◎	◎	×
③ Facility Plan	Appropriate Technology	Essential	◎	○	○	○	◎	○
	Investment Cost	Essential	◎	△	○	○	◎	△
	Operation Cost	Essential	○	○	◎	◎	○	○
④ Operation, *Maintenance &* Management Plan	Population of Beneficiary	Supple-mentary	○	◎	○	◎	○	○
	Cost Sharing	Essential	△	△	○	○	○	×
	Heavy Users	Supple-mentary	△	△	△	△	△	△
	Support by PNGWB	Essential	◎	○	◎	○	◎	◎
	Appropriate Personnel	Essential	○	○	○	○	○	○
⑤ Applicability as Model	Possibility of *Application*	Essential	○	○	○	○	○	○
	Geographical Characteristic	Supple-mentary	○	○	○	○	○	○
	Effect of Exhibition	Supple-mentary	◎	○	◎	△	◎	○
Total Evaluation			◎	△	◎	○	◎	×

NB ◎ : Very good /advantageous to implement the Pilot Project, ○ : Good /advantageous, △ : Fair, × : Bad /disadvantageous

- All of the 6 District Town satisfy most of the essential conditions and are feasible. However, in Oro Bay, there is uncertainty about the sustainable water supply operation because the municipal institutions are yet to be settled in the area, and most of the consumers are presumably villagers.
- In Bereina, Kwikila, Kupiano, and Oro Bay, the need for water supply is very high because the existing water supply systems have stopped or there is no system at all.
- Kwikila and Finschhafen have advantages of using the existing public electric power supply systems of ELCOM. On the other hand, Oro Bay, Bereina and Kupiano have no existing power supply system. It is planned that the costs for power are minimized by introducing solar generating systems.
- Regarding the support from PNGWB, Mutzing and Oro Bay are more advantageous as they are close to the cities (Lae and Popondetta) where there are branches of the PNGWB.
- If the Pilot Project is successful, the town could be a model for other similar District Town. However, in that sense, the potential of Oro Bay is rather limited because the

town is not organized as a District Town.

- Geographically, Mutzing, Finschhafen and Oro Bay in the northern side of the island can be grouped together, while Bereina, Kwikila and Kupiano are in the south. However, Mutzing is situated on an inland and has different characteristics.

From the above-mentioned evaluation, Mutzing, Kwikila and Bereina are considered more suitable as the Pilot Project areas, while others still seem to be promising. However, the project areas would be finalized after considering "chances of proper Implementation as the Pilot Project".

Therefore, after the evaluation concerning "Feasibility of Sustainable Water Supply Services", the area selection is done concerning "Chances of Proper Implementation as the Pilot Project ".

It was evaluated that the execution of the Pilot Project in Kupiano was not easy from the viewpoint of " Chances of Proper Implementation ". There is no restriction in the particular execution about Mutzing, Oro Bay, and Bereina. It was judged that about 2-3 areas were appropriate to the number of District Towns, to target the Pilot Project.

Table-11.4 Chances of Proper Implementation as the Pilot Project

Evaluation object		Bereina	Kupiano	Kwikila	Finsch hafen	Mutzing	Oro Bay
① Water Source	Essential	◎	△	◎	◎	◎	×
② Execution System	Essential	○	○	○	○	○	△
③ Construction Period	Essential	◎	×	△	×	◎	◎
④ Weather & Access	Essential	◎	×	△	△	◎	◎
⑤ Scale of Budget	Essential	○	×	△	×	◎	△
Final Evaluation		◎	×	△	×	◎	×

NB ◎ : Very good /advantageous to implement the Pilot Project, ○ : Good /advantageous,
△ : Fair, × : Bad /disadvantageous,

Regarding Oro Bay and Kupiano the water sources have not been finally confirmed due to unsuccessful test drillings and current majority of the population being villagers. And it is difficult to collect water charges from house connections. Therefore, Oro Bay and Kupiano were removed from the selection.

It was evaluated that the execution of the Pilot Project in Kwikila was not easy from the viewpoint of " Chances of Proper Implementation ". However, the local government and PNGWB requested to select Kwikila as one of targets in the Pilot Project because the

evaluation from the viewpoint on "Feasibility of Sustainable Water Supply Services" for Kwikila is not low.

The above-mentioned evaluation was analysed overall, and three areas, namely Bereina, Kwikila, and Mutzing, were selected consequently as the areas for the water supply system construction in the Pilot Project.

In addition, it is also suggested that a Pilot Project would be implemented in Daru apart from the District Town, although Daru was initially one of the Provincial Towns for Feasibility Studies. The validity has been highly justified as having "Feasibility of Sustainable Water Supply Service" and "Chances of Proper Implementation as the Pilot Project".

11.2 Outline of Pilot Project

1) Outline of Pilot Project

The construction of the water supply system was decided as the Pilot Project on the following four areas namely Bereina, Kwikila, Mutzing and Daru. The outline of the Pilot Project executed for each area is shown in the following Table-11.5.

Table-11.5 Outline of Pilot Project

Pilot Project Area			Content of Plan	
1	Bereina		① Repair and new establishment of water supply systems	
			② Organizing and management of residents, Training on operation and maintenance of water supply facilities	
2	Kwikila		① Repair and new establishment of water supply systems	
			② Organizing and management of residents, Training on operation and maintenance of water supply facilities	
3	Mutzing		① Repair and new establishment of water supply systems	
			② Organizing and management of residents, Training on operation and maintenance of water supply facilities	
4	Daru	Daru island	① *Introduction of water vending unit in the* residential area of low-income group	*Construction of water vending unit*
		Binaturi	② Environmental study along the Binaturi river	Water supply improvement in villages along Binaturi River
				Water quality investigation of Binaturi River

2) Pilot Project in Bereina

The water source for the water supply system in three areas of Bereina, Kwikila, and Mutzing is groundwater developed in Phase-I in 2000. The improvement of integrated water supply facilities is executed under the Pilot Project. The component of Pilot Project in Bereina is as follows.

Table-11.6 Components of Pilot Project in Bereina

Components	① Repair and new establishment of water supply systems
	② Organization of water management committee, Training on operation and maintenance of water supply facilities

There was no water supply for several months because the power supply was stopped in December 1999. Although the power system was managed by the District, the generator broke down several months ago and is yet to be fixed. Since there is no plan for ELCOM's power supply service, a solar generating system will be introduced in this Pilot Project.

The discharge of water from the existing well is not enough. Therefore, the borehole drilled as a test drilling will be used as the water source with a newly installed pump. The existing water supply facilities, such as rising main, water tank and distribution pipe will be continuously utilized after rehabilitation and extension. Public faucets are installed to supply water to the surrounding 8 villages. Organization of Water Management Committees are considered to be key components for the Pilot Project to conduct maintenance of public faucets and collect water charges in each village.

3) Pilot Project in Kwikila

The component in the Pilot Project of Kwikila is ① Repair and new establishment of water supply systems, ② Organizing and management of residents and training on operation and maintenance of water facilities similar to Bereina as mentioned above.

In Kwikila, there is an abandoned well and existing water supply facilities with rising main and distribution pipes. Although the existing pipeline was fragmentarily repaired several times in the past, these repairs did not have enough effect. The existing pipeline of Kwikila is complex and intertwined. Moreover, it has problems with clogging due to scale or sand in the pipeline and many parts in the existing system are damaged, because the existing pipeline had been left unused for a long time after the water supply had stopped in 1993.

Therefore, accurate information on the current situation of the existing system is necessary for the rehabilitation. Moreover, it was necessary to confirm the position, diameter, the type of existing pipeline, the existing valve position, the damage situation, etc. from the plumber and/or test diggings when information was vague before starting construction. The repair was done on the part judged to be necessary by the field survey.

Because public electric power of ELCOM is supplied to Kwikila, this is used for the power source of the system in the Pilot Project. The pump will be installed in the production well that was successful as a test borehole drilled in 2000, and a pump station and new water storage tank will be constructed. In addition, one public faucet is set up in a compound located in the eastern part of the Kwikila station.

4) Pilot Project in Mutzing

The component in the Pilot Project of Mutzing is ① Repair and new establishment of water supply systems, ② Organizing and management of residents and training on operation and maintenance of facilities similar to Bereina and Kwikila as mentioned previously.

In Mutzing, a small-scale water supply is carried out in the Station (the centre of the municipal activities in the District). The water supply system using the existing well and distribution pipes is operating, although the facilities are not in a perfect condition. The existing well is shallow (4m deep) and enough quantity of water cannot be pumped up. Thus, a new pumping system is to be installed in the borehole drilled by the test drilling in 2000, and replacement and extension of pipelines and water tank are to be carried out. Since the water supply system is currently being operated within the Station, it is assumed that pipelines of the existing system can be utilized in the new system. The public electric power supply of ELCOM has just reached Mutzing in June 2001. Public faucets are constructed for water supply to the surrounding villages.

5) Pilot Project in Daru

The Pilot Project of Daru is composed of the Water Vending Unit (WVU) of the Daru Town and component of rural water supply improvement and environmental study in the Binaturi River area as shown in Table -11.7.

Table-11.7 Component of Pilot Project for Daru

Daru	Introduction of water vending unit in residential area of low income group	Construction and management of Water Vending Unit (WVU)
Binaturi River Area	Environmental survey and rural water supply improvement in Binaturi River	a) Rural water supply improvement in villages of Binaturi River
		b) Environmental study in Binaturi River

① Introduction of Water Vending Unit in the Residential Area of Low-Income Group

Although the water supply system is working in the low-income area in Daru, most of them are disconnected due to the failure of monthly water charge payment. The Water Vending Unit is planned for such people so that they can still have access to safe drinking water during the dry seasons. Water vendors who contract with PNGWB are selected. PNGWB collects water charge from the vendor according to water meter readings, and the vendor collects fees from the consumers for the amount of water they sell by a bucket.

② Environment Survey and Rural Water Supply Improvement

Water for Daru is taken from the mainland and transmitted to the water treatment plant in Daru island through a 16km pipeline. There are some villages downstream of the Binaturi River pumping station (U'ume area). They are dependent upon river water because there is no water supply facility in the area. Some villagers in the area claim compensation for the environmental destruction, which might have been caused by the water intake.

Since the situation of water supply is very poor, the residents are aiming to establish Binaturi River Development Corporation as apart of the development plan in the area. According to this plan, rainwater collection tanks will be installed and hand dug wells will be constructed so as to improve the water supply facility. In addition, the environmental impact assessment will be carried out as part of the Pilot Project.

Table-11.8 shows the summary of components for the improvement of water supply facilities in the above four (4) areas of Pilot Project under the Phase-II in 2001.

Table-11.8 Summary of the Components for the Pilot Project

Area	System		Facilities	
Bereina	1	Intake Facility	Pump Station	Submersible Pump & Pump Pit
				Solar Generating System Diesel Engine Generator
				Pump House
				Concrete Block Fence
	2	Distribution Facility	Water Storage Tank : Elevated Water Tank	
			Distribution Pipe	
			Rehabilitation of Existing Pipe	
	3	Supply Facility	Public Faucet	
Area	System		Facilities	
Kwikila	1	Intake Facility	Pump Station	Submersible Pump & Pump Pit
				Power Line (ELCOM)
				Pump House
				Crimped Wire Fence
	2	Transmission Facility	Rising Main Pipe	
			River Crossing	
	3	Distribution Facility	Water Storage Tank : Ground Water Tank	
			Distribution Pipe	
			Rehabilitation of Existing Pipe	
	4	Supply Facility	Public Faucet	
Area	System		Facilities	
Mutzing	1	Intake Facility	Pump Station	Submersible Pump & Pump Pit
				Power Line (ELCOM)
				Pump House
				Crimped Wire Fence
	2	Transmission Facility	Rising Main Pipe	
	3	Distribution Facility	Water Storage Tank : Elevated Water Tank	
			Distribution Pipe	
			Road Crossing & River Crossing	
			Rehabilitation of Existing Pipe	
	4	Supply Facility	Public Faucet	
Area	Location		Facilities	
Daru	1	Daru Town	Water Vending Unit (Public Faucet)	
	2	Binaturi River Area	Hand Dug Well with Hand Pump	
			Rainwater Collection Tank	

11.3 Water Supply Facilities in Pilot Project

(1) Water Supply Facilities in Bereina

One of the features of the Pilot Project in Bereina is to supply water to the village residents by extending the water supply pipeline and setting up public faucets at eight villages in the surrounding where unsanitary shallow well and/or rainwater collection tanks have been used until now. A big feature moreover was to introduce the solar generating system as a power source for the water supply system because there is no steady public electric power supply service such as ELCOM in Bereina

It is thought that a lot of District Towns in PNG are facing similar problems as above. Therefore, it is expected that the Pilot Project in Bereina as a case study becomes a model with high diffusion for the future in PNG.

1) Water Demand in Bereina

In the Pilot Project, the design criteria of the master plan were adopted, and details of the water supply plan for each Study Area were confirmed. Based on the results of water demand study in Chapter 7, the supply population of Bereina in Stage-I (2005) are covered by the construction of the water supply system of this Pilot Project. The supply area and supply population of District Town and eight villages in the surrounding of Bereina, 2000-2015 is shown in Table-11.9.

Table-11.9 Supply Area and Supply Population of Bereina, 2000-2015

Water Supply Area			2000		Stage-I	Stage-II	Stage-III	Public
			HH	Population	2005	2010	2015	Faucet
A	1	Central(Formal Residents)	96	700	773	853	941	—
	2	Health Centre	—	130	143	158	176	—
	3	Community/Elementary school ssSchoolSchool	—	60	60	60	60	—
B	1	Toorena No.1	7	41	45	50	55	1
	2	Toorena No.2	9	47	52	57	63	1
	3	Ponepone	20	130	144	158	175	2
	4	Paikua	16	95	105	116	128	1
	5	Karoapaina	5	44	49	54	59	1
	6	Baukeke	23	40	44	49	54	1
	7	Hihive No.1	11	60	66	73	81	1
	8	Hihive No2	7	56	62	68	75	1
Total			194	1,343	1,483	1,636	1,805	9

Based on the results of water demand study in Chapter 7, the Average Daily Flow (ADF) in 2005, which is the target of Pilot Project in Bereina, is 99,046 lit/day and the Peak Daily Flow (PDF) becomes 118,855 lit/day as shown in Table-11.10. Moreover, the water demands of each water supply area in Bereina are shown in Table-11.11.

Table-11.10 Water Demand in Bereina, 2005-2015

Target Year		2005	2010	2015
Target Population		1,483	1,636	1,805
Demand (lit/day)	DF : Daily Flow	82,538	103,981	127,167
	ADF : Average Daily Flow	99,046	124,777	152,600
	PDF : Peak Daily Flow	118,855	149,732	183,120

Table-11.11 Water Demand and Supply Area of Bereina in 2005

Water Supply Area			Population	PDF (lit/day)	Water Tank
Area-A	Central		916	82,156	
Area-B	1	Toreno No.1	45	2,933	
	2	Toreno No.2	52	3,362	
	3	Ponepone	144	9,300	
	4	Paikwa	105	6,796	80 m^3
	5	Karoapaina	49	3,148	
	6	Baukeke	66	4,292	
	7	Hihive No.1	62	4,006	
	8	Hihive No2	44	2,862	
Total			1,483	118,855	80 m^3

2) Water Supply Facilities in Bereina

The water supply system for Pilot Project in Bereina is composed of intake, transmission, distribution and supply facilities. The concept and details of each facilities in the water supply system of Bereina are as follows and the details of designed facilities are shown in Table-11.12.

