3.4.3 Staffing Requirement

The more the service area/population is expanded, the more the staff required. The ratio of staff number to the service population is also largely dependent on the qualification and efficiency of the staff. The staffing ratio is rather experimental. If it is too tight, the total efficiency will be reduced. If there are more staff than practically required, the economic feasibility will deteriorate.

Based on the figures obtained by experience in many countries, the staffing ratio to service connections is roughly in the range of 100 to 200. If the efficiency increases, the staffing can be reduced.

The existing connections of NCDC are about 19,000, of which about 75% are metered. The total operating staff for water supply and sewerage is 235 positions, not all filled. A rough calculation indicates that one staff of water supply is working for a little over 100 connections. This means that the Water Supply Division is a little overstaffed, because they are purely for operation. This situation can be improved in the course of reorganization.

The staff requirement proportional to the increase in connection is calculated in Table 3.4. This is a temporary figure. There are many assumptions for this. As mentioned above, if the management efficiency increases, less staff will be required and vice-versa.

Table 3.4 Connection and Staffing

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Population	195,382	206,768	218,189	229,593	240,996	252,400	264,780	277,160	289,540	310,920	314,300
Fa. Member	7.2	73.1	7.0	6.9	6.8	6.7	6.6	6.5	6.4	6.3	6.2
Households**	27136	29125	31170	33271	35441	37672	40118	42640	45241	47924	50694
Connections	19000	22220	24084	25949	27813	29677	31541	33405	35269	37133	38997
Residents	16000	17465	48930	20396	21861	23326	24791	26256	27722	29187	30652
Others*	2850	3333	3613	3892	4172	6351	6750	7149	7548	7947	8345
Connect Rate	70.0%	76.3%	77.3%	78.0%	78.5%	78.8%	78.6%	78.3%	78.0%	77.5%	76.9%
Connect/Staff	110	112	114	116	118	120	122	124	126	128	130
Staff Number	173	198	211	224	236	247	259	269	280	290	300

Note : * means 15% of total connections.
** is assumed that 50% of households will be
Res. connects in 2015 are assumed at 52,630

3.4.4 Implementation schedule and management

It was agreed that this Study would cover a period of more than 20 years up to 2015 in the Master Plan. The Master Plan period was divided into three phases. The JICA study team worked out the details to set the Feasibility Study frame up to year 2000. This was agreed upon with the PNG Government this time.

The items to be included in F/S are:

a) Intake at Rouna 4
b) Raw Water Main
c) Pumping Station
d) Expansion of Mt. Eriama water treatment plant
e) Transmission System from Mt. Eriama
f) WTP Construction at 9 mile
g) Transmission System from 9 Mile
h) Distribution System

For the detailed implementation schedule of F/S, refer to the other section of the Study. The additional water is scheduled to be available for the population first in 1997, after the expansion of Mt.Eriama WTP has been completed. However because the water demand will increase by that time, a water shortage is predicted.

In the period between now and 1996, for about three years, a Water Rationing Program (WRP) will be scheduled to enable the equitable distribution of the limited water. This will require some additional staff.

There will also be a pipe construction to alleviate the current water shortage experienced in the Town area. These are called "Immediate Remedial Measures." However, it is predicted that additional staff will not be required for operation after the completion, because the system will not be changed nor expanded.

Table 3.5 shows the staff requirement for the F/S implementation. This is based on the fact that all the staff would be included in the administration, finance, planning, construction within the Water Supply division. Based on the table, the proper staffing for the existing system would be 184. The staffing requirement will increase to 300, after the F/S construction has been completed for full operation in 2000.

The total number of employees of NCDC is presently a little over 1,000 (see Table 3.6). This figure will also increase as the population of the city increases. Assuming an annual increase of 4%, the total number of employees in 2000 will be about 1,500. This means that the ratio of the water supply staff to the total will be 20% in 2000, which is almost the same as the present figure.

Table 3.5 Implementation Schedule and Management

Year	1993	1994	1995	1996	1997	1998	1999	2000
Facility	Exist <-- First Phase (F/S) Period -->							
1. Conveyance System								
Intake					2	2	2	2
R/W Main					1	2	2	2
P/S					2	2	2	2
2. High Zone								
WTP (MT. E.)	32	32	32	32	35	35	35	35
Transmission					2	2	2	2
3. Low Zone								
WTP (9 Mile)								32
Transmission								1
4. Distribution								
Res. & Pipes	134	136	138	140	142	144	146	148
5. Connections								
M/Con & Ins	0	10	11	12	13	14	15	16
M/Reading	0	13	14	15	16	17	18	19
6. Head Office								
Adm/Mngmnt	15	15	16	17	18	19	20	21
Plan/Const.	0	11	12	13	14	15	16	17
7. Others								
Store/o.	3	3	3	3	3	3	3	3
8. Water Rationing P.		<- program ->						
Required Op.		10	10	10				
Total	184	230	236	242	248	255	261	300

Table 3.6 Number of NCDC Employees

Year	1988	1989	1990	1991	1992	1993
Employees						
Permanent	955	974	1028	1090	1112	1099
Casual	44	52	112	83	0	69
On Training	4	4	1	45	8	6
Total	1003	1030	1141	1218	1120	1174
Increase		2.64%	10.78%	6.75%	-8.05%	4.82%
W/S&S Staff	235	235	235	235	235	184
Rate	23.4%	22.8%	20.6%	19.3%	21.05	15.7%

Note: Staff in 1993 are only for water supply.

3.4.5 Personnel Cost

NCDC has a similar salary system to that in other countries. The employees are categorized depending on their qualification and experience when they are employed by NCDC. The promotions are decided by their performance. The salary structure is divided into two parts: L(level) and CC(Clerk Class). There are nine levels (L1 to L9), and ten classes (CC1 to CC10). This means that there are 19 salary grades. The Chairman is entitled to L9, while a new driver is entitled to CC1. The difference in salary between the highest and lowest levels is about 7.3 times.

Table 3.7 shows the salary structure of NCDC. From the last few years the annual increase was 2.7%, which is moderate.

Table 3.8 shows that presently there are 235 positions in the Water Supply & Sewerage division. But only about 85 % of these positions are filled. The average salary per employee was 5,368 K in 1989. This figure appears to be lower than usually considered in the per capita GNP. But this is because the division was/is staffed with relatively low level employees. But in the future, the division should be staffed with more qualified personnel for efficient management. This will undoubtedly increase the average salary.

Table 3.7 Salary Structure of NCDC

unit: Kina/annum

Year	1989	1990 estimate.	1991	1992	Increase %/annum
L9	–	–	28,485	29,255	2.70%
L8	–	–	25,950	26,650	2.70%
L7	21,940	22,840	23,740	24,380	2.70%
L6	20,285	21,058	21,830	22,420	2.70%
L5	18,630	19,395	20,160	20,705	2.70%
L4	17,295	18,005	18,715	19,220	2.70%
L3	16,125	16,790	17,455	17,925	2.69%
L2	15,115	15,733	16,350	16,790	2.69%
L1	14,235	14,820	15,405	15,820	2.69%
CC10	13,740	14,023	14,575	14,970	2.71%
CC9	11,635	12,355	13,075	13,430	2.72%
CC8	9,580	10,173	10,765	11,055	2.69%
CC7	7,945	8,403	8,860	9,100	2.71%
CC6	6,800	7,153	7,505	7,710	2.73%
CC5	5,955	6,290	6,625	6,805	2.72%
CC4	5,155	5,560	5,965	6,125	2.68%
CC3	4,505	4,905	5,305	5,450	2.73%
CC2	3,955	4,343	4,730	4,860	2.75%
CC1	3,225	3,553	3,880	3,985	2.71%
Average	11,521	12,082	14,178	14,561	2.07%

Table 3.8 Staffing Structure for Water Supply (1989)

Level	Headoff Number	Works	Conserv.	Superv.	Shift	Sewerage	Plant	Total	Salary (k)in 92	Total (k)
L2/3	1							1	17,358	17,358
CC10/L1	1							1	15,395	15,395
CC9/10	2						1	3	14,200	42,600
CC8/9	1	1	1			1		4	12,243	48,972
CC7/8				1			3	4	10,078	40,312
CC6/7		1	2		2	1	2	8	8,405	67,240
CC5/6	1	2	3	2	2	2	1	13	7,258	94,354
CC4/5		2						2	6,465	12,930
CC3/4							3	3	5,788	17,364
CC2/3	12		12	11	2	14	1	52	5,155	268,060
CC1/2		9	37	36	8	33	21	144	4,423	636,912
Total	18	15	55	50	14	51	32	235		1,261,497
									Average	5,368

3.4.6 Personnel Costs for F/S Implementation

The number of Water Supply division employees is estimated as 184 in 1993 and will increase to 300, when the F/S has been implemented. The average salary per employee is estimated to be 8,000 K , and will increase by 5% per year. The final salary will be 11,257 K in 2000. But this annual increase of the average salary is a rough estimate, and may change.

The total personnel cost could be estimated as 1,472,000 K in 1993 and 3,377,000 K in 2000 (see Table 3.9).

Table 3.9 Personnel Costs for F/S Implementation

Year	1993	1994	1995	1996	1997	1998	1999	2000
Staff	184	230	236	242	248	255	261	300
Ave Salary (K)	8,000	8,400	8,820	9,261	9,724	10,210	10,721	11,257
Increase	5.0%	5.0%	5.0%	5.0%	5.0%	5.0%	5.0%	5.0%
Total Cost (K1,000)	1,472	1,932	2,082	2,241	2,412	2,604	2,798	3,377

The new organization of the Water Supply Division is shown in Fig. 3.4, This figure excludes meter readers and others. Fig. 3.5 shows the same organization, including meter readers and others.

3.5 New Organization for Sewerage

Sewerage is not in the scope of this Study. But the sewerage system has been operated jointly until now by the same division. The new management of NCDC is planning to separate it from the Water Supply division. There is some overlapping of staff and storage. Fig. 3.6 shows the temporary new organization of the Sewerage division. This is just temporary, and will be rearranged after a careful study. The temporary number of staff is estimated to be 57.

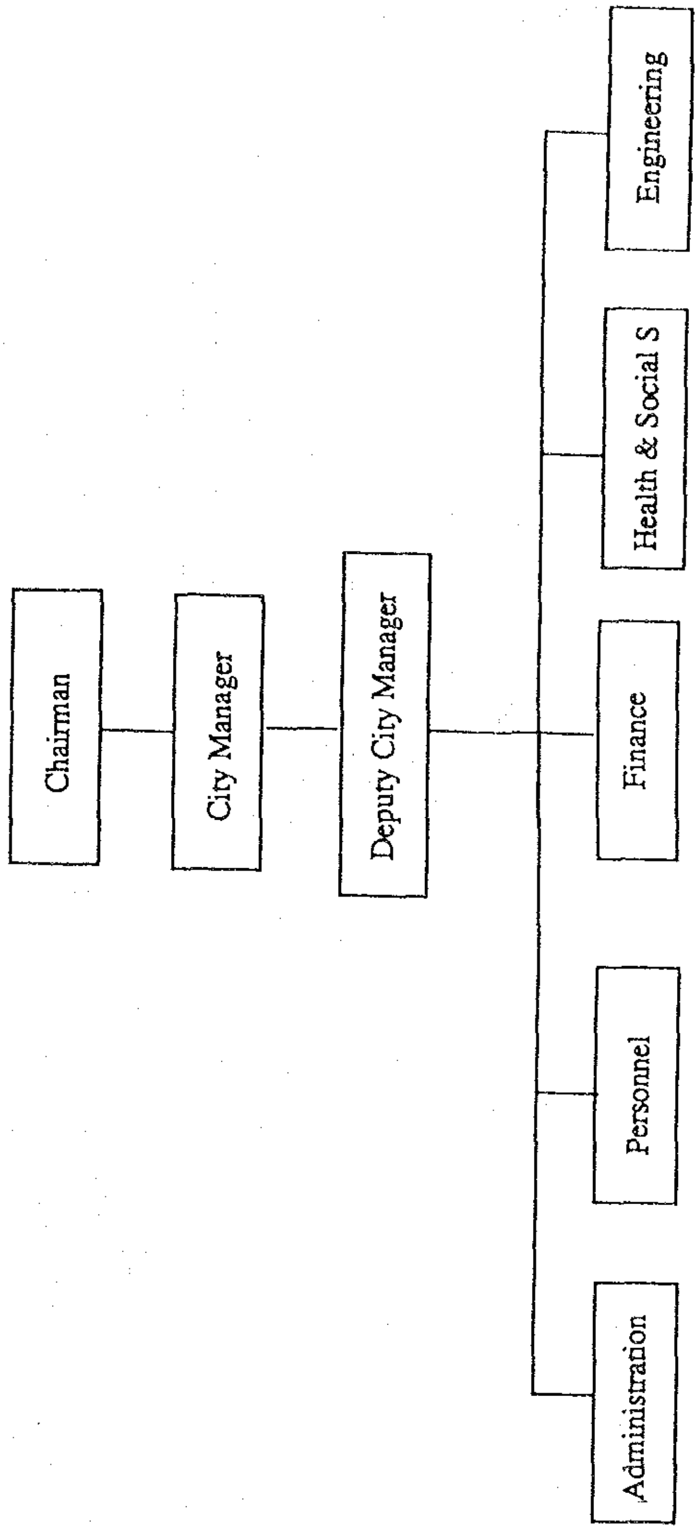
3.6 Recommendations

Based on the above discussions, the following recommendations can be given:

1) Water Supply division should be reorganized, according to the discussion here.
2) Sewerage division should also be reorganized.
3) Meter reading operation should be strengthened.

4) Record keeping for claims and repairs should be strengthened.
5) The existing network should be upgraded.
6) Training should be financed and strengthened.

The recommendations 1) to 4) can be implemented at no cost, while 5) and 6) would require some financial resources mentioned later.



