Also emergency telephones, surplus manpower, and spare water carts must be stationed in the designated "emergency center". Needless to say, this operation will affect citizens' lives greatly. Social impacts need to be considered beforehand. The number of claims will increase at the beginning of this operation because this operation, now limited to the persons in the coastal strips will involve every person in the city. Advance announcements, education, and cooperation from the citizens are key elements of this operation. Therefore, this operation must not be considered from technical aspects only but from the administrative aspect as well, to emphasize teamwork

6.3.2 Duplication of Trunk Mains [2]

Necessity

The location of existing water shortage areas are shown in Fig. 3.4. The Table 6.1 summarizes these problem areas.

Table 6.1 Characteristics of Water Shortage Areas

Census Division (CD)		Population		Problem Areas Percentage (%)		Demand (m^3/day)	
No.	Name	1992	Problem Area	Against CD	Problem Area	Total	Problem Area
80	Gerehu	24,845	910	4	2	16,700	668
81	Waigani/University	17,743	0	0	0	16,000	0
82	Hohola/Tokalala	35,554	9,494	27	21	27,300	7,382
83	Gordon/Saraga	36,202	4,827	13	11	37,000	3,726
84	Boroko/Korobosea	28,839	3,251	11	7	21,100	2,678
85	Kilakila/Kaugere	31,755	3,725	12	8	20,900	2,847
86	Town/Hanuabada	27,694	22,063	80	51	23,100	17,934
87	Laloki/Napanapa	5,744	0	0	0	3,500	0
88	Bomana	12,179	0	0	0	8,500	0
TOTAL		220,555	44,270	20	100	174,100	35,235

From the Table, the following characteristics of water shortage areas can be observed. The area suffering from the worst water shortage is Town/Hanuabada area: the estimated population in this area is 22,000, which is equivalent to about 50 % of the total population in the water shortage areas. This figure corresponds to 80 % of the Town/Hanuabada census division population.

[2] The details are explained in a separate volume.

Therefore, this area should be targeted first for immediate remedial measures. Together with this strategy, immediate remedial measures are likely to have positive effects.

Network analysis of existing system revealed that there is no water filling at Town and Koki reservoirs. Thus, to recover residual head in these areas, either installation of pump facilities or duplication of trunk mains is recommended. Generally, constructing a pumping facility is less expensive but operation and maintenance costs are higher compared with duplication of trunk mains. Additionally, the duplication of trunk mains is likely to result in proper functioning in the long term and the diameter should be chosen carefully. In this study, duplication of trunk mains is selected as a part of the immediate remedial measures.

Pipe Alignment

Three possible pipeline routes to the water shortage area in coastal strips, ranging from diameter 1100 mm pipe at 9 mile, which are Spring garden road (A) , along Hubert Murray highway (B) and extension of the Spring garden road (C), are compared in Table 6.2.

The proposed (Spring Garden road) route follows basically the existing trunk mains route, but diverts from the existing route between Gordons area and Three mile area. The pipe alignment runs along Geauta Drive, Spring Garden Road and Wards Road. This is in order to avoid heavy traffic in the Hubert Murray Highway as far as possible for construction purposes. This detour will also give some flexibility in flow distribution. In the future, connections can be made allowing flow to be diverted to Waigani and Tokarara area, if the need arises. The existing trunk mains are concentrated on the Highway, giving hydraulic advantage to the nearby Boroko and Gordons areas.

TABLE 6.2 COMPARISON OF ADDITIONAL TRUNK MAIN ALIGNMENT

ALTERNATIVE	A:Spring garden	B:Hubert Murray	C:Others
Affect to traffic	O(small)	X(large)	O(small)
Distance	O(short)	O(short)	X (long)
Flexibility for future pressure zoning	O(large)	X(small)	O(large)
Ease of construction	O (easy)	X(difficult)	O (easy)
Construction Cost	O (low)	X(high)	X (high)

Provision for connection with the existing trunk mains is made but no connection will be made until the expansion program is commissioned. This is to avoid withdrawal of water on the way and to facilitate zone-restriction service.

Pipe Size

Network (hydraulic) analysis clearly indicates the inadequate capacity of existing trunk mains. The most severe problem is with the trunk main that carries water to the coastal strips. The existing arrangement of 600 mm and 450 mm mains is inadequate. Additional main of 600 mm diameter from Gerehu off-take to Koki reservoir can correct the deficiency. The additional pipe should preferably cater to a future demand of at least ten years in order to avoid immediate duplication.

The above sizes and sections were determined during the master plan stage. However, after the feasibility study, it was found that other sizes and sections were appropriate (refer to Fig. 6.4). That is a combination of 1,100 mm pipe and 600 mm pipe, as given below;

	Pipe Length (meter)	Pipe Size (mm)	
		Originally proposed	Modified
9 mile to junction with 9 mile plant	1,280	600	--- *
Junction with 9 mile plant to Erima	2,596	600	1,100
Erima to 3 mile	7,195	600	600
3 mile to Koki Reservoir	2,280	600	--- *

* utilizing existing pipes

This modification reduces the length of pipes by 3,560 m but, instead, the size of the pipe in the first section increases from 600 mm to 1,100 mm. Both alternatives give the same hydraulic effect and cost to divert water to the coastal strips (refer to Fig.6.5).

The modified 1,100 mm pipe is a part of the Phase One works. Therefore, this pipe could be utilized effectively in the near future and hence this modified proposal is recommended.

Cost

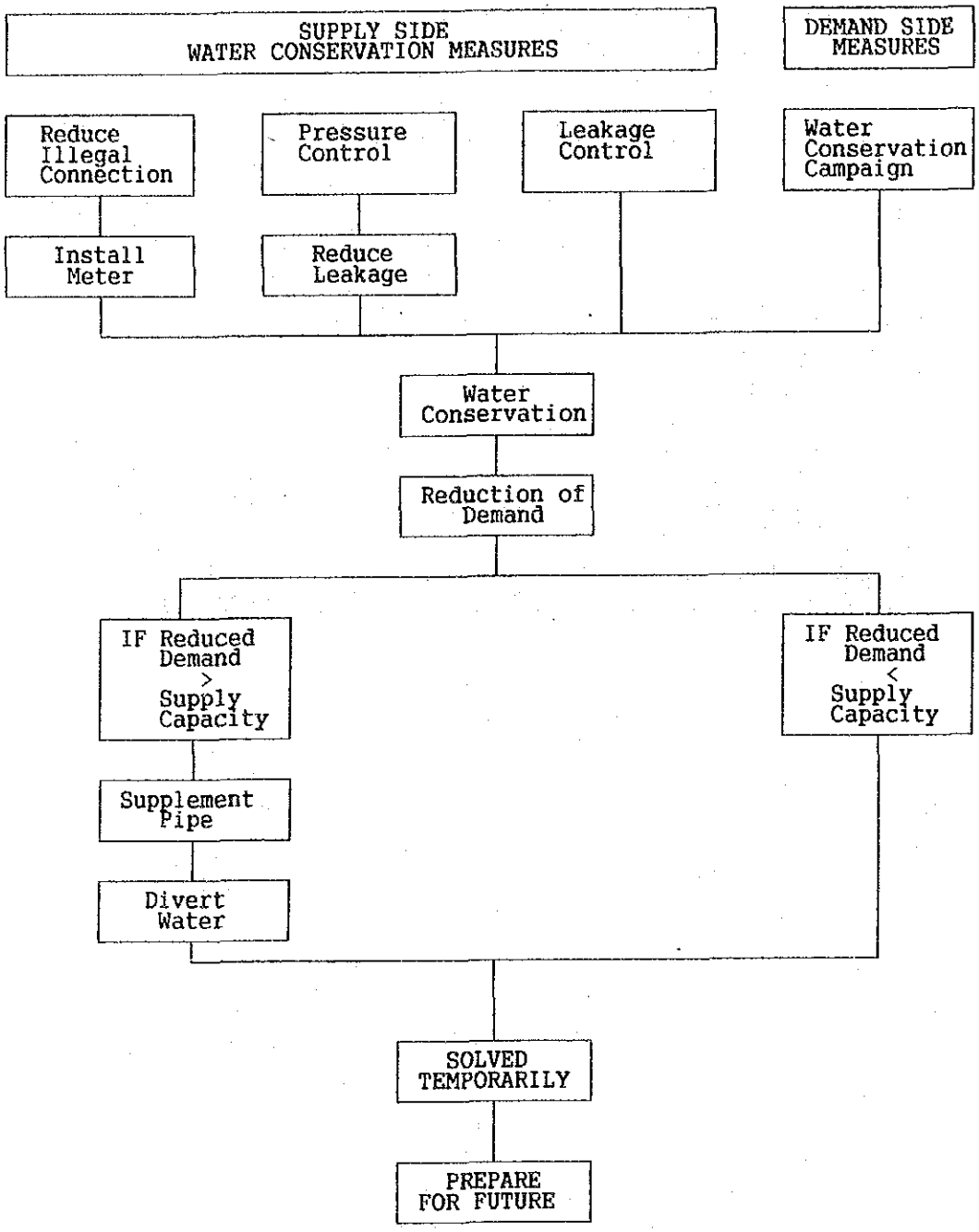
The total cost of the proposed work is estimated at 14 million U.S. Dollars (approximately 14 million Kina), including materials, freight and insurance fees, installation works, trench works, restoration of pavement, design and supervision works.

Effect

The result of the network analysis by adding the trunk mains mentioned above, shows improvement in the current water shortage problem, as explained in the following Table.

Table 6.3 Improvement by the Proposed Mains

Census Division (CD) No	Name	Population Improved	Percentages(%) Against problem Pop.	Daily Max. Demand (m^3/day) Improved
80	Gerehu	0	0	0
81	Waigani/University	0	0	0
82	Hohola/Tokalala	5,990	63	3,556
83	Gordons/Saraga	0	0	0
84	Boroko/Korobosea	3,251	100	2,060
85	Kilakila/Kaugere	3,275	100	2,190
86	Town/Hanuabada	22,063	100	13,795
87	Laloki/Napanapa	0	0	0
88	Bomana	0	0	0
	Total	36,696	83	21,601



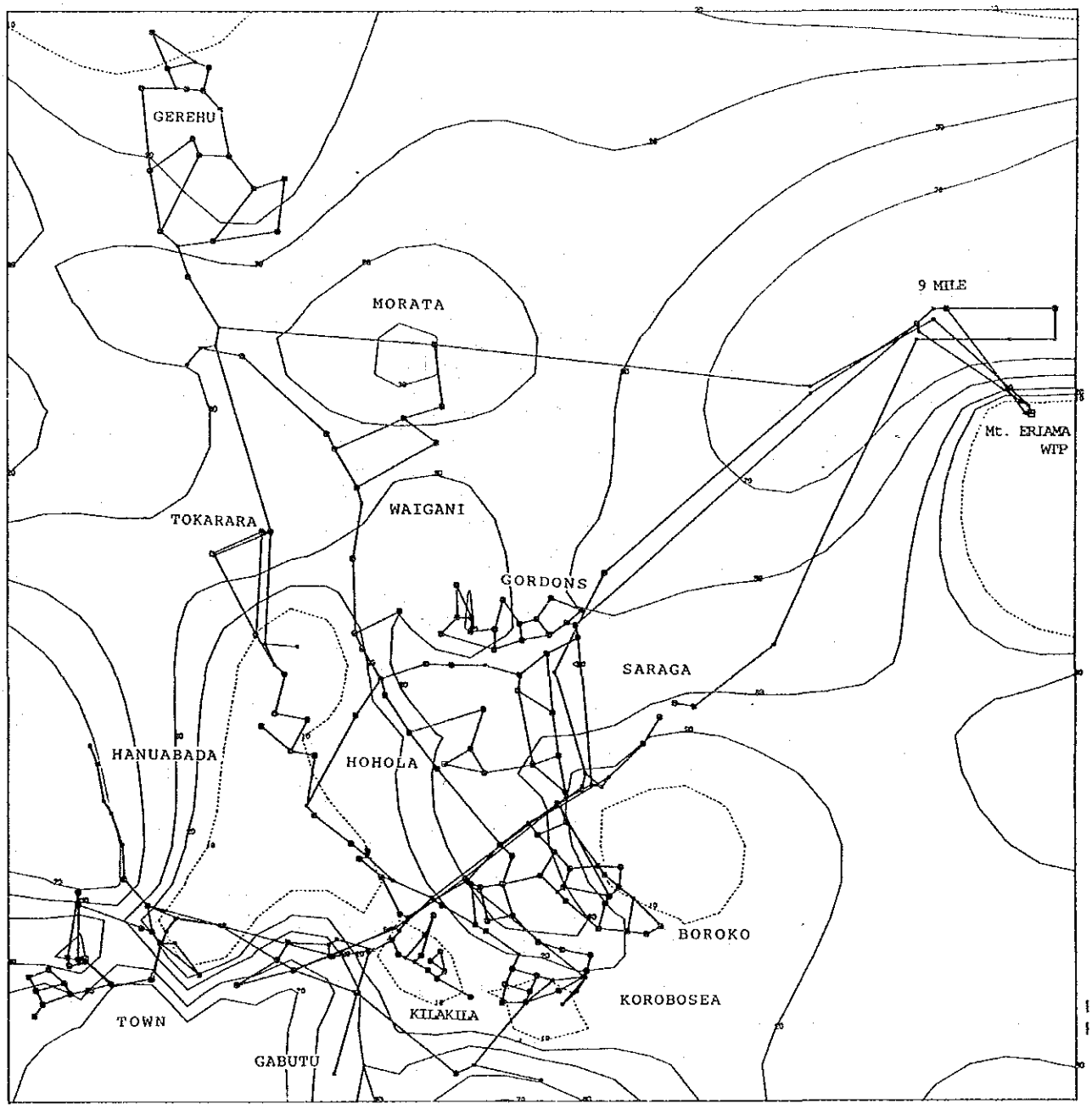
TITLE

CONCEPT OF IMMEDIATE REMEDIAL MEASURES

Fig. No.
6.1

PORT MORESBY WATER SUPPLY DEVELOPMENT PLAN

TOKYO ENGINEERING CONSULTANS in association with PACIFIC CONSULTANTS INTERNATIONAL