1. The water supply pipeline was extended from the existing pipeline to eight villages, and public faucets were set up in the villages.
2. Because there is no public electric power supply of ELCOM in Bereina, the solar power generating system is adopted as the power source for water supply system. The standby diesel generator is set up for emergency.
3. Blocked fence of 3.25m in height was adopted in consideration of crime prevention of the solar power generating system and other water facilities

Table-11.12 Pilot Project of Water Supply Facilities and Specification for Bereina

Facility		Specification
Intake Facility	Pump Installation	Submersible Motor Pump : AC 3-Phase, 400V Q: 300 l/min, H: 45 m , and Control Panel
	Pump Pit	RC Mortar Finish, Pressure Gauge, Air Valve
	Solar Generating System	Solar Generating System: 9kw Inverter for the Pump
	Diesel Engine Generator	10 KVA: Generator for the Pump
	Pump House	Reinforced Concrete (RC) and Block Structure: $28m^2$ Sand Separator, Water Meter, Pressure Switch, Safety Valve, Chlorinator, Alarm Buzzer, and Alarm Light.
	Fence and Gate	Fence : Block Fence, Mortar Finish, L: 115 m with Barbed-Wire Gate : Steel Plate t: 1.5 mm with Pad Lock
Transmission Facility	Rising Main Pipe	PVC ϕ 80～100 mm, Total Length: 50 m
Distribution Facility	Elevated Water Tank	Water Storage Tank : Pre-Fabricated Galvanized Steel, Volume $80m^3$ Accessories－Water Level Indicator, Lockable Manhole Cover, Rung Type Ladder (Inside)
		Tank Stand : Earthquake-Resistant Specification Pre-Fabricated Galvanized Steel, 15 m Height RC Foundation Accessories－Grating Deck and Platform with Handrail, Safety Ladder with Cage and Lightning Conductor
	Distribution Pipe	PVC ϕ 25～100 mm, Total Length: 2.8 km with Water Meters and Gate Valves
Supply Facility	Public Faucet	Reinforced Concrete Mortar Finish, 2 Taps x 9 Units with Water Mater and Valves including Soakaway & Drainage Pipe, PVC ϕ 100 mm

The water supply area and the flow diagram of water supply system in Bereina are shown in Fig.-11.1 (1) and (2), respectively. The valves and flow meters were installed for systematic O, M & M of water supply areas. The flow meter is set up in each branch pipeline in consideration of the O, M & M to the specific water supply area. Each public faucet at surrounding villages was installed with a water meter for the water charge collection. The integrated layouts for the water supply system of Bereina are shown in Fig.-11.2.

Figure.-11.1 (1) Flow Diagram of Water Supply Area in Bereina

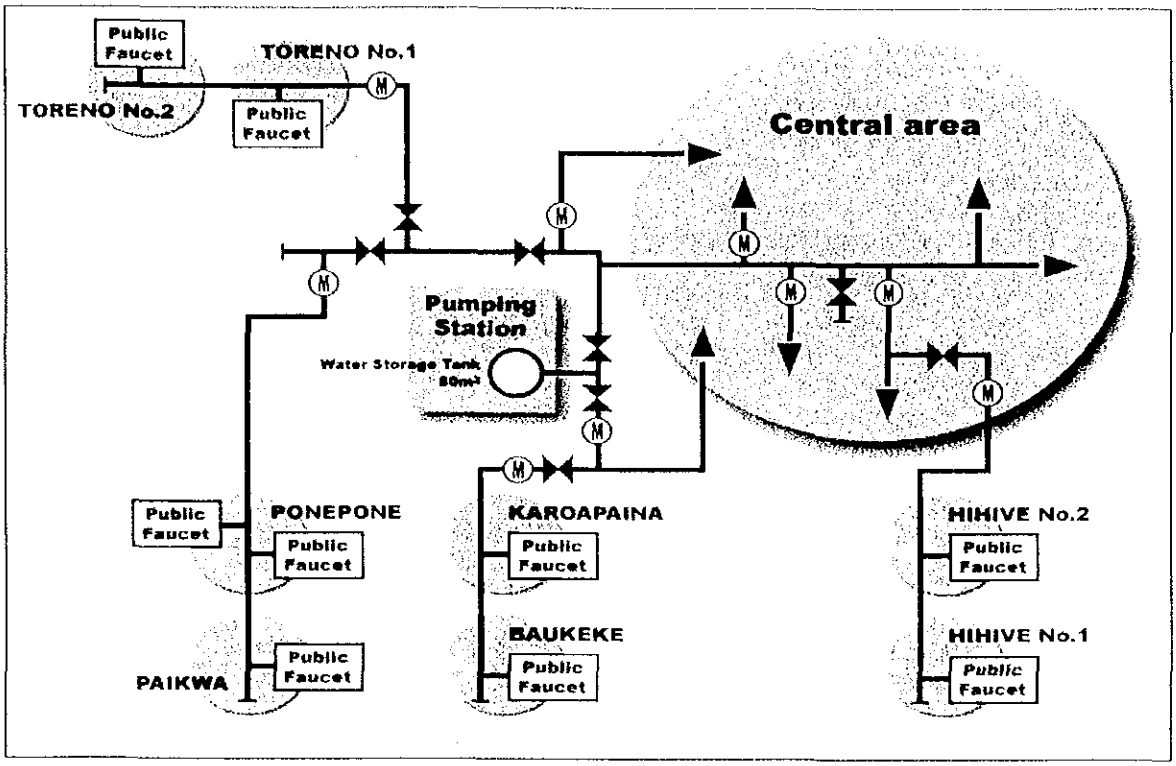
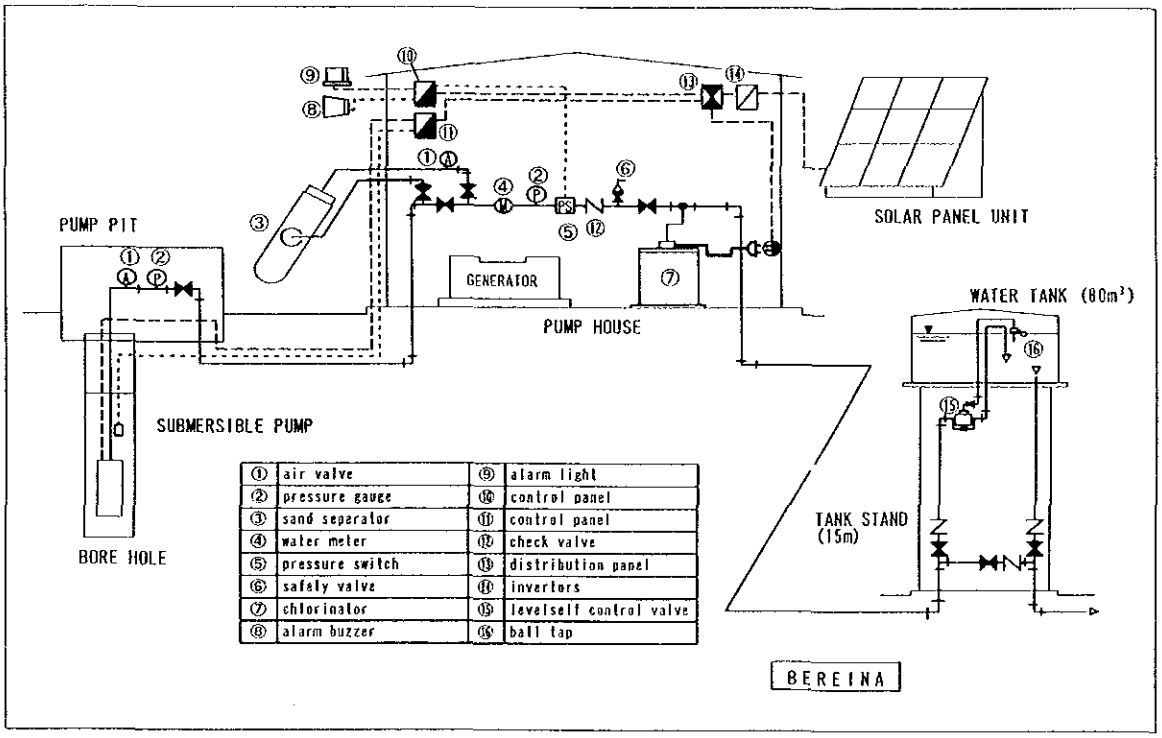
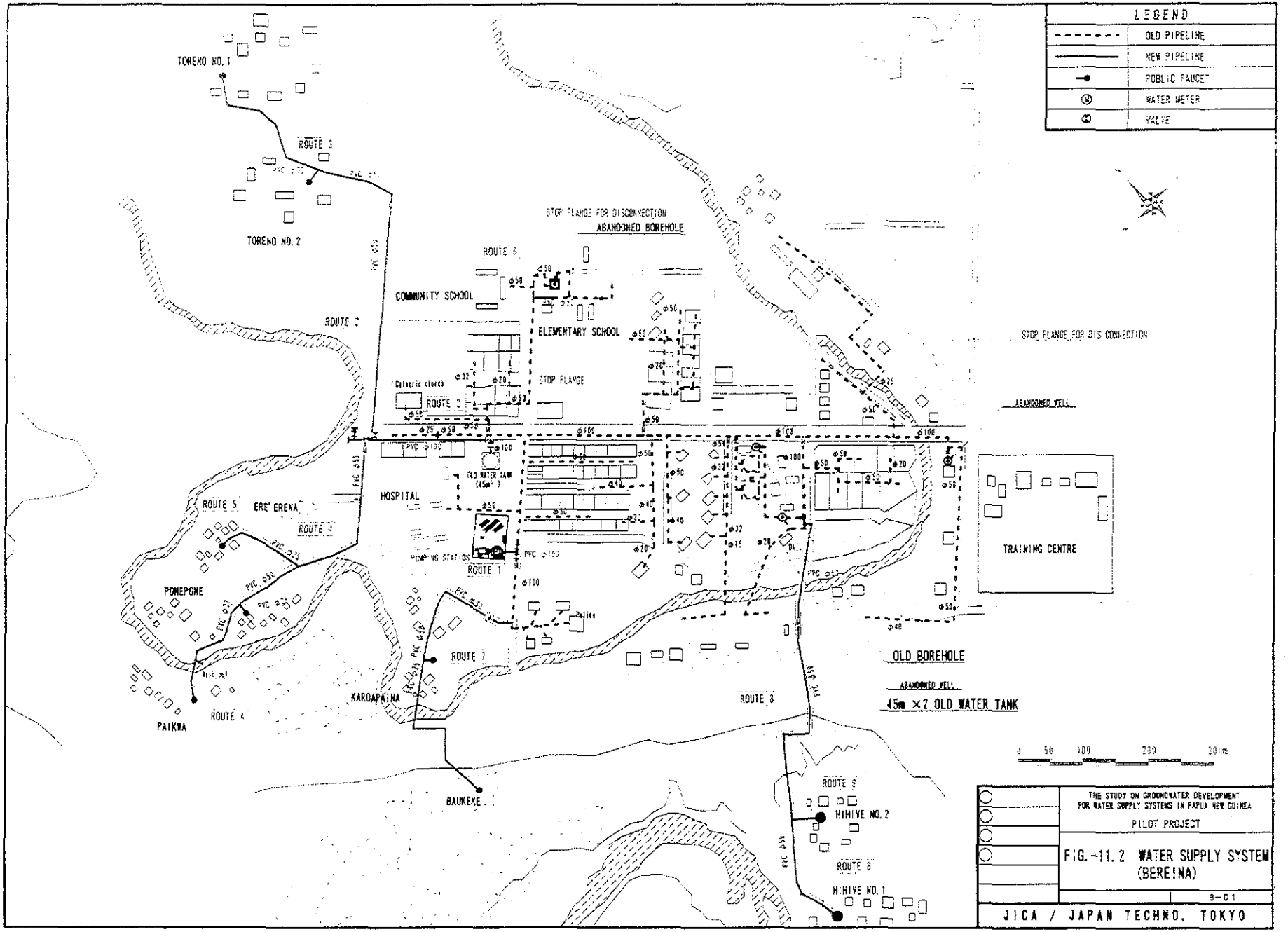


Fig.-11.1 (2) Flow Diagram of Water Supply System in Bereina




LEGEND
OLD PIPELINE
NEW PIPELINE
PUBLIC FAUCET
WATER METER
VALVE
TORENO NO. 1
TORENO NO. 2
ROUTE 9
ROUTE 8
ROUTE 2
ROUTE 5
ROUTE 3
ROUTE 1
ROUTE 7
ROUTE 4
ROUTE 6
STOP FLANGE FOR DISCONNECTION
ABANDONED BOREHOLE
COMMUNITY SCHOOL
ELEMENTARY SCHOOL
Catholic church
STOP FLANGE
HOSPITAL
OLD WATER TANK (45m³)
ERE'ERENA
PONEPONE
KAROAPAINA
PAIKWA
BAUKEKE
STOP FLANGE FOR DIS CONNECTION
ABANDONED WELL
TRAINING CENTRE
OLD BOREHOLE
ABANDONED WELL
45m ×2 OLD WATER TANK
HIHIVE NO. 2
HIHIVE NO. 1
0 50 100 200 300m
THE STUDY ON GROUNDWATER DEVELOPMENT FOR WATER SUPPLY SYSTEMS IN PAPUA NEW GUINEA
PILOT PROJECT
FIG.-11.2 WATER SUPPLY SYSTEM (BERE!NA)
3-01
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(2) Water Supply Facilities in Kwikila

Kwikila has an abandoned water supply facility constructed by PNG Government in 1970's and rehabilitated by Chinese assistance in 1980's including construction of water intake facility from the Kemp Welch River. There are abandoned boreholes and distribution pipelines, which the PNG constructed. However, all are becoming deteriorated, and the water supply was stopped since long time ago in the early 1990's. Therefore, the situation of existing water facilities and distribution pipelines are complicated and difficult to start operation.

Additionally, information, data and drawings concerning existing water facilities including pipelines were lost, and it is difficult to confirm the details of the current situation. Moreover, the existing pipelines are clogged with scale and sand, and many parts are damaged because they have been abandoned for a long term since the water supply stopped in the early 1990's. In the consideration of master plan for the water supply facilities in Kwikila, the above problems became obstacles for effective use of the existing facilities.

Many District Towns water supply in PNG are in a similar situation as Kwikila, and therefore, it is expected that modelling the Pilot Project in Kwikila may contribute as a case study that is applicable to other District Towns in PNG in the future.

1) Water Demand in Kwikila

Based on the results of water demand study in Chapter 7, the water supply area and projected population of Kwikila, 2000-2015 was confirmed in the master plan as shown in Table-11.13. Water demand of Stage-I (2005) is planned to be covered by the construction and rehabilitation of water supply facilities in this Pilot Project. The details of water supply area, supply population, households and the number of planned public faucets are shown in Table-11.13.

Table-11.13 Supply Area and Supply Population of Kwikila, 2000-2015

Water Supply Area			2000		Stage-I	Stage-II	Stage-III	Public Faucet
			Household	Population	2005	2010	2015	
A	1	Central	184	1,180	1,302	1,425	1,586	—
	2	Health Centre	—	170	173	177	181	—
	1	Vada Compound	11	70	78	85	94	1
	2	Mr.Broun Compound	2	10	11	12	14	
	3	Makan Compound	14	100	110	122	134	
B	4	Kwikila High school	—	1,000	1,091	1,190	1,302	—
C	5	Vocational Centre	—	318	349	383	421	—
	6	Community School	—	78	81	84	89	—
Total			211	2,926	3,197	3,488	3,821	1

Based on the results of water demand study in Chapter 7, the Average Daily Flow (ADF) in 2005, which is the target of Pilot Project at Kwikila, is 212,576 lit/day and Peak Daily Flow (PDF) becomes 255,091 lit/day. The water supply in Kwikila is grouped into three areas namely Central, Kwikila High School and Vocational Centre, the details of the water demand of each water supply area in Kwikila are shown on Table-11.14.

Table-11.14 Water Demand in Kwikila, 2005-2015

Target Year		2005	2010	2015
Target Population		3,197	3,488	3,821
Water Demand (lit/day)	DF : Daily Flow	177,147	205,883	247,184
	ADF : Average Daily Flow	212,576	247,059	296,620
	PDF : Peak Daily Flow	255,091	296,471	355,944

Table-11.15 Water Demand and Supply Area in Kwikila in 2005

Water Supply Area	Population	PDF (lit/day)	Water Tank (m^3)
Area-A : Central (Station)	1,675	146,922	60 m^3 ×2
Area-B : Kwikila High School	1,092	78,383	45 m^3 ×2 (Existing)
Area-C : Vocational Centre	430	29,786	45 m^3 (Existing)
Total	3,197	255,091	210 m^3

2) Water Supply Facilities in Kwikila

In the Pilot Project, the utilization of the existing water tank for water supply to Kwikila High School and Vocational Centre were included and repair of existing pipelines at 30 points were carried out. However, these existing water supply facilities shall be replaced in the next Stage-II, 2010 and/or Stage-III, 2015 due to lack of strength in the system. The concept and features of water supply facilities in Pilot Project of Kwikila are as follows.

1. The existing distribution pipelines within the District Town are so complicated due to the many rehabilitation works and repairs. Therefore, water supply area was divided into three areas namely the Kwikila Station, Kwikila High School, and Vocational Centre regions.

2. Two new ground water tanks were constructed at the Station, and the existing water tanks in Kwikila High School and the Vocational Centre were rehabilitated and utilized effectively in this Pilot Project.

3. Since the existing water supply facility had stopped operation for a long time, more than 7 years, damages and clogging at many places along the existing pipeline were identified during the field survey. The confirmation of these damages and clogging were carried out by digging, and the existing pipelines were cleaned in this Project.