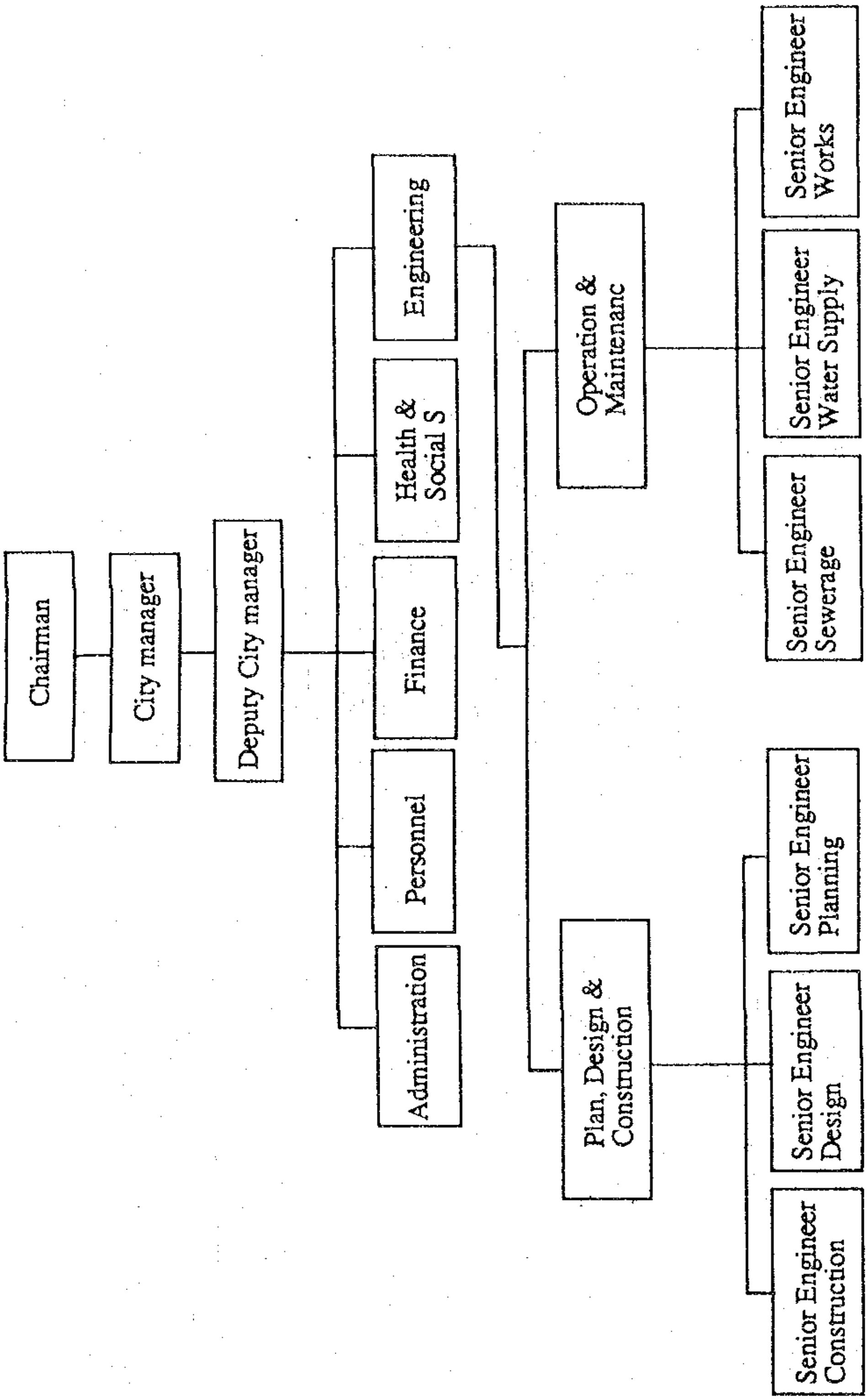
TITLE

NEW ORGANIZATION OF NCDC

Fig. No.
3.1

PORT MORESBY WATER SUPPLY DEVELOPMENT PLAN

TOKYO ENGINEERING CONSULTANTS in association with PACIFIC CONSULTANTS INTERNATIONAL



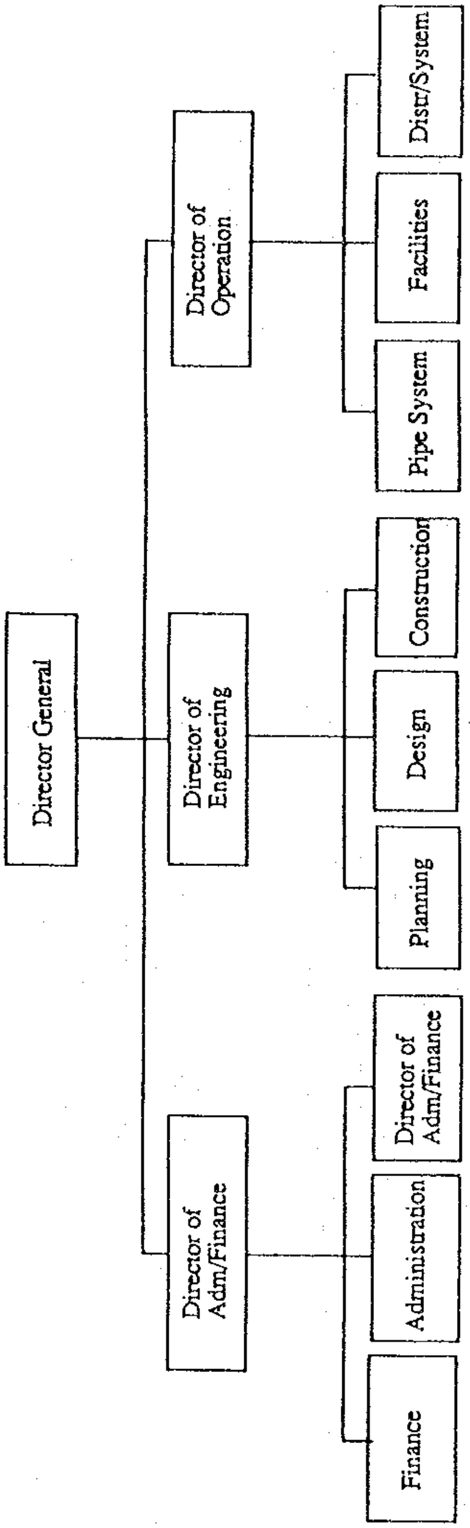
TITLE

NEW ORGANIZATION OF NCDC FOR WATER SUPPLY

Fig. No. **3.2**

PORT MORESBY WATER SUPPLY DEVELOPMENT PLAN

TOKYO ENGINEERING CONSULTANTS in association with PACIFIC CONSULTANTS INTERNATIONAL



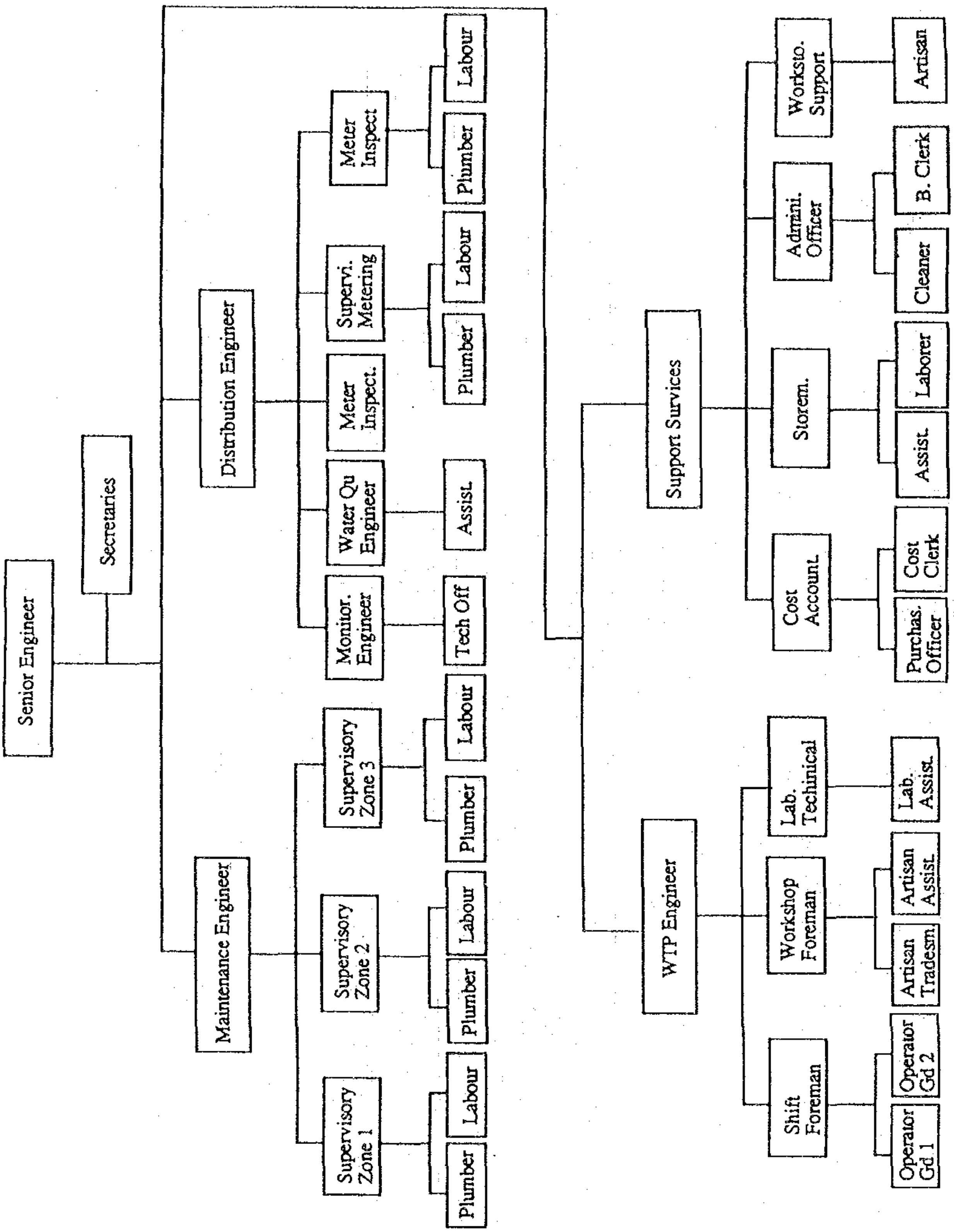
TITLE

WATER SUPPLY MANAGEMENT (COMMON)

Fig. No. **3.3**

PORT MORESBY WATER SUPPLY DEVELOPMENT PLAN

TOKYO ENGINEERING CONSULTANTS in association with PACIFIC CONSULTANTS INTERNATIONAL



TITLE

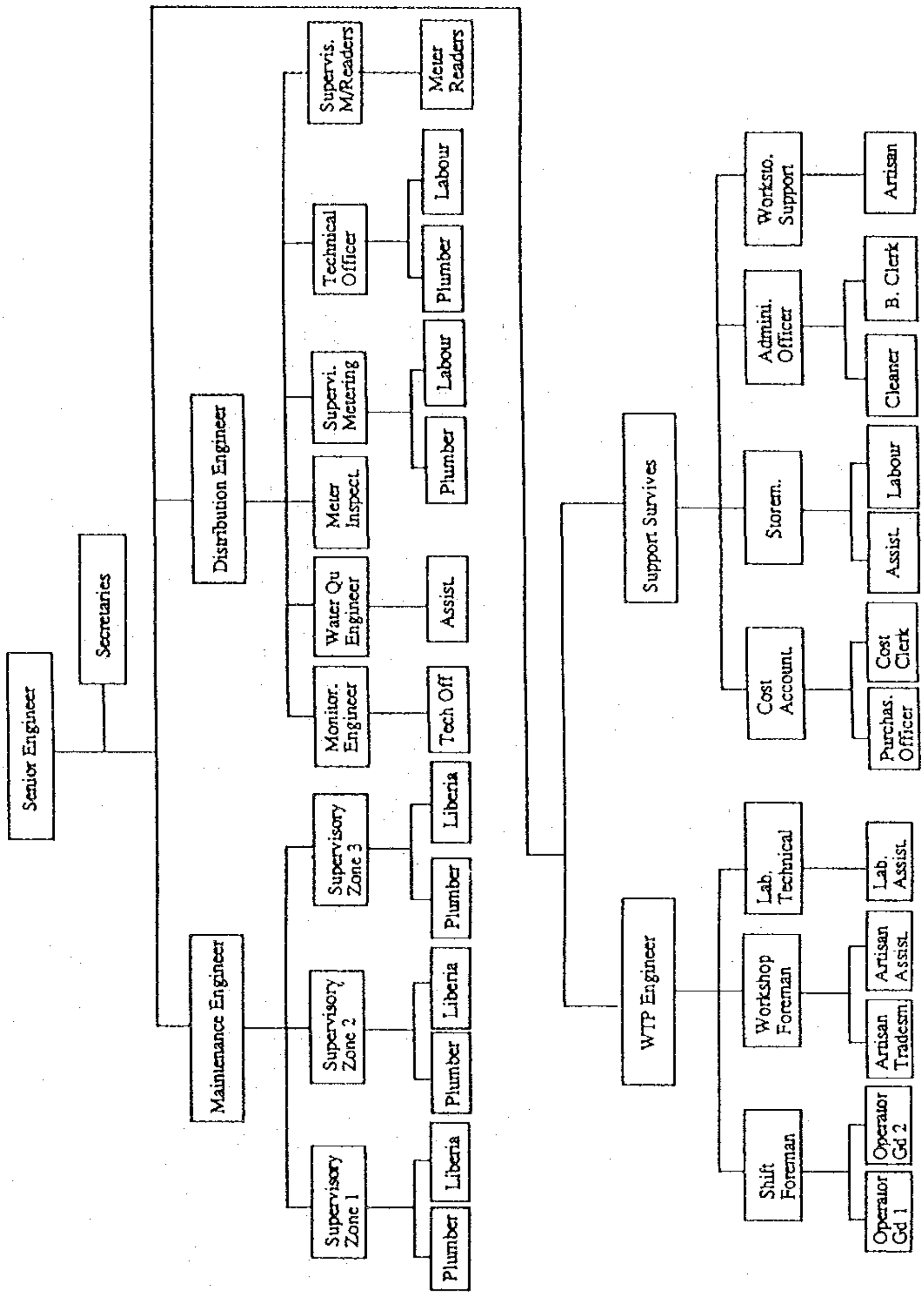
Fig. No.

NEW ORGANIZATION OF WATER SUPPLY DIVISION (SYSTEM 1)

3.4

PORT MORESBY WATER SUPPLY DEVELOPMENT PLAN

TOKYO ENGINEERING CONSULTANTS in association with PACIFIC CONSULTANTS INTERNATIONAL



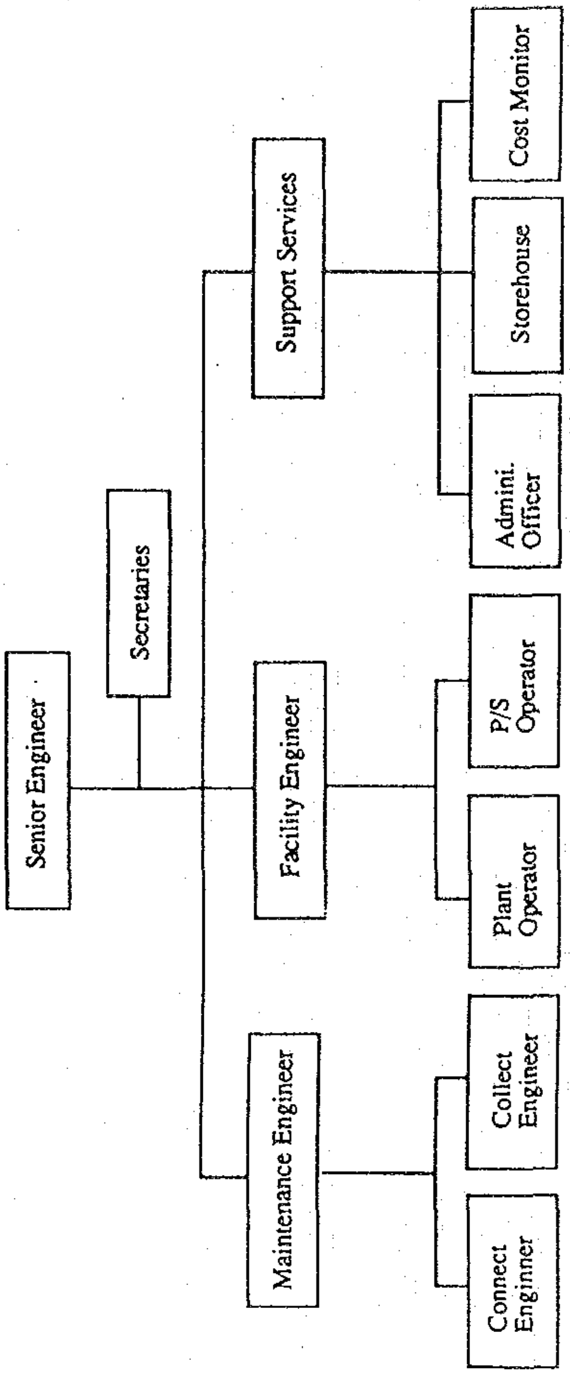
TITLE

Fig. No.