TITLE

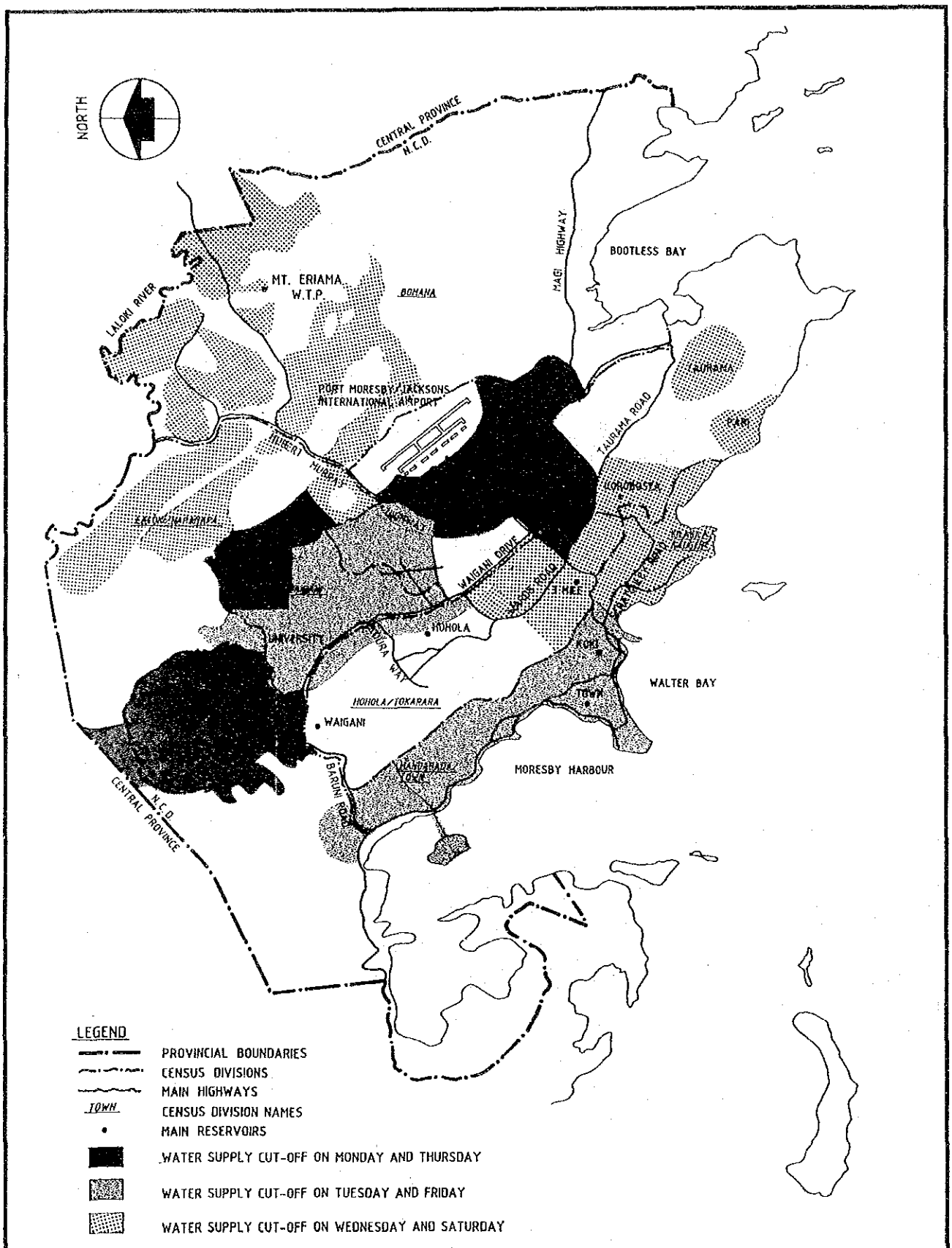
ISO-RESIDUAL HEAD LINE

Fig. No.

6.2

PORT MORESBY WATER SUPPLY DEVELOPMENT PLAN

TOKYO ENGINEERING CONSULTANS in association with PACIFIC CONSULTANTS INTERNATIONAL



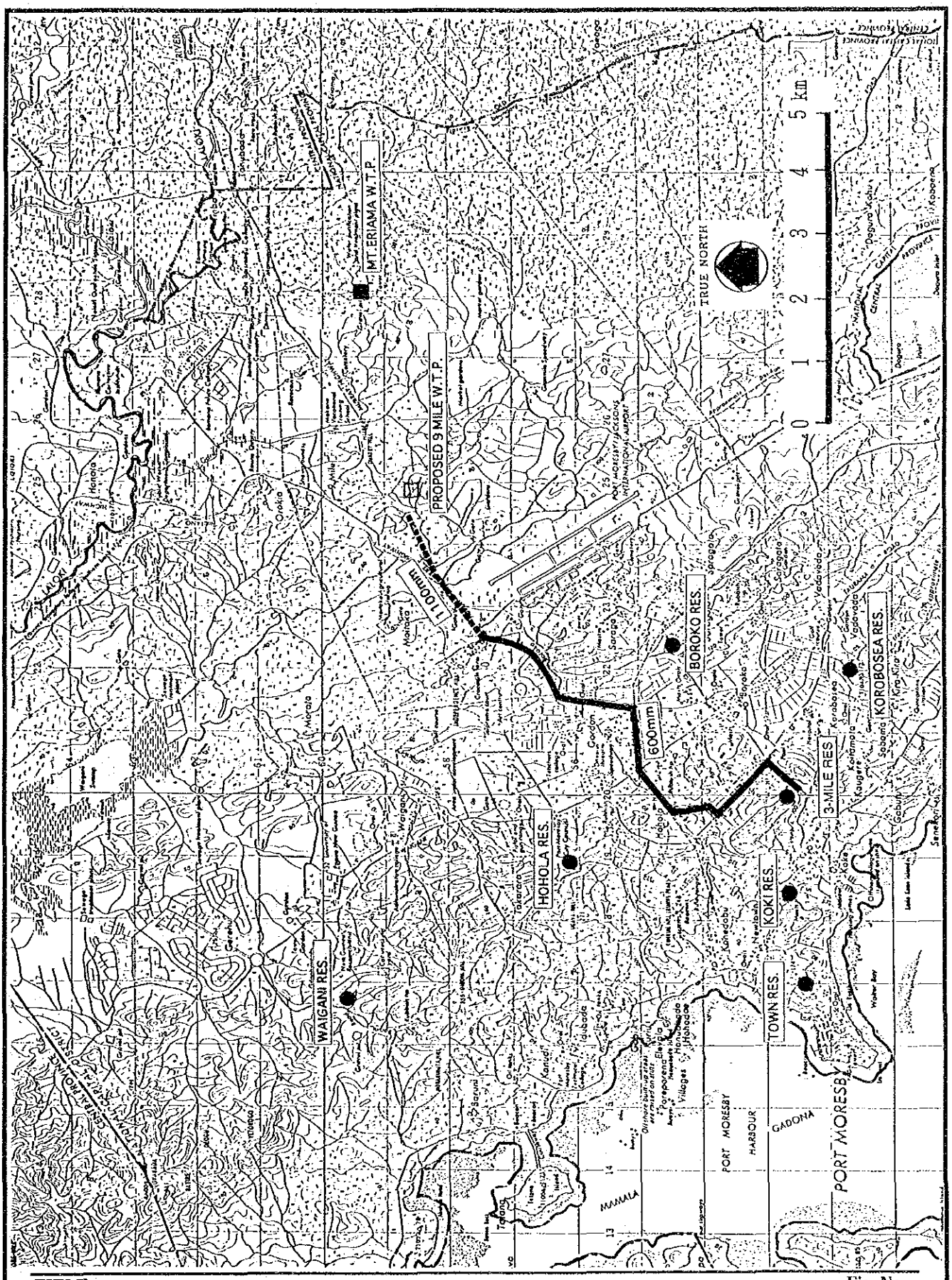
TITLE

ZONE-RESTRICTION SERVICE

Fig. No.
6.3

PORT MORESBY WATER SUPPLY DEVELOPMENT PLAN

TOKYO ENGINEERING CONSULTANTS in association with PACIFIC CONSULTANTS INTERNATIONAL



TITLE

PROPOSED TRUNK MAIN

Fig. No.

6.4

PORT MORESBY WATER SUPPLY DEVELOPMENT PLAN

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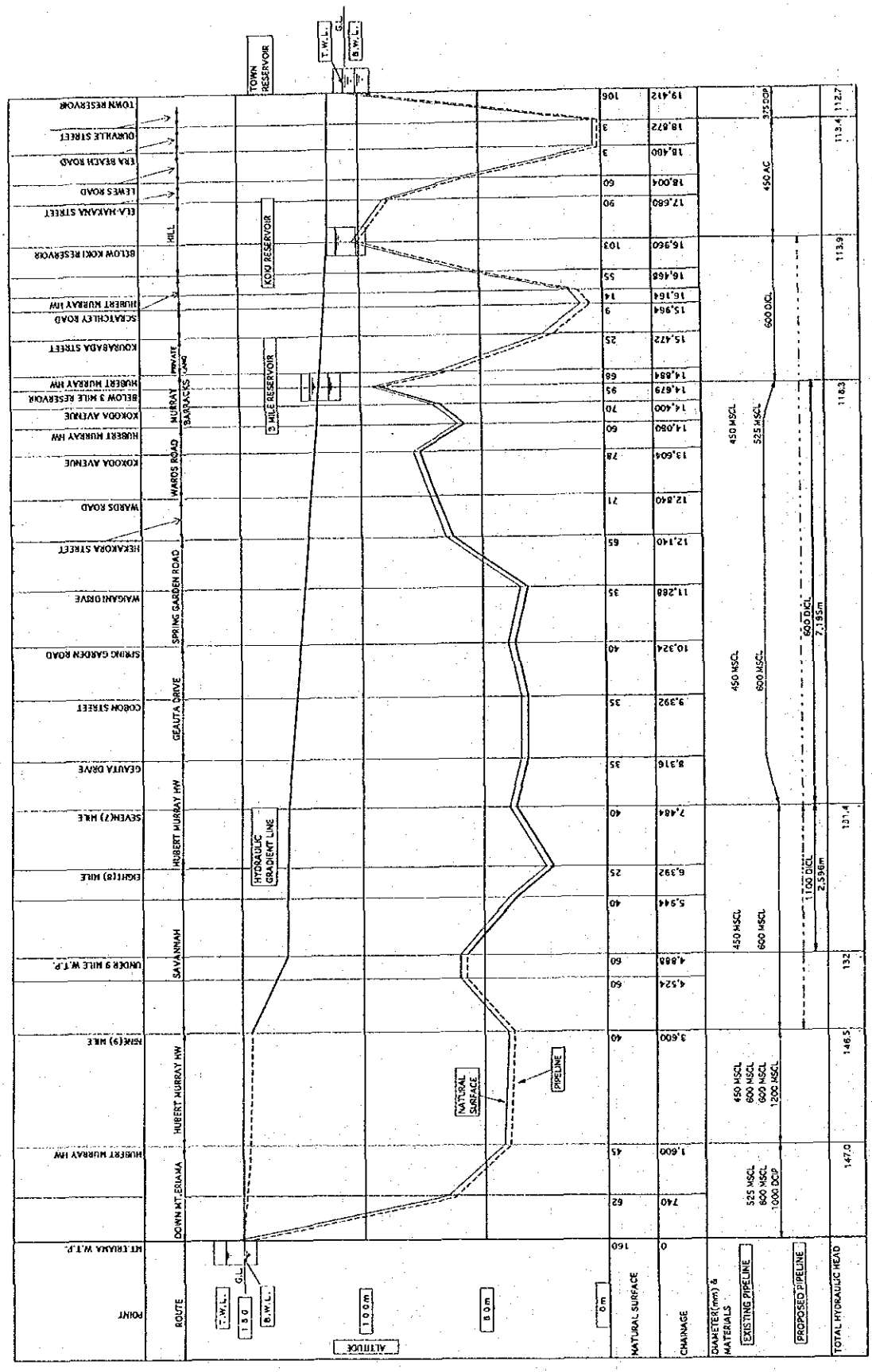

TITLE

LONGITUDINAL SECTION OF PROPOSED TRUNK MAINS

Fig. No. 6.5

PORT MORESBY WATER SUPPLY DEVELOPMENT PLAN

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7 LONG TERM PROGRAM

7.1 Basic Concept

The water supply system must meet the demand in the year 2015. The existing raw water mains from the Rouna 1/3 headpond can convey 98 mld, while the existing Mt. Eriama system can treat 135 mld.

7.1.1 Water Source

The water source needs to be set up first for delineating long term water supply system to cater not only to the increasing water demand in the future, but also to cater to the pressing, immediate demand. The quantity of water from the Laloki river is found to be adequate for the foreseeable period until the master plan target year. The existing abstraction point upstream of Rouna 1/3 head pond was proposed for the additional abstraction of 281 mld[1] because water can be conveyed to the city by gravity, resulting in much higher reliability and less maintenance work and costs than any other abstraction points which would require pumping. However, this proposal would decrease the quantity of water used currently for hydro-power generation so ELCOM did not concede the water.

Various meetings were held concerning this proposal, among NCDC, ELCOM and the Bureau of Water Resources. As a result, Rouna 1/3 head pond was abandoned and, instead the downstream Rouna 4 head pond (refer to Fig. 7.1) was agreed upon as an additional abstraction point in May 1993. The Rouna 4 head pond would necessitate partial pumping for the NCDC water supply system and would reduce hydro-power generation for ELCOM.

The abstraction point of Bomana further downstream, which is now supplementing water to the Mt. Eriama treatment plant would be suspended again and reserved only for standby use since it has given and would give the highest unit operation cost, because of the high cost of pumping of water.

The amounts required are shown in Table 7.1.

[1] This figure includes 26 mld, the intake point of which will be shifted from Bomana.

TABLE 7.1 WATER AMOUNT FOR NCD WATER SUPPLY SYSTEM

(mld)

Water Source	YEAR					
	1990	1995	2000	2005	2010	2015
Total Required	160	207	227	275	326	379
Rouna 1/3 (existing)	98	98	98	98	98	98
Bomana (existing)	21	21	0	0	0	0
Rouna 4 (New)	0	0	129	177	228	281
(m^3/sec)			(1.49)	(2.05)	(2.64)	(3.25)

Above figures are larger than the demand because they include various losses within the water supply system.

7.1.2 Zoning

It is high time to introduce "zoning" of the distribution system, aiming at supplying water with equal water pressures throughout the NCD area. The existing system has been constructed to serve every part of the NCD area by gravity, with one treatment plant. This has been the largest asset of the NCD water supply system with less maintenance works and costs, however, with one inherent disadvantage; there is unnecessary high pressure, particularly in the low-elevation areas, resulting in high leakage.

When a new Rouna 4 water source is added to the water supply system, since the elevation of the new intake point is lower than the existing Rouna 1/3 headpond, the distribution area would be divided into two zones; "high" and "low" zones, aiming at reducing leakage. The high-elevation areas of NCD would be served by high zones; low by low zones. The low zone would receive water from the proposed new treatment plant which would utilize water abstracted at the downstream Rouna 4 head pond. On the other hand, the existing Mt. Eriama treatment plant, which abstracts water at upstream Rouna 1/3 head pond, would serve the high zone economically but cannot satisfy the total demand. Therefore, the high zone needs to be supplemented with water abstracted at the Rouna 4 head pond.

Water at the Rouna 4 headpond (145.4 m: low water level) could be delivered economically by gravity to areas at 45 to 75 meters elevation, considering the head losses between them and the residual heads at the consumers' locations. This is

calculated in Table 7.2. Therefore, the 60 meter height can be the boundary of the two zones.

Even though the coastal strips are generally low in height, they should be within the high zone because water needs to pass beyond the 100 m Three-Mile area, the highest elevation, between the coastal strips and the existing Mt. Eriama treatment plant.

The other parameters to be considered for the division of the two zones are as follows;

a) Balance of Supplied Amount
   The high zone should be as small as possible because supply to the high zone would involve high-cost pumping. The amount of water from the Rouna 1/3 headpond for the high zone is limited.

b) Existing Network System

c) Road Network and Administrative Boundary
   The road network and administrative boundary could be taken as boundaries of the zones so that the distribution facilities can be operated and maintained smoothly.

As a result, the NCD area is divided as shown in Fig. 7.2. Tokarara, Hohola, Boroko and Korobosea areas will be within the high zone while Gerehu and Waigani areas will be within the low zone:

Low Supply Zone - Gerehu, Waigani, Bomana, and Morata
High Supply Zone - Town, Gordon, Boroko, Korobosea, Kilakila, Tokarara, and Hohola

Daily maximum demand of each zone in the year 2015 is estimated as 191 mld (low zone) and 177 mld (high zone) as shown in Table 7.3.