The water supply facilities of the Pilot Project in Kwikila is composed of the water intake, transmission, distribution and water supply facility. The contents of each facility and the specification in Kwikila are shown in Table-11.16. The water supply area and the flow diagram of water supply system of Kwikila are shown in Fig.-11.3 (1) and (2), respectively. The valves and flow meters were installed for systematic O, M & M of water supply areas. The one public faucet was installed in the Station of Kwikila, and the water management committee by villagers was planned to manage and collect water charges. However, because of the problems of organization of the water committee by villages the public faucet shall be utilized as a water vending unit decided by the PNGWB for water charge collection. The integrated layouts for the water supply system of Kwikila are shown in Figure-11.4.

Table-11.16 Pilot Project of Water Supply Facilities and Specification for Kwikila

Facility		Specification
Water Intake Facility	Pump Installation	Submersible Motor Pump : AC 3-Phase, 400V Q: 300 l/min, H: 65 m including Control Panel
	Pump Pit	RC Mortar Finish, Pressure Gauge, Air Valve
	ELCOM Power Line	Wiring with Transformer
	Pump House	RC and Block Structure: 28 m^2 Sand Separator, Water Meter, Pressure Switch, Safety Valve, Chlorinator, Alarm Buzzer and Light.
	Fence and Gate	Fence: Wire Fence with Barbed-Wire, L: 67 m
Transmission Facility	Rising main pipe	PVC ϕ 80～100 mm, Total Length : 2.2 km including River Crossing
Distribution Facility	Ground Water Tank	Water Storage Tank : Pre-Fabricated Galvanized Steel, Volume: 60 m^3 ×2 Units Accessories: Water Level Indicator, Lockable Manhole Cover, Rung Type Ladder (inside) RC Foundation
	Distribution Pipe	PVC ϕ 25～100 mm, Total Length : 2.0 km with Water Meters and Gate Valves including River Crossing
Supply Facility	Public Faucet	RC Mortar Finish, 2 Taps x 1 Unit with Water Meter and Valves including Soakaway & Drainage Pipe , PVC ϕ 100 mm

Fig.-11.3 (1) Flow Diagram of Water Supply Area in Kwikila

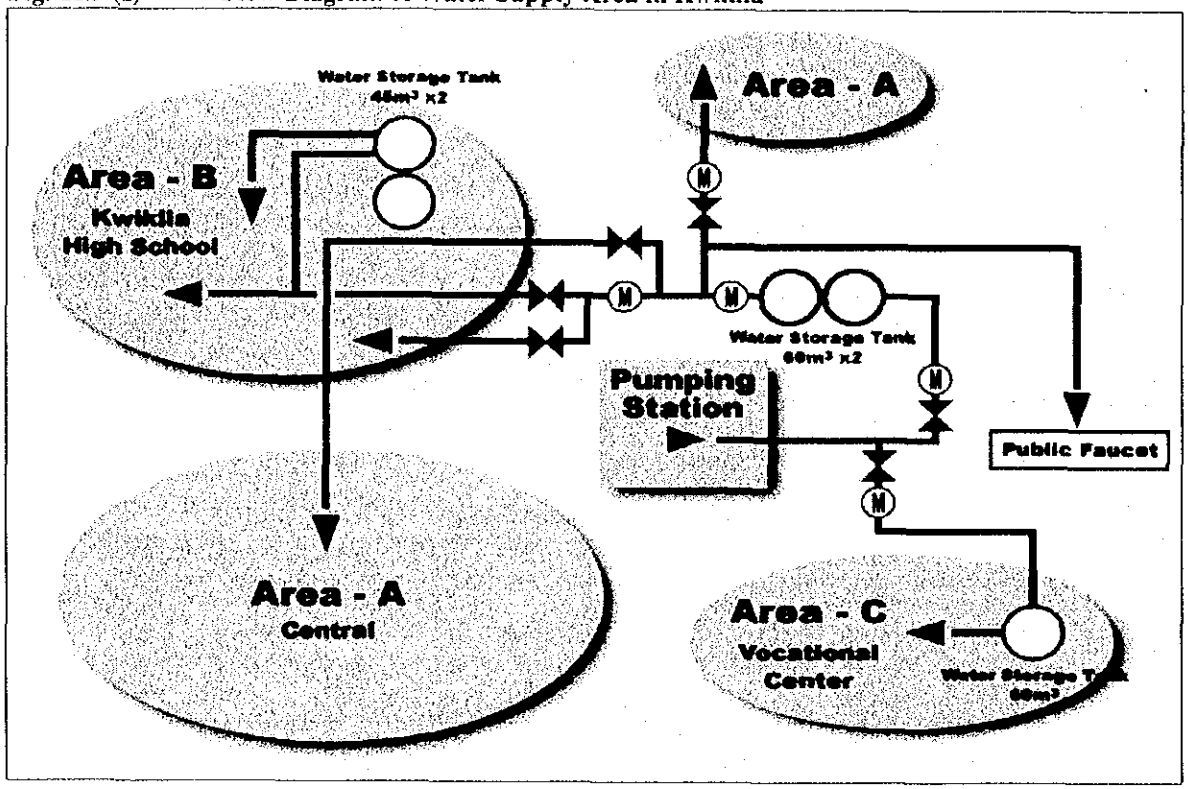
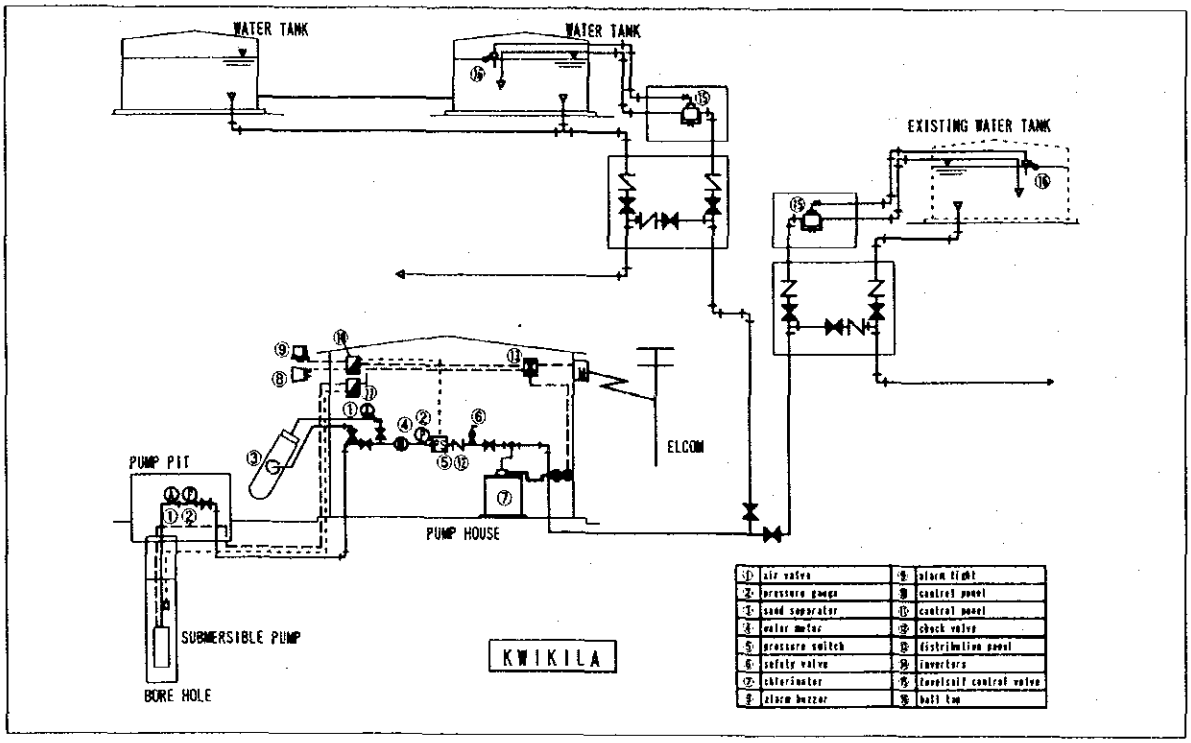
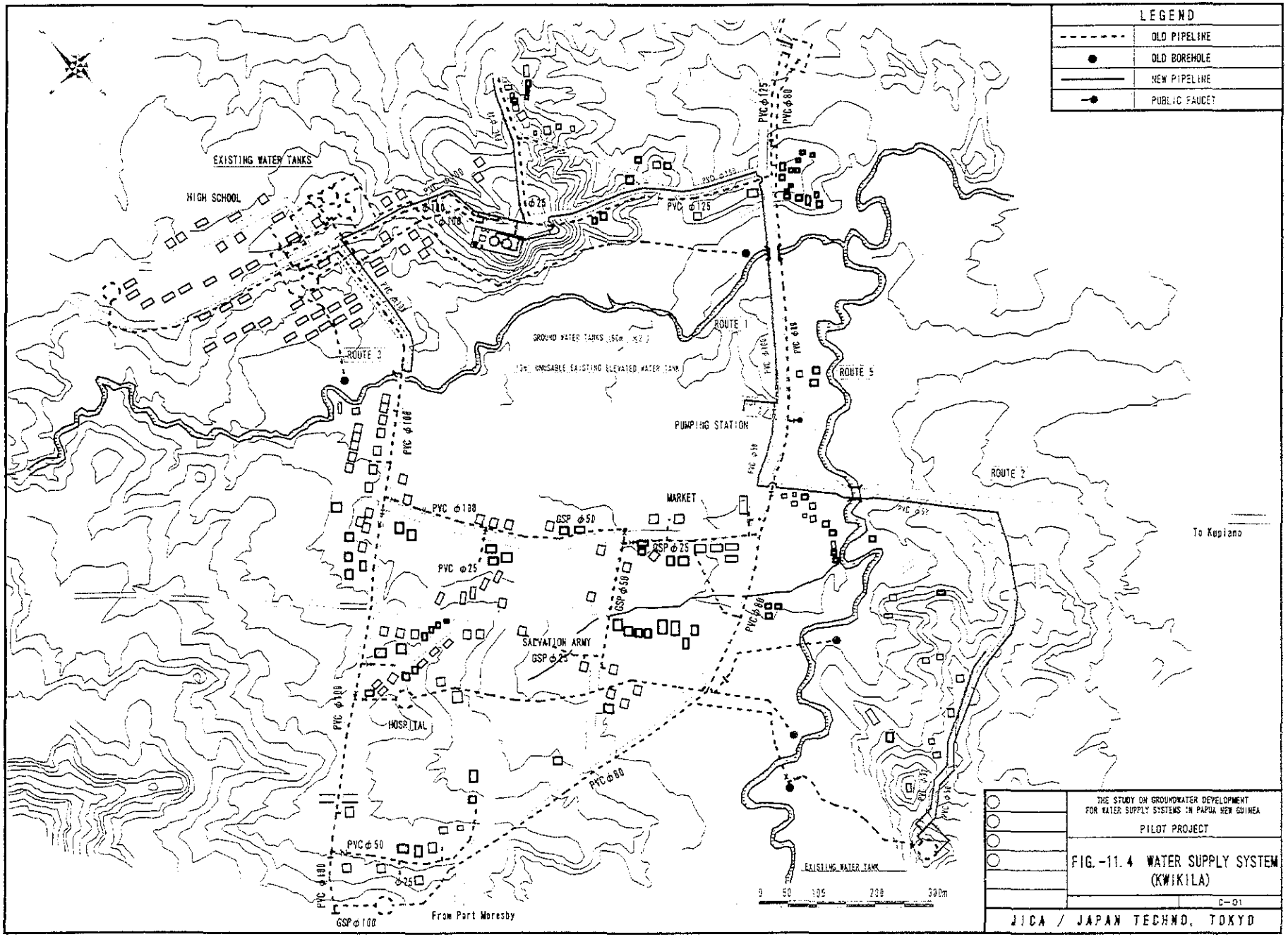


Fig.-11.3 (2) Flow Diagram of Water Supply System in Kwikila




LEGEND
OLD PIPELINE
OLD BOREHOLE
NEW PIPELINE
PUBLIC FAUCET
EXISTING WATER TANKS
HIGH SCHOOL
ROUTE 1
ROUTE 2
ROUTE 3
ROUTE 5
ROUTE 7
PUMPING STATION
MARKET
SALVATION ARMY
HOSPITAL
EXISTING WATER TANK
From Port Moresby
To Kupiano
PVC φ125
PVC φ80
PVC φ100
PVC φ50
PVC φ25
GSP φ50
GSP φ25
GSP φ100
0 50 105 230 390m
THE STUDY ON GROUNDWATER DEVELOPMENT FOR WATER SUPPLY SYSTEMS IN PAPUA NEW GUINEA
PILOT PROJECT
FIG.-11.4 WATER SUPPLY SYSTEM (KWIKILA)
C-01
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(3) Water Supply Facilities in Mutzing

When the water supply system in Mutzing is compared with Bereina or Kwikila, a remarkable situation is that the existing water supply facility has been operated several hours in a day by the District Town. Mutzing is the main relay point on Highlands Highway when going to Madang or Goroka, and expected development centre in the Mahakam Valley. Execution of the Pilot Project in Mutzing has significance as a model for the future having different character from the other two areas.

Effective use of the existing pipeline has more reliability than the other Pilot areas. However, there were some elements that had to be examined for facilities improvement. Most of the existing pipelines were GSP and those diameters were less than ϕ50mm. Because the height of the existing elevated tank was about 5 m, water pressure at the end of the pipeline was insufficient. As a result, a part of the existing pipeline was rehabilitated due to increase in the water pressure.

1) Water Demand in Mutzing

Based on the study results of projected water demand in Chapter 7, the supply population and supply area of Mutzing was confirmed as shown in Table-11.17. The supply population of Mutzing in Stage- III (2015) is covered by constructing the water supply system in this Pilot Project.

Table-11.17 Supply Area and Supply Population of Mutzing, 2000-2015

Water Supply Area			2000		Stage-I	Stage-II	Stage-III	Public Faucet
			House hold	Popula-tion	2005	2010	2015	
A	1	Central	72	500	556	619	688	—
	2	Intoap Model Village	—	115	128	142	158	—
	3	Health Centre	—	120	133	148	165	—
B	1	Sampubagin Village	37	261	290	323	359	2
	2	Mutzing Village	18	124	138	153	171	1
	3	Community School	—	150	167	187	207	1
C	1	Markham High School	—	830	923	1,027	1,141	--
Total			127	2,100	2,335	2,598	2.888	4

Based on the results of water demand study in Chapter 7, the Average Daily Flow (ADF) in 2015, which is the target of Pilot Project in Kwikila, is 242,718 lit/day and Peak Daily Flow (PDF) becomes 291,262 lit/day as shown in Table-11.18. The details of the water demand

for each water supply areas in Mutzing are shown in Table-11.19.

Table-11.18 Water Demand in Mutzing, 2005-2015

Target Year		2005	2010	2015
Target Population		2,335	2,598	2,888
Demand (lit/day)	Daily Flow	131,696	165,993	202,265
	Average Daily Flow	158,036	199,192	242,718
	Peak Daily Flow	189,643	239,030	291,262

Table-11.19 Water Demand and Supply Area in Mutzing 2015

Water Supply Area	Population	PDF (lit/day)	Water Tank (m^3)
Area-A : Central	1,217	126,741	80 m^3 31 m^3 (Existing)
Area-B : Villages in East Area	530	49,550	
Area-C : M.V. High School	1.141	114,971	9+10 m^3 (Existing)
Total	2.888	291,262	130 m^3

2) Water Supply Facilities in Mutzing

The water supply system of the Pilot Project in Mutzing is composed of the intake facilities, rising main, and supply facilities similar to the Pilot Project in Bereina and Kwikila. The concept and details of each facility in the water supply system of Mutzing are as follows, and the details of designed facilities are shown in Table-11.20.

---

1. Since water pressures in the end taps were insufficient, the existing pipes should be rehabilitated to increase the pressure.
2. New pipeline installation would be considered for the connection to the existing water tank that has possibility to be rehabilitated or newly constructed in this Pilot Project.

Since the existing water tank was old and damaged considerably and the height was not enough to secure the water pressure, a new elevated water tank was installed. Consideration was made for pipelines in order to increase the water pressure and new connection to the surrounding villages. Table-11.20 shows the contents of designed facilities and specifications for Mutzing.

On the other hand, water supply areas and the flow diagram of water supply system in Mutzing are shown in Fig.-11.5 (1) and (2). The valves and flow meters for the water supply control are installed in each water supply specific area. The flow meter is set in each branch in consideration of the operation and maintenance. Two public faucets would be installed in Sampubangin Village, and one public faucet would be installed in Mutzing Village and Primary School, respectively managed by the water committee. The integrated layouts for the water supply system of Mutzing are shown in Fig.-11.6.