NEW ORGANIZATION OF WATER SUPPLY DIVISION (SYSTEM 2) **3.5**

PORT MORESBY WATER SUPPLY DEVELOPMENT PLAN

TOKYO ENGINEERING CONSULTANTS in association with PACIFIC CONSULTANTS INTERNATIONAL



TITLE

NEW ORGANIZATION OF WATER SUPPLY DIVISION (SYSTEM 2)

Fig. No. **3.6**

PORT MORESBY WATER SUPPLY DEVELOPMENT PLAN

TOKYO ENGINEERING CONSULTANTS in association with PACIFIC CONSULTANTS INTERNATIONAL

4 Operation and Maintenance

4.1 Introduction

As we discussed in chapter 3, Management, certain improvements will be required in the future. The period of Feasibility Study (F/S) is set from 1994 to 2000 (7 years).

In this section several issues of operation and maintenance will be discussed in detail, including implementation schedule and rough cost estimate.

4.2 Current Issues of Operation and Maintenance

4.2.1 Total metering

1) General

Studies on metering carried out worldwide indicate that universal water metering is not always feasible. In the history of the Port Moresby water supply system, maintenance and repair of water meters have left much to be desired. Nevertheless, apart from these two drawbacks, based on general observation and local realities, metering has had a considerable impact on consumers. Studies on metering have revealed that the impact has been considerable and long-lasting soon after the initiation of a metering program. The fact that it is most effective in external-to house-use and use during peak periods would lend metering more credibility. Metering is aimed at water conservation and revenue increase. Meter installation of domestic consumers is considered to be effective due to the following reasons:

- Equitable:
  - Consumers are charged depending on the actual quantity of water used and measured by meters.
  - Reduction of consumer complaints arising from estimated charges.
- Efficient:
  - It is necessary to examine the balance between the cost and revenue from metering. It should be noted that meter installation increases costs (fitting of meter and replacement, repair and maintenance fee, labor costs for meter reading, etc.)
  - Meter installation may not always increase revenue.
  - From the economic point of view, reduction of water loss is a monetary gain in the form of saved water, especially in drought periods.

2) Policy

The total bill units now are estimated to be about 23,000, which are considered equivalent to the number of registered households. There are also illegal settlers or unregistered residents. They may be staying on a short or a long term basis. NCDC installs about 19,000 accounts of water supply. This means that there are a several households who are sharing one connection. The JICA study team examined the records and found that the reading ratio of the metered connections is as low as 46.5%, that not all of the installed meters are functioning properly, some are damaged and others are not calibrated.

Inaccurate estimations by NCDC are causing frustration among the consumers. Therefore, all the connections should be metered as soon as possible in Port Moresby. It is recommended that large meters be installed at least for unplanned settlements, because water use by the residents in such settlements is totally out of control. Some persons are illegally connecting to the transmission line to use water, while others are lifting water all the time at public taps, This is causing a serious problem for the management. Therefore it is recommended by the study team that large meters be installed to monitor the use of water in settlements. In the long run, gradual installation of meters is desirable.

The JICA study team recommends total metering during the next 3 years, except the settlements mentioned above. Further, the installed meters should be monitored and maintained on a regular basis.

3) Installation

The location of the water meter affects the efficiency of meter reading, meter replacement and repair. The following points are to be considered in meter installation work ;

- Installing meters within premises but as near as possible to the boundary with public roads so as to enable easy access for meter reading;
- Installing meters horizontally, at a level lower than the water tap elevation
- Installing meters at a clean and dry location where dirt or waste water will not soil meters
- Installing meters in accordance with the flow direction mark so that water will not flow in the reverse direction

In selecting the type of water meter, its characteristics should be considered carefully. Even when the selected type is appropriate, if it is undersized with respect to consumption, it may lead to malfunctioning during very high instantaneous flows and possibly, failure in measurement. If, on the contrary, it is oversized, the measurement may become inaccurate for very low flows. Therefore, selection of meter size requires careful consideration.

The size should be selected based on the planned maximum daily demand. Table 4.1 gives guidelines for selection.

Of the various types of water meters available, two types are proposed - the dual-pipe inferential type and the vertical axial (Woltman) flow type, after considering accuracy, performance durability, economy and maintenance. Both are wet types.

Table 4.1 Selection of Type of Meter

Size (mm)	Type	Max. Daily Demand (m3/day)	Regulated Max. Flow (m3/hour)
13	Straight line, inferential	6.0	1.0
20	Dual-pipe, inferential	12.0	1.5
25	- ditto -	15.0	2.0
40	Vertical, axial flow (Woltman)	48.0	8.0
50	- ditto -	120.0	25.0
75	- ditto -	240.0	40.0
100	- ditto -	360.0	60.0
150	- ditto -	720.0	120.0

4) Repair

Meters gradually become inaccurate with time. Also, the filter provided in the water inlet of the meter will gradually get choked with silt. The various factors and causes of meter malfunction are given in Table 4.2. To identify the cause, the meter should be inspected.

For the meter to work properly, it has to be regularly monitored and calibrated when necessary. Monitoring will be done efficiently during regular meter reading (see Figure 4.1).

Table 4.2 Meter Problems, Causes and Solutions

ITEMS	CAUSE	MEASURES
Slow or fast rotation	• Clogging due to silt and fine sand • Over load and high pressure • Slippage of packing • Encrustation	• Change the axial bearing, pivot and gear • Control pressure • Change packing • Cleaning
Idle running and no rotation	• Something wrong with the rotating part	• Change axial bearing and gear
Broken cover or unreadable cover	• Excessively high pressure or breakdown	• Change meter cover
Leakage from gasket	• Loose gasket between water and gear chamber	• Cleaning and meter test.

5) Equipment and Tools

Required spare parts and equipment are ;

- Gear
- Axial bearing
- Meter cover
- Pivot
- Packing
- Standard meter
- Cleaning equipment
- Tools for repair of meter

The following precautions must be taken to ensure long life of the meter;

- Do not subject the meter to strong impacts
- Install meter vertically

- Use appropriate packing in case of leakage and /or over estimation.
- Confirm the plan configuration.
- Flange bolts should be tightened uniformly.
- Air should be released from the inside of the meter.

We expect all the above points will be incorporated in the complete meter shop by the Director of Operation. Required spare parts and equipment should be kept in the meter workshop for repairs. New foremen will be required to carry out these tasks.

6) Manning, Organization and Schedule

The experiences and observations during the study period indicate that the following combination of staff members would make a good team;

- 1 supervisor
- 2 technicians
- 2 laborers

Based on meter installation work during the study, the time required for meter installation can be calculated as follows : Assuming 4 meters can be installed in 1 working day, 4 meters x 20 days x 12 months = 960 meters per year by one team. Two teams will be able to install 5,760 meters in three years.

After completing the meter installation, it should be reported to the distribution section and the meter reading section, so that pipe ledger work, drawings/map, renewal and computerization, or the water bill be prepared.

Meter reading needs to be carried out regularly. The time required for a meter reading depends greatly on the relative location of houses. Since large users are not scattered in the city, but are instead concentrated in specific areas, four readings per hour would not be an unrealistic figure, if appropriate transportation is provided. If commuting time to and from the sites is excluded, the time available in a working day is four hours. Then 240 days or 8 months will be required for reading 5760 meters. Hence four meter readers are sufficient for monthly reading and two in case of bimonthly reading or eventually, every three-month reading.

At present NCDC has about 13 meter readers for reading all the meters every three month. Hence it seems to be overstaffed. Their work loads need to be examined. The reading frequency can be increased to a bimonthly basis.

The cost of metering for the remaining households is estimated at 0.9 million K over a period of three years.

4.2.2 Leakage Prevention

1) General

The post-rehabilitation output of the plants will not change. However, the reliability of the systems from the point of view of water output will improve. Since, the absolute output will not increase, there must be an increase in the amount of water available within the water supply system, particularly within the distribution system, through leakage control. If leakage control measures are not undertaken, the leakage level will increase.

Leakage is a general problem for water supply and an endless battle requiring a routine careful maintenance. Fortunately the present leakage of NCDC was estimated as about 30% by the JICA study team. This is a reasonably good figure, taking into account the existing conditions.

2) Leakage Control Strategy

The total wastage and unaccounted for water can be assessed and controlled by systematic waste and leakage survey and detection, followed by prompt corrective action and consumer education. Such a program has to be continuing in nature; careful planning and preparatory work, plenty of time-consuming and labor-intensive field surveys and intelligent investigations are required in embarking on a program of leak reduction and control. This leak detection exercise, once established, will need to be an on-going commitment from NCDC. Initial supervision and training will be required, but ultimately NCDC should be able to continue the work on its own.

The choice of methodology must be made in the light of the fact that this will be a long-term venture. It would be impractical to change adopted methods every few years, in view of the investment required to be made in water meters and in training personnel. The change from one leakage control method, a passive leakage control, to a more intensive method, will create a short-term increase in the number of leaks requiring repair. However, once the more intensive leakage control method is established, the rate of leak repair in the long-term will remain substantially unchanged.

A suitable strategy has to be evolved for implementation of measures for conservation of water. The proposed strategy must tackle two basic problems :

- The provision of reliable data and records to monitor leakage levels so as to be able to establish priorities
- The establishment of leak detection teams to identify the source of leakage and to supervise repairs

3) Procedure

Leaks are of two kinds-visible, or those that are above-ground and invisible, or those that are underground. Leakage control measures should start with the former. Measures for the former can start easily and will be very effective, especially during the initial stages. An example is the replacement of packings in privately owned consumer taps, in addition to distribution pipes and valves. Since there is no metering system in place for the majority of consumers, replacement of packings should be at NCDC expense. Figure 4.4 shows the procedure to be followed for above-ground leakage control, consisting of patrolling, detection and repair.

Nevertheless, preparation should start for underground leakage control simultaneously. As illustrated in Figure 4.5, it needs to be conducted systematically. The creation of "waste districts" covering the whole network is an effective way. "Waste districts" need to be worked out during the "establishment of leakage control strategy", as a first step by NCDC. It enables routine monitoring of night-time flows into the districts. Permanent sites should be constructed where portable flow measurement equipment can be installed.

Each "waste district" should be "completely isolated hydraulically", preferably by closing all stopcocks in consumer connection, as also the boundary valves from other districts. The supply of water is allowed through a single feed pipe, on which a flow meter is installed. The continuously recorded flow in the meter indicates wastage due to leaks in the mains. In residential areas with a 24-hour supply, minimum night flow (MNF) indicates the amount of wastage. Exact location of leaks in mains is carried out during night time, by means of sounding rods and electronic leak detectors after the exact alignment of pipes is traced by electronic pipeline detector, as well as from the records. Also, after leakage repair, MNF is measured to confirm that leakage drops to within allowable limits. Leakage detection and leakage repairs are continued until observed MNFs are within allowable ranges.

Exact alignments of pipes and valves, particularly those of boundary pipes and valves are a prerequisite to making waste districts. However, since the NCDC pipe drawings are inadequate, preparing correct drawings must be the first step in underground leakage control. This is discussed in a separate section entitled "Mapping".

The following should be considered in creating and operating a waste district ;

- Total length of pipes within a waste district should be less than 2,000 meters.
- Valves should be provided to enclose a waste district.
- Inflow valve and inflow meter should branch off from adjacent distribution mains, so as not to result in low pressure in the waste district.

Leakage control should start with districts where leakage is high. Hence, patrolling the whole distribution area for above-ground leakage control should come first. However, for underground leakage, patrolling is not effective. It needs area-wise analysis of leakage level through measurement of minimum night flow, preferably during the "Establishment of Leakage Control Strategy", although, this will take a considerable amount of time. Alternately, high-leakage areas have to be identified empirically, based on experience and prior information, both formal and informal.

Such high leakage will occur in areas with 1) old pipes, 2) long, small service pipes instead of distribution pipes, and 3) high pressures. The areas covered by items 1) and 3) above are generally in the center, while those covered by 2) are in outlying areas. Study on the three model areas does not give sufficiently conclusive data as to which areas have high leakage levels, and therefore, needs to be confirmed during leakage control. Nevertheless, it is proposed that underground leakage control start from outlying areas with the objective of shooting the item 2), judging from the fact that few areas have enjoyed high pressures and that little external corrosion has been observed.

4) Schedule

To attain the target leakage level, about half the underground leaks and all the above-ground leaks must be identified and stopped by the target year. The schedule to achieve this objective is shown in Figure 4.6. In the first year, above-ground leakage detection and repairs should start. The basic preparatory work for the underground leakage control, such as establishment of strategy, pipe drawings, procurement of equipment, waste districts establishment and training should also start in the first year. Underground leakage detection should start in the second year, and will take 3 years to cover about the half the distribution area. This schedule is a bigger challenge for NCDC. It is noted, however, that most of other work could be better done concurrently by the same personnel, because all involve field work and household visits.

Even though leakage control requires vigorous efforts, it is recommended because this alone could produce sufficient water within the distribution system. Most of the other work like laying pipes, which aims at providing sufficient carrying capacity in the system, would be useless without availability of sufficient water. Further, this work will not be costly, but labor-intensive. Therefore, NCDC should be able to complete leakage control successfully.

5) Manning, Equipment, Tool and Material

Leakage control has not been successful so far in many cities. This failure is apparently due to the fact that even passive control has not been done by a special task force, but rather it has been done under conditions similar to ordinary work, like service pipe connection. Leakage control must be started at the engineer level at NCDC. The work must be executed as a team or organization, with daily and routine work performed by well-trained technicians monitored by engineers. Creation of a pipe inventory, formulation of 'waste districts', measurements of flow and pressure, etc., must accompany leakage control. Leak detection teams should be established under the direct control of the distribution manager.