TABLE 7.2 HEAD LOSS FROM ROUNA 4 TO CONSUMER

Type of Loss	Loss (m)	
Pipe	30 - 60	Length 30 km, Hydraulic Gradient 1 - 2/1,000
Treatment Process	15	includes effective height at clear water reservoir
Storage Reservoir	10	Difference between high and low water levels
Effective Head	15	at consumers
TOTAL	70 - 100	
Available Height	45 - 75	(Rouna 4 headpond 145.4) - (Total loss 70 to 100)

TABLE 7.3 DEMAND IN ZONES AND RESERVOIR BLOCK

unit : mld

Zone or Reservoir Block	YEAR 1990	1995	2000	2005	2010	2015
High zone	101	126	132	153	170	177
Boroko	20	27	30	31	31	32
Korobosea	17	20	20	21	22	22
3 Mile	16	20	21	26	31	31
Koki	15	17	17	20	22	22
Town	5	6	6	7	7	7
Waigani	13	16	19	25	30	36
Hohola	16	20	20	23	28	27
Low zone	55	75	88	113	144	191
Gerehu	15	19	21	27	35	43
Erima	30	38	40	45	50	51
9 Mile	9	16	23	33	43	62
Laloki	0	2	4	8	16	35
Total	156	201	240	266	314	368

The NCD areas range from 0 m to over 100 m in height. However, areas higher than 100 m are limited in number and can be economically served by the "storage and pump schemes" currently undertaken at the sites. Parts of the Town area and the Korobosea area will be served by the above schemes. The other areas currently served with the schemes could be served without pumping.

7.1.3 Separation of Trunk Mains from Distribution System

The current trunk mains have been constructed to convey the maximum daily demand constantly from the plant to the consumers. The diurnal fluctuation can be controlled with service reservoirs located at or near the designated demand districts; water filled up in the reservoirs during night (off-peak demand period) is released to meet the peak demand during daytime. This system will not require manual operation since the system itself can control hydrological performance. It can be said to be a theoretically efficient system. It had actually worked well until the middle of 1980's when demand surpassed the supply capacity of the water supply system.

Insofar as the system can meet the demand, it can work, and it will work when the expansion work is completed. This system was not intended to be connected with service or distribution pipes. However, during the course of time, these pipes have been connected intentionally or un-intentionally. Rectifying this situation is difficult. Therefore, for the expanded water supply system to function properly, a different system is proposed for the expanded water supply system; separation of the trunk mains from the distribution mains.

No branch will be allowed to be taken from the trunk mains. A constant quantity of water is conveyed exclusively to the service reservoirs first. Water is then distributed from the reservoirs to the designated service areas. It may cost a little more than the current system. However, it is easy to control the water when necessary, for example, when the correct quantity is not supplied. Also, the pressure of the delivered water can be controlled with the help of a pressure reducing valve at the outlet of the reservoir, and leakage can be controlled as well. Pressure at the outlet of the reservoirs can be reduced during the off-peak period.

7.2 Options

7.2.1 Location of Treatment Plant

Low zone demand can be met with gravitational flow from the new treatment plant. New treatment plant could be located either at the abstraction point of Rouna 4 or near the demand site of 9 mile.

Inspection of Rouna 4, however, suggests that the new treatment plant cannot be located there. The flat land at the base of the embankment to the north side of the head pond would be the first choice and would suit the required land size for the new treatment plant. But its elevation of about 110 m, which is approximately a 40-meter drop from the head pond itself, would inevitably require pumping of not only the high zone demand but also the low zone demand, although gravitational supply to the low zone could be possible if uneconomical, large diameter pipe is installed.

There are two sites considered (Fig. 7.3) in the demand areas. The two sites are in the ridges between the airport-Moitaka-Morata corridor and the 9-mile. Both sites are government-owned land, and are close to the designated low zone.

Site No. 2 is a better choice in terms of the length of the pipe. Furthermore, site No. 2 is preferable to the site No. 1 as far as the following points are concerned:

a) Settlements have been developed near site No. 1, hence, it would be difficult to clear the site.
b) Site 2 is closer to the demand area and will be located at the center of demand in future.
c) Site 2 is also closer to the existing trunk mains with which water can be conveyed, should one system fail.

d) Site 2 is also closer to the Hubert Murray Highway along which new trunk mains can be easily installed.

Hereafter, a candidate for the new treatment plant at site No.2 is referred to as the 9-mile treatment plant.

7.2.2 Supply to High Zone

Once the additional abstraction point is determined at Rouna 4, new treatment plant is located at 9-mile, and zoning system is introduced, the flow distribution is clear.

a) water of 281 mld abstracted at Rouna 4 is partly treated at the new 9-mile treatment plant to distribute water to the low zone with a demand of 191 mld.
b) water of 98 mld abstracted at Rouna 1/3 is treated at Mt. Eriama treatment plant and distributed to the high zone with a demand of 177 mld.
c) The remaining high zone demand needs abstraction from Rouna 4.

TABLE 7.4 SUPPLY AND DEMAND

unit : mld

Supply side		Demand side		Difference
Supply from Rouna 1/3	98	Demand in High zone	177	-79
Supply from Rouna 4	281	Demand in Low zone	191	+90
Total *	379	Total *	368	

* Supplied amounts include losses, and are, therefore, larger than demand amounts.

The a) and b) measures above can be gravitational flows from the source to the consumer. On the other hand, the measure c) requires pumping. There are three pumping methods to meet the high demand;

a) Supply side pumping (option A: see Fig. 7.4)
   - Pumping to Mt. Eriama treatment plant
   - Treating at Mt. Eriama treatment plant
   - Distributing by gravity to service reservoir
b) Demand side pumping (option C: see Fig. 7.6)
   Conveying by gravity to a 9-mile treatment plant
   Treating at a 9-mile treatment plant
   Pumping to service reservoir in the high zone
c) Two-side pumping (option B: see Fig. 7.5)
   partly by the a) above and partly by b) above

In the following section, these methods are analyzed.

7.2.3 Comparison

1) Expansion of Mt. Eriama Treatment Plant (Option A)

If all the required water can be abstracted at the Rouna 1/3 head pond, it is obviously thought best, that a) the Mt. Eriama treatment plant be expanded, until the sites allow physically, for the high zone demand and b) a new treatment plant be constructed for low zone demand. All the water could be transported by gravity from the abstraction point to the consumers' end.

If we still follow the once-thought of best plan, water quantity required for the high zone demand, which exceeds the quantity supplied from the Mt. Eriama treatment plant, must be pumped up to Mt. Eriama. Then, water can be treated at the expanded Mt. Eriama treatment plant, increasing its capacity by 41 mld to 177 mld, which is the high zone demand. From there water would be distributed, by gravity to the high zone. This option "A" would require a fewer additional trunk mains for the high zone since the existing trunk mains have the capability to satisfy basically the entire high zone demand.

2) Compensation Of Bomana (Option B)

Low zone demand could be met by the supply from the 9 mile treatment plant, same as option A. Water abstracted at the Rouna 4 is partly pumped to the Mt. Eriama treatment plant. Water is then treated there, and is distributed to the high zone.

Option B would not expand the Mt. Eriama plant but 42 mld of raw water is pumped up to the Mt. Eriama treatment plant to compensate the quantity, now pumped from Bomana. The remaining 41 mld for the high zone would be treated at 9 mile together with the entire low zone demand of 191 mld. The 41 mld would first be distributed by gravity, then boosted to the Waigani and Hohola reservoirs in the high zone.

3) Full Scale 9 Mile (Option C)

The option C would convey the entire raw water abstracted at Rouna 4 head pond to the new treatment plant at 9 mile. The treated water would be distributed by gravity to the low zone. It is also distributed by gravity to the high zone, and then boosted up to the Waigani, Hohola and Koki reservoirs. Therefore, trunk mains for the low zone must accommodate the surplus high zone demand as well.

TABLE 7.5 LOCATIONS OF TREATMENT PLANTS

		High Zone Demand *1	Low Zone Demand
Option A	"expansion of Mt. Eriama"	Expansion of Mt. Eriama	NTP at 9 mile
Option B	"compensation of Bomana"	NTP at 9 mile	NTP at 9 mile
Option C	"full scale 9 mile"	NTP at 9 mile	NTP at 9 mile

Note: * 1. Existing Mt. Eriama treatment plant is common to each option.
* 2. NTP: New Treatment Plant

TABLE 7.6 MAIN FACILITIES FOR EACH OPTION

unit : mld

	OPTION A		OPTION B		OPTION C	
ZONE	Low	High	Low	High	Low	High
Intake facilities	Rouna 4 (281)		same as option A		same as option A	
Raw Water Main (from Rouna 4 to)	9 mile (197)	Mt.Eriama (84)	9 mile (239)	Mt.Eriam a (42)	9 mile (281)	
Raw Water Pump	No	Yes (84)	No	Yes (42)	No	No
Treatment Plant	9 mile (191)	Mt.Eriama (41)	9 mile (232)		9 mile (273)	
Trunk Main (from)	9 mile (191)	Mt.Eriama (177)	9 mile (232)	9 mile (136)	9 mile (273)	9 mile (95)
Boosting Pump (from Low to High zone)	No	No	No	Yes (41)	No	Yes (82)

Note 1) NTP: New Treatment Plant at 9 mile
2) The existing Mt. Eriama for the high zone is excluded from this table.

7.2.4 Selection of Options

1) Cost Comparison

To evaluate these options for construction, the depreciation and electricity costs are considered here. Since the purpose of cost estimation in this section is limited to the comparison of options on the same basis, the following assumptions are made.

(1) costs are in 1992 in Kina
(2) price escalation is neglected
(3) electricity charges are based on the commercial tariff of ELCOM
(4) the life of facilities is based on the Water Assets Report by NCDC
(5) facilities common to the three options are excluded.

The costs for three options are shown in Table 7.7. Option B is the cheapest, followed by option A. Option C with the highest cost reflects the fact that a part of the existing Mt. Eriama treatment plant' s capacity of 41 mld, which has been treated with the quantity abstracted at the Bomana pumping station would be reserved. Options B and C would utilize the plant's capacity. Accordingly, the additional capacity of the treatment plant could be reduced by 41 mld in options A and B.

Annual operation cost of pumps in 2015 are 0.463 million Kina for option A, 0.737 million Kina for B and 1.158 million Kina for C. Net Present Values (NPV) of the three options, considering the operation costs for the pumps are (discount rate is assumed as 10 %, 40 years operation is considered):

Option A : 150 million Kina
Option B : 147 million Kina
Option C : 163 million Kina

The ranking of each of the three options is still the same but the difference is small.

TABLE 7.7 COST OF OPTIONS

(million Kina)

	option A		option B		option C	
	item	cost	item	cost	item	cost
Intake	not included		not included		not included	
Raw water main						
Diameter (mm)	1600 - 900		1600 - 700		1600	
Length (km)	17.8 km	32	17.8 km	33	15.8 km	32
Pump	760 kW	2	400 kW + 520 kW,	3	780 kW	2
Treatment plant						
Mt. Eriama	41 mld	27				
9 mile	191 mld	115	232 mld	137	273 mld	159
Trunk mains						
Diameter (mm)	600 to 1200		400 to 1350		400 to 1350	
Length (km)	41 km	38	36 km	32	45 km	37
Reservoir	not included		not included		not included	
Distribution pipe	not included		not included		not included	
Engineering fee		24		22		25
TOTAL		238		227		255

2) Non-Cost Comparison

Cost would be one of the decisive factors in laying out the future water supply system. In addition, the nature of each option must be considered to select the best layout, particularly when costs do not differ significantly. The factors to be considered are as follows:

* operation and maintenance
* control of distribution network
* whether the diversion of water from one zone to another zone is easy or difficult

From the viewpoints of operation and maintenance of the system, options A and C would be preferable to option B. The fewer the number of pumping stations, the better the operation and maintenance. Number of pumping stations is one in options A and C, while it is two in option B.

The two treatment plants together with the pumping stations have to be operated to meet the daily demand: All the plants do not have to be operated at full design capacity every day, since the plants are designed to meet the daily maximum demand in the target year.

The most economical operation, needless to say, is to utilize the gravitational flow from Rouna 1/3 at the Mt. Eriama treatment plant to the maximum extent possible, in the three options. The treating capacity and pumping capacity could be controlled to meet the demand for the day. Options A and C are easy to control; a number of raw water pumps could control the supply to the high zone in option A while a number of boosting pumps could control the supply in option B. On the other hand, in option B, both raw water pumps and booster pumps, need to be adjusted. For the low zone demand, inflow quantity can control the supply to the low zone in the three options.

The last factor considered here is flexibility in case of accidents or system failure. Diversion would become necessary, aiming at reducing leakage since there will be two zoning systems. In this regard, option A is superior to the other two options. Water could be diverted from the high zone to the low zone hydraulically, but the diversion route varies for the three options; via Mt. Eriama in option A, partly via Mt. Eriama and partly via Waigani in option B, and via Waigani in option C. Option A could intentionally distribute water to the high zone utilizing the entire network of the high zone, while option C limits the diversion, restricted from the pipe capacity between Waigani and the high zone.

Similarly, option A is superior to the other two options in terms of diverting water from the low zone to the high zone.

3) Selection Of Options

Option A is recommended from the considerations above.

TABLE 7.8 SALIENT FEATURES OF OPTIONS

	option A EXPANSION OF MT. ERIAMA	option B COMPENSATION OF BOMANA	option C FULL SCALE 9 MILE
Operation and maintenance of pumping station	one (raw water pumping station near Mt. Eriama)	two (raw water near Mt. Eriama and booster at Waigani pumping stations)	one (booster pumping station at Waigani)
Response to demand variation in the high zone	for HIGH ZONE: base supply from Mt. Eriama (Rouna 1/3) and peak supply from raw water pumps (Rouna 4)	for HIGH ZONE: base supply from Mt. Eriama (Rouna 1/3) and peak supply from raw water pumps (Rouna 4) and booster pumps (Rouna 4)	for HIGH ZONE: base supply from Mt. Eriama (Rouna 1/3) and peak supply from booster pumps (Rouna 4)
Diversion of water (from low to high zone)	84 mld (via Mt. Eriama)	42 mld (via Mt. Eriama), 41 mld (via Waigani)	82 mld (via Waigani)

7.3 Major Works

7.3.1 General

Based on the proposed option A, water supply works under a long term program are identified and proposed in this section. Layout of the facilities is shown in Fig. 7.7 while the schematic layout of the proposed system is shown in Fig. 7.8.

1) Mt. Eriama WTP Expansion

The layout of Mt. Eriama for the long term program is shown in Fig. 7.9.

a) Location: Mt. Eriama

b) Capacity: 180 mld (44 mld expansion)

c) Treatment Process:

Upward flow settling tank, pressure-type filter, receiving well and chemical dosing system. At the existing rapid filters (No. 3 to 6), filter media(sand and gravel) has not been changed for about 20 years. Therefore, the frequency of back washing is increased. This problem should be cleared by improvement.

d) Clear Water Reservoir:

Since the detention time is about 1 hour for 180 mld after expansion, no expansion is planned

e) Intake: Rouna 4 Head Pond
f) Raw Water Main and booster pumping station: 900 mm branching from the raw water main to the 9 mile water treatment plant by pumping

2) 9 Mile WTP

Fig. 7.10 shows the layout of the new 9 mile WTP.

a) Location: near Jackson Airport
b) Capacity: 200 mld
c) Treatment Process:
Conventional method (horizontal flow sedimentation tank and gravity type filter) is recommended, giving priority to operation & maintenance.
d) Intake: Rouna 4 Head Pond
e) Raw Water Main: 1600 mm (Rouna 4 head pond to branch to Mt. Eriama plant) and 1350 mm (Branch to 9 mile plant) by gravity flow

7.3.2 Major Works in Each Zone

(1) Trunk Mains

Trunk mains are planned to connect the treatment plants with the service reservoirs exclusively. The existing trunk mains are utilized fully and additional trunk mains are planned.