Table-11.20 Pilot Project of Water Supply Facilities and Specifications in Mutzing

Facility		Specification
Intake Facility	Pump Installation	Submersible Pump : AC 3-Phase, 400V, Q: 300 l/min H: 45 m including Control Panel
	Pump Pit	RC Mortar Finish, Pressure Gage, Air Valve
	ELCOM Power Line	Wiring with Transformer
	Pump House	RC and Block Structure, Area: 28 m^2 Sand Separator, Water Meter, Pressure Switch, Safety Valve, Chlorinator, Alarm Buzzer, and Alarm Light.
	Fence and Gate	Fence : Wire Fence with Barbed-Wire, L: 67 m
Transmission Facility	Rising main Pipe	PVC ϕ 80～100 mm, Total Length : 50 m
Distribution Facility	Elevated Water Tank	Water Storage Tank : Pre-Fabricated Galvanized Steel, Volume: 80 m^3 Accessories – Water Level Indicator, Lockable Manhole Cover, Rung Type Ladder (inside)
		Tank Stand : Earthquake-Resistant Specification Pre-Fabricated Galvanized Steel: 15 m height RC Foundation Accessories – Grating Deck and Platform with Handrail, Safety Ladder with Cage and Lightning Conductor
	Distribution Pipe	PVC ϕ 25～100 mm, Total Length: 2.4 km with Water Meters and Gate Valves including River Crossing
Supply Facility	Public Faucet	RC Mortar Finish, 2 Taps x 4 Units With water meter and Valves including Soakaway & Drainage Pipe , PVC ϕ 100 mm

Fig.-11.5 (1) Flow Diagram of Water Supply Area in Mutzing

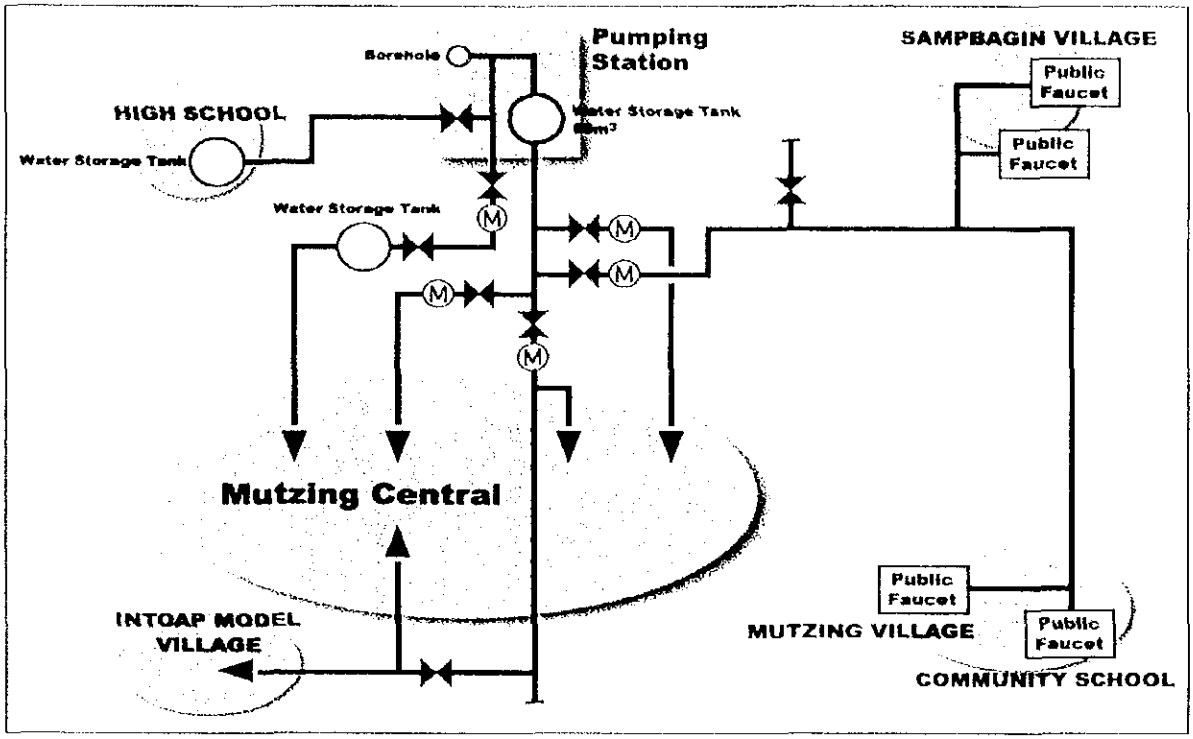
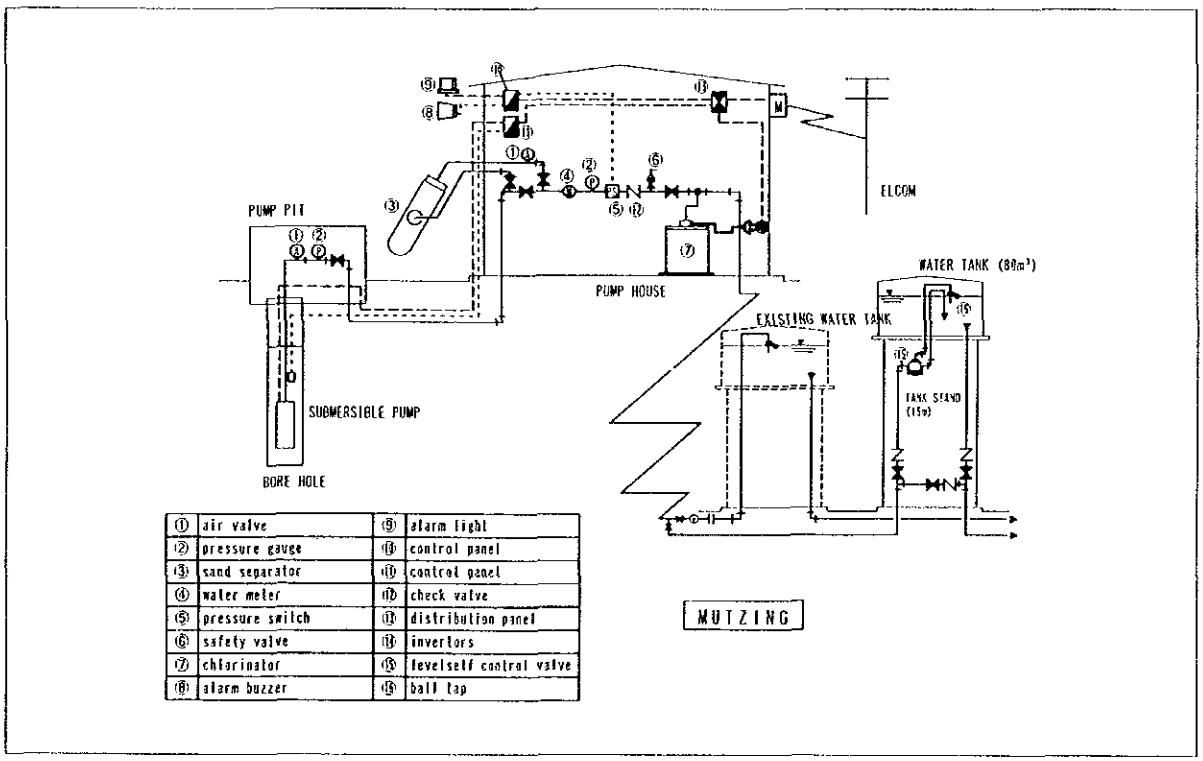
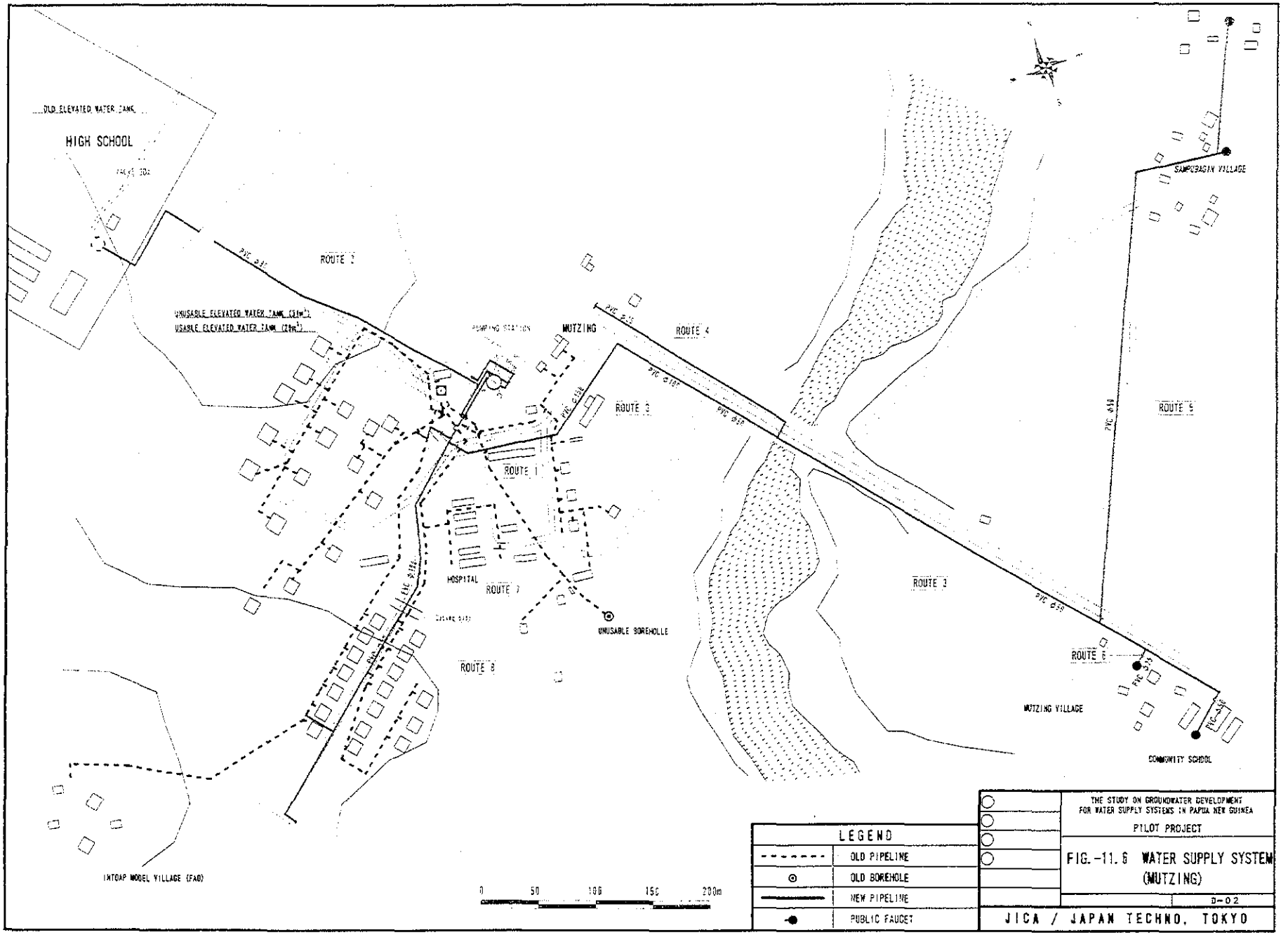


Fig.-11.5 (2) Flow Diagram of Water Supply System in Mutzing



①	air valve	⑨	alarm light
②	pressure gauge	⑩	control panel
③	sand separator	⑪	control panel
④	water meter	⑫	check valve
⑤	pressure switch	⑬	distribution panel
⑥	safety valve	⑭	invertors
⑦	chlorinator	⑮	levelself control valve
⑧	alarm buzzer	⑯	ball tap


OLD ELEVATED WATER TANK
HIGH SCHOOL
UNUSABLE ELEVATED WATER TANK (31m³)
USABLE ELEVATED WATER TANK (24m³)
PUMPING STATION
MUTZING
ROUTE 1
ROUTE 2
ROUTE 3
ROUTE 4
ROUTE 5
ROUTE 6
ROUTE 7
ROUTE 8
PVC ø75
PVC ø150
PVC ø100
PVC ø200
PVC ø250
PVC ø350
HOSPITAL
UNUSABLE BOREHOLE
SAMPUSAGAN VILLAGE
MUTZING VILLAGE
COMMUNITY SCHOOL
INTOAP MODEL VILLAGE (FAD)
0 50 100 150 200m
LEGEND
OLD PIPELINE
OLD BOREHOLE
NEW PIPELINE
PUBLIC FAUCET
THE STUDY ON GROUNDWATER DEVELOPMENT FOR WATER SUPPLY SYSTEMS IN PAPUA NEW GUINEA
PILOT PROJECT
FIG.-11.6 WATER SUPPLY SYSTEM (MUTZING)
D-02
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(4) Water Supply Facilities in Daru

The water supply facilities constructed as Pilot Project in Daru consist of 2 components: the Water Vending Unit on Daru island, and the environmental improvement of Binaturi river. The water supply facilities for each component are shown Table-11.21.

Table-11.21 Water Supply Facilities in Daru

Facility		Specification
Daru Island	Water Vending Unit (Public Faucet)	RC mortar finish, 2 taps With water meter and valves Including Soakaway & drainage pipe PVC ϕ 100 Number of Water vending units : 2
Binaturi River	Shallow Wells	Dug well with Hand Pump (ϕ 1.0m) Hand Bore with Hand Pump (ϕ 4" $\times$10m) With Tools for Maintenance
	Rainwater Collection Tank	Rainwater Tank, Metal Roof Sheet Rain water Gutter, and Tools for Maintenance

1) Water Vending Unit

The water vending units can improve the shortage of water even in the dry seasons by selling the water to the low-income residential area where the water supply service was stopped. The water vendors sell water by bucket to the water user and PNGWB collects the water charge from the vendors based on the PNGWB current tariffs.

The water vending unit has two taps and a water meter for the water charge collection similar to the public faucet. Water vending units were installed in low-income residential areas such as Samari Corner and Frog Town. Because these target areas have security problems, awareness promotion and education were given to local residents. During the construction period, the quality control on the main facilities and water meter box was executed to create a strong facility that can prevent Vandalism.

2) Hand Dug Wells and Rainwater Collection Tank

The Pilot Project for construction of hand dug wells and installation of rainwater collection tanks were executed at villages (11 sites) along the Binaturi river based on the development plan which the Binaturi river residents had planned under the support of the Provincial government. The total population of the village in 1990 is reported as 1,660 persons, and

the population in 2000 is estimated to be 2,372 persons with 399 households as shown in Table-11.22.

Table-11.22 Village Household and Population in Binaturi Area

	U'ume	Boje	Giringarade	Kunini	Tureture	Masingle	Mawatta	Total
Household	38	67	72	50	61	84	27	399
Population	198	385	425	270	397	497	200	2,372

The procurement of materials necessary for construction of the Pilot Project was executed, in addition to the construction of the hand dug wells and installation of the rainwater collection tanks through community participation. The main procurement materials are as shown in Table-11.23.

Table-11.23 Procurement of Materials for Binaturi Area

Facility	Materials		
Materials for Construction of Hand Dug Well	1	Hand Auger	Hand Drilling Kit
	2	Steel Form for Casing	Steel Form, Dia.: ϕ 1 m, Height: 0.5 m
	3	Hand Pump	ONGA Pump (NP-90) including Riser Pipe, PVC: ϕ 40 mm with Joint Sockets and Hardwires
	4	Casing Pipe	PVC ϕ 75 mm for Hand Bore
	5	Wood Form	1m×1m×0.1m including Nails
	6	Cement	Portland Cement (40kg) Bag
	7	Gravel	Size ϕ 5mm & 25mm for Construction
	8	Cover Sheet for Material	Tarpaulin Cover Sheet for Material
	9	Tools for Maintenance	Pipe Wrench, Pliers and Pick
Materials for Construction of Rainwater Collection Tank	1	Rainwater Collection Tank	Polyethylene Tank Split type Volume: 300 gallon included Joint rubber and Hardware
	2	Metal Roof Sheet	Zinc Iron Sheet for Roofing with fixing Materials
	3	Rainwater Gutter	Zinc Iron Gutter with Brackets
	4	PVC Pipe	PVC Pipe for Water Collection
	5	Tools for Construction	Hammer, Metal Sheet Cutter

The construction of the hand dug wells with community participation and the installation of the rainwater collection tanks were executed by using materials mentioned above under the

guidance of NGOs. Sand and wood for the construction, which could be obtained locally, were procured by the village side as much as possible. The construction of the hand dug wells was divided into two categories: one by hand digging and another with hand auger, and the digging method was adopted depending on the geological features of the target village. An example of the shallow well by hand digging is shown on Fig.-11.7.