From experiences during the Study, it takes about a half month to complete an area of 0.5 km^2. The most critical part is trial digging. The area required for the placement of the waste districts is half of the entire distribution area. Underground leakage control, including the formulation of waste districts, needs to be completed in four years. Accordingly, four teams need to be established; one team for formulation of waste districts and three teams for leakage detection and repair. An engineer can oversee the teams and the proposed organization is shown in Figure 4.7, which also indicates staffing levels, tools, equipment and materials.

Leakage control teams must be equipped with suitable tools, materials and transportation to enable them to carry out repairs quickly and efficiently. Sophisticated equipment should generally be avoided because of maintenance problems, although due to the low system pressures initially, some form of leak noise amplification device may be required.

A systematic approach for leakage prevention is needed for NCDC. The cost is estimated at 1.3 million K, including site surveys.

6) Training

Teams should be proficient in the use of sounding techniques for detecting leakage and should carry out routine visual inspections of all mains and service lines. The teams should be provided with facilities, equipment, materials and the necessary training to carry out a wide variety of repairs including the rehabilitation and replacement of washouts, fire hydrants, gate valves and air valves.

Pipe fitters must be confirmed 'acceptable' for repair work and bad practices, if found, must be pointed out. All valves must be located and operated. Any leaking valve should be repaired and defective valves replaced. All air valves must be located, inspected and replaced, if necessary. Spares for old parts are now difficult, if not impossible, to obtain. All fire hydrants must be located, cleaned and operated and any defect repaired.

4.2.3 Mapping

1) Information on Mapping

Maps and drawings are vital tools for leakage control and also to record detected leak locations, and to establish and operate "waste districts", etc. The benefits accruing from an accurate system of mapping records include reduction in time and cost savings for design of new installations, excavation and reinstatement work, improvement in management of the distribution network and efficient running of the undertaking.

Generally, in urban areas, maps of at least 1:2,500 scale, and preferably larger, are normally considered necessary. Precise details should be recorded in 1:2,500 scale pipeline drawings, which are the most fundamental drawings for managing the distribution system. All details of waterworks' properties are to be recorded in them and they are to be used for confirming locations of distribution and service installations, and for indexing as-built drawings. Each plan is preferably drawn on a standard A1 sheet, this size being the optimal balance between the two main requirements of a single sheet drawing - small enough for ease of handling in the field, but with sufficient clarity for identifying system details. The following information is to be recorded on the maps/ drawings :

(i) Pipelines
- schematic alignment
- street name

- diameter
- material
- age (year laid)
- size and number of meter (if used for accounting purpose)

(ii) Valves, fire hydrants and air valves

- location
- diameter
- type
- clock-wise or anti-clock-wise direction of opening/closing

Large-scale drawings can be utilized for accounting purposes also. If accounting number and other information for service pipe connection is superimposed on the 1:2,500 maps which clearly show houses, each house will be identified as either connected or not, billed or not if connected, paid or not if billed.

Apart from maps/drawings, ledgers are also useful for maintaining facilities and providing information for planning and overall management of the waterworks, stabilization of long term supply, improvements in the distribution system, provision of emergency supply and preparation of statistical data.
The ledgers are :

- quantitative information (pipeline ledger)
- functional information (records on leakage, burst and survey reports of pipe conditions)
- information for pipeline improvement (renovation/renewal pipe ledger)
- information for the analysis of the distribution system (survey reports of high pressure areas and iso-pressure contour maps)

2) Procedure

Works required to be performed first for making new pipe maps and drawings are ;

- Collection of maps.
- Evaluate past records and information about pipes, both formal and informal.
- Confirm doubtful records and information, particularly regarding pipe connections with trial diggings.
- Off-set survey for location of service pipes, meter boxes, taps, stand pipe.
- Enter pipe information on to 1:2,500 scale drawings.

Accuracy is the most important requirement for pipeline maps and drawings. Failure or delayed updating of maps and drawings can decrease their utility and reliability.

Correction and updating of maps/drawings are to be made whenever new pipes are installed and repairs are made on existing pipes.

In order to rectify and update maps/drawings correctly and efficiently henceforth, as-built drawings should be made in compliance with the following rules;

- Alignment of pipeline shall be accurately recorded.
- As-built geographical conditions are input on geographical maps, which are a component of 1: 2,500 scale pipeline drawings.
- As-built drawings shall be marked in accordance with the coordinate system.

Based on large-scale 1:2,500 drawings, 1:5,000 scale distribution system maps and 1:25,000 scale distribution are to be modified. Geographical features are also to be corrected on the basis of the latest information.

3) Manning, Organization and Equipment

The confirmation of pipe alignments etc., with trial diggings in the fields is to be performed not by the mapping section, but under such activities as placement of waste districts, conducting air scouring and lining. Instead, the mapping section will act as an information center about pipes and appurtenances. Hence, stock drawings and correction of maps/drawings are to be centralized at NCDC service zones. The mapping section has to collect the necessary information through the sub-branch offices and make corrections, following standard procedures, and distribute the corrected maps/drawings to each branch office.

What is needed is to establish a mapping plan including record keeping, is estimated to cost 0.4 million K over two years.

4) Schedule

Making of new maps and drawings starts in 1994. Information will be collected from various field activities of waste district, such as metering, air scouring and lining. After or even during the making of new maps, their updating should continue.

5) Training

The previous sections dealt with the methods for arrangement and drafting of maps/drawings, and for this, the waterworks depends on the skills of individuals involved. Therefore, it would require some training under experts to make maps/drawings, so that the distribution section can expect to obtain the latest information about its network system for emergencies, planning and daily operations.

4.2.4 Tariff Study

It appears that the income distribution ranges widely among the residents. There are many poor people who live at the outskirts of the city or in settlements, while rich people who live in the center are enjoying lots of water, even for gardening.

However, the existing water tariff does not serve its purpose well. The low-income people can get water at low price, while rich people can cross-subsidize it and avoid water wastage. To this end a one year study at 0.1 million K would be desirable. This would alleviate unequal feelings among the users and create a feeling of participation.

4.2.5 Asset Registration

The water supply system is a typical heavy-capital business. Asset management is therefore, very important. However it was found that NCDC has not managed its assets properly. The asset records are unsystematic.

Asset management should be strengthened, because it directly relates to the operational costs of the system. It is also necessary to decide the water tariff.

The cost for tariff study is estimated at 0.2 million K over two years.

4.2.6 Bill collection

NCDC is reading the meters of all users or making estimates for unreadable meters every three months. It is sending the bills to users after that. The users start to pay the bills. The payment is due within two months. However, the efficiency of the bill collection is as low as about 60%. This would deteriorate the feelings of honest users and the financial soundness of the system.

The bottle-neck should be uncovered. This would not need any money, but NCDC should appeal to the users by intense PR activities.

4.3 Recommendations

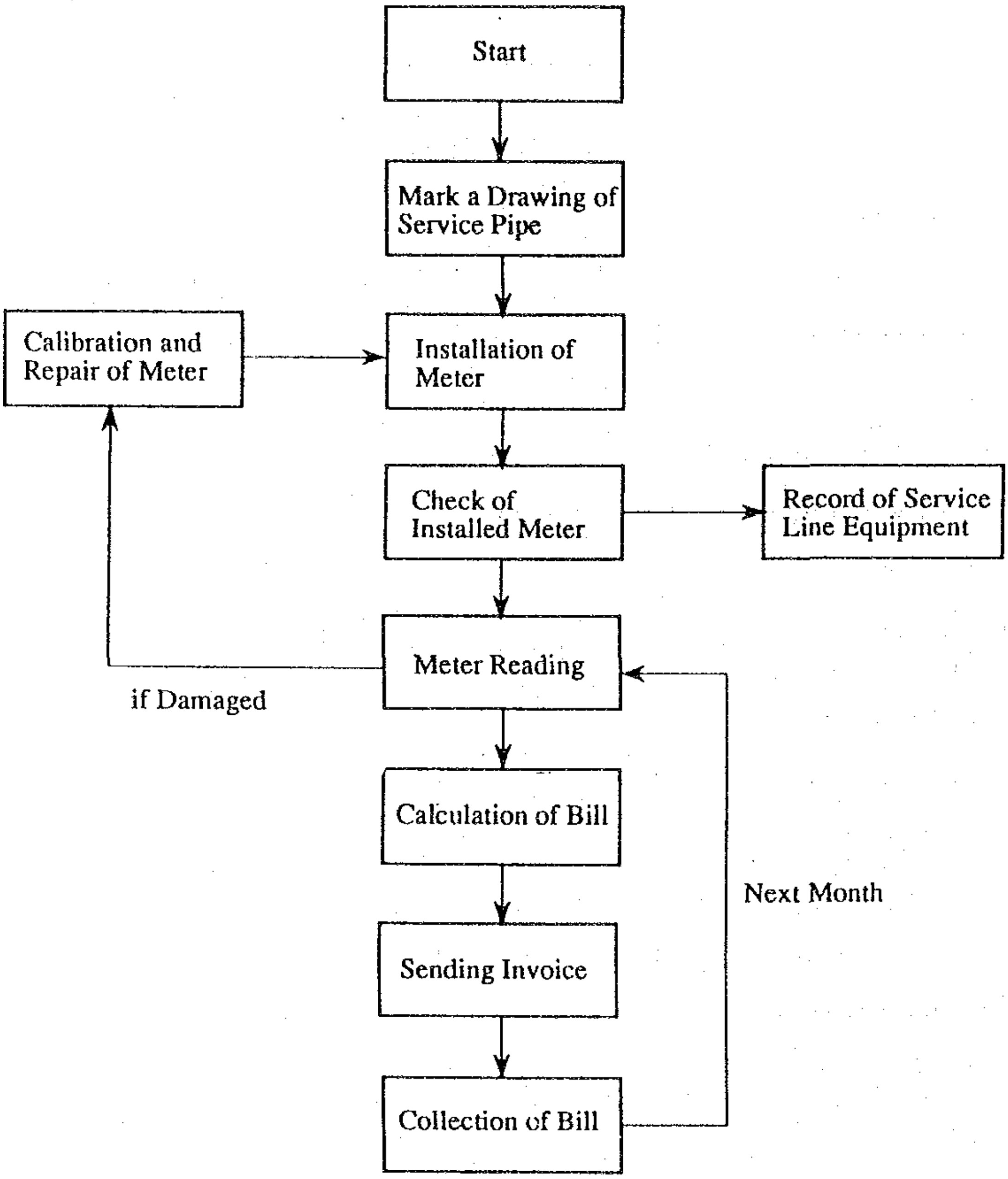
This section describes the six above-mentioned measures, which should be taken during the F/S period up to 2000. They are all important, and should be carefully prepared by the Water Supply Division.

4.4 Summary of F/S Implementation

All the items of management and O/M are summarized in Table 4.3.

TABLE 4.3 COST ESTIMATES OF OPERATION AND MAINTENANCE

	Item	Cost	Year (Unit : Million K)							
			1994	1995	1996	1997	1998	1999	2000	Total
I	Management									
	a) Personnel Cost	O	1.9	2.1	2.2	2.4	2.6	2.8	3.4	17.4
	b) Reorganization	X								0.0
	c) Meter Reading	X								0.0
	d) Record Keeping	X								0.0
	e) Network Upgrading	O	0.3	0.3						0.6
	f) Training	O	0.4	0.4	0.4	0.3	0.3	0.3	0.3	2.4
II	Operation & Maintenance									0.0
	a) All metering	O	0.3	0.3	0.3					0.9
	b) Leakage Prevention	O	0.3	0.3	0.2	0.2	0.1	0.1	0.1	1.3
	c) Mapping	O	0.2	0.2						0.4
	d) Tariff Study	O	0.1							0.1
	e) Asset Registration	O	0.1	0.1						0.2
	f) Bill Collection	X								0.0
	Total		3.6	3.7	3.1	2.9	3.0	3.2	3.8	23.3



TITLE

METERING SYSTEM FLOW CHART

Fig. No. 4.1

PORT MORESBY WATER SUPPLY DEVELOPMENT PLAN

TOKYO ENGINEERING CONSULTANTS in association with PACIFIC CONSULTANTS INTERNATIONAL

Description	1994	1995	1996	1997	1998
(A) INITIAL WORK					
1) Make Drawing of Service Pipe					
2) Installation of Meter					
3) Check of Installed Meter					
(B) ROUTINE WORK					
4) Meter Repair					
5) Meter Reading					
6) Preparation of Bill					
7) Sending Invoice					
8) Collection of Bill					

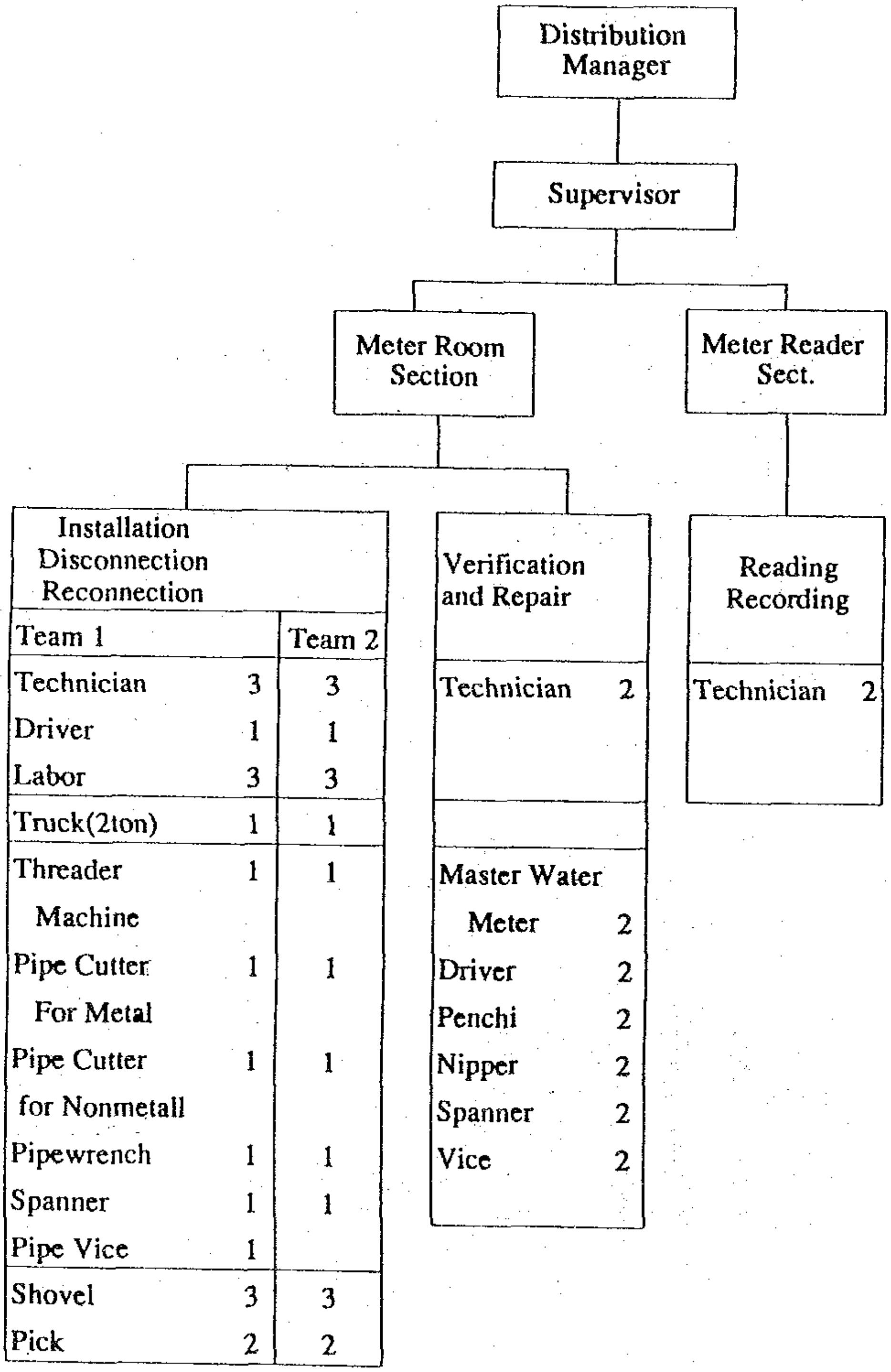
TITLE

METERING SCHEDULE

Fig. No. **4.2**

PORT MORESBY WATER SUPPLY DEVELOPMENT PLAN

TOKYO ENGINEERING CONSULTANTS in association with PACIFIC CONSULTANTS INTERNATIONAL