The existing system has been analyzed with reference to present consumption by an in-house computer model (MSNET). System deficiencies were apparent on this basis but additional deficiencies were confirmed by analysis of the system until the target year (2015). Further, new trunk mains are required to connect the new plant with the areas to be supplied.

To analyze the trunk mains and the distribution system it would be necessary to prepare a schematic model of the zoned system as it is at present. This model would be necessary to calculate the estimated flows at various points in the trunk main and the distribution system.

The model indicates the connectivity of major elements of the existing system and shows the point from which each zone is supplied. Starting at the extremities of the distribution system, zone flows were summed up at each junction to give the flow for the next upstream main analysis.

The trunk mains between the Mt. Eriama treatment plant and the coastal strips do not have adequate capacity even for the present demand. The shortage will become more acute in future as demand increases. Therefore, additional trunk mains are planned as immediate remedial measures.

New trunk mains will be installed to connect the 9 mile treatment plant with three reservoirs - Erima, Gerehu and Laloki. Additional trunk mains will be installed to connect the Mt. Eriama treatment plant with the 4 existing reservoirs - Waigani, Hohola, Boroko and Korobosea reservoirs. Fig. 7.11 shows the new trunk mains.

TABLE 7.9 TRUNK MAINS

System	Route	Diameter. (mm)	Length (m)
High Zone (Mt. Eriama System)			
	Mt. Eriama Reservoir to Dia. 1000 pipe	1000	20
	9 Mile to Hubert Murray Highway.	1350	2,180
	Hubert Murray Highway. to 7 Mile	1350	2,000
	7 Mile to Mokaraha Rd.	1000	3,560
	Mokaraha Rd. to Waigani Drive	1000	1,400
	Waigani Drive to Waigani Res.	800	2,940
	Waigani Drive to Hohola Res.	600	3,000
	7 Mile to Boroko res.	900	3,300
	Hubert Murray Highway to Korobosea Res.	500	2,760
	subtotal		21,160
Low Zone (Nine Mile System)			
	9 Mile W.T.P. to Hubert Murray Highway.	1200	1,280
	Hubert Murray Highway to 7 Mile	1100	2,000
	7 Mile to Erima Res.	700	440
	7 Mile to Mokaraha Rd.	800	3,560
	Mokaraha Rd. to Gerehu Res.	800	3,620
	Hubert Murray Highway to Laloki Res.	600	2,340
	subtotal		13,240
total			34,400

(2) Distribution System

If the distribution mains starting from each reservoir are improved, the existing distribution pipes which are appropriately arranged, will meet the requirement of the future demand in fully developed areas; Boroko, Gordons, Morata, Gerehu, Tokalala,

Hohola and the Town. Proposed distribution pipes to be added to existing one in this area are shown in Fig. 7.12.

Reticulation system requirements in the developing areas were not included in detail, in this report. It is usually developed to suit the particular development of housing, industry etc. when actually implemented. Nevertheless, for the project cost estimation, the overall requirements of the distribution pipes are estimated as follows;

The density of pipe in the areas are 87 meters per 100 meters square. The existing distribution of pipe sizes in the NCD area is as follows;

100 mm	46 %
150 mm	35%
200 mm	10 %
250 mm	9 %

Using the above density and distribution, pipes of about 291 km are required in the developing area as shown in Table 7.10. This table shows the lengths for the developing areas and for the urbanized areas.

TABLE 7.10 ADDITIONAL DISTRIBUTION PIPES BY 2015

	High zone			Low zone			
	urbanized area	developing area	Sub Total	urbanized area	developing area	Sub Total	Total
Length m	28,070	37,612	65,682	14,540	253,294	267,834	333,516
Diameter:mm	600 - 150	250 - 100		800 - 150	400 - 100		

Note: Routes are indicated in Tables 9.5 and 9.6.

(3) Service Reservoir

Service reservoirs must balance the peak hourly demand and the average demand. The currently used 12-hour volume was found to satisfy the requirement on the day when the daily demand is maximum. However, the less 6-hour volume was also found adequate. Accordingly, for the maximum daily demand of 368 mld, the total required volume will be 92 ml throughout the NCD area, distributed in proportion to demand.

The total storage at present is approximately 66 ml, including the Mt.Eriama treatment clear water storage. (see Table 7.11 in detail)

The existing reservoirs will have sufficient volume and can serve the high zone. There are no service reservoirs in the low zone. The low zone will be divided into four sub-zones; Gerehu, Erima, Laloki and 9 mile. The required volumes and heights are determined as shown in Table 7.11, taking into account the demand and height in the designated sub-zones.

Table 7.11 SERVICE RESERVOIR

Reservoir	Capacity (m^3)	Water Level (m)	
		TWL	BWL
Existing (for high zone)			
Boroko	7,750	132.3	123.5
Waigani	9,000	132.0	124.1
Hohola	9,100	123.1	115.2
3 Mile	9,000	120.7	112.8
Korobosea	9,100	115.9	107.9
Koki	9,000	109.8	101.8
Town	2,270	105.8	101.2
Mt. Eriama	10,300	157.5	149.6
Sub Total	65,520		
New (for low zone)			
Gerehu	11,000	88	80
Erima	13,000	98	90
Laloki	9,000	93	85
9 Mile	24,000	111	105
Sub Total	57,000		
Total	122,520		

(4) Pumping Station

The pumping station is installed at the foot of the Mt. Eriama treatment plant and lifts water from the proposed raw water mains running between the Rouna 4 head pond and the 9 mile treatment plant.

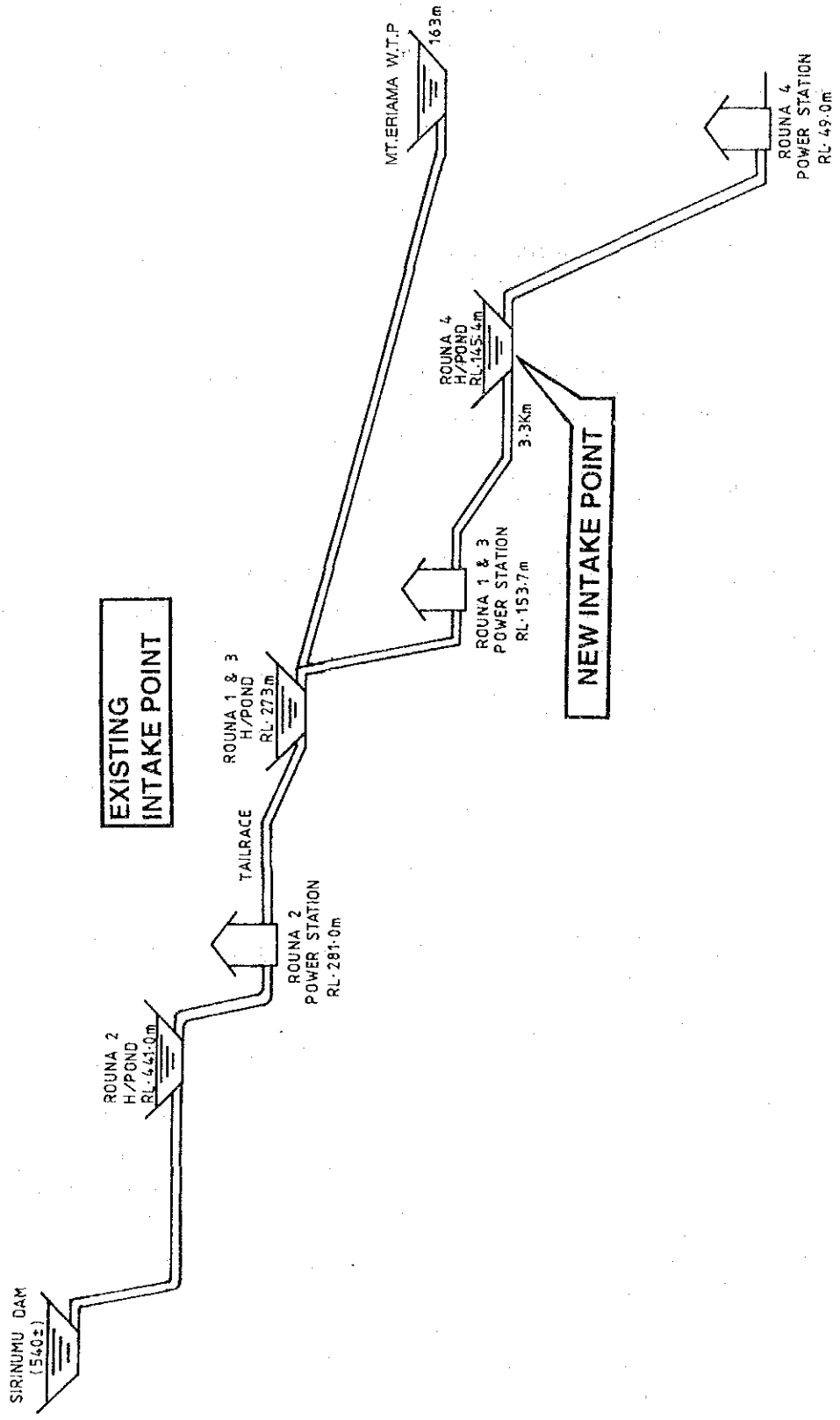
The existing 11 small booster stations can be suspended when the system is expanded. The areas will be supplied directly from the service reservoirs. Exceptions are three pumps at Touaguba hill, Air New Guini estate, and Murray barracks where elevations are over 100 m.

(5) Proposed Monitoring Points

Monitoring points for flow and pressure check for low and high zones are as shown in Fig. 7.13. The selected monitoring points are mainly at the beginning of the trunk mains, at the end of the distribution system, and at each of the service reservoirs.

(6) Water Supply System

Proposed and existing major water supply facilities in 2015 (master plan) are summarized in Fig. 7.14.



TITLE

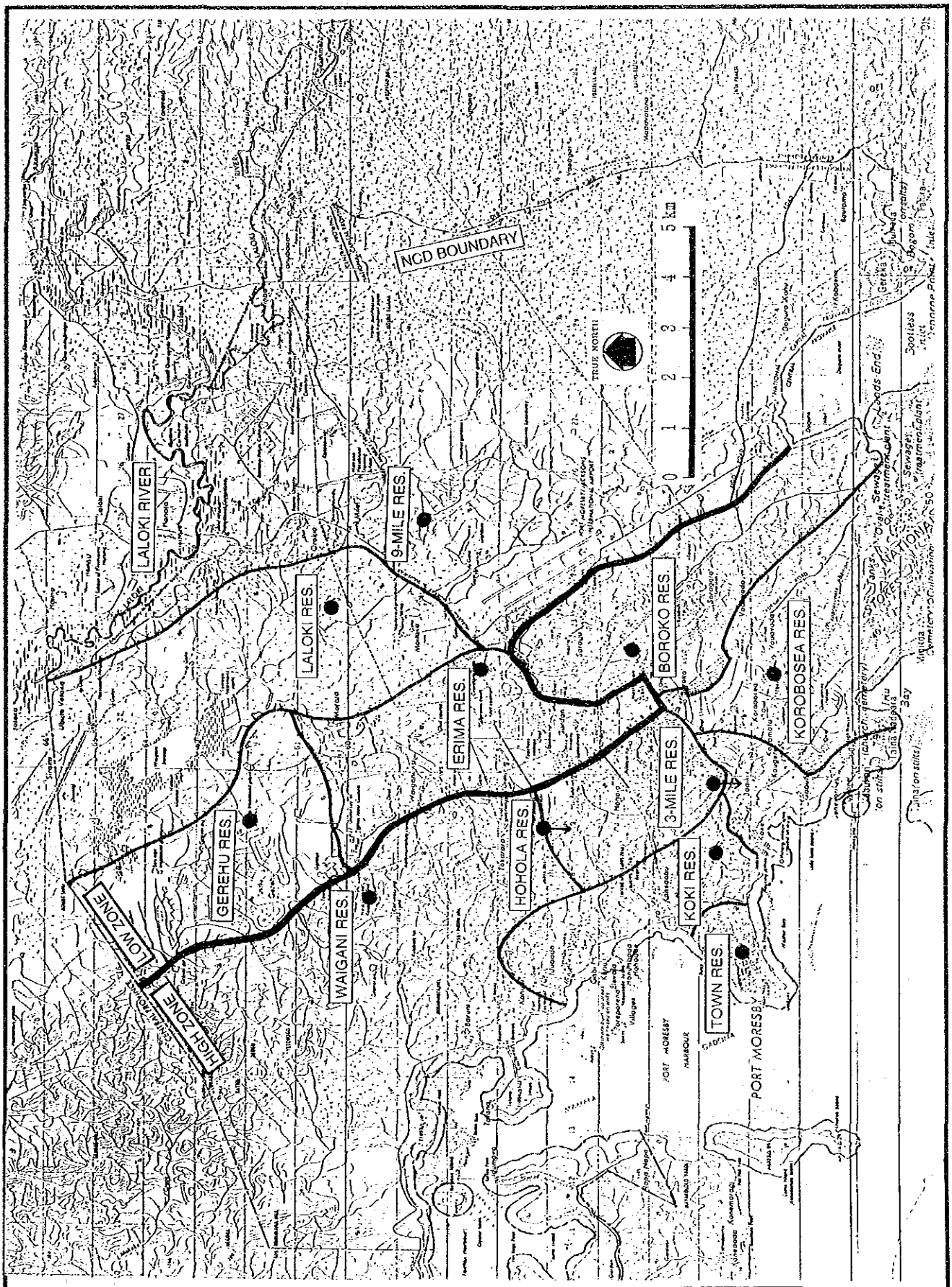
INTAKE POINT

Fig. No.