Moreover, the staff of the NGOs employed by this Project organized a detailed process and the residents' construction with community participation. The manuals of " Hand Dug Well Construction " and " Rainwater Collection Tank Installation " was prepared by the study team as a tool for guidance to the residents to promote understanding on water facilities construction. These manuals are effectively used during the construction work, and proved effective as a tool for communication with the residents.

(5) Tasks on the Papua New Guinean Side

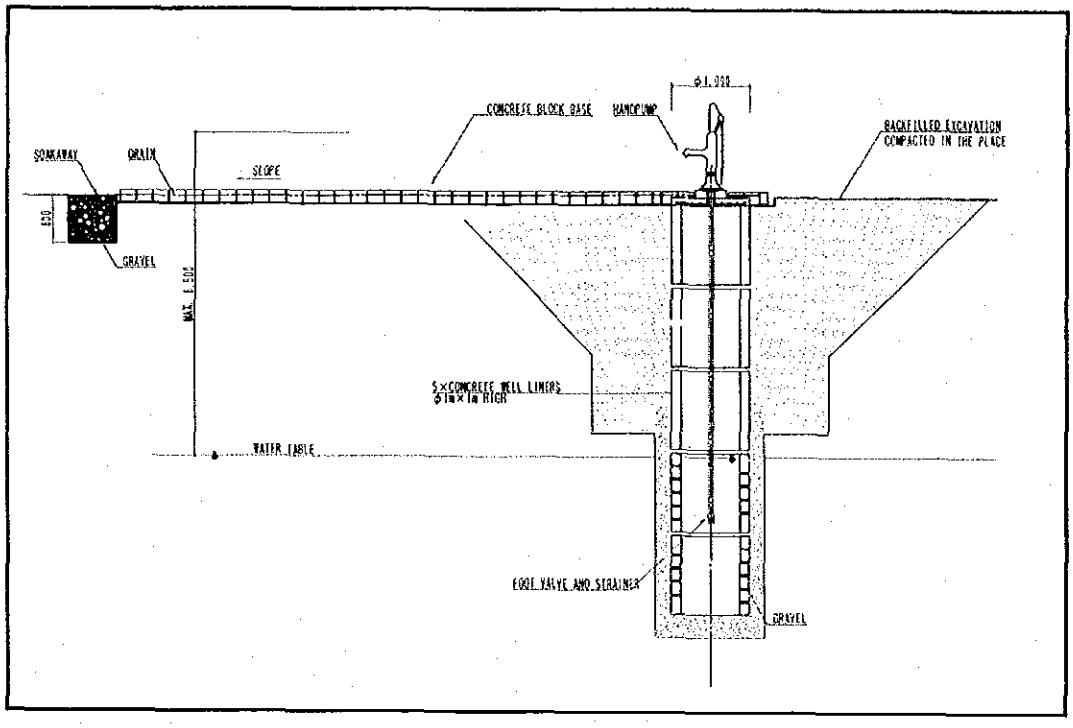
The District Town water supply systems of the Bereina, Kwikila and Mutzing are improved in this Pilot Project, but the works for house connections and repair of taps are excluding the Pilot Project due to the rule of Japanese assistance. Therefore, it is necessary that the Papua New Guinean side including PNGWB should make house connections and increase new taps based on the requests from the residents. The necessary tasks of the Papua New Guinean side are shown in Table-11.24.

Table-11.24 Responsibility of House Connection for Pilot Project

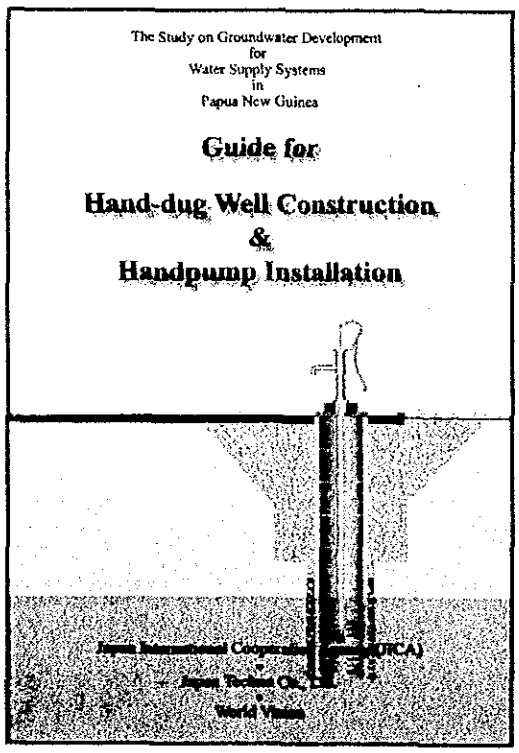
Item	Actors in Charge
1) Service Connection From main supply pipes to water meters, Max 25m in length	PNGWB
2) House Connection After the water meters to the water taps for residents	Residents or Provincial and/or Local Level Government

The tasks of PNGWB mentioned above were approved by the Board Meeting, which was held in February 2001. The counterpart funding of Kina 150,000 has already been budgeted for this task. It has been positively promised that the Provincial Governments and the Local Level Governments confer on the implementation of house connections and advance this task under the guidance of the PNGWB.

Fig-11.7 Example of Hand Dug Well Construction



Manual of " Hand-Dug Well Construction "



Manual of "Rainwater Tank Installation"

11.4 Water Supply Service Plan

(1) Direction for O, M & M of District Town Water Supply and the Pilot Project

1) The direction for O, M & M of District Town water supply, which had been steered from Phase-I of the Study, was proposed to PNGWB. The objective and the status of the Pilot Project were explained to PNGWB and understood.

a) Regarding water supply in the Provincial Towns in the entire country, PNGWB has been making its effort to improve the facilities and to upgrade the services mainly utilizing funding of foreign aid. It is expected that all the Provincial Towns will have certain satisfactory level of services of water supply within the coming three to four years under management of PNGWB except Port Moresby, Goroka and Arawa where the services are not provided by PNGWB. On the other hand, water supply situation in rural areas is still very poor due to lack of water supply facilities or even though the facility is there the water supply is insufficient or stopped in most cases. It is assumed that improvement of water supply in rural areas is one of the important missions for PNGWB from now onward. In the rural areas, District Towns are strongholds of public services and development in each District and improvement of water supply at District Towns must be highly prioritized.

b) Currently water supply services in District Towns are managed by Provincial Government. However, both capital investment and O, M & M for the District Town water supply are insufficient, and immediate remedies by governmental/public sectors are requested. It is judged that PNGWB is the most suitable organization to fulfill this task, while it is presumed that sustainable O, M & M by Provincial Government and/or Local Level Government is difficult.

c) Population of the District Towns is small and the water supply business there is not commercially viable. However, deficit to cover the recurrent cost other than the capital investment cost is not a large amount. If provision of the subsidy to PNGWB by Provincial Government and Local Level Government to cover the deficit is set as the condition, PNGWB can serve for District Town water supply. Currently Provincial Government is bearing the financial burden to run the water supply in the District Town. If the service is improved and managed properly by PNGWB with affordable amount of subsidy it is to the advantage of Provincial Government.

d) With the above mentioned assumptions it is thought that establishing a model of water

supply in District Towns must be meaningful for promotion of water supply improvement in rural areas of PNG in the future. The Pilot Project is carried out in the areas where such a model can be experimented, among the Study Areas.

e) Selection of the areas for implementation of the Pilot Project was done as follows. All eight Study Areas of this Study were evaluated on adequacy for the Pilot Project from the various viewpoints of water supply plan, O, M & M plan for the Pilot Project and applicability to similar water supply projects as model in future development, and so on. Concerning the water source, the test drilling was done during Phase-I of the Study in 2000 and potential of groundwater was confirmed, and test boreholes can be utilized for production wells in most of the Study Areas. Therefore, utilization of these test boreholes was considered as prerequisite condition for planning of the Pilot Project. Finally Bereina, Kwikila and Mutzing were selected as the sites of the Pilot Project which aimed at improving District Town water supply by rehabilitation and construction of facilities. Meanwhile other components of the Pilot Project were also decided. These are: i) introduction of the water vending unit to service in the residential area of low-income group in Daru Town, ii) water quality and environmental survey in the area along Binaturi River which is the water source for Daru Town water supply, iii) rural water supply project on installation of rainwater collection tanks and hand dug wells through community participation in the villages along Binaturi river.

f) Implementation of the Pilot Project contains various types of tasks such as rehabilitation and construction of facilities, formulation of O, M & M system, and community development in the water supply areas. Therefore, the appropriate work structure to meet the respective type of task is required and prepared accordingly.

The exchange of ideas with the PNGWB and other relevant organizations and discussions within the Study Team were reflected to the implementation of the Pilot Project.

2) Activities during Implementation Period of the Pilot Project

The followings are the activities related to the O, M & M plan during implementation of the Pilot Project and shown in calendar order.

December, 2000:

a) The contents of the Pilot Project and task of the Papua New Guinean side were explained and agreed by the relevant organizations at PNG side. This process was practiced not only with PNGWB's headquarters and the Technical Services Division, but

also with the Lae District Office of PNGWB, Central Provincial Administration, Morobe Provincial Administration, and Dept. of National Planning & Monitoring.

b) Selection of the contractors for rehabilitation and construction of water supply systems and for community development proceeded.

c) The following activities were planned as preparatory steps for commencement of operation of the water supply systems at three District Towns, i.e., Mutzing, Bereina, and Kwikila

   i) Briefing to the relevant District administers of the project area regarding implementation plan of the Pilot Project.

   ii) Holding a workshop to flow information on the Pilot Project and to explain the task of PNG side to the administrative officers and the residents of the project area.

   iii) Briefing on the Pilot Project and community development (facilitation of establishment of water committee, health education, capacity building, etc.) of the residents in villages / settlements within the station and/or the surrounding area.

   iv) Pre-registration of the users (residents and institutions) to confirm their willingness to receive the new water supply service in the project area.

   v) Identification of updated situation of existing water distribution facilities (distribution pipes, water tap, etc.)

   vi) Formal registration of the users prior to start of the water supply service.

   vii) Preparation of the work to be done by the PNG side, i.e., installation of meters and pipes for service connections by PNGWB and tap installations and others for house connection by the owners of houses.

d) Estimation of financial balance of operation of water supply systems in the project area was done.

e) The required procedures to set up the institutional framework of the O, M & M of the new water supply systems by PNGWB were confirmed with PNGWB.

f) The policy on pricing for water supply service of new water supply systems at three District Towns and at the Water Vending Unit in Daru was discussed with PNGWB.

g) Following schedule for January and February 2001 was examined by the Study Team.

February-March, 2001:

a) The workshop was held at the project area of the Pilot Project. Outline of the Pilot Project, O, M & M system of new water supply system, burden of the Provincial and Local Level Governments, "User Pay Policy" and responsibility of payment, etc. were explained to the administrative officers and residents. The local stakeholders understood these points explained in the workshop.

b) The draft of MOU on implementation of the Pilot Project was proposed to PNGWB and the Provincial Governments, and was accepted by both parties.

c) Similarly the draft of MOA on O, M & M of the new water supply system was submitted to PNGWB and the Provincial Governments, and both parties agreed to that.

d) Arrangement of the personnel such as operator, manager, and cashier for the new water supply system was examined and its practical plan was discussed with PNGWB.

e) PNGWB's policy on expenses for operation of new water supply systems was confirmed and views exchanged on estimated financial balance.

f) Workshop to discuss "Project Design Matrix" (PDM) of the Pilot Project was held with participation of managers and senior staff of respective divisions of PNGWB, and the PDM for the Pilot Project was made.

April-May, 2001:

a) The construction work of the Pilot Project proceeded and simultaneously PNGWB continued their internal examination on the above-mentioned issues.

b) MOU and MOA regarding improvement of the water supply system in Mutzing by the Pilot Project was signed on May 31, 2001 at Mutzing between Morobe Provincial Government, Umi-Atzera Local Level Government and PNGWB.

June-July, 2001:

a) MOU and MOA regarding improvement of the water supply system in Bereina and Kwikila by the Pilot Project was signed on June 1, 2001 at Port Moresby between Central Provincial Government and PNGWB.

b) Workshop to discuss the activity plan to fulfil the PDM for O, M & M was held on June 8, 2001 at Port Moresby, and managers and senior staff of respective divisions of PNGWB participated. Practical activity plan was formulated and target date for completion of the work to be done by PNGWB was also set.

c) MOA on the Pilot Project and O, M & M of Water Vending Unit in Daru was agreed between Provincial Government of Western Province, Daru Urban Local Level Government, the nominated water vendors and PNGWB.

d) MOA on rural water supply improvement project with community participation in the villages along Binaturi River was agreed between Provincial Government of Western Province and water committee in the villages in Binaturi area.

e) Details for the operation of water supply systems at these District Towns and the preparatory work to be done by PNGWB were discussed and encouraged.

f) In the Board Meeting of PNGWB held on June 28, 2001 it was decided to recommend

the Minister to declare the new Water Districts at these three District Towns.

g) Workshop on O, M & M of water supply systems at district towns under the Pilot Project was held on June 29, 2001 in Port Moresby. PNGWB, the relevant governments and administration such as District Administration, Local Level Government, Dept. of National Planning and Monitoring, Office of Rural Development, Dept. of Health, JICA, etc. attended. The institutional framework and organization for O, M & M were explained and accepted by the participants. (Details of the workshop are shown in the Data Book.)

Throughout the entire process of implementation of the Pilot Project as mentioned above, PNGWB always showed their tireless and constructive attitudes to the project and many relevant staff including the counterpart staff participated in the process. The District administration offices, Local Level Governments and other people recognized themselves as the direct beneficiary of the project and provided cooperation accordingly.

PNGWB supported the above-described direction and the concept of the Pilot Project. Reflecting discussions with PNGWB, the schedule of implementation of the Pilot Project was prepared. The following points related to O, M & M of the District Towns were examined in the preparation of this schedule.

a) PNGWB and the respective Provincial Government and Local Level Government make the Minutes of Understanding (MOU) on implementation of the Pilot Project to confirm the status of the Project and responsibilities of each party.
b) PNGWB takes necessary measure to be ready for O, M & M of the water supply systems after rehabilitation and construction are completed. In practice PNGWB decides in its board meeting to recommend to the Minister to declare new Water Districts at Bereina, Kwikila and Mutzing.
c) PNGWB collects the water charge from the users as their water supply business (applying "User Pay Policy"). When any deficit is made from the operation, the Provincial Government provides subsidy to PNGWB to cover the shortfall.
d) PNGWB, the respective Provincial Government and Local Level Government make the Minutes of Agreement (MOA) on O, M & M of the water supply facilities constructed under the Pilot Project to clarify the responsibilities of each party regarding O, M & M.
e) Enough explanation and information flow to the administrative officers and the residents in the project area shall be performed for appropriate consensus building among them on the Pilot Project and the new water supply services after the Pilot Project.

f) Any other necessary preparatory work shall be done for the planned O, M & M by PNGWB.

These points were examined by the Study Team and discussed with PNGWB, and other relevant organizations. Consequently, these were reflected in the implementation of the Pilot Project.

(2) Institutional Framework for O, M & M of New Water Supply Systems in District Towns

1) Operation, Management and Maintenance

Through the discussions with PNGWB it was agreed to have an institutional framework for O, M & M of new water supply systems in the District Towns as follows:

a) PNGWB will operate the water supply systems in Bereina, Kwikila and Mutzing as its Water Districts. According to the National Water Supply and Sewerage Act (NWSS Act) these water supply facilities will become the property of the PNGWB upon the declaration of the new Water District. This includes the facilities that were originally constructed by the Dept. of Works and managed by the Province. Therefore, PNGWB will be responsible not only for day-to-day O, M & M, but also for repair and replacement of facility and equipment, and extension in the future.

b) Concerning the water supply systems at Mutzing, Bereina, and Kwikila that are renovated by the Pilot Project, PNGWB decided to recommend the minister to declare new Water Districts in the Board Meeting of June 28, 2001. Consequently it is scheduled that Minister of Privatization and Cooperatisation declares the new Water Districts at Mutzing, Bereina and Kwikila in early July 2001. After this declaration, the Water District of Mutzing will be under management of Northern Regional Office, while Bereina and Kwikila will be under Southern Regional Office.