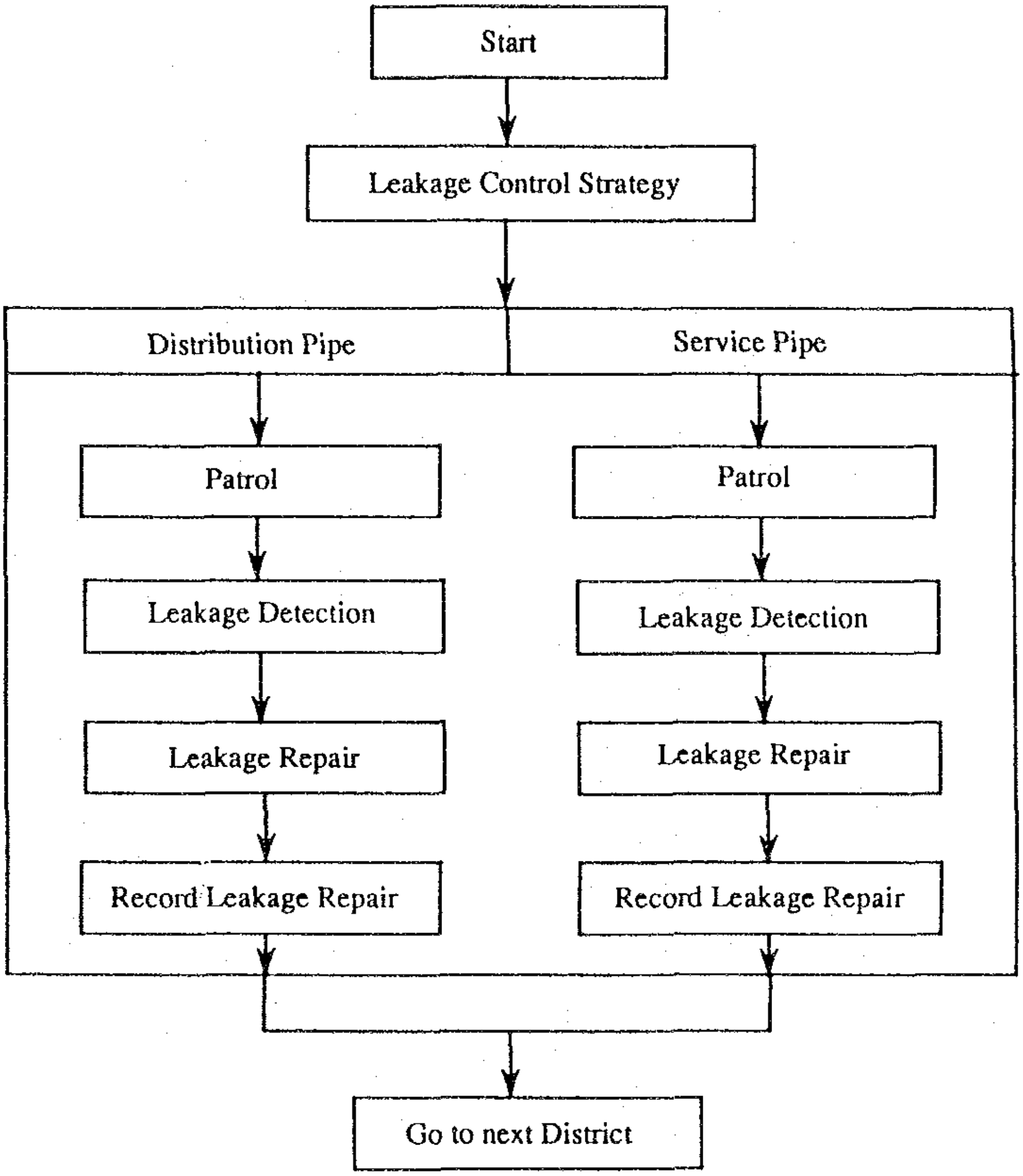
TITLE

MANNING AND EQUIPMENT OF METERING SYSTEM

Fig. No. **4.3**

PORT MORESBY WATER SUPPLY DEVELOPMENT PLAN

TOKYO ENGINEERING CONSULTANTS in association with PACIFIC CONSULTANTS INTERNATIONAL



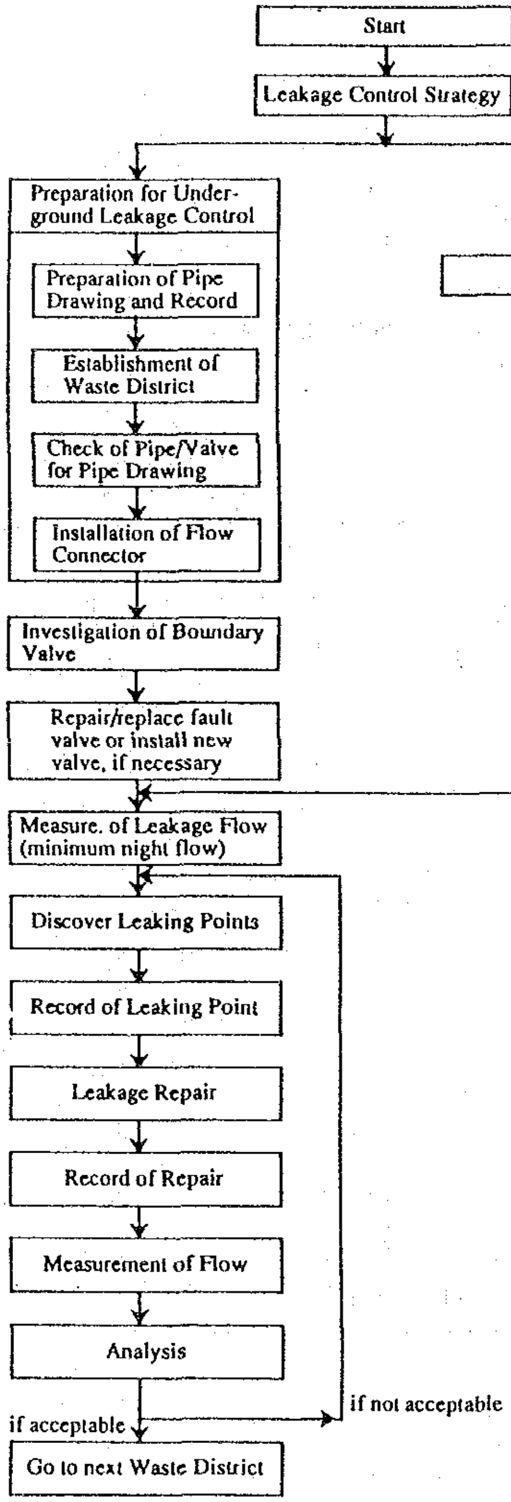
TITLE

PROCEDURE OF ABOVE -GRAND LEAKAGE CONTROL

Fig. No. **4.4**

PORT MORESBY WATER SUPPLY DEVELOPMENT PLAN

TOKYO ENGINEERING CONSULTANTS in association with PACIFIC CONSULTANTS INTERNATIONAL



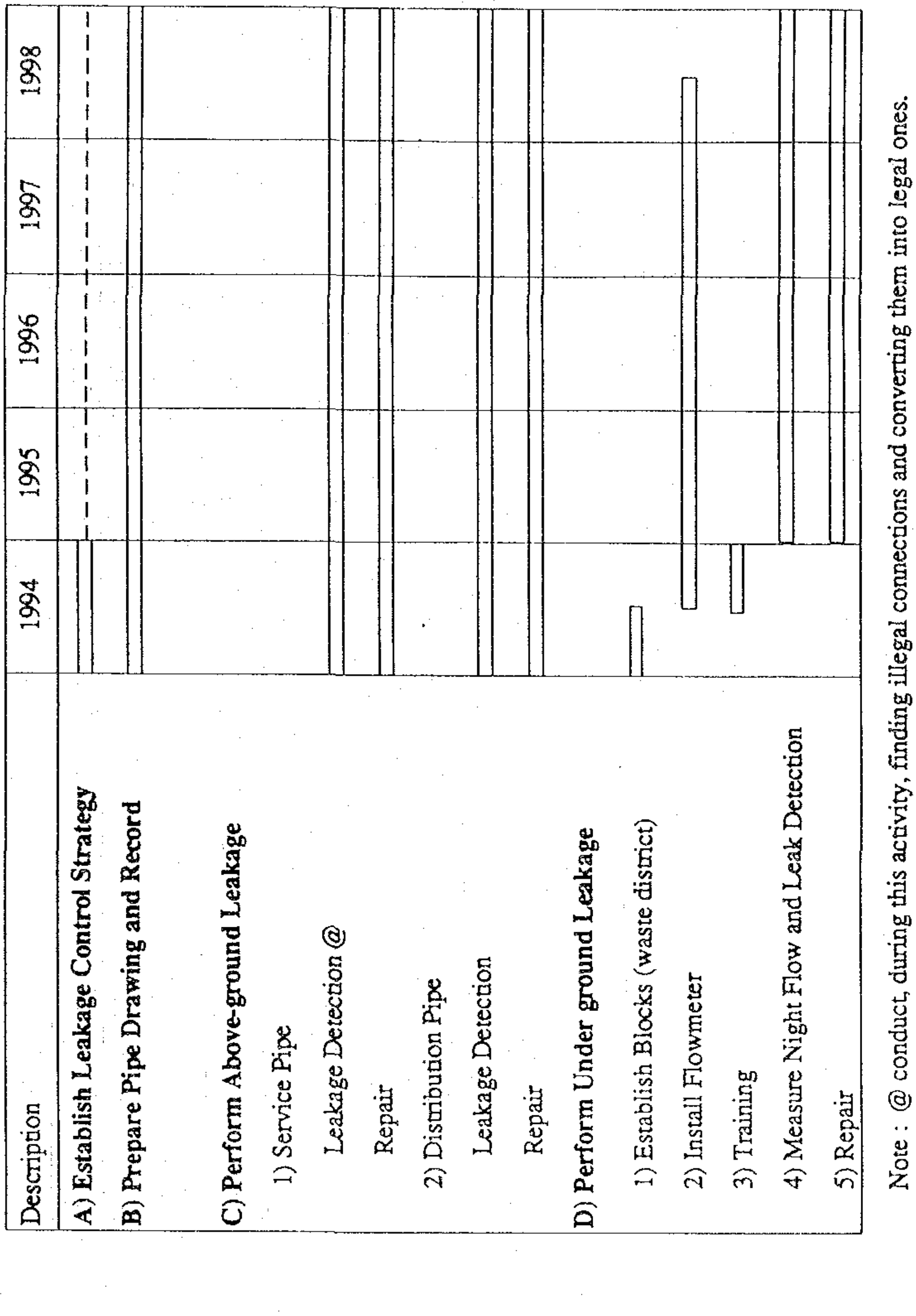
TITLE

PROCEDURE OF UNDERGROUND LEAKAGE CONTROL

Fig. No. **4.5**

PORT MORESBY WATER SUPPLY DEVELOPMENT PLAN

TOKYO ENGINEERING CONSULTANS in association with PACIFIC CONSULTANTS INTERNATIONAL



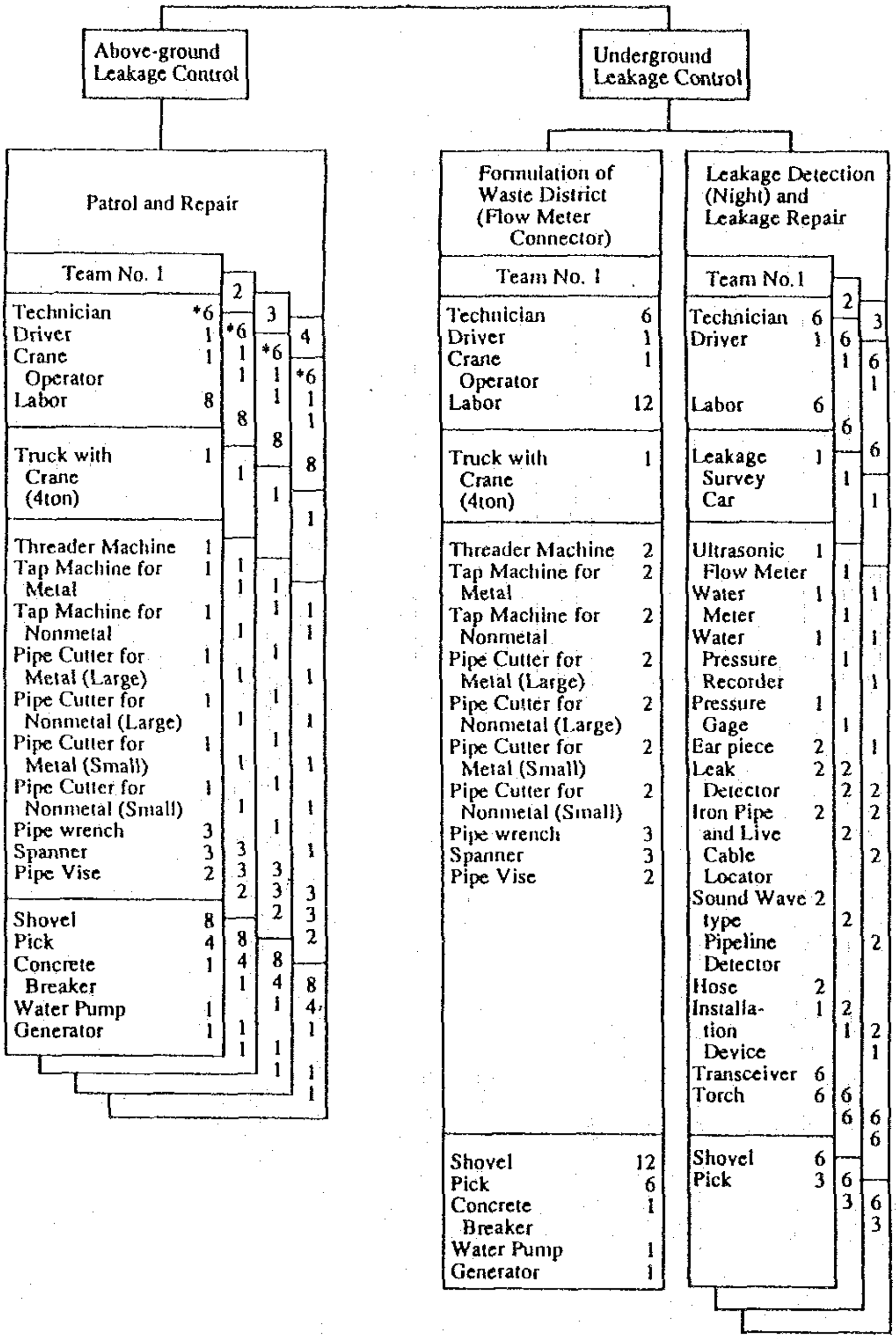
TITLE

LEAKAGE CONTROL SCHEDULE

Fig. No.
4.6

PORT MORESBY WATER SUPPLY DEVELOPMENT PLAN

TOKYO ENGINEERING CONSULTANS in association with PACIFIC CONSULTANTS INTERNATIONAL