7.1

PORT MORESBY WATER SUPPLY DEVELOPMENT PLAN

TOKYO ENGINEERING CONSULTANTS in association with PACIFIC CONSULTANTS INTERNATIONAL



TITLE

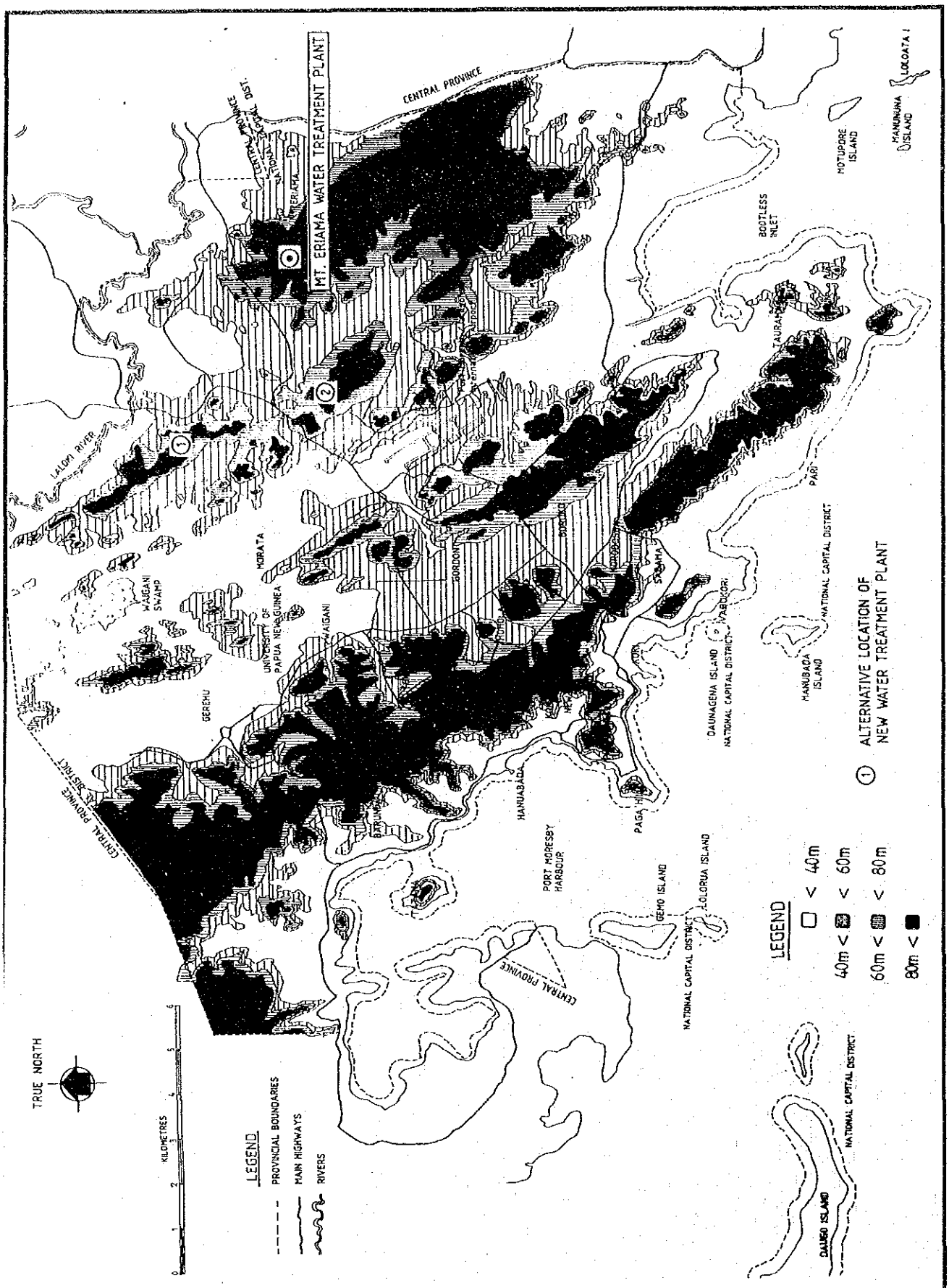
DISTRIBUTION ZONING

Fig. No.

7.2

PORT MORESBY WATER SUPPLY DEVELOPMENT PLAN

TOKYO ENGINEERING CONSULTANS in association with PACIFIC CONSULTANTS INTERNATIONAL



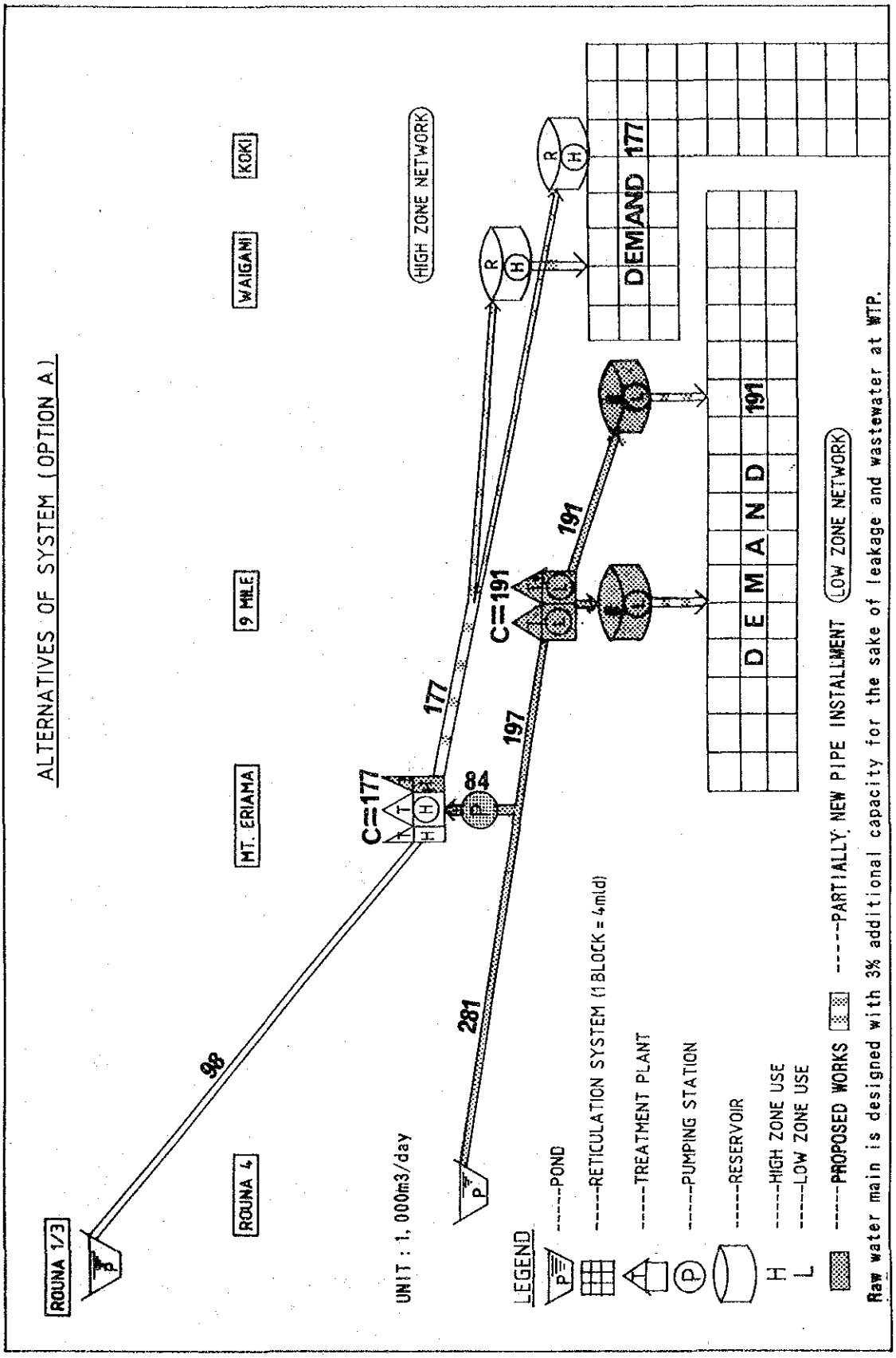
TITLE

LOCATION OF NEW TREATMENT PLANT

Fig. No.
7.3

PORT MORESBY WATER SUPPLY DEVELOPMENT PLAN

TOKYO ENGINEERING CONSULTANTS in association with PACIFIC CONSULTANTS INTERNATIONAL



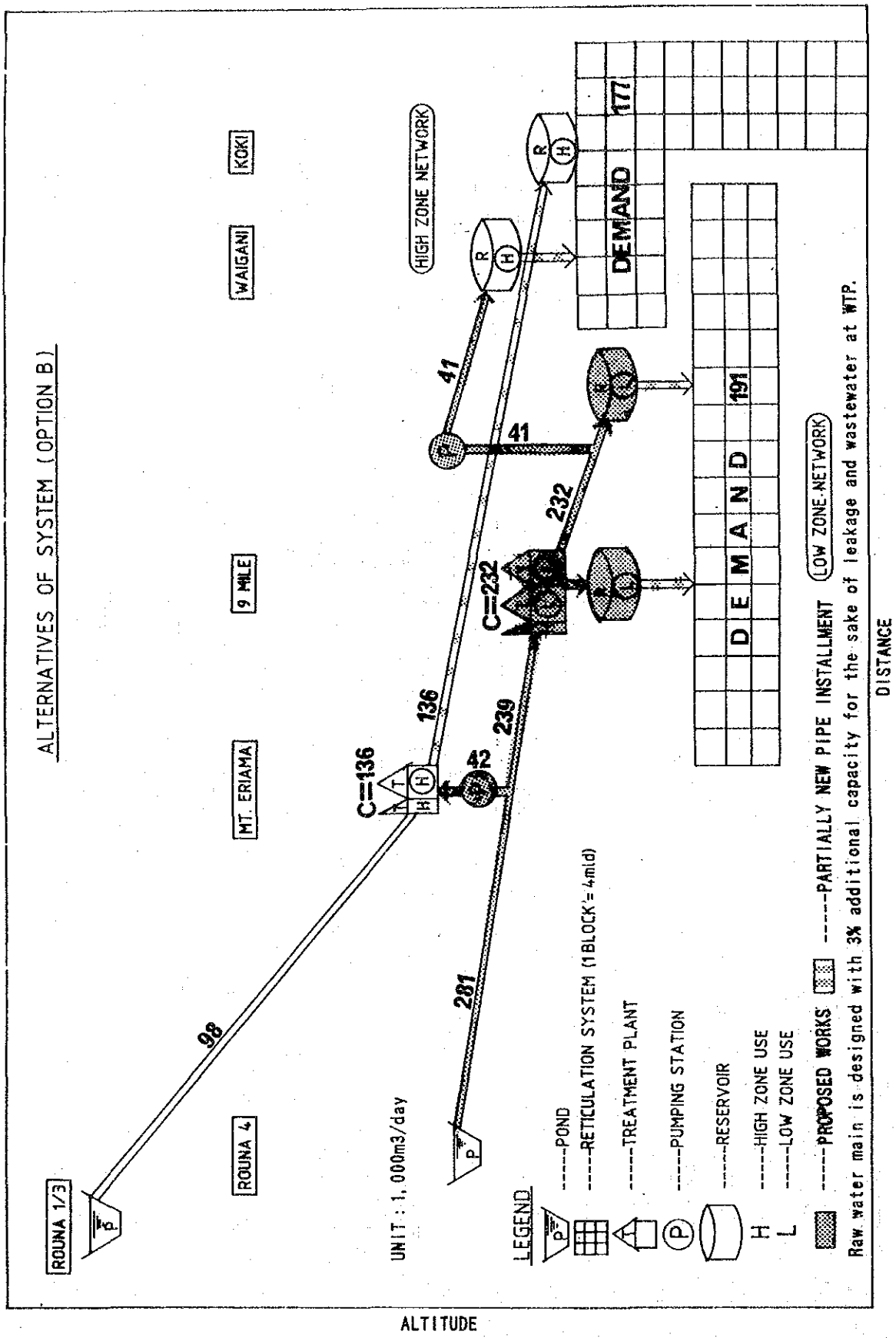
TITLE

ALTERNATIVE OF SYSTEM (OPTION A)

Fig. No. **7.4**

PORT MORESBY WATER SUPPLY DEVELOPMENT PLAN

TOKYO ENGINEERING CONSULTANS in association with PACIFIC CONSULTANTS INTERNATIONAL



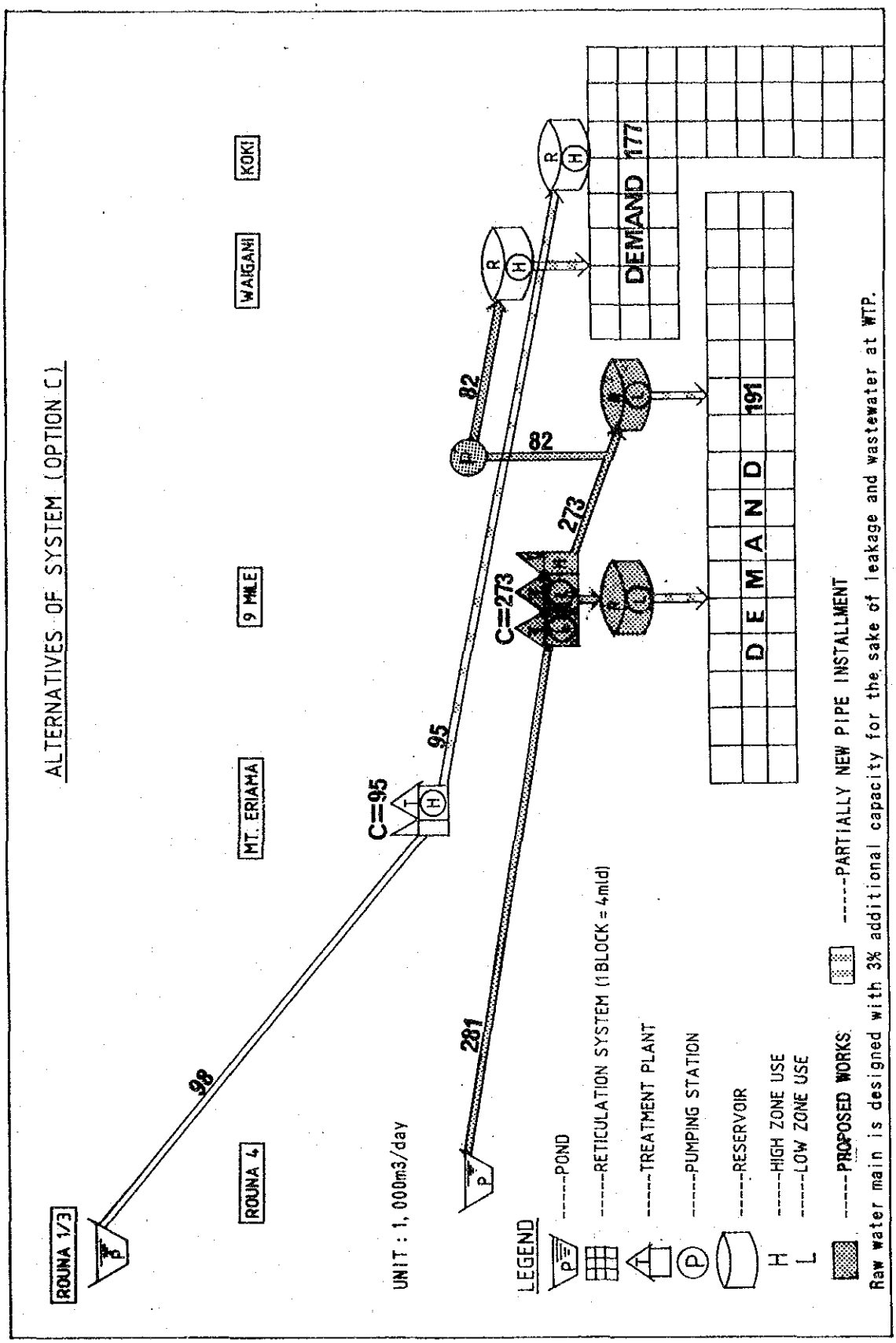
TITLE

ALTERNATIVE OF SYSTEM (OPTION B)

Fig. No. 7.5

PORT MORESBY WATER SUPPLY DEVELOPMENT PLAN

TOKYO ENGINEERING CONSULTANS in association with PACIFIC CONSULTANTS INTERNATIONAL