2) Estimated Balance of Revenue and Expenses

Since Phase-I of this Study in 2000, the estimation of revenue, expenses and balance of these new Water Districts were done repeatedly. Recent discussions with PNGWB concerning details of operation and management at the new Water Districts were reflected in the estimation which was updated as of just before the operation started in June 2001. This part is explained as below.

a) Revenue: Revenue is limited to the billing of water rate in principle. The water rate

is based on the PNGWB's standard tariffs (refer to Table-11.25) and the bills will be charged to the individual and institutional users in the Water Districts. Number of users (individuals and institutions) is counted based on the pre-registration which was done in February to March 2001. The water consumption is basically calculated as the pre-registered population of respective user multiplied by the design water consumption per capita per day. However, water consumption is kept on the conservative side to make sure that actual revenue would reach at least this estimated. The water meter at each user's connection will be read every month and it will be charged by consumed quantity as per the standard tariffs. The water bill will be issued, delivered and paid accordingly. However, for the transitional period from the completion of the Pilot Project construction until the proper billing system becomes ready, temporary billing by a flat rate will be considered since the preparation for setting up the billing system such as installation of water meters, and arrangement of cash handling at the Water Districts will require several weeks.

Table-11.25 PNGWB's Standard Tariffs

Water Supply Charge per Month (Kina)	
1. Residential Occupancy /Metered	
Up to 15 kilo litres	4.05 per customer as Minimum Charge (flat rate)
15 to 30 kilo litres	0.58 per kilo litre
Above 30 kilo litres	0.98 per kilo litre
2. Non-Commercial, Government Institutions and Related Occupancy/ Metered	
Metered (per Month)	1.25 per kilo litre Minimum charge K20
3. Commercial/Industrial Occupancy/ Metered	
Metered (per Month)	1.25 per kilo litre Minimum charge K20
4. Connection/Junctions Fee	
4-1. New Connection/ Junctions Fee	
For standard new connections of 15mm Not more than 26 m from the nearest main	K60.00 per connection
Connections/Junctions exceeding the above	At cost
4-2. Reconnection	
Where services have not been disconnected	K25.00
Where services have been disconnected and water meter removed	K25.00

NWSS Act, 1986 (1st September 1997)

b) Expenses: For estimation of the expenses, the following operation and management system at the Water Districts is used as the assumption.

i) Staff: Personnel cost is a large burden for small scale water supply systems, and minimizing this cost as much as possible shall be considered when operation and management system is designed. In the Water District a Water Operator of PNGWB will be stationed. The required qualification for Water Operator is PNGWB's Grade7 or higher and knowledgeable on plumbing work. As an assisting staff to the Water Operator, an assistant will be employed locally. This assistant shall be with qualification of PNGWB's Grade 4. The management of the entire system will be done by the Regional Manager. In case of Bereina and Kwikila the Regional Manager is stationed at the Southern Regional Office in Port Moresby, while Mutzing will be managed similarly by the Regional Manager at the Northern Regional Office in Lae. The Regional Manager shall visit the Water District every two weeks in principle, and does the administrative and managerial work for the Water District. The Water Operator shall do daily operation and inspection, recording of operation data, meter reading, reporting to the Regional Office, simple repair and relevant plumbing work. Based on the meter reading, the water bills shall be issued at the Regional Office and the bills shall be delivered by the Water Operator. When it is required, the Water Operator also shall organize sales promotion activity and public relations campaign including "Pay Water Bill" campaign. The data of meter reading and delivery of the water bills between the Water Operator and the Regional Office will be done when the Regional Manager visits the Water District for supervision and/or when the Water Operator visits the Regional Office for reporting. In principle water fee collection will be done at the National Treasurer's account counter at the District administration by delegation from PNGWB to the District administration. When necessary the Regional Office dispatches its cashier or adequate staff to the Water District to fulfil the fee collection. The personnel cost of the Water Operator and the Assistant shall be charged to the Water District and the cost of the Regional Manager shall be absorbed by the general administrative cost.

ii) Energy Cost: In Bereina, solar generating system is used and a stand-by diesel engine generator is set for supplementary energy source when irradiation in daytime is not enough depending on weather condition. This generator shall be run when it is necessary. In Kwikila and Mutzing, ELCOM supplies constant public power supply. The cost of electricity will be charged as per the ELCOM's rate.

iii) Chemicals: Breaching powder for chlorination is only one chemical to be used in the new water supply system and it will be procured by the Regional Office and delivered to the Water District. The cost shall be charged to the Water District. It

is expected that the procurement together with chemicals for other Water Districts minimize the procurement cost.

iv) Office Cost: There is a simple office space within the pump house. If required an appropriate office space can be provided by the District administration. The details shall be concluded between PNGWB and the District administration. The office may require procurement of office furniture, office equipment and the procurement will be done by the Regional Office and the cost will be charged to the Water District as the depreciation accordingly. The procurement shall be limited to the minimum items which are essential for the work for a while. Similarly the consumables shall be arranged.

v) Other Expenses: Installation of security alarm equipment, insurance coverage for facilities and staff, and procurement of bicycle for the Water Operator to make the round for inspection in the Water District, shall be done by the Regional Office. These costs also shall be charged to the Water District accordingly. The transport cost for the Water Operator's visit to the Regional Office for reporting and the general administration cost of the Regional Office are considered. Installation of radiophone is proposed for the communication between the Water Districts in Bereina and Kwikila and the Southern Regional Office in Port Moresby. It is assumed that use of radiophone is effective since the service of TELIKOM is not reliable in these areas.

c) Estimated Financial Balance: Based on the above described revenue and expenses for operation of water supply systems the financial balance of each Water District was estimated. The details for respective Water District are shown as below.

i) Bereina:

The pre-registration of users for the residents and institutions within the station of Bereina was done. These users will receive water supply service from the existing distribution pipeline and its extensions with house connections. There are eight public faucets constructed by the Pilot Project in the surrounding villages, and each public faucet has a water committee formed by the village residents. The water committee will identify the household who will use the facility and share the water charge. Certain amount of money will be paid by these users as reserve for the water committee.

The water consumption and the water charge of each user group calculated from this

pre-registration data are indicated in the following table. Details of the calculation are shown in Table-11.26.

Table-11.26 Water Consumption and Water Revenue of Bereina

Type of User	Pre-Registered Users Number	Estimated Consumption (m^3/month)	Estimated Revenue (Kina/month)
House (incl. houses owned by Provincial Government)	70 households	840	336
Public & Private Institution (administration office, health centre, school, church, shop, etc.)	19 institutions	300	221
Village/Settlement	96 households	350	47
TOTAL	185 users	1,490 m^3/month	604 Kina/month

As a result of the above estimation, the revenue of Bereina WD is assumed as approximately K604 per month. On the other hand, its expenses are estimated as follows in Table-11.27.

Table-11.27 Details of Operation Cost (Expense) of Bereina

Item of Expense	Unit Price	Quantity	Base of Calculation	Expenses
Energy Cost: Stand-by Diesel Engine Generator (10KVA)	K0.842 / litre	Fuel consumption 10 litres/hour Operation 60.83 hours/ month 608 litres/ month	Solar power source: 5 hours run /day Generator: 2 hours run / day	K512 / month
Chemicals: Bleaching Powder for Chlorination	K177.84 /40kg bag, Purity 70%	Injection ratio 0.0001%	Water quantity for chlorination 1,790 m^3/month	K12 / month
Personnel: Water Operator Assistant	Water Operator: PNGWB's Grade7, existent trained operator of PNGWB Assistant: PNGWB's Grade4, locally employed			K2,478 / month
Office Expense:	Depreciation of furniture, equipment, transport fee for reporting			K437 / month
Insurance:	Asset value as K1.2million (cost of PNGWB's existent water district is applied)			K416 / month
Administration:	Temporary lump sum is charged in the initial stage. Cost of Regional Manager, bill issuance, etc. are considered.			K1,000 / month
TOTAL				K4,855 / month

The financial balance from the above mentioned revenue (K604) and expenses (K4,855) will become deficit of K4,251 per month. This means that further effort to reduce this amount of deficit and also Central Provincial Government has to provide subsidy to cover the shortfall. Amount of the subsidy shall be decided

between PNGWB and Central Provincial Government in the Consultation Meeting (at least one meeting per year shall be held) stipulated in the MOA. The budget appropriation by Central Provincial Government is required and the Study Team presented the proposed amount of the subsidy at K4,500 per month (K54,000 per annum) and recommended to reflect to its budget of the next fiscal year.

Table-11.28 Monthly Balance of Operation Cost of Bereina

Revenue	K604
Subsidy from PG/LLG	K4,500
Expenses	K4,855
Balance	K249

ii) Kwikila:

In Kwikila the pre-registration within the station was also done. Similarly to Bereina's case the users will receive water supply from the house connection of the existing pipelines and its extensions. However, in case of Kwikila more than 7 years passed since the existent water supply system had stopped, and this may require continuation of rehabilitation of distribution pipeline. For the residents of the settlements within the station, one public faucet was installed. This facility will be shared by the residents of three settlements nearby and one water committee was formed by the residents. The identification of the user households and preparation of the reserve for the committee are on-going.

The water consumption and the water rate of each user group calculated from this pre-registration data are indicated in the following table. Details of the calculation are shown in the table in the attachment.

Table-11.29 Water Consumption and Water Rate (Revenue) of Kwikila

Type of User	Pre-Registered Users Number	Estimated Consumption (m^3/month)	Estimated Revenue (Kina/month)
House (incl. houses owned by Provincial Government)	86 households	1,459	825
Public & Private Institution (administration office, health centre, school, church, shop, etc.)	18 institutions	1,977	2,035
Village/Settlement	27 households	97	4
TOTAL	131 users	3,533m^3/month	K2,864/month

As a result of the above estimation, the revenue of Kwikila WD is assumed as approximately K2,864 per month. On the other hand, its expenses are estimated as

follows.

Table-11.30 Details of Operation Cost (Expense) of Kwikila

Item of Expense	Unit Price	Quantity	Base of Calculation	Expenses
Energy Cost: ELCOM Power Supply Pump: 3.7KW, Chlorinator:0.14KW)	K0.184/KWh	517 hours/month 1,986KWh/month	Operation: 17 hours / day	K365/month
Chemicals: Bleaching Powder for Chlorination	K177.84 /40kg bag, Purity 70%	Injection ratio 0.0001%	Water quantity for chlorination 4,240m^3/month	K27 / month
Personnel: Water Operator Assistant	Water Operator: PNGWB's Grade7, existent trained operator of PNGWB Assistant: PNGWB's Grade4, locally employed			K2,478 / month
Office Expense:	Depreciation of furniture, equipment, transport fee for reporting			K437 / month
Insurance:	Asset value as K1.2million (cost of PNGWB's existent water district is applied)			K416 / month
Administration:	Temporary lump sum is charged in the initial stage. Cost of Regional Manager, bill issuance, etc. are considered.			K1,000 / month
TOTAL				K4,723/ month

The financial balance of the above indicated revenue (K2,864) and expenses (K4,723) results as deficit of K1,859 per month, and similarly to the case of Bereina, effort to minimize the deficit and subsidy from the Provincial Government is required. The subsidy amount shall be discussed between PNGWB and the Provincial Government in the Consultation meeting as stated in the MOA. As the recommendation, the subsidy of K2,500 per month (K30,000 per annum) was proposed by the Study Team to the Provincial Government to secure the budget in the next fiscal year.

Table-11.31 Monthly Balance of Operation Cost of Kwikila

Revenue	K2,864
Subsidy from PG/LLG	K2,500
Expenses	K4,723
Balance	K641

iii) Mutzing:

The water consumption and the water rate of each user group in Mutzing were estimated with the data of pre-registration in the station area. These users will receive water supply service with house connections from the existing pipelines and its extension. There are four public faucets which were built by the Pilot Project and these will be used by the residents of these surrounding villages. Each public faucet has its Water Committee and the committee is doing identification of the user households and collecting money for reserving the deposit for the payment of water rate.

Table-11.32 Water Consumption and Water Rate (Revenue) of Mutzing

Type of User	Pre-Registered Users Number	Estimated Consumption (m^3/month)	Estimated Revenue (Kina/month)
House (incl. houses owned by Provincial Government)	81 households	881	635
Public & Private Institution (administration office, health centre, school, church, shop, etc.)	25 institutions	1,367	1,143
Village/Settlement	90 households	324	63
TOTAL	196 users	2,572m^3/month	K1,841/month

As a result of the above estimation the revenue of Mutzing water district is assumed as approximately K1,841 per month. On the other hand, its expenses are estimated as follows.

Table-11.33 Details of Operation Coast (Expense) of Mutzing

Item of Expense	Unit Price	Quantity	Base of Calculation	Expenses
Energy Cost: ELCOM Power Supply Pump: 4.0KW, Chlorinator: 0.14KW	K0.184/KWh	395 hours/month 1,637KWh/month	Operation: 13 hours / day	K301/month
Chemicals: Bleaching Powder for Chlorination	K177.84 /40kg bag, Purity 70%	Injection ratio 0.0001%	Water quantity for chlorination 3,090m^3/month	K20 / month
Personnel: Water Operator Assistant	Water Operator: PNGWB's Grade7, existent trained operator of PNGWB Assistant: PNGWB's Grade4, locally employed			K2,478 / month
Office Expense:	Depreciation of furniture, equipment, transport fee for reporting			K437 / month
Insurance:	Asset value as K1.2million (cost of PNGWB's existent Water District is applied)			K416 / month
Administration:	Temporary lump sum is charged in the initial stage. Cost of Regional Manager, bill issuance, etc. are considered.			K1,000 / month
TOTAL				K4,652/ month

The financial balance from the above mentioned revenue (K1,841) and expenses (K4,652) is deficit of K2,811 per month. The reducing of the deficit amount and provision of subsidy by Morobe Provincial Government and Umi-Atzera Local Level Government is required to cover this shortfall. Amount of the subsidy shall be discussed and decided in the Consultation Meeting between PNGWB and Morobe Provincial Government and Umi-Atzera Local Level Government. The subsidy of K3,000 per month (K36,000 per annum) was proposed by the Study Team for the budgeting in the coming fiscal year.

Table-11.34 Monthly Balance of Operation Cost of Mutzing

Revenue	K1,841
Subsidy from PG/LLG	K3,000
Expenses	K4,652
Balance	K189

3) Operation, Management and Maintenance of Water Vending Unit introduced in Daru and Rural Water Supply Facilities in Villages along Binaturi River

Apart from the District Town water supply, the Pilot Project introduced Water Vending Unit in Daru and rural water supply facilities (rainwater tanks and hand dug wells) in the villages along Binaturi River. The O, M & M of these facilities are planned as follows.

a) O, M & M of Water Vending Unit in Daru

In the urban area, there are some areas where mainly low-income groups reside. It is seen very often in such an area that some town water supply users fail to pay the water bill and are disconnected. Consequently these residents start using unsanitary water from unprotected dug well or water hole. It was confirmed in Phase-I that also in Daru there are certain number of households who failed the water bill payment and disconnected in the areas where low-income group resides. However, these residents are buying a bucket of water at more expensive price, and nevertheless they failed to pay the water bill. Therefore, it was assumed that selling water per bucket at reasonable price at officially installed public faucet would contribute a lot to improve the water supply condition of these residents. For this purpose the component to install two public faucets as the Water Vending Unit and to supply water to these residents in this area was proposed to PNGWB. This was accepted and implemented. For PNGWB similar situation is found in various Water Districts other than Daru and interest on the result of this component is shown.

- Operation of the Water Vending Unit is simple and does not require special skills. O, M & M system of Water Vending Unit is planned as follows.
- Concerning location of the Water Vending Unit, following factors were considered for selection. Water supply situation in the area, existence of the residents who are disconnected due to failure of payment, water demand and willingness to pay among the residents, etc. The areas where reaction of the residents is positive and candidates of water vendor are found, and land dispute is not existing were selected.
- Prior to the installation of the Water Vending Unit, the minutes of agreement was agreed among the water vendors (individuals) and PNGWB together with Fly River Provincial Government and Daru Town Local Level Government as the supervisors of appropriate O, M & M.
- Water Vendor shall receive the approval of PNGWB for the selling price of the water to the residents. When it is found that Water Vendor sells at unjustifiable price the Water Vendor shall be penalized.
- Water Vendor shall pay the water rate as per the standard rate of PNGWB. Meter reading shall be done at the Water Vending Unit and the bill shall be delivered to the Water Vendor for the payment. However, in case of high level of sales at the Water Vending Unit the water bill should become high. Therefore Water Vendor shall deposit every week the amount equivalent to 25% of the estimated monthly bill. This is to avoid any trouble of payment by the Water Vendor.
- The facility of Water Vending Unit is property of PNGWB. The day-to-day cleaning and maintenance of the facility shall be done by the Water Vendor and repair will be done by PNGWB when necessary.