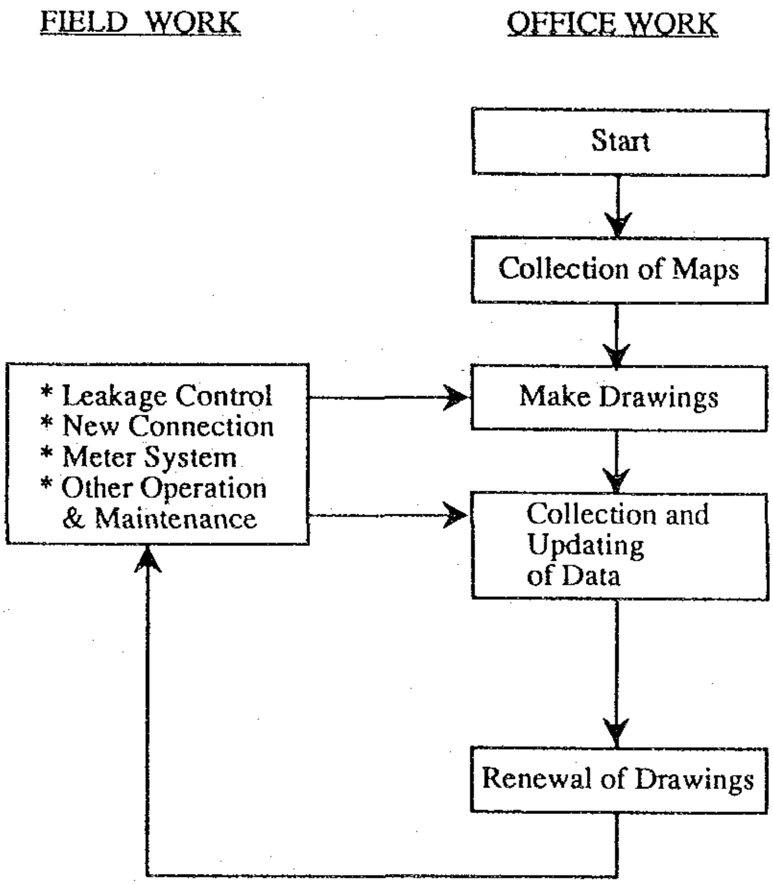
TITLE

MANNING, EQUIPMENT AND TOOLS FOR LEAKAGE

Fig. No. 4.7

PORT MORESBY WATER SUPPLY DEVELOPMENT PLAN

TOKYO ENGINEERING CONSULTANTS in association with PACIFIC CONSULTANTS INTERNATIONAL



TITLE

MAPPING SYSTEM FLOW CHART

Fig. No. **4.8**

PORT MORESBY WATER SUPPLY DEVELOPMENT PLAN

TOKYO ENGINEERING CONSULTANS in association with PACIFIC CONSULTANTS INTERNATIONAL

5. COST AND IMPLEMENTATION SCHEDULE

5.1 Construction Considerations

As a result of on-site jobs (data collection and research on the construction situation at Port Moresby), the following three points were discovered. The first point concerns locally available construction materials, the second point concerns labor force conditions in general, and the third point deals with natural conditions at Port Moresby. These are summarized below.

Due to Port Moresby's geographical conditions (close to Australia and New Zealand), its economic situation and relationships with neighboring countries, most of construction materials are locally available (can get them at the local market[1]). In this project, it was decided to import the following materials.

- Pipes & valves
- Electrical & mechanical equipment
- Filter materials

It seems that skilled and non-skilled labors for construction works are not in short supply in Port Moresby. The Department of Labour and Employment has classified occupations based on the International Standard Classification of Occupation (ISCO 1981) and published a book "Papua New Guinea Classification Of Occupations" in 1990. The purposes of this publication as clearly stated in it are:

1) To provide a classification of occupations and titles appropriate to the Papua New Guinea work-force.
2) To allow a more rigorous classification by the type of work performed.
3) To facilitate the standardization of occupation classifications throughout the country.

This department also provides the service of offering a list of types of labor, if requested.

Natural conditions in Port Moresby are not so favorable for construction works in general. Relatively high temperatures through the year and the rainy season (normally from December to June) are specially to be taken into account in formulating the construction schedule.

1 Most of the locally available materials are imported from neighboring countries.

5.2 Project Cost

The cost of this scale of construction works may vary significantly depending on the source of finance, bidding procedure and contract methods in general. Therefore, the following conditions are assumed:

1) Physical contingency is assumed as 5 % of the cost (direct and indirect cost) in terms of the depth of the preliminary engineering design.

2) The following countries are taken into account for the origin of imported materials or equipment:

Ductile Cast Iron Pipe :	Australia
Mild Steel Pipe :	New Zealand
Mechanical & Electrical Equipment :	Japan

3) Exchange Rates are,

   1 Kina = 1.047 U.S. Dollars (as of July, 1993)
   1 A$ = 0.662 U.S. Dollars (as of July, 1993)
   1 U.S. Dollars = 110 Yen (as of July, 1993)

The total project cost for the feasibility study is approximately 219 Million Kina of which foreign and local currency portions are 198 Million Kina (90 %) and 21 Million Kina (10 %), as shown in table 5.1 (Local currency is used mostly to cover local labor cost).

In general, a capital investment of about 200 Million Kina for this kind of project is relatively high. This has mainly resulted from the fact that there has been no major investments on water supply system for a long time and NCD has expanded rapidly. It is also noted that the portion of this capital cost (feasibility study) is about 70 % of the total project cost (master plan), that indicates the press of projects' implementation, in other words, under the schemes for the master plan.

It is clear that the existing main problem of the water supply system is the excess demand over the supply amount. That is the main reason that NCDC agreed to this implementation schedule. Thus, it should be reminded that the management of this project is extremely important for timely completion, namely, utilizing money, people, and materials is the key point.

Table 5.1 PROJECT COST

Unit: Million Kina

Classification and Work Item	Foreign Currency Portion	Local Currency Portion	Total
1. Intake Facility	1.68	0.18	1.86
2. Raw Water Main	29.24	3.14	32.38
3. Pumping Station	3.05	0.27	3.32
4. Mt. Eriama Expansion	25.05	2.82	27.87
5. Nine Mile WTP	57.07	6.44	63.51
6. Transmission Pipe	28.22	3.02	31.24
7. Distribution Pipe			
Mt. Eriama System	8.29	1.13	9.42
9 Mile System	11.18	1.52	12.70
8. Reservoir	4.63	0.57	5.20
9. Sub Total	168.41	19.09	187.50
10. Physical Contingency (5 % of 9)	8.42	0.95	9.38
11. Engineering Fee	20.83	1.42	22.25
12. Total Project Cost	197.66	21.47	219.13

5.3 IMPLEMENTATION SCHEDULE

From the standpoint of investment, this feasibility scope can be divided into two stages, which is also reasonable in terms of engineering design. That is, the scopes of the feasibility study are made up of two main construction works, viz., expansion of Mt. Eriama WTP and construction of new 9 Mile WTP. Accordingly, the first stage is up to 1996 (completion of expansion works), and the second stage is from 1997 to 2000. Table 5.2 shows the staging cost. The implementation schedule for the project is shown in Fig. 5.1, while Table 5.3 shows the schedule for transmission and distribution pipes.

Table 5.2 COST ESTIMATION BY YEAR

	1994	1995	1996	1997	1998	1999	2000
Cost(Million Kina)	16.93	41.15	59.79	32.02	21.51	45.18	2.55
Capacity (mld) (A)	125	125	125	180	180	180	280
Demand(Daily Max.)(B)	192	201	205	209	213	217	221
A - B	-67	-76	-76	-29	-33	-37	+59

Table 5.3 (A) Implementation Schedule

- Transmission Pipe -

System	Route	Dia. (mm)	Length (m)	Pipe length (m) by year 1994	1995	1996	1997	1998	1999	2000
High Zone (Mt. Eriama System)										
	Mt. Eriama Res. to Dia.1000 pipe	1000	20	7	7	6				
	9 Mile to Hubert Murray Highway.	1350	2,180	727	727	726				
	H.M.HW to 7 Mile (along H.M.HW.)	1350	2,000	667	667	666				
	7 Mile to Mokaraha Rd.	1000	3,560	1,187	1,187	1,186				
	Mokaraha Rd. to Waigani Drive	1000	1,400	467	467	466				
	Waigani Drive to Waigani Res.	800	2,940	980	980	980				
	Waigani Drive to Hohola Res.	600	3,000				1,000	1,000	1,000	
	7 Mile to Boroko res.	900	3,300	1,100	1,100	1,100				
	H.M.HW to Korobosea Res.	400	2,760				920	920	920	
	subtotal		21,160	5,135	5,135	5,130	1,920	1,920	1,920	0
Low Zone (Nine Mile System)										
	9 Mile W.T.P. to H.M.HW.	1200	1,280				427	427	426	
	H.M.HW. to 7 Mile	1100	2,000	667	667	666				
	7 Mile to Erima Res.	700	440				147	147	146	
	7 Mile to Mokaraha Rd.	1000	3,560	1,187	1,187	1,186				
	Mokaraha Rd. to Gerehu Res.	800	3,620				1,207	1,207	1,206	
	H.M.HW. to Laloki Res.	600	213							213
	subtotal		11,113	1,854	1,854	1,852	1,781	1,781	1,778	213
Total			32,273	6,989	6,989	6,982	3,701	3,701	3,698	213

Table 5.3 (B) Implementation Schedule

- Distribution Pipe, Existing Urban Area -

System	Reservoir Block	Route	Phase 1 stage1	Phase 1 stage 2	Phase 2, 3	Dia. (mm)	Length (m)	Pipe Length (m) by year 1994	1995	1996	1997	1998	1999	2000
High Zone (Mt. Eriama System)														
	Boroko	H.M. HW. to Gordons	1			300	2,230	743	743	744				
		near Boroko res. to Air port	1			250	570	190	190	190				
	Korobosea	Korobosea res. to Horse camp	1			300	2,400	800	800	800				
		Pari rd. to Pari	1			200	4,000	1,333	1,333	1,334				
	3 Mile	3 Mile res. to Scratchley rd.	1			300	1,130	377	377	376				
		Scratchley rd. to Horse camp	1			150	810	270	270	270				
		Scratchley rd. to Gabutu	1			200	960	320	320	320				
	Koki	Konedobu to Hanuabada	1			250	1,620	540	540	540				
	Waigani	Waigani res. to Waigani Drive	1			500	250	83	83	84				
		Waigani Drive to Sivari rd.	1			450	1,100	367	367	366				
		Sivari rd. to mountain pass		2		300	1,540				513	513	514	
		mountain pass to Tatana		2		150	3,620				1,207	1,207	1,206	
		Waigani Drive to Koura way			3	500	159							159
		June valley		2		150	980				327	327	326	
	Hohola	Hohola res. to H.M. HW.	1			600	2,250	750	750	750				
		Ward rd. to H.M. HW.	1			400	2,060	687	687	686				
	subtotal						25,679	6,460	6,460	6,460	2,047	2,047	2,046	159
Low Zone (Nine Mile System)														
	Gerehu	Gerehu res. to Gerehu drive		2		600	1,280				427	427	426	
		Gerehu Drive to Tauramana Ave.			3	400	66							66
	Erima	Erima res. to B.P.Sogeri rd.		2		800	1,430				477	477	476	
		B.P. Sogeri rd. to Waigani Drive		2		450	2,260				753	753	754	
		Waigani Drive		2		400	1,330				443	443	444	
		Waigani Drive to Spring Garden rd		2		250	500				167	167	166	
		Erima		2		200	1,030				343	343	344	
		B.P. Sogeri rd. to Mokaraha rd.		2		500	1,800				600	600	600	
		Mokaraha rd. to Waigani rd.			3	350	69							69
		Mokaraha rd. to Curlew St..		2		300	600				200	200	200	
		mokaraha rd. to Morata		2		300	960				320	320	320	
		Morata		2		150	1,200				400	400	400	
	subtotal						12,525	0	0	0	4,130	4,130	4,130	135
Total							38,204	6,460	6,460	6,460	6,177	6,177	6,176	294

Table 5.3 (C) Implementation Schedule
- Distribution Pipe, Development Area -

CD NO.	Census Division (CD) Name	Diameter	1995 high	2000 high	Total high	1995 low	2000 low	Total low
80	Gerehu	100	0	0	0	443	1,070	1,513
	High zone 0 :	150	0	0	0	337	814	1,151
	Low zone 1	200	0	0	0	96	233	329
		250	0	0	0	87	209	296
	sub-total		0	0	0	963	2,326	3,289
81	Waigani/University	100	106	250	356	422	998	1,420
	High zone 0.2 :	150	80	190	270	322	760	1,082
	Low zone 0.8	200	23	54	77	92	217	309
		250	21	49	70	82	195	277
	sub-total		230	543	773	918	2,170	3,088
82	Tokarara/Hohola	100	345	845	1,190	345	844	1,189
	High zone 0.5 :	150	263	643	906	262	642	904
	Low zone 0.5	200	75	184	259	75	183	258
		250	68	165	233	67	165	232
	sub-total		751	1,837	2,588	749	1,834	2,583
83	Gordons/Saraga	100	299	808	1107	0	0	0
	High zone 1 :	150	227	615	842	0	0	0
	Low zone 0	200	65	176	241	0	0	0
		250	58	158	216	0	0	0
	sub-total		649	1,757	2,406	0	0	0
84	Boroko/Korobosea	100	1,393	2,393	3,786	0	0	0
	High zone 1 :	150	1,060	1,821	2,881	0	0	0
	Low zone 0	200	303	520	823	0	0	0
		250	273	468	741	0	0	0
	sub-total		3,029	5,202	8,231	0	0	0
87	Laloki/Napanapa	100	159	743	902	1,168	5,448	6,616
	High zone 0.12 :	150	121	565	686	889	4,146	5,035
	Low zone 0.88	200	35	162	197	254	1,184	1,438
		250	31	145	176	229	1,066	1,295
	sub-total		346	1,615	1,961	2,540	11,844	14,384
88	Bomana	100	0	0	0	1,928	6,648	8,576
	High zone 0 :	150	0	0	0	1,467	5,059	6,526
	Low zone 1	200	0	0	0	419	1,445	1,864
		250	0	0	0	377	1,301	1,678
		300*	0	0	0	0	0	0
		400*	0	0	0	0	1,400	1,400
	sub-total		0	0	0	4,191	15,853	20,044
	Total		5,005	10,954	15,959	9,361	34,027	43,388