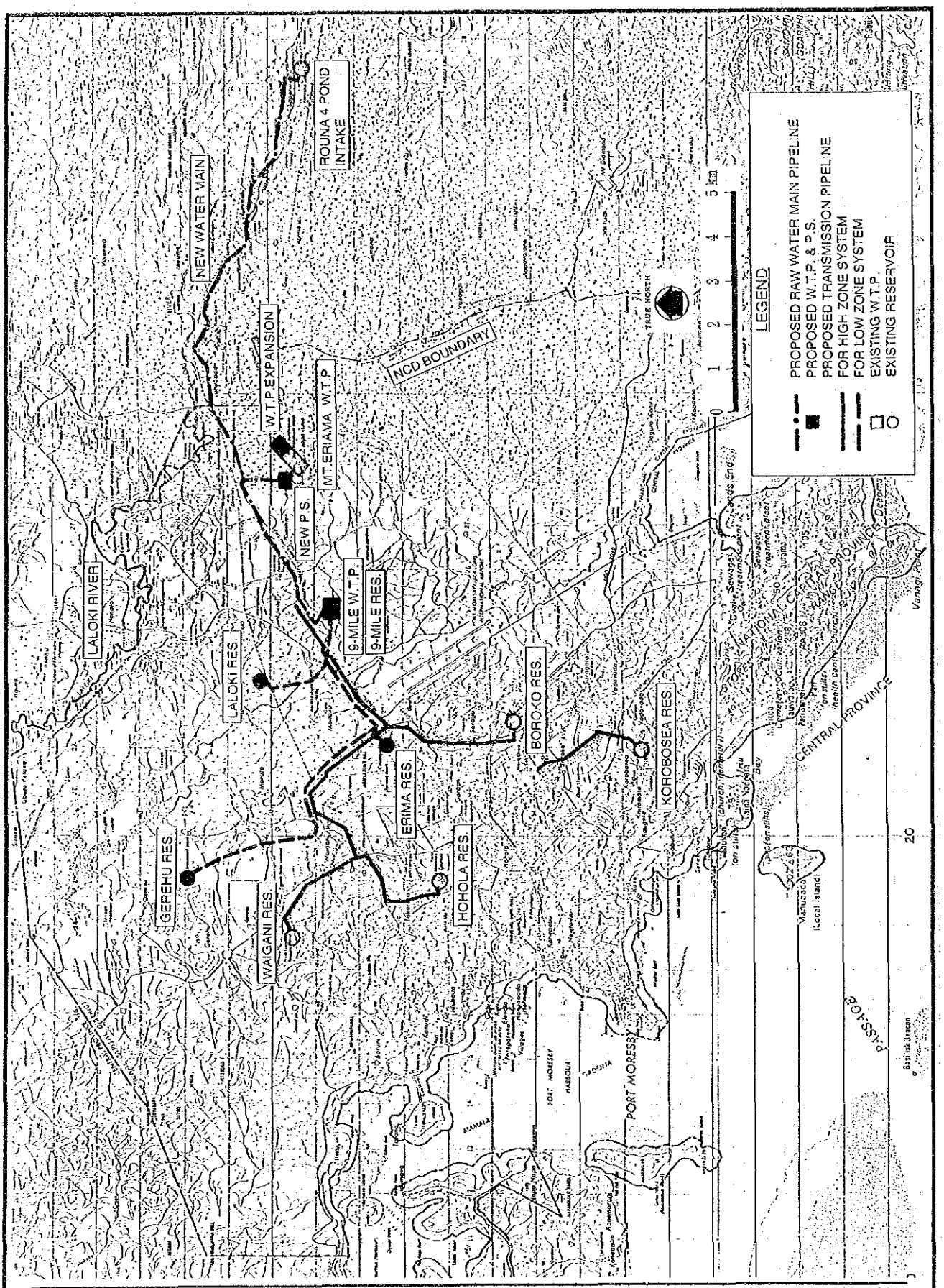
TITLE

ALTERNATIVE OF SYSTEM (OPTION C)

Fig. No. **7.6**

PORT MORESBY WATER SUPPLY DEVELOPMENT PLAN

TOKYO ENGINEERING CONSULTANS in association with PACIFIC CONSULTANTS INTERNATIONAL



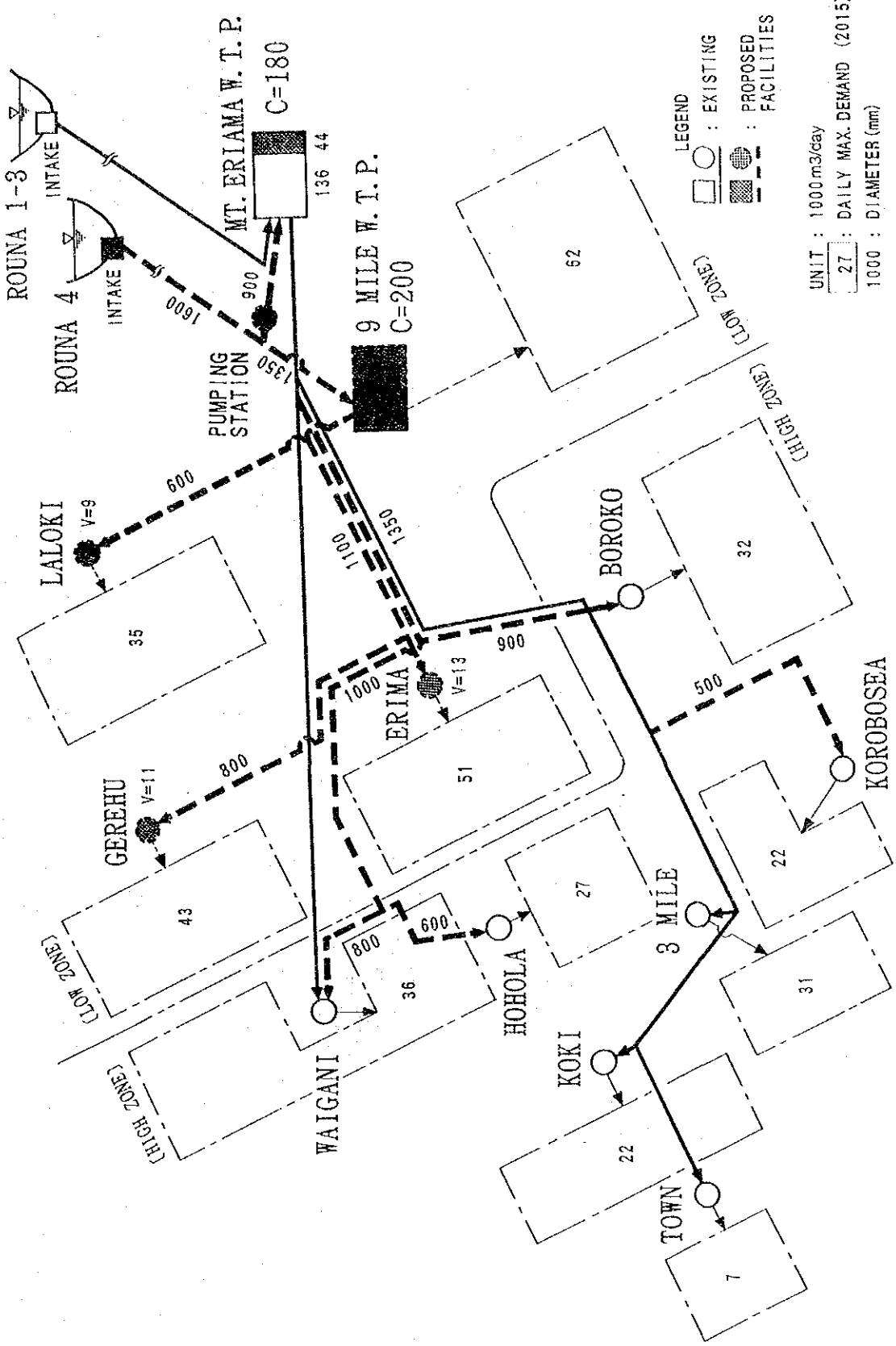
TITLE

PROPOSED FACILITIES FOR MASTER PLAN

Fig. No.
7.7

PORT MORESBY WATER SUPPLY DEVELOPMENT PLAN

TOKYO ENGINEERING CONSULTANS in association with PACIFIC CONSULTANTS INTERNATIONAL



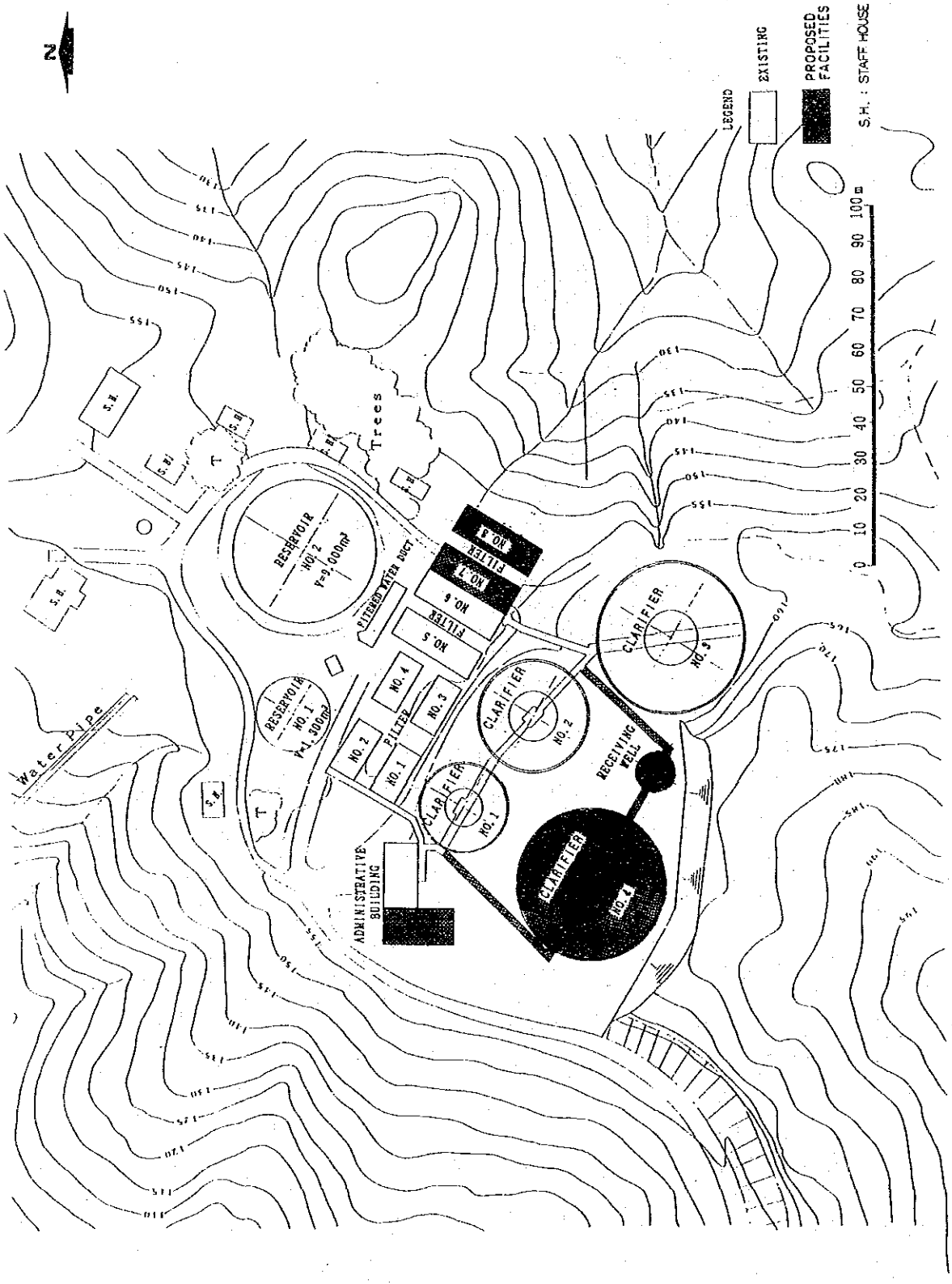
TITLE

SCHEMATIC LAYOUT OF PROPOSED SYSTEM

Fig. No. **7.8**

PORT MORESBY WATER SUPPLY DEVELOPMENT PLAN

TOKYO ENGINEERING CONSULTANS in association with PACIFIC CONSULTANTS INTERNATIONAL



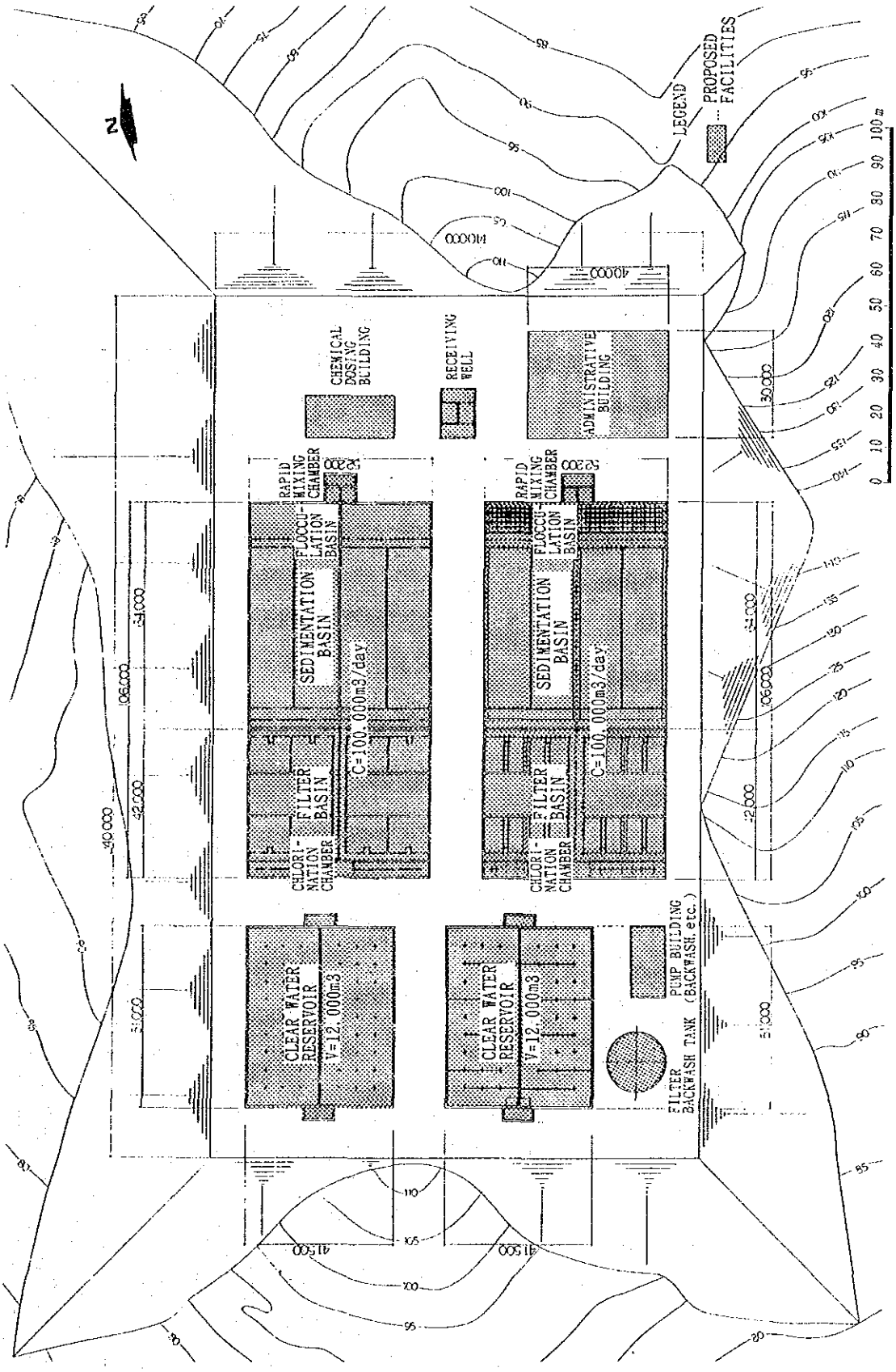
TITLE

MT. ERIAMA TREATMENT PLANT

Fig. No.
7.9

PORT MORESBY WATER SUPPLY DEVELOPMENT PLAN

TOKYO ENGINEERING CONSULTANS in association with PACIFIC CONSULTANTS INTERNATIONAL