When operation of the Water Vending Unit is started, PNGWB Daru Water District Office frequently inspects and monitors the operation at the sites during the initial operation stage.

b) O, M & M of the Rural Water Supply Facilities in the Villages along Binaturi River

Water source of Daru Town water supply is Binaturi River that is located in the mainland. Along this River there are several villages. However, these villages hardly have water supply facilities. The residents of these villages are frustrated since they suffer from shortage of water during dry season while water is pumped from Binaturi River to Daru Town. There are incidents that some of the residents occupy pumping facility and interrupt operation of water supply system. PNGWB is regarding this as a considerable issue.

Installation of rainwater collection tanks and construction of hand-dug wells as rural water supply facilities for these villages where residents suffer from unstable water supply were proposed by the Study Team and implemented with consent of PNGWB.

The work to be done for installation of rainwater collection tanks and construction of hand-dug wells are comparably simple and it is suitable to be done by the residents when technology transfer is provided. The residents agreed to do the work as their participation and will continue construction work by themselves. By community development activity water committees were established in the villages and Binaturi River Development Corporation (BRDC) which is the higher organization in the area is supported to continue improvement of the water facilities. These community based organizations will be responsible for O, M & M of the water facilities. Although the water facilities are very simple and do not require much attention like piped water supply system, it is assumed that it will take time to reach a stable O, M & M by the residents. As the technology required for these facilities are simple, Health Division's water & sanitation team of Western Province can assist them visiting from Daru. The Government of Western Province has confirmed that this activity would be supported by the Provincial Government.

11.5 Plan to Organize People

1) Organization of Water Management Committee

i) The Pilot Project Sites of Kwikila, Bereina and Mutzing

As mentioned previously, for the Pilot Project it has been mentioned that usual services operated by PNGWB may be difficult to apply to informal residents/villagers because of their disadvantageous socio-economical condition. Therefore, public faucets and organization of Water Management Committees are considered to be key components for the Pilot Project. The main objectives in organizing Water Management Committees are to conduct maintenance of installed public faucets through the participation of beneficiaries. In the Pilot Project, informal residents are exempt from the target related to the organization, because each formal resident household is expected to make a contract with PNGWB as is the case in other Provincial Towns in which PNGWB operates.

The reasons for installing public faucets are as follows. First, the cost of installing water taps and extension pipes in households at a user's own expense is thought to be difficult for informal residents/villagers. Secondly, it is expected that regular monthly water charge payments per

household are rather difficult for this group of people according to experiences at other sites.

Reasons for the organization and participation method are as follows. First, it is obvious that PNGWB cannot directly take care of the public faucets and other organizations like local municipalities do not have enough capability to substitute its services. Therefore, unless the beneficiaries themselves participate in maintenance, the water supply services are thought to be unsustainable. Secondly, in the case of water supply services by way of public faucets, operations should be adjusted in accordance with the actual situation at each site and such flexibility would be realized most effectively through the participation of beneficiaries. Water supply services operated by beneficiaries are seen in many developing countries, however, this is the first time for PNGWB.

Although at the beginning of the Pilot Project, Water Management Committees had planned to be organized per public faucets, in reality however, several public faucets have been grouped along main water pipes and one committee has been organized for them considering the maintenance work requirements of some sites. The unit for one organization is varied and the committee covers part of one area - a whole village or the entire group of informal residents of one District Town. It would be useful to conduct an inquiry to detail the difference between different units of committees in the future. In addition, as for future projects where sites are separated from the JICA Study like the Islands and the Highlands, it will be required to reconsider more appropriate ways of implementation in light of PNG's rich and complex cultural background.

The main processes of the organization are: 1) Selection of members for the Water Management Committee, 2) Establishment of rules to utilize the public faucets by the Committee, 3) Establishment of a training course for the Committee (management of the organization, facility maintenance, health/sanitation, and accounting), and 4) Initial fund raising. After completing the above process and other required preparation, each committee will be able to register with PNGWB and commence water supply services at each site.

Throughout the period of the Pilot Project, one community organizer, a local NGO staff member, in each site has been allocated to assist the activities of informal residents/villagers. Although their ability has been observed as sufficient in a field staff capacity, their capability is insufficient to supervise the entire above-mentioned process. Therefore, human resources that have sufficient ability to manage the Project, together with adjusting procedures to develop appropriate organizations in accordance with the situation of each Project site will need to be developed.

Table-11.35 Summary of Established Organizations

	Kwikila	Bereina	Mutzing
Number of Public Faucets	1	9	3
Target	Informal residents	Villagers	Villagers
Unit of the Water Management Committee	The unit covers all informal residents	Several communal taps along the same water pipes are grouped.	The committee has been established based on village units.
Number of Water Management Committee	1	4	2

ii) The Pilot Project of Daru

In case of Daru, instead of organizing people, two Water Venders have been selected and given required training for operation, maintenance and management for Water Vending Units. Due to the profit driven and private entrepreneurial approach, the process is rather quicker and simpler than that of public faucet approach. However, the cost borne by each beneficiary (customer) is higher than that of faucet approach. In addition, it is thought to be a potentially problematic approach because of the benefit for the Water Vendors. Thus the occurrence of vandalism had been worried, however, any incident has not been reported since the completion of facilities except the slight mischief by children. It is also crucial to establish certain awareness of communal benefit towards the Water Vending Unit in neighboring residents.

Although this approach seems to be viable in PNG at this stage, some consideration should be required in case of additional implementation. First, the Water Vending Unit should be located in the State Land to avoid involving in any land dispute and compensation issue. Second, the population surrounding the Water Vending Unit is to be enough for generating certain income. In advance, it should be made sure that expected income is attractive amount compared with other small enterprises in each site.

iii) The Pilot Project in Binaturi Area

In case of Binaturi, a Community Based Organization, Binaturi Water Issue Committee, is identified in the first field survey, thus the main objectives are to enhance the organization and adjust the structure for the Pilot Project. Seven (7) villages are located along the Binaturi River and one community organizer, a local NGO staff member, has been allocated to catalyze the above processes. The core part of the Project is to introduce appropriate water supply facilities like rainwater collection tanks, hand pumps with dug well and hand pumps with borehole, and Health Division of Western Province has co-operated with and given technical support to those villages.

Although the basic concept of this Pilot Project was the beneficiaries' participation, it was followed in a very passive way. In short, it would be concluded that the concept of people's participation is not yet so much mature in PNG and more intensive support from specific experts should have been applied.

2) Collection of Water Charges

i) The Pilot Project Sites of Kwikila, Bereina and Mutzing

Water Management Committees accept overall responsibility for maintenance of the public faucets. The estimated required cost includes monthly water charge payments and occasional replacement costs for water taps. The maintenance from main water supply facilities to water meter boxes installed nearby each public faucet will be done by PNGWB, thus the responsibility of committees falls only on the water taps.

It is agreed that K5 per household as an initial fee is collected before official registration with PNGWB and some committees were reported to have already completed this collection. After acquiring the initial fees, the Committees will be officially registered with the PNGWB and will receive water supply services. After starting the water supply services, Committees are responsible for collecting K5 of monthly water charges per household and paying a monthly water charge to PNGWB. At present, usage of water at all sites is limited to drinking and cooking by beneficiaries, therefore the K5 monthly amount is thought to be sufficient to cover the monthly water charge for PNGWB and still allow some savings for future emergencies. It is recognized that some Committees fix a different water charge for single families, for example, K2.5.

At the beginning of the Project, each Committee was encouraged to open their own bank account and then manage the collected money themselves. However, it is very difficult for private organizations to open their own bank account in PNG, thus PNGWB allows money to be kept in their own deposit account. Although PNGWB decided to grant special treatment to participants of the Pilot Project, the management of collected money is still a pending issue.

ii) The Pilot Project of Daru

In case of Daru, the Water Venders sell water directly to the customers (beneficiaries) and bear overall responsibility related to the Water Vending Unit. They are expected to keep a certain portion of sales from their Water Vending business to pay water charge and future maintenance cost.

In the third field survey, it is observed that the Water Vending business show positive results and the Water Venders and customers (beneficiaries) also convey their positive opinion about this Pilot Project. According to the record of Samari Water Vender, the net monthly profit is around K200 and this amount is thought to be attractive enough as a small enterprise in Daru. The number of beneficiaries is still increasing and the area covered by one Water Vending Unit is also extending more than the expectation of the Study Team.

11.6 Plan for Improving Health and Sanitation

1) Required Consideration for Water Supply and Health Education

Considering present practices related to washing hands after visiting toilets and boiling water, it is obvious that health education should be a high priority. However, learning about these necessities will not be effective until safe, stable, and easily accessible water sources become available.

In addition, considering the different perception of diarrhoea and differing experiences of health education between formal and informal residents/villagers, opportunities for education regarding health and sanitation is necessary in preference to the informal residents/villagers.

2) Required Improvement for Toilet and Sewage

As results of the survey in the Pilot Project show, it is evident that most houses of formal residents are equipped with sewage-related facilities such as kitchens, flush toilets, showers, etc., thus it is not certain if improving these facilities is necessary. However, some households are equipped with pit latrines in addition to flush toilets due to problems surrounding water availability. Furthermore, it is not sure that existing flush toilets are still usable even if water does become available. In the cases of Bereina and Kwikila, where the main water source for formal residents is water tanks, there is a potential risk that the existing sewage system will need to be repaired or an enhanced water supply service will need to be devised because the volume of drainage will increase dramatically.

Table-11.36 Sewage Facilities per Households (average number)

	Kwikila	Bereina	Mutzing
Formal Residents			
Kitchen	0.9	0.8	1.0
Shower	0.9	0.9	0.8
Flush Toilet	0.7	1.0	0.8
Washing Stand	0.8	0.8	0.6
Laundry Stand	0.1	0.2	0.6

As for informal residents/villagers, the spread of sanitation facilities is thought to be a very urgent issue, in particular, in Oro Bay, Bereina and Kupiano, where very few households have sanitation facilities. In order to handle this, not only assistance in targeting facilities is important, but also assistance in targeting the beneficiaries (informal residents/villagers) to improve the awareness of health and sanitation, or training for the construction and maintenance of sanitation facilities. It is not realistic that sanitation facilities for informal residents/villagers can be integrated into the services by PNGWB, therefore co-operation with other organization, like the Department of Health will be required.

CHAPTER 12 MANAGEMENT OF PILOT PROJECT

12.1 Local Contractor

1) Drilling Contractor

Local drilling contractors were chosen to do the test drillings. The Study Areas were located in 8 Areas of 4 Provinces. Most were accessible by road except Daru Island and Finschhafen. After comparing the quotations for the test drilling submitted by these drilling contractors, three (3) drilling companies were selected. These companies had to have the advantage of mobility to each Area. Since there was no geoelectric logging company in PNG, an Australian firm and another third world country firm were considered and in the end a Thailand company was selected based on cost performance. The drilling and geoelectric contractors are as listed below shown in Table-12.1.

Table-12.1 Selected Drilling and Geophysical Logging Contractor

Study Area	Province	Drilling Contractor	Company Location	Geo-electric Contractor
Bereina, Kwikila, Kupiano, Daru	Central	Central Drillers Ltd	Port Moresby	Siam Tone, Thailand
Popondetta, Oro Bay 1&2, Finschafen 1&2	Oro (Northern)	New Britain Drillers	Kokopo	Siam Tone, Thailand
Mutzing	Morobe	Paradise Drillers	Lae	Siam Tone, Thailand

The three drilling contractors completed their drilling works. However there were large differences in their outfit, such as capacity of drilling machine, supporting machine and equipment for drilling, drilling method and technique between each company. Concerning technology and skills for groundwater development the Study Team carried out the evaluation of concerned drilling companies and the geophysical logging company as follows (Table-12.2).

Table-12.2 Summary of Evaluation of Concerned Drilling Company

	1. Central Drillers	2. New Britain Drillers	4. Paradise Drillers	5. Siam Tone (Logging)
1.Equipment	○	◎	△	○
2.Technique	○	◎	○	○
3.Drilling	△	◎	○	-
4.Geological	◎*1	○	△	△
5.Pumping Test	△	○	△	-
6.Logging	—	—	—	○
7.Reporting	◎*1	◎*2	△	○

◎Very Good ○Good △Fare ×Not good — Not concerned

* 1: Supported by PNG Geological Survey

* 2: Supported by Douglas Partners, Australian Consultants

2) Construction Companies in Papua New Guinea

General construction companies which can manage large-scale construction works including the water supply facility construction are available in Papua New Guinea but these companies' headquarters are in Australia or New Zealand. In Papua New Guinea, local builders are not few, but most of their experiences are small to medium-scale constructions. If these local builders are to conduct large-scale construction, they must employ various special engineers individually.

For most builders and subcontractors, Australian or Philippines are engaged in management such as site managers, and Papua New Guinean people are engaged in labour under their management as field-workers. Since technical workers who have special skills are few in general, technological guidance is necessary in line with the method of construction adopted in the Pilot Project. Especially, the dispatch of skilled workers from each special trade is indispensable for the panel tank which is adopted as the water tank type and for the solar generating system in this Pilot Project.

The use of construction equipment such as backhoes, graders, and cranes are effective for efficient construction of the water supply facilities. However, it is necessary to consider the limit in kind and number of construction equipment which the local builder has. Moreover, trailers are usually used to transport construction equipments, but if there is a problem in access to the site, necessary construction equipment may not be used. Therefore, it is necessary to consider the kind and availability of the construction equipment which the builder has, and the situation of access to the sites.

A suitable general contractor for implementation of the Pilot Project was selected based on the above-mentioned Papua New Guinea's construction circumstances. The selection of the company was done carefully based on criteria which consist of adequate number of engineers, business scale, experiences, results, and financial situation. Additionally, opinions collected from the counterpart organization and people concerned were referred to in the consideration.

Moreover, the qualifications of construction companies was screened before the evaluation on the cost estimates which the traders had submitted. The under mentioned items were examined in the qualification examination.

1) Performance records concerning construction works of more than Aus$500,000 in Papua New Guinea
2 Contract amount in the last financial year showing an amount more than Aus$10,000,000 regardless of domestic or overseas works
3) Similar experience in construction works for water supply facilities (including subcontracted works) in the last ten years, regardless of domestic or overseas works
4) Financial statement for the last two consecutive annual terms showing sound financial status
5) Key personnel who will be assigned to this construction works and qualification of these key personnel showing their capabilities and experiences for the works

In this Study, the construction company judged to be appropriate was selected for the facility construction work of the Pilot Project through the qualification screening above-mentioned and evaluation of the cost estimation. When negotiating on the contract, more detailed discussions were held concerning concrete schemes of execution such as human resources layout and equipment & material procurement plan.

12.2 Supervision of Pilot Project

1) Objectives of Pilot Project

There are mainly three objectives in this Pilot Project.

① To examine the improvement in water supply systems suggested in the master plan and make recommendations for other areas for future reference;
② To improve the water supply systems in Bereina, Kwikila and Mutzing;
③ And to transfer the skills and technologies for construction, operation and management of

water supply systems to the counterpart, PNGWB.

2) Stakeholders of the Construction Works in Pilot Project

According to the objectives listed above, considerations were made to transfer the technologies and skills for construction works to the PNGWB during the construction works.

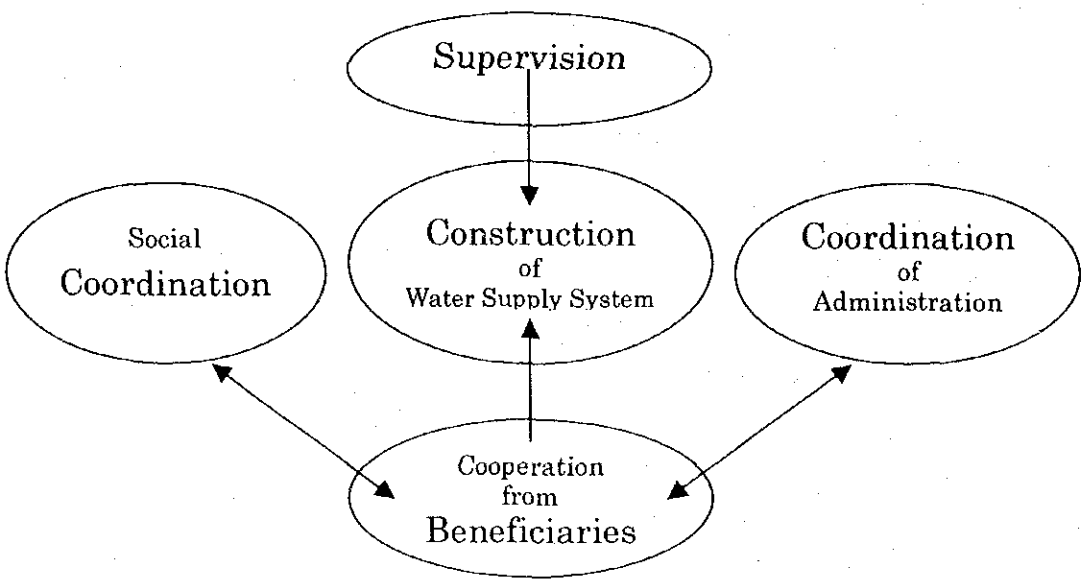


Fig.-12.1 Function and Roles of the Construction Works

The system of the construction works was described the above in Fig.-12.1. Stakeholders were involved in each role(s) as shown in Fig.-12.2 below.