Cost : Million Kina Capacity : mld

Program Item		Total Cost	NCD Water Supply System Works Program						
Phase			First Phase			219.13 kina			
			Stage 1		117.87	Stage 2			101.26
Year			1994	1995	1996	1997	1998	1999	2000
Cost		219.13	16.93	41.15	59.79	32.02	21.51	45.18	2.55
Capacity			115	115	115	180	180	180	280
Demand (Daily Max)			192	201	205	209	213	217	221
1.	Conveyance System	39.69	2.32	14.26	14.29	0.00	0.69	8.13	0.00
	Intake	2.14	0.02	2.12					
	Raw Water Main	37.55	2.30	12.14	14.29		0.69	8.13	
2.	Transmission pipe	36.01	8.79	8.79	8.81	3.16	3.16	3.16	0.14
3.	High Zone System (Mt.Eriama W.T.P.)	47.29	4.96	16.62	22.74	0.84	0.84	0.82	0.47
		Capacity	125	125	125	180	180	180	180
	W.T.P. & P.S.	36.36	2.29	13.95	20.12				
	Distribution pipe	10.93	2.67	2.67	2.62	0.84	0.84	0.82	0.47
4.	Low Zone System (9 Mile W.T.P.)	96.14	0.86	1.48	13.95	28.02	16.82	33.07	1.94
		Capacity	0	0	0	0	0	0	100
	Water Treatment Plant	75.38		0.62	12.71	18.71	13.54	29.80	
	Distribution reservoir	6.03				6.03			
	Distribution pipe	14.73	0.86	0.86	1.24	3.28	3.28	3.27	1.94

W.T.P. : Water Treatment Plant
P.S. : Pumping Station

TITLE

IMPLEMENTATION SCHEDULE FOR THE FEASIBILITY STUDY

Fig. No. **5.1**

PORT MORESBY WATER SUPPLY DEVELOPMENT PLAN

TOKYO ENGINEERING CONSULTANS in association with PACIFIC CONSULTANTS INTERNATIONAL

6 PROJECT APPRAISAL

6.1 FINANCIAL EVALUATION

6.1.1 General

The feasibility study covers the first two stages in the whole of the master plan that is dealt in part one. Therefore the presumptions used in this study are in line with those of the master plan. We only take into account the investments made up to 2000 in terms of the feasibility study.

The volume of water produced by these investments would amount to 155 thousand cubic meters per day, which would cover the demand up to 2007. Benefits and costs are modified accordingly.

6.1.2 Financial plan

Financial statements for the F/S are given in Table 6.1. Its format is identical with that used in the master plan study; attention is paid only to the relationship between the investment and the increased income due to the augmented volume of net supply of water.

The flows are given up to 2015. Investments in the first stage will end in 2000, consequently the volume of gross production would stop at the level of 2006.

6.1.3 FIRR

The project life is set to 37 years, i.e., 30 years after the completion of the first phase. With the above mentioned assumptions, the FIRR of the project is calculated at 7.37 per cent. Table 6.2 gives the cash flows of the benefits and costs throughout its project life.

Sensibility Analysis:

1. Ten percent increase in costs throughout the construction period gets the FIRR to reduce itself to 7.26 per cent.

2. A year's delay in the first construction stage* gets the FIRR to reduce itself to 7.22 per cent.

   * The first stage:1994-96=>>94-97, the rest of the stages would be behind the original schedule by one year each.

3. A composite case of 1) and 2), e.g., ten percent increase in costs throughout the construction period in the case 2) gets the FIRR to reduce itself to 6.32 per cent.

6.1.4 EIRR

Besides the assumptions made for the calculation of FIRR, we provide two more for the EIRR.

1. Economic cost of the unskilled labour is set at half of its financial cost, i.e., economic cost of investment is 95 per cent of its financial cost.

2. Unit price of water is set at 0.58 Kina per cubic meter, which is equivalent to the unit price according to the principle of willingness to pay. At this level, logical financial efficiency ought to be 100 per cent. (0.72*0.8=0.58)

The EIRR of the project is calculated at 5.73 per cent. Table 6.3 gives the cash flows of the benefits and costs throughout its project life.
Sensibility Analysis:

1. Ten percent increase in costs throughout the construction period gets the EIRR to reduce itself to 5.56 per cent.

2. A year's delay in the first construction stage* gets the EIRR to reduce itself to 5.48 per cent.

   * The first stage:1994-96=>>94-97, the rest of the stages would be behind the original schedule by one year each.

3. A composite case of 1) and 2), e.g., ten percent increase of costs throughout the construction period in the case 2) gets the EIRR to reduce itself to 4.65 per cent.

6.1.5 OTHER BENEFITS

Improvement in drinking water supply has two dimensions: quantity and quality. The former is by far the dominant factor, as quality always accompanies the treated water.

Increase of supply would give tremendous impact on productivity in both industrial and commercial sectors, not to speak of domestic users. Furthermore, within the domestic users, the increase would give benefits to both the rich and the poor across the community.

Increase in the supply of the existing system would reduce the area and time of suppressed use, which would enable factories to run closer to their full capacity, the rich to reduce investment on installation of tanks with pumping sets, and the poor to reduce chances of suffering from water borne diseases like cholera, especially in the hot dry season when water shortage usually occurs.

Expansion of the water supply area with sewerage would result in the overall improvement of the so far marginal areas of the city economically, as well as ecologically. The effect is two-fold. This is the area where the quality aspects of the drinking water would attract most attention. It would reduce the incidence of epidemics of water borne diseases by enhancing the standards of hygiene. This would contribute to buildup of better human resources in the area. At the same time, it would liberate many womenfolk and children from the labour of carrying water from sources some distance away.

6.1.6 Appraisal

The FIRR of the project phase one is a little less than that of the master plan. This implies that the initial investment is meant for the total expanded system. The first phase is a part of the master plan, and the second phase would reap extra benefits of this investment to conclude the system.

The value of the EIRR of the phase one works may indicate that its implementation is viable within the context of national economy, above the fact that the project is indispensable for the development of the capital district.

TABLE 6.1 FINANCIAL STATEMENTS OF WATER SUPPLY ENTERPRISE: F/S

BALANCE SHEET

Unit: Mil. Kinas in 1993 price

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Assets	16.93	58.07	117.87	149.89	171.40	216.58	219.13	219.13	219.13	219.13	219.13	219.13	219.13	219.13	219.13	219.13	219.13	219.13	219.13	219.13	219.13	219.13
Depreciation	0.42	1.45	2.95	3.75	4.29	5.41	5.48	5.48	5.48	5.48	5.48	5.48	5.48	5.48	5.48	5.48	5.48	5.48	5.48	5.48	5.48	5.48
(-)Accum.Depreciation	0.42	1.88	4.82	8.57	12.85	18.27	23.75	29.23	34.70	40.18	45.66	51.14	56.62	62.09	67.57	73.05	78.53	84.01	89.49	94.96	100.44	105.92
Assets: net	16.51	56.20	113.05	141.32	158.55	198.31	195.38	189.91	184.43	178.95	173.47	167.99	162.51	157.04	151.56	146.08	140.60	135.12	129.64	124.17	118.69	113.21
Current Assets	0.00	0.36	1.48	4.30	7.59	10.72	15.60	22.22	28.40	39.05	50.11	60.29	68.95	77.50	85.86	92.18	98.67	105.45	112.61	119.98	127.65	135.62
TOTAL ASSETS	16.51	56.55	114.53	145.62	166.14	209.03	210.98	212.12	212.82	218.00	223.58	228.29	231.46	234.54	237.42	238.26	239.27	240.58	242.25	244.15	246.34	248.83
Long Term Loan	16.93	41.14	59.80	32.02	21.51	45.18	2.55	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Loan:Cumulative	16.93	58.07	117.87	149.89	171.40	216.58	219.13	219.13	219.13	219.13	218.28	215.38	209.49	201.99	193.42	182.59	171.64	160.68	149.72	138.77	127.81	116.85
[(-)Amortization:5%]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.85	2.90	5.89	7.49	8.57	10.83	10.96	10.96	10.96	10.96	10.96	10.96
Reserved Fund	-0.42	-1.52	-3.34	-4.27	-5.26	-7.55	-8.15	-7.01	-6.31	-1.13	5.29	12.91	21.98	32.54	43.99	55.67	67.63	79.90	92.53	105.38	118.53	131.98
TOTAL LIABIL.&CAPITAL	16.51	56.55	114.53	145.62	166.14	209.03	210.98	212.12	212.82	218.00	223.58	228.29	231.46	234.54	237.42	238.26	239.27	240.58	242.25	244.15	246.34	248.83

INCOME AND EXPENDITURE STATEMENT

	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Income of Water	0.00	0.76	1.52	8.64	9.68	10.74	13.83	16.27	17.72	19.34	20.85	22.25	23.87	25.48	26.28	26.21	26.21	26.21	26.28	26.21	26.21	26.21
From NCDC	0.40	0.00	0.00	0.00	0.00	0.00	-0.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Gov.Contribution	0.46	1.57	3.18	0.00	0.00	0.00	-0.46	-1.57	-3.18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Income	0.86	2.32	4.71	8.64	9.68	10.74	12.97	14.70	14.54	19.34	20.85	22.25	23.87	25.48	26.28	26.21	26.21	26.21	26.28	26.21	26.21	26.21
O/M Costs	0.40	0.40	0.40	1.76	1.76	1.76	2.17	2.16	2.45	2.77	3.06	3.34	3.66	3.98	4.13	4.13	4.13	4.13	4.13	4.13	4.13	4.13
Depreciation	0.42	1.45	2.95	3.75	4.29	5.41	5.48	5.48	5.48	5.48	5.48	5.48	5.48	5.48	5.48	5.48	5.48	5.48	5.48	5.48	5.48	5.48
Interest Payment:2.7%	0.46	1.57	3.18	4.05	4.63	5.85	5.92	5.92	5.92	5.92	5.89	5.82	5.66	5.45	5.22	4.93	4.63	4.34	4.04	3.75	3.45	3.16
Expenditure	1.28	3.42	6.53	9.56	10.68	13.03	13.57	13.55	13.84	14.16	14.43	14.64	14.80	14.92	14.83	14.53	14.24	13.94	13.65	13.35	13.06	12.76
BALANCE	-0.42	-1.10	-1.82	-0.92	-0.99	-2.29	-0.60	1.14	0.70	5.18	6.42	7.61	9.07	10.57	11.45	11.67	11.97	12.26	12.63	12.85	13.15	13.45

CASH FLOW

	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Loan	16.93	41.14	59.80	32.02	21.51	45.18	2.55	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Income	0.00	0.76	1.52	8.64	9.68	10.74	13.83	16.27	17.72	19.34	20.85	22.25	23.87	25.48	26.28	26.21	26.21	26.21	26.28	26.21	26.21	26.21
Gov.Contribution+NCDC	0.86	1.57	3.18	0.00	0.00	0.00	-0.86	-1.57	-3.18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total Inflow	17.79	43.46	64.51	40.66	31.19	55.92	15.52	14.70	14.54	19.34	20.85	22.25	23.87	25.48	26.28	26.21	26.21	26.21	26.28	26.21	26.21	26.21
Investment	16.93	41.14	59.80	32.02	21.51	45.18	2.55	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
O/M Costs	0.40	0.40	0.40	1.76	1.76	1.76	2.17	2.16	2.45	2.77	3.06	3.34	3.66	3.98	4.13	4.13	4.13	4.13	4.13	4.13	4.13	4.13
Amortization: 5%	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.85	2.90	5.89	7.49	8.57	10.83	10.96	10.96	10.96	10.96	10.96	10.96
Interest Payment:2.7%	0.46	1.57	3.18	4.05	4.63	5.85	5.92	5.92	5.92	5.92	5.89	5.82	5.66	5.45	5.22	4.93	4.63	4.34	4.04	3.75	3.45	3.16
Total Outflow	17.79	43.11	63.38	37.83	27.90	52.79	10.64	8.08	8.36	8.68	9.80	12.06	15.21	16.93	17.92	19.89	19.72	19.42	19.13	18.83	18.53	18.24
Net Cash Inflow	0.00	0.36	1.12	2.82	3.29	3.13	4.88	6.62	6.18	10.65	11.06	10.19	8.65	8.55	8.36	6.32	6.49	6.78	7.15	7.38	7.67	7.97
Cash Balance	0.00	0.36	1.48	4.30	7.59	10.72	15.60	22.22	28.40	39.05	50.11	60.29	68.95	77.50	85.86	92.18	98.67	105.45	112.61	119.98	127.65	135.62