TITLE

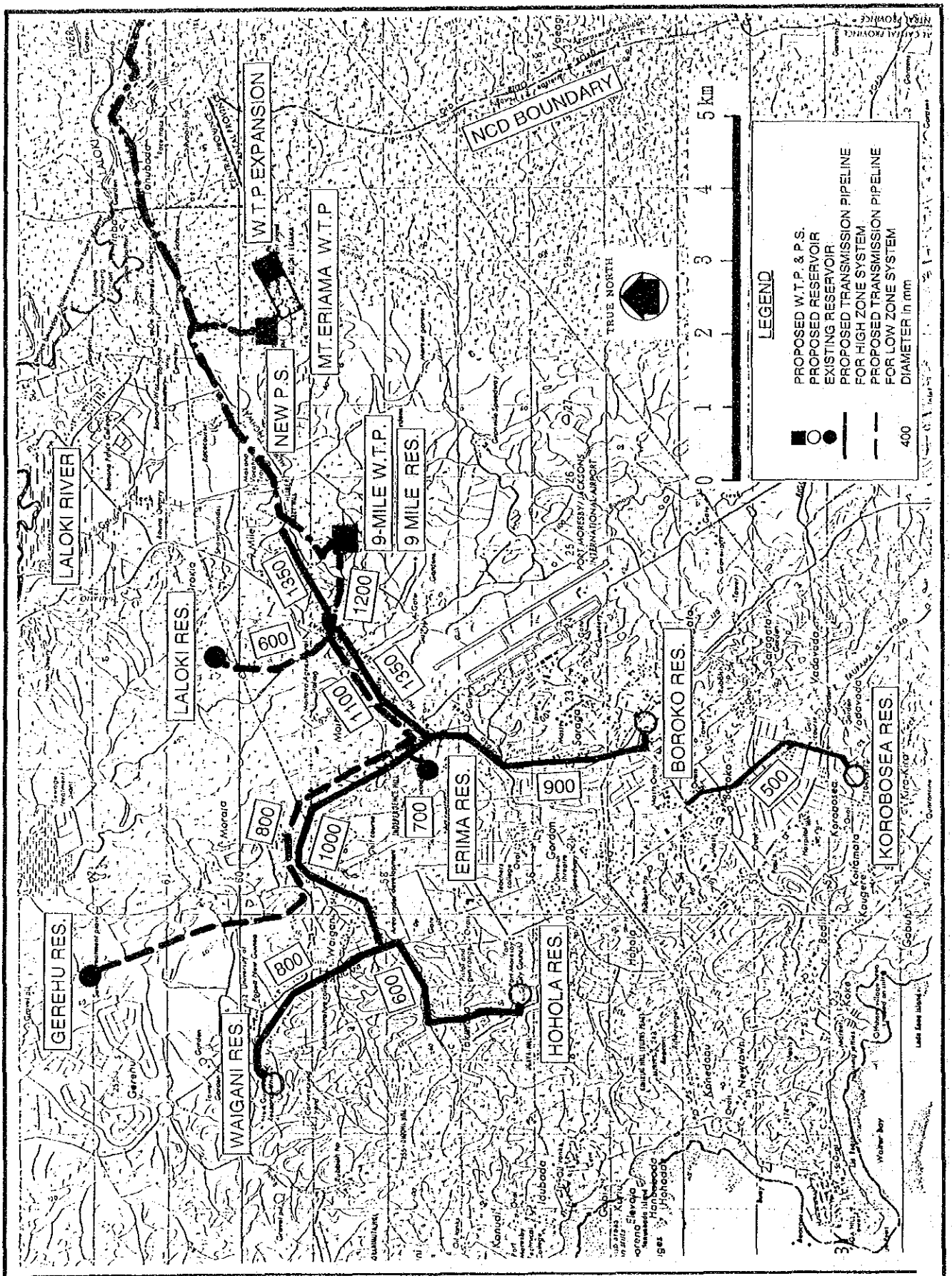
NINE (9) MILE TREATMENT PLANT

Fig. No.

7.10

PORT MORESBY WATER SUPPLY DEVELOPMENT PLAN

TOKYO ENGINEERING CONSULTANTS in association with PACIFIC CONSULTANTS INTERNATIONAL



TITLE

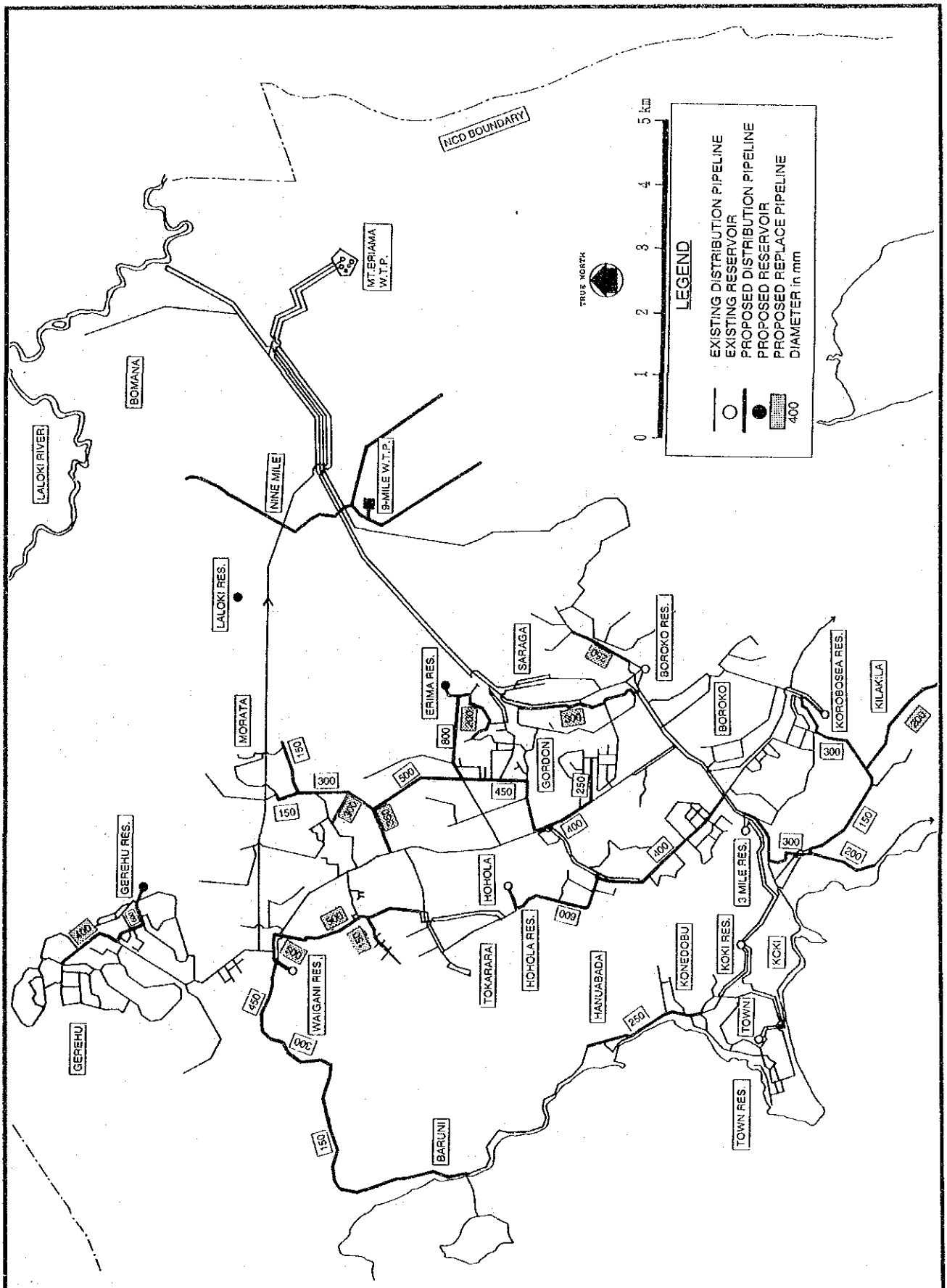
PROPOSED TRANSMISSION

Fig. No.

7.11

PORT MORESBY WATER SUPPLY DEVELOPMENT PLAN

TOKYO ENGINEERING CONSULTANS in association with PACIFIC CONSULTANTS INTERNATIONAL



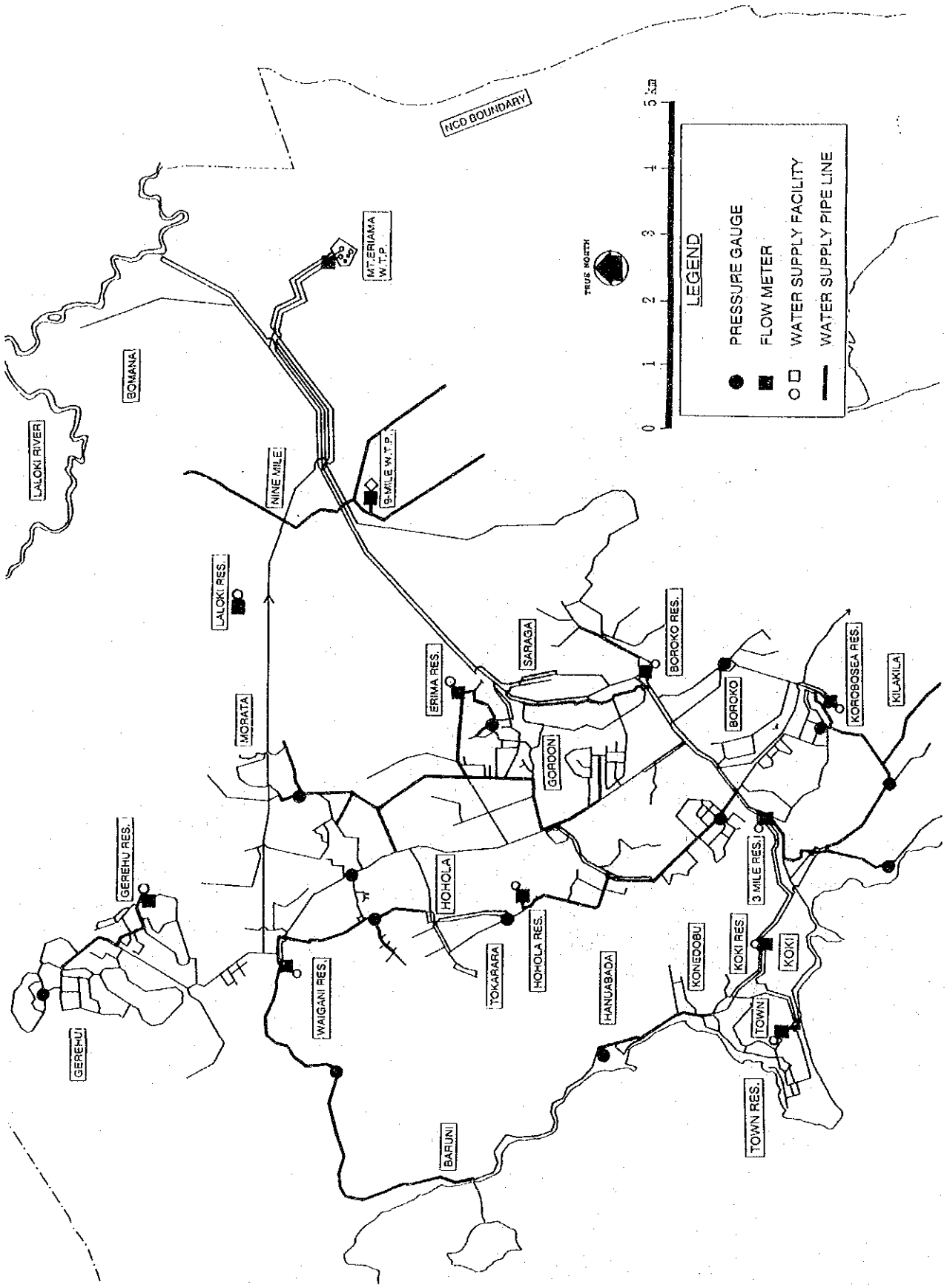
TITLE

IMPROVEMENT OF DISTRIBUTION IN EXISTING URBAN AREA

Fig. No. **7.12**

PORT MORESBY WATER SUPPLY DEVELOPMENT PLAN

TOKYO ENGINEERING CONSULTANS in association with PACIFIC CONSULTANTS INTERNATIONAL



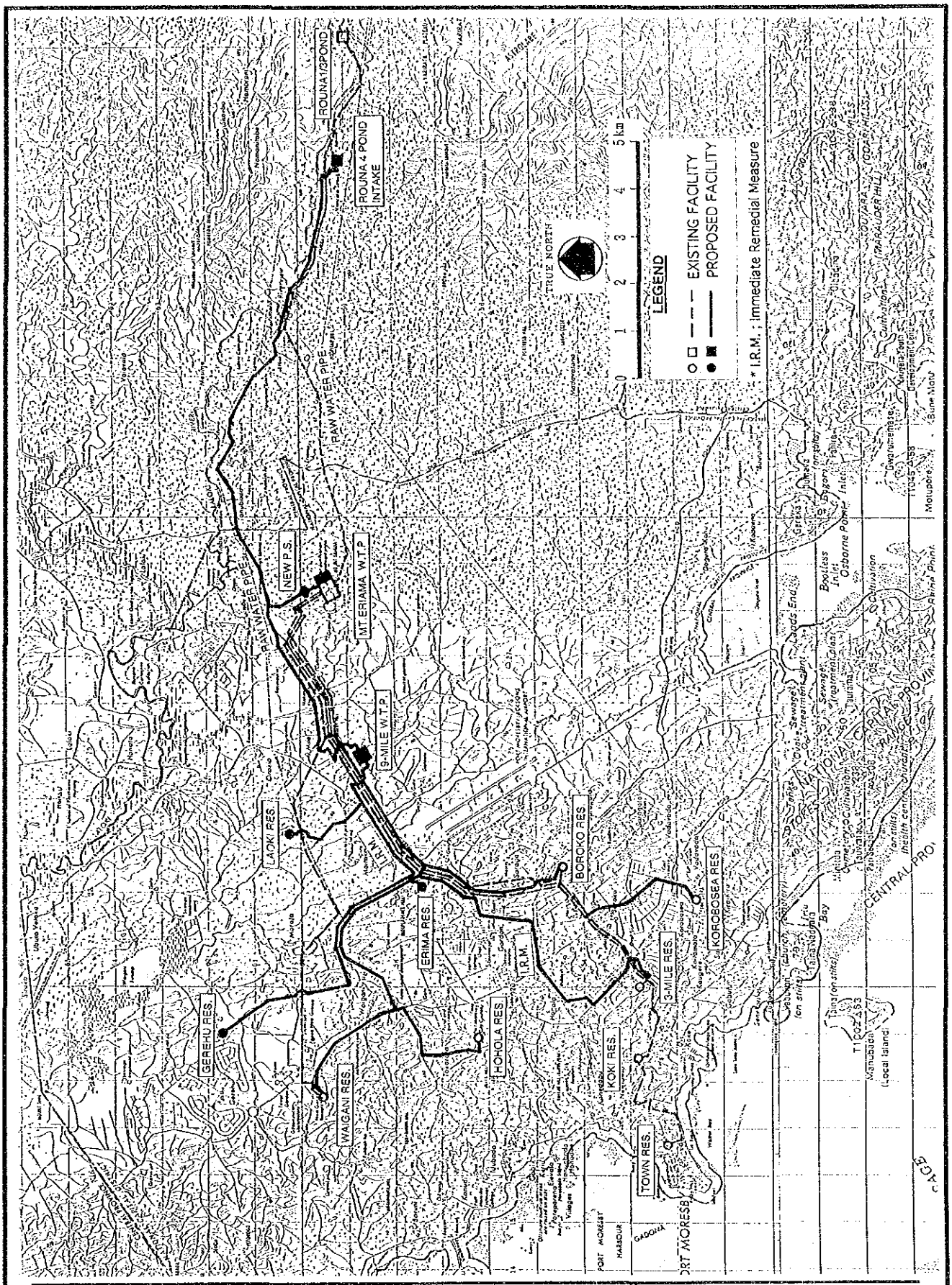
TITLE

PROPOSED PRESSURE AND FLOW METER INSTALLATION POINTS

Fig. No. **7.13**

PORT MORESBY WATER SUPPLY DEVELOPMENT PLAN

TOKYO ENGINEERING CONSULTANS in association with PACIFIC CONSULTANTS INTERNATIONAL



TITLE

WATER SUPPLY SYSTEM IN 2015

Fig. No.