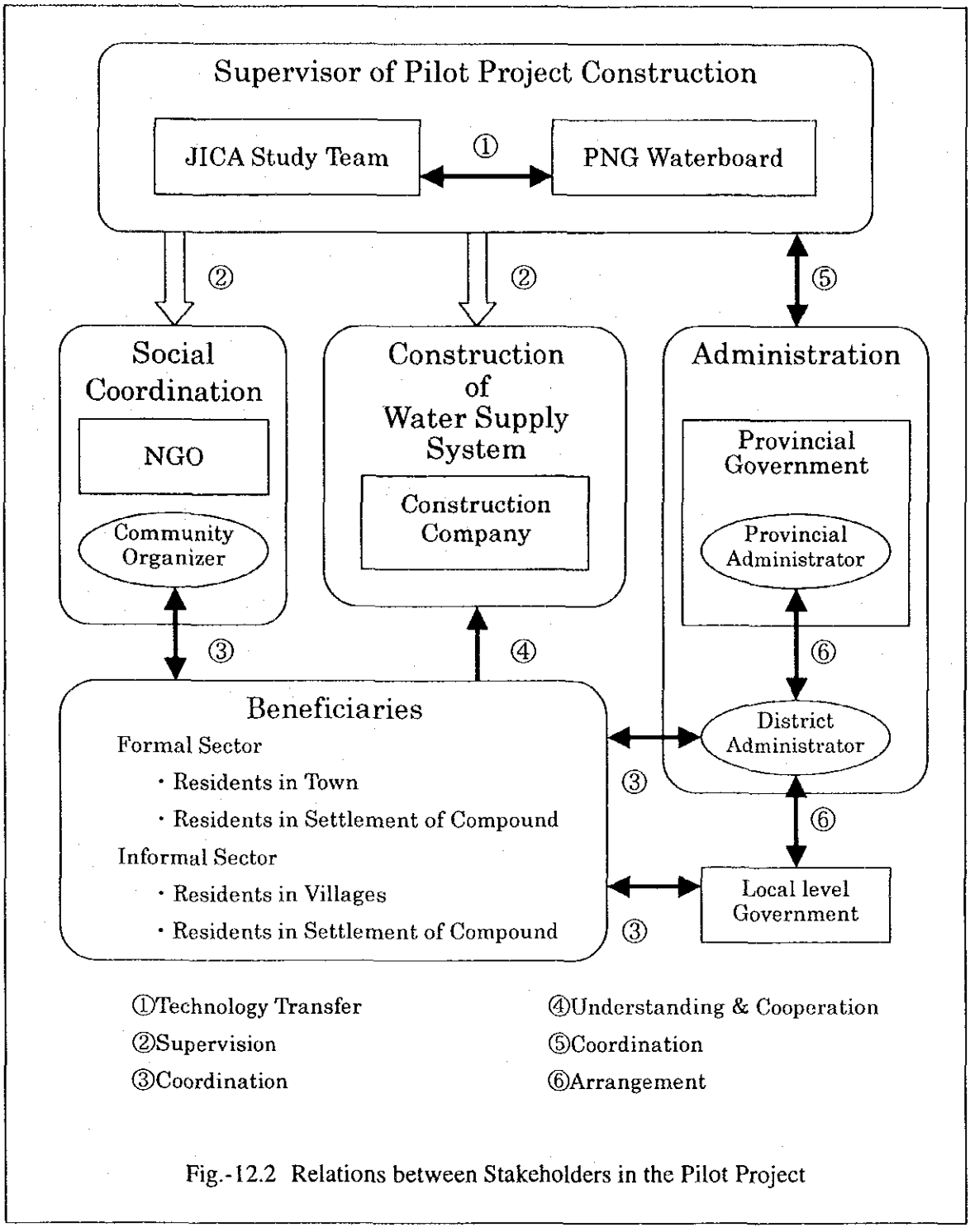


Fig.-12.2 Relations between Stakeholders in the Pilot Project

In this Pilot Project, along with the contract for construction with a construction company, a contract was made with a Non Governmental Organization (NGO) in order to have enough communication and coordination with the local residents. Coordination of local residents was

confirmed in the agreements prior to launching the construction works. Therefore, the coordination of the Community Organizers from the NGO and the cooperation from the District Administrations and the Local Level Governments are essential for the success of the construction works.

12.3 Implementation of the Construction Works

How the contractors play their roles is one of the important factors to influence the success of the construction works. The following Organisation system was structured for smooth performance of construction works.

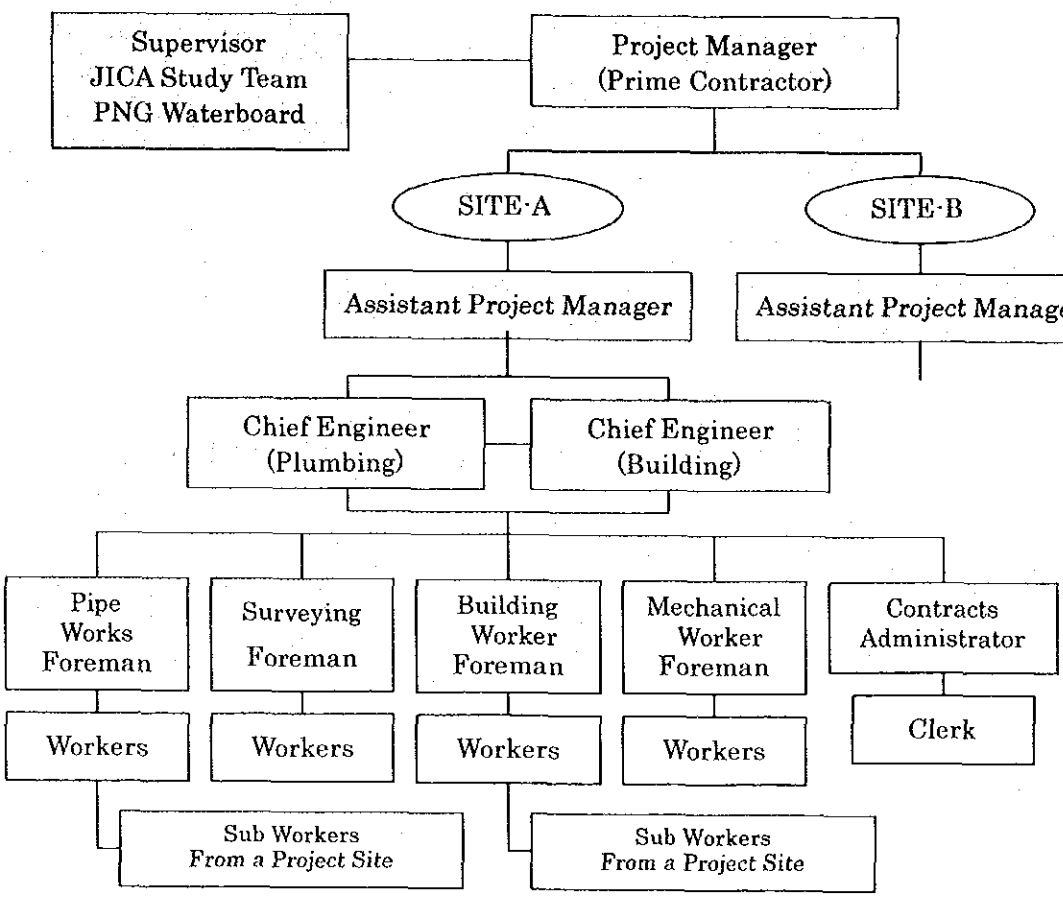


Fig.-12.3 Organisation Chart of the Construction Works

For the construction works in this Pilot Project, the tendering selection of the contractor was done. The selected contractor is a Joint Venture formed by a local construction company and a Japanese

construction company to provide co-operation in terms of schedule management and quality management. The organisation for construction works were formed considering the following.

1. An Assistant Project Manager is allocated in each site.
2. Two chief engineers in charge of plumbing and building support the Assistant Project Manager.
3. These two chief engineers manage piping, surveying, building, and mechanical works.
4. Each foreman gives orders to the workers.
5. The local villagers are employed as simple labourers.

A suitable construction organization is necessary for an effective work operation. At the same time, the Project Manager, Assistant Project Managers, Chief Engineers share the information so as to manage the situation in a flexible manner.

12.4 Supervision of Construction Works

In addition to the three Pilot Project sites for water supply systems, i.e. Bereina, Kwikila and Mutzing, Water Vending Units are constructed in Daru, and materials and equipment for installation of rain water tank and construction of wells are delivered to the villages along Binaturi River. Thus, a total of five sites are to be supervised in the Pilot Project. The access roads to Bereina and Kwikila are in bad condition, and the flights to Daru are often not on time. Therefore, allocation of enough time is required to supervise the construction works.

Table-12.3 Accessibility for Pilot Project

Site	Accessibility	Communication
Bereina	About 100km away from Port Moresby. A 4 hours drive by 4WD vehicle.	No public communication system Therefore, satellite telephone and radio communication system installed.
Kwikila	About 30km away from Port Moresby. About 1.5 hour drive by 4WD vehicle.	No public communication system therefore, satellite telephone installed.
Mutzing	The flight from Port Moresby to Lae about 1 hour and. about 2 hours from Lae to Mutzing by vehicle.	No public communication system therefore, satellite telephone installed. Telephones are available in Lae.
Daru	About 1.5 hour from Port Moresby by flight	Telephones are available in Daru.
BINATURI	About 2.5 hours from Daru Port by dinghy .	Satellite telephones are available .

The supervision of the works: The engineers of the JICA Study Team and PNGWB supervise implementation of the Pilot Project. They are based in Port Moresby, and visit the sites in turns. They visit each site once a week and/or 2 weeks. The guideline for the supervision is described in

Table-12.4 below.

Table-12.4 Guidelines for Supervision of Pilot Project

Activity		Guidelines	
1	Regular meeting	Timing and venue	Saturdays after Paydays (once every two weeks) The accommodation of JICA Study Team or PNG Waterboard office
		Contents of discussion	✓ Progress of the construction works ✓ Check on the schedule ✓ Check on the construction works
2	Monthly meeting	Timing and venue	The end of every month, on site
		Contents	✓ Discussion of the progress in the month ✓ Check on the schedule next month ✓ Check on the safety measures
3	Technical meeting	Timing and venue	When necessary, on site
		Contents	✓ Technical discussion ✓ Check on methods for construction
4	Presence for tests and inspections	Timing and venue	When necessary, on site and laboratories
		Contents	✓ Test for materials ✓ Soil penetration test and soil test ✓ Reinforcing bar arrangement test ✓ Concrete compression test ✓ Concrete placing test ✓ Water pressure test ✓ Water filling test for tanks ✓ Partial inspection of constructed facilities
5	Approval for Shop drawings and Instruction letters	Timing	On the event of meetings
		Contents	✓ Issuing shop drawings ✓ Approval for material samples ✓ Issuing instruction letters
6	Co-ordination with Relating agencies	Timing	When necessary
		Contents	✓ Discussion with the related agencies ✓ Submission and acceptance of letters

The following is the proposed supervision for the construction work. The supervision in Bereina and Kwikila is carried out one week due to the available one day trip and schedule shown in Table-12.5. On the other hand, the supervision in Mutzing, Daru and Binaturi takes two weeks due to air flight and other transports as shown in Table-12.6

Table-12.5 Proposed Schedule of Supervision in Bereina and Kwikila

MON	TUE	WED	THU	FRI	SAT	SUN
MS ●	SV ◄——►		CM ◄·····►		RM ◎	

Table-12.6 Proposed Schedule of Supervision in Mutzing, Daru and Binaturi

MON	TUE	WED	THU	FRI	SAT	SUN	MON	TUE	WED	THU	FRI	SAT	SUN
MS ●	◄——►	SV	——►	CM ◄·····►			MS ●	◄·····►	CM	·····►		RM ◎	

SV : Supervision at the Site
CM : Coordination in Port Moresby
RM : Regular Meeting (Once in 2 weeks)
MS : Meeting of Supervisor or JICA Study Team (Every Monday)

One of the advantages of periodical supervision at the respective sites is to encourage the contractors to proceed. However, the actual schedule is likely to be changed by unexpected factors such as the delay of materials' deliveries and others. On the other hand, the regular trips to Bereina and Kwikila in fixed rotations may not be recommendable due to security reasons mentioned below. Therefore, schedule of the supervision should be adjusted flexibly depending on the situations.

12.5 Security Management

The Study Team requested the contractor for construction works to take necessary measures for security management. Regarding the security management, the Japanese Contractor gives the following instructions to the workers.

1) Safety Meetings	A meeting is held once every two weeks.
	The security measures are instructed.
2) Safety Instructions	Instructions to new workers.
3) Safety Checks	Instructions to handle harmful materials.

Since robberies have frequently occurred near Port Moresby and Bereina, three to four policemen should be allocated in the construction sites at all times. Also, there are possibilities to be attacked by "Rascals", groups of robbers with weapons such as knives and guns, on the access roads. Therefore, it is recommended that policemen be always accompanied, especially on the way to

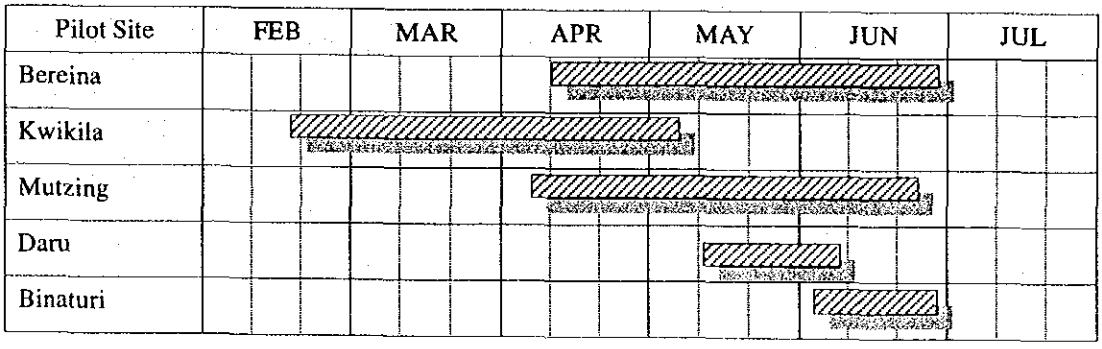
Bereina.

12.6 Schedule of Pilot Project

The construction works were launched in Kwikila at first where the accessibility is better than the other sites. It was aimed that Chief engineers and foremen become used to know the characteristics of this Pilot Project during the construction works in Kwikila.

The following is the schedule of Pilot Project including the Water Vending Units in Daru and the procurement of materials for Binaturi villages. Bereina and Kwikila are located in Central Province, while Mutzing is located in Morobe Province. For this reason, the construction works were carried out by two Teams.

Table-12.7 Construction Schedule



The period of construction works in the Pilot Project is 25 weeks from late February 2001 to the middle of July 2001. This period is not necessarily enough in the conditions of Papua New Guinea where there are various unpredictable factors.

The main factors which caused the delay in the schedule could be attributed to the delay of legal processes for deteriorated conditions of the access roads due to heavy rains and floods; the delay of electric installation works by ELCOM; land issues, especially changing opinions of the villagers; and so forth.

Regarding the land issues, there are possibilities that land owners and /or any other concerned parties may raise additional issues even after the construction works started. These are also attributed to the historical problems between the Government and the landowners. Because of these unpredictable factors, the construction works should be ready for flexible adjustment with several options.

The construction works started in the mist of this situation. The progress of works has not been seriously diverted from the initial schedule except for some minor problems caused by the deteriorated access roads and land issues. The implementation of the construction works was scheduled as shown in Table-12.8.

Table-12.8 Construction Work Schedule