TABLE 6.2 FIRR: F/S

million Kina

		Cost						Benefit					
		Invest.	O/M	Train	Total	Q	Q'+	Sale 1	Sale 2	Total	Balance	ef:f	ef:ph
1	1994	16.93		0.4	17.33						-17.33	0.6	0.7
2	1995	41.14		0.4	41.54		3		0.76	0.76	-40.78	0.63	0.7
3	1996	59.8		0.4	60.2		6		1.52	1.52	-58.68	0.66	0.71
4	1997	32.02	1.46	0.3	33.78	35	9	6.34	2.29	8.64	-25.15	0.69	0.71
5	1998	21.51	1.46	0.3	23.27	35	12	6.61	3.07	9.68	-13.59	0.71	0.72
6	1999	45.18	1.46	0.3	46.94	35	15	6.87	3.87	10.74	-36.21	0.74	0.72
7	2000	2.55	1.87	0.3	4.72	45	18	9.15	4.68	13.83	9.1	0.77	0.73
8	2001		2.16		2.16	52	20	10.92	5.35	16.27	14.11	0.8	0.73
9	2002		2.45		2.45	59	20	12.37	5.35	17.72	15.27	0.8	0.73
10	2003		2.77		2.77	67	20	13.99	5.35	19.34	16.57	0.8	0.73
11	2004		3.06		3.06	73	20	15.49	5.36	20.85	17.8	0.8	0.73
12	2005		3.34		3.34	80	20	16.9	5.35	22.25	18.91	0.8	0.73
13	2006		3.66		3.66	88	20	18.52	5.35	23.87	20.2	0.8	0.73
14	2007		3.98		3.98	96	20	20.13	5.35	25.48	21.5	0.8	0.73
15	2008		4.13		4.13	99	20	20.91	5.36	26.28	22.15	0.8	0.73
16	2009		4.13		4.13	99	20	20.86	5.35	26.21	22.08	0.8	0.73
17	2010		4.13		4.13	99	20	20.86	5.35	26.21	22.08	0.8	0.73
18	2011		4.13		4.13	99	20	20.86	5.35	26.21	22.08	0.8	0.73
19	2012		4.13		4.13	99	20	20.91	5.36	26.28	22.15	0.8	0.73
20	2013		4.13		4.13	99	20	20.86	5.35	26.21	22.08	0.8	0.73
21	2014		4.13		4.13	99	20	20.86	5.35	26.21	22.08	0.8	0.73
22	2015		4.13		4.13	99	20	20.86	5.35	26.21	22.08	0.8	0.73
23	2016		4.13		4.13	99	20	20.91	5.36	26.28	22.15	0.8	0.73
24	2017		4.13		4.13	99	20	20.86	5.35	26.21	22.08	0.8	0.73
25	2018		4.13		4.13	99	20	20.86	5.35	26.21	22.08	0.8	0.73
26	2019		4.13		4.13	99	20	20.86	5.35	26.21	22.08	0.8	0.73
27	2020		4.13		4.13	99	20	20.91	5.36	26.28	22.15	0.8	0.73
28	2021		4.13		4.13	99	20	20.86	5.35	26.21	22.08	0.8	0.73
29	2022		4.13		4.13	99	20	20.86	5.35	26.21	22.08	0.8	0.73
30	2023		4.13		4.13	99	20	20.86	5.35	26.21	22.08	0.8	0.73
31	2024		4.13		4.13	99	20	20.91	5.36	26.28	22.15	0.8	0.73
32	2025		4.13		4.13	99	20	20.86	5.35	26.21	22.08	0.8	0.73
33	2026		4.13		4.13	99	20	20.86	5.35	26.21	22.08	0.8	0.73
34	2027		4.13		4.13	99	20	20.86	5.35	26.21	22.08	0.8	0.73
35	2028		4.13		4.13	99	20	20.91	5.36	26.28	22.15	0.8	0.73
36	2029		4.13		4.13	99	20	20.86	5.35	26.21	22.08	0.8	0.73
37	2030		4.13		4.13	99	20	20.86	5.35	26.21	22.08	0.8	0.73
		219.13		2.4							7.37%		

TABLE 6.3 EIRR: F/S

million Kina

		COST						BENEFIT					
	year	invest.	o/m	train	TOTAL	Q	Q'+	sale 1	sale 2	TOTAL	balance	ef : f	ef : ph
1	1994	16.08		0.4	16.48						-16.48	1	0.7
2	1995	39.08		0.4	39.48		1		0.13	0.13	-39.36	1	0.7
3	1996	56.81		0.4	57.21		1		0.25	0.25	-56.96	1	0.71
4	1997	30.42	1.46	0.3	32.18	35	2	7.45	0.38	7.83	-24.35	1	0.71
5	1998	20.43	1.46	0.3	22.2	35	2	7.45	0.5	7.96	-14.24	1	0.72
6	1999	42.92	1.46	0.3	44.69	35	3	7.45	0.63	8.08	-36.6	1	0.72
7	2000	2.42	1.87	0.3	4.59	45	4	9.55	0.76	10.31	5.72	1	0.73
8	2001		2.16		2.16	52	4	10.99	0.76	11.75	9.59	1	0.73
9	2002		2.45		2.45	59	4	12.46	0.76	13.21	10.77	1	0.73
10	2003		2.77		2.77	67	4	14.09	0.76	14.84	12.07	1	0.73
11	2004		3.06		3.06	73	4	15.59	0.76	16.35	13.3	1	0.73
12	2005		3.34		3.34	80	4	17.02	0.76	17.77	14.43	1	0.73
13	2006		3.66		3.66	88	4	18.65	0.76	19.4	15.74	1	0.73
14	2007		3.98		3.98	96	4	20.27	0.76	21.03	17.05	1	0.73
15	2008		4.13		4.13	99	4	21.06	0.76	21.82	17.69	1	0.73
16	2009		4.13		4.13	99	4	21	0.76	21.76	17.63	1	0.73
17	2010		4.13		4.13	99	4	21	0.76	21.76	17.63	1	0.73
18	2011		4.13		4.13	99	4	21	0.76	21.76	17.63	1	0.73
19	2012		4.13		4.13	99	4	21.06	0.76	21.82	17.69	1	0.73
20	2013		4.13		4.13	99	4	21	0.76	21.76	17.63	1	0.73
21	2014		4.13		4.13	99	4	21	0.76	21.76	17.63	1	0.73
22	2015		4.13		4.13	99	4	21	0.76	21.76	17.63	1	0.73
23	2016		4.13		4.13	99	4	21.06	0.76	21.82	17.69	1	0.73
24	2017		4.13		4.13	99	4	21	0.76	21.76	17.63	1	0.73
25	2018		4.13		4.13	99	4	21	0.76	21.76	17.63	1	0.73
26	2019		4.13		4.13	99	4	21	0.76	21.76	17.63	1	0.73
27	2020		4.13		4.13	99	4	21.06	0.76	21.82	17.69	1	0.73
28	2021		4.13		4.13	99	4	21	0.76	21.76	17.63	1	0.73
29	2022		4.13		4.13	99	4	21	0.76	21.76	17.63	1	0.73
30	2023		4.13		4.13	99	4	21	0.76	21.76	17.63	1	0.73
31	2024		4.13		4.13	99	4	21.06	0.76	21.82	17.69	1	0.73
32	2025		4.13		4.13	99	4	21	0.76	21.76	17.63	1	0.73
33	2026		4.13		4.13	99	4	21	0.76	21.76	17.63	1	0.73
34	2027		4.13		4.13	99	4	21	0.76	21.76	17.63	1	0.73
35	2028		4.13		4.13	99	4	21.06	0.76	21.82	17.69	1	0.73
36	2029		4.13		4.13	99	4	21	0.76	21.76	17.63	1	0.73
37	2031		4.13		4.13	99	4	21	0.76	21.76	17.63	1	0.73
		208.17		2.4							5.73%		

6.2 Environmental Assessment

6.2.1 General

Once the environment is damaged, a great deal of cost and time will be required for recovery. There are some damages which are irrecoverable. This is the reason why an environmental impact assessment (EIA) is required prior to project planning and implementation. If a complicated project is planned, the EIA will accordingly be complicated. Nowadays it has been decided that a project over a certain size should be accompanied by environmental assessment where the public gives its consent for the project.

The environmental assessment and its disclosure is important to ensure democracy. Those projects which might potentially influence the lives of the residents in the neighborhood should be disclosed to them. Environmental assessment must satisfy the following criteria :

- Neutral
- Scientific and exact
- Democratic
- Timely

First of all the environmental assessments of a project should be conducted on a neutral basis : any bias should be avoided. If a project has a potential danger to the environment, the costs need to be estimated. If the estimated costs are larger than the benefits from the project, it may have to be abandoned.

Secondly, the methods of environmental assessment should be scientific and exact. It is true that there are uncertainties in environmental assessment, but an effort needs to be made to minimize them.

Thirdly, the total process of environmental assessment should be conducted on a democratic basis to the maximum possible extent. Those residents concerned and interested with the project should have free access to any information revealed about the project.

Lastly, the timely disclosure of the project information should be ensured within the established procedures of the project formation.

There are two kinds of environmental assessment :

1) EA during construction
2) EA during Operation

It is clear that the environment should be protected from adverse effects both during construction and operation.

The legal system of PNG is far from the implementation of environmental assessment : it lacks detailed procedures to ensure environmental soundness of the project. The Japanese laws and others require that environmental assessment be conducted for the following types of projects :

- Road construction
- Dam and river construction
- Railroad
- Airport
- Reclamation
- Land adjustment project
- Residential area development
- Industrial area development
- New infrastructure construction
- Circulation area project
- Special land development

6.2.2 Summary of Implementation Schedule

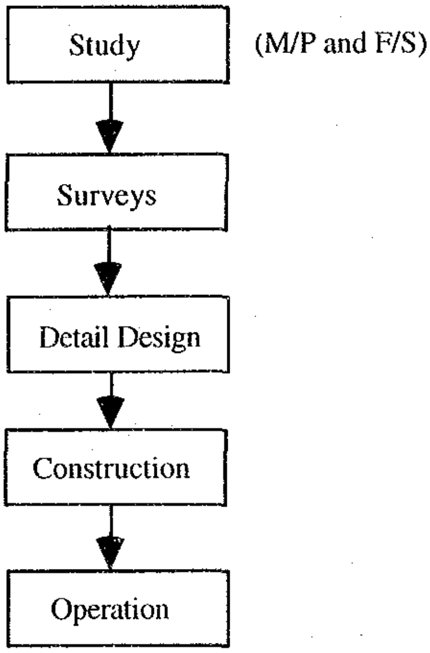
The JICA study team examined three options (A, B, C) and two cases (1,2) and found out that option A and Case 2 would be most feasible from the technical and financial points of view. The previous sections explain the details.
The proposal made by the study team can be summarized as follows:

1) Conveyance System
   - Intake
   - Raw water main
   - Pumping station
2) High Zone System (Mt.Eriama WTP)
   - Water treatment plant
   - Transmission System
3) Low Zone System (9 mile WTP)

- Water Treatment Plant
- Transmission system

4) Distribution system
   - Reservoir
   - Distribution Pipe

A general flow of the implementation schedule is as follows :



There are several contracts in the construction such as supplier and construction contracts. Prior to the construction, preparatory activities need to be carried out : orders of materials, mobilization of machines, construction of offices and shelters, and transportation of materials.

The environmental impacts largely depend on the construction methods employed for implementation. For piling works, there are basically two kinds of methods : hammer method and vibration method. The latter is more silent than the former, though the cost may be the opposite.

6.2.3 Possible Environmental Impacts

As mentioned above, environmental impacts largely depend upon the following factors :

- Construction site
- Construction method
- Construction machines
- Material transport
- Neighboring situations (residential areas)

In Japan the following impacts are to be regulated according to the laws and regulations of environmental impact assessment :

- Air pollution
- Water pollution
- Soil pollution
- Noise
- Vibration
- Low-frequency vibration
- Land subsidence
- Odors
- Sunshine disturbance
- Broad casting disturbance
- Wind damage
- Flora and fauna
- Soil erosion
- Historical site
- Scenic site

Of these environmental impacts the following ones are possible during the construction of F/S :

- Air pollution (mainly dust)
- Noise
- Vibration
- Soil erosion

Next, each construction of the proposed project will be reviewed, taking into account the possible environmental impacts.

(I) Intake

The construction of the intake at Rouna 4 head pond is scheduled to be carried out from 1994 to 1996 (3 years).

- Content : Weir, Intake mouth
- Possible environmental impacts :

The site of Rouna 4 head pond is located to the north of Port Moresby at an elevation of 147 m. The Laloki river flows through Rouna 4 head pond. The area is basically surrounded by forests, where almost no residential settlements are located. Therefore, noise or vibration, if any, may not cause environmental disturbance. There is no possibility of land subsidence.

Some possibilities of environmental impacts may be material and vehicular transport. However the transportation amounts are limited, so it can not be harmful to the environment.

(II) Raw water main

The raw water main is scheduled to be laid from Rouna 4 head pond to the existing Mt. Erima water treatment plant and the 9 mile water treatment plant over a period of 4 years (1994 to 1997).

- Content : Mild steel pipe (Diameter 1,600 mm, 1,350 mm and 900 mm)
- Construction method : Open cut
- Possible impacts :

The Pipes (Ø 900~1600 mm, 32 km) will be transported from the port to the site. Several trailer-trucks will be used. This may cause some disturbances along the road and in the neighborhood, but the disturbance if any will be only temporary.

Some soil may be eroded due to the construction, but this can be avoided by careful survey and construction.

(III) Pumping Station

A new pumping station will be constructed to pump raw water to Mt.Eriama WTP for three years (1994 to 1996).

- Content : Power 1,120 kW, Head 50 m
- Possible impacts :

There may be noise and vibration disturbances caused by the construction. The site conditions will decide whether some soils will be eroded by the construction. However, the neighboring area is basically inhabited and the possible impacts will not be serious.

(IV) Expansion of Mt. Eriama WTP

The existing Mt.Eriama WTP will be expanded to increase the capacity from 136,000 m^3/d to 180,000 m^3/d. The construction will be carried out from 1994 to 1996 (3 years).

- Content : Clarifier, filter, administrative building etc.
- Possible impacts :

A total soil quantity of 60,000 m^3 will be excavated and dumped on the hills surrounding the existing WTP. This may cause surface water pollution. The water is used for agricultural purposes.

There are almost no residents living in the neighborhood, so noise and vibration will not be serious for the people.

(V) Transmission System

The transmission system will be laid for 3 years (1994 to 1996). The size is 32 km long pipe lines of 500 to 1350 mm.

- Content : Mild steel pipe and ductile iron pipe
- Construction methods : Open cut
- Possible impacts :

The same problems as the raw water main will occur.

(VI) 9 mile WTP

This is the major construction work which will be carried out from 1996 to 1999 (4 years) to have a capacity of 100,000m^3/d.

- Content : Receiving well, mixing chamber, sedimentation basin, filter basin, chlorination chamber, clear water reservoir and administrative building
- Construction method :
- Possible impacts :

A large volume of soil (360,000 m^3) will be excavated, but filled in the surroundings of the hill (320,000 m3). The area is just a little inhabited, so no serious disturbances are expected.

(VII) Distribution System

A total length of 91 km will be laid with diameter of 100 to 800 mm.

- Content : Ductile iron pipe and mild steel pipe
- Construction method : open cut

- Possible impacts :

There may be noise and vibration disturbances caused by the construction. However careful construction and good consultation with police will help minimize the disturbances.

6.2.4 Environmental Assessment during Operation

When the system construction has been completed, it will go into operation. It is necessary to assess the environmental impacts during operation. They can be summarized as follows:

- Water intake
- Water treatment plant
- Waste water

(I) Water intake

The drought discharge of 20 year return of the Laloki river is estimated at 8 m^3/s, while the maximum intake will be 3.4 m^3/s in 2000, or 42.5 %. Judging from this, there will be no significant environmental impacts.

(II) Water treatment plant

The water treatment plants at Mt. Eriama and 9 mile will be operated with less noise and will not cause significant environmental impacts.
One problem may occur by the newly proposed pumping station. This will need to be examined carefully.

(III) Waste water

It is clear that, if more water is supplied, more waste water will be generated. This may cause adverse environmental impacts.

This is a major environmental problem, which can not be solved easily without fundamental commitment to environmental strategy.

JICA