7.14

PORT MORESBY WATER SUPPLY DEVELOPMENT PLAN

TOKYO ENGINEERING CONSULTANS in association with PACIFIC CONSULTANTS INTERNATIONAL

8 SYSTEM MANAGEMENT

8.1 NCDC Organization

NCDC is a local government responsible for administration of Port Moresby City. It consists of the three departments given below:

- Department of Finance and Administration (FA)
- Department of Technical and Engineering (TE)
- Department of Community Services (CS).

NCDC has only the minimal functions of monitoring, controlling and regulating the capital district, without major functions which are common to capital cities such as police, fire department, education, etc. These functions are administered by the National Government. The total staff of NCDC is 1,133. There is one staff member for 185 residents (assuming the total population of NCDC at 210,000).

The water supply of Port Moresby is managed by NCDC; the actual work of maintenance, operation and development has been done by the Water Supply Sub-division of the Water Supply and Sewerage division (WS &S), and the financial affairs, from budgeting to daily transactions, managed by the financial division.

Regarding the water supply service, Dep of FA is monitoring and controlling major issues such as:
budgeting, billing/collection, disconnections/reconnections/new connections, staff recruiting, training, purchasing of materials, hiring of heavy equipment and water trucks, water delivery, etc.
Dep of TE consists of four Divisions:

- Division of Water Supply and Sewerage
- Division of Works
- Division of Technical Services
- Division of Buildings

The Dep of TE deals with technical matters. The Division of Water Supply and Sewerage (WS &S) is responsible for daily operation and maintenance of the water supply system of Port Moresby, and does not deal with long-term planning. The detailed organization chart of WS & S Division is shown in Fig 8.1.

This organizational structure has serious problems. Since the Dep of FA has no knowledge of technical details, it is spending money as demanded. On the other hand, the Dep of TE is carrying out minimal maintenance of the system without understanding the costs or financial implications.

Water supply is a "give and take" relationship: the water authority gives water to the residents and receives money required for operating the system. Water is one of the basic human needs. A water authority is not a profit-seeking entity, but needs to recover the costs it has incurred.

A good understanding between financial and technical aspects among all staff, or at least managers, is essential not only for the daily activities but also for the long-term planning. The latter would involve capital investment and capital repayment which would cause water tariff to increase.

8.2 Management

Many problems are observed in the management of the water supply system. In this section the major problems are discussed. A certain amount of funds will be needed for improvement. The present organization needs to be reorganized. Qualified staff must be recruited for management. There will also be training requirements. More sophisticated techniques should be developed to monitor the whole system properly.

8.2.1 Effective Meter Reading

The total service connections of water supply are estimated as 19,090, of which 75.5% are metered and 24.5% are not metered. About 60% of the metered connections are actually read every three months, while the remaining metered connections are estimated, because they are broken or cannot be located. This figure is surprisingly high. The details are shown in Table 8.1.

There are at present 13 meter readers in Dep of FA who read about 15,000 meters every three months. This means that each meter reader should read only 15 meters in one day. More efficient meter reading is possible by zoning or route selection.

8.2.2 Metering of All the Connections

The total bill units are estimated to be about 23,000, which is the number of registered households. There are short or long-term illegal settlers, and unregistered residents. There are about 19,000 accounts in water supply. This means there are cases where two or more households share one connection. The metered connections being read are as low as 46.5%.

TABLE 8.1 WATER SERVICE CONNECTIONS OF NCD

	Resident	Commerce/Ind.	Stand Pipe	Public	Straight Pipe	Exempt	Total	Ratio
Metered								
Actual	8,030	811	10	4	17	1	8,873	46.5%
Estimated	5,205	281	32	1	14	1	5,534	29.0%
Sub total	13,235	1,092	42	5	31	2	14,407	75.5%
Unmetered	2,765	341	1,558	3	12	4	4,683	24.5%
Total	16,000	1,433	1,600	8	43	6	19,090	100.0%
(%)	83.8%	7.5%	8.4%	0.0%	0.2%	0.0%	100.0%	
Ratio								
Metered								
Actual	50.2%	56.6%	0.6%	50.0%	39.5%	16.7%	46.5%	
Estimated	32.5%	19.6%	2.0%	12.5%	32.6%	16.7%	29.0%	
Sub total	82.7%	76.2%	2.6%	62.5%	72.1%	33.3%	75.5%	
Unmetered	17.3%	23.8%	97.4%	37.5%	27.9%	66.7%	24.5%	
Total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	

(as of 1992)

Inaccurate estimations are causing frustration and resulting in claims from users. Therefore all connections and all households should be metered as soon as possible. If a connection is shared by several households, charge collection may be difficult and may be cause inconveniences for the users.

For the same reason, all straight pipes should be metered. Exempted users should also be metered for monitoring the consumption although they are exempted from bill payment.

8.2.3 Elimination of Illegal Connections

Meter readings are conducted every three months and bills are sent to the users. The payment is due within two weeks. Overdue payments are subject to disconnection, which is also a responsibility of the Dep of FA. When a user whose line is disconnected pays the bill and the necessary charge, his line will be reconnected for service resumption. The

reconnection charge is 20 Kina. When a new house is constructed, the owner can apply for a new connection for 20 Kina. These details are given in Table 8.2.

According to the Table, the annual increase in connections is estimated to be 1,200. However it is noted that half the disconnected services have been converted to illegal connections. They do not figure in the accounts, but use the same amount or more water, free of charge through illegal connections. This situation will worsen the financial condition of NCDC and cannot be tolerated.

NCDC should take quick action to investigate illegal connections and stop the water supply to them, unless they pay the bills. All the users must be metered, regardless of whether they pay the bills or are exempted, because the total water consumption as well as leakage, must be monitored for system operation.

8.2.4 Decrease of Standpipes

Standpipes are generally constructed for low-income people and hence they are found in settlements. There are many illegal connections from the stand pipes, according to the JICA survey.

Water is, in a sense, a social commodity, which should be provided to poor people at a low price. All users must pay for it. However it is practically very difficult to collect money for water through standpipes, because the users are poor and cannot afford to pay. Therefore, it is recommended that standpipes be reduced gradually to the minimum level, consistent with welfare needs. Table 4.3 shows that the water consumption in standpipes amounts to 3.2%. This table also shows that the total daily average water consumption amounts to 81,333 m^3.

TABLE 8.2 NUMBER OF DISCONNECTIONS, RECONNECTIONS AND NEW CONNECTIONS

Month	Disconnect.	Reconnect.	Illegal Conn (estimated)	New Conn.	Increase*
1991					
January	0	140	0	38	178
February	480	306	240	30	96
March	510	220	255	11	-24
April	570	268	285	36	19
May	570	337	285	62	114
June	480	231	240	182	173
July	540	232	270	60	22
August	540	267	270	22	19
September	480	307	240	31	98
October	570	314	285	43	72
November	510	312	255	12	69
December	360	117	180	3	-60
Sub total	5,610	3,051	2,805	530	776
Average 1	467.5	254.3	233.8	44.2	64.7
1992					
January	0	64	0	14	78
February	480	226	240	29	15
March	540	306	270	23	59
April	540	278	270	23	31
May	480	251	240	25	36
June	540	218	270	29	-23
July	540	286	270	43	59
August	510	183	255	133	61
September	540	236	270	96	62
October	510	208	255	14	-33
November	510	287	255	46	78
December					
Sub total	5,190	2,543	2,595	475	423
Average 2	471.8	231.2	235.9	43.2	38.5
Total	10,800	5,594	5,400	1,005	1,199
Average	469.6	243.2	234.8	43.7	52.1

* -(Disconnect.)+(Reconnect.)+(Illegal Conn)+(New Connect.)

TABLE 8.3 WATER CONSUMPTION BY CATEGORY

(m^3/day) Quarters	Resident.	Commer.	Stand Pipe	Public	Straight Pipe	Exempt	Total
2nd Q/92	45,241	34,781	2,590	141	32	16	82,800
1st Q/92	52,235	31,170	2,688	174	36	18	86,322
4th Q/91	39,848	34,781	2,545	91	34	17	77,316
3rd Q/91	44,942	31,170	2,517	214	34	17	78,895
2nd Q/91	41,570	32,660	2,505	192	37	18	76,983
Total	182,266	131,902	10,340	620	136	68	325,332
Ratio(%)	56.0%	40.5%	3.2%	0.2%	0.0%	0.0%	100.0%
Average	45,566	32,975	2,585	155	34	17	81,33
Gr Rate(%)	108.83%	106.49%	103.39%	73.29%	86.46%	86.46%	107.56%

8.2.5 Strengthening of Asset Management

The water supply system is a typical heavy capital business and its asset management is important. However NCDC has not managed its assets properly, including management of necessary records. This needs to be strengthened, because it relates to operational costs.

8.2.6 Improvement of Bill Collection

NCDC is reading the meters and sending the bills to the account holders every three months. Then they start paying the bills. The payment is due within two months. However the efficiency of bill collection is as low as about 60% (see Table 8.4). This needs to be improved.

TABLE 8.4 EFFICIENCY OF BILL COLLECTION

	Billing Amount (K)			Collected (K)		
Month	Minimum	Excess	Sub total	Amount	Sub total	Rate
1991						
January				1,041,605		
February				357,326		
March	439,113	1,676,225	2,115,338	146,465	1,545,396	
April				683,838		
May				524,496		
June	442,119	1,676,300	2,118,419	126,162	1,334,496	63.1%
July				485,059		
August				699,237		
September	442,107	2,179,659	2,621,766	23,694	1,207,990	57.0%
October				911,467		
November				626,331		
December	445,137	2,298,270	2,743,407	131,913	1,669,711	63.7%
Sub-total	1,768,476	7,830,454	9,598,930	5,757,593		
Average per month	147,373	652,538	799,911	479,799		61.3%
1992						
January				682,491		
February				669,057		
March	446,166	2,637,402	3,083,568	294,631	1,646,179	60.0%
April				386,160		
May				835,427		
June	446,660	2,395,063	2,841,723	477,815	1,699,402	55.1%
July				639,386		
August				582,564		
September	444,651	2,696,995	3,141,646	220,988	1,442,938	50.8%
October				1,000,674		
November						
December						
Sub-total	1,337,477	7,729,460	9,066,937	5,789,193		
Average per month	148,609	858,829	1,007,437	578,919		55.3%
Total		3,105,953	15,559,914	18,665,867	11,546,786	
Average per month	147,903	740,948	888,851	577,339		58.3%

8.3 *Operation and Maintenance*

8.3.1 Appropriate Location of Meters

Water meters should be located on the boundary line between public and private premises and they should be protected properly from damage. Correct meter reading is essential for proper operation. However, there are quite a few examples of inappropriate meter locations in Port Moresby. Meters are damaged by vehicles or vandals. This is why 38% of all meters are not read but estimated. This is quite a high figure.

Water meters should be located appropriately so that meter readers can access them easily. This will improve efficiency in meter reading. All present locations need to be located and recorded in the Book of Meters. If the locations are not appropriate, they should be relocated, and the cost should be borne either by users or NCDC.

8.3.2 Promotion of PR Activities

It is important to educate the population occasionally about how expensive water is and how rationally they can use it. They should be informed regularly about the following:

- Present situation of water supply
- Measures for saving water,
- Prevention of illegal connections,
- Price of water (example, per m^3 of water)

In this context, the Water Patrol should be strengthened to educate the population and to find illegal consumption. Mass media are also important. The required budget should be allocated.

8.3.3 Establishment of Water Committee in NCDC

NCDC should give correct information about water to the residents, for example, information on water availability. If the residents are given incorrect information on water, they will be confused and suspicious about NCDC. There are working water specialists in other agencies besides NCDC. Therefore, a Water Committee should be established in NCDC to verify the information given to the public.

The Water Committee should consist of the representatives of the following agencies:

- Dep of Works
- Bureau of Water Resources
- Waterboard
- National Disaster and Emergency Services
- ELCOM
- others.

8.3.4 Proper Record Keeping

There are no systematic records related to operation and maintenance, such as number of repairs or claim calls. If records are maintained systematically, NCDC can monitor roughly the consumption, leakage and water shortage.

NCDC has divided Port Moresby into three zones for the purpose of services and operation/maintenance, as shown in Fig 8.2. The three service zones are divided as follows:

Zone 1	Gerehu, University, Waigani, Morata, Ensisi Valley, Tokarara, Waigani Government Offices
Zone 2	Hohola, Gordons 5, Gordons, Erima, Boroko, Saraga/Airport, Bomana, 8 mile settlement, 9 mile settlement
Zone 3	Korobosea, Sabama, Kaugere, Kila kila/Vabukori, Gabutu, Badili/Koki, Town, Hanuabada, Baruni/Tatana, Idubada

A person who finds a leak will call Shed 20 (Div of WS&S). Shed 20 will send a repair team to the site and repair the leak with necessary materials and hired equipment. These calls are recorded in Record Book of Repairs. A person having water shortage or low pressure will also call Shed 20, which in turn will send staff to the caller and try to provide water by operating valves. These calls are recorded in the Book of Claim Calls.

However, these records are unsystematic and improper. There are no records for the last couple of years. There are only incomplete or no records on materials that were used, types of repairs, and number of man-days required for the repair. The system of record keeping should be improved.

Table 8.5 gives a rough idea of repairs and claim calls, though it is incomplete. This table shows that there are 3,780 calls for repair each year, or about 10 calls daily. The calls are distributed almost equally in the three zones, indicating that the existing system has deteriorated all over the city. It was also seen that there are 1,567 calls for no water each

year, of which about 80% are concentrated in Zone 3. This Zone includes the major business and commercial areas of Town. This means that the supplied water does not reach the downstream sections of the system.

TABLE 8.5 REPAIR AND NO WATER CALLS TO NCDC

	Repairs Calls				No Water Calls			
Zone Year/Month	1	2	3	Sub-total	1	2	3	Sub-total
1991								
May	39			39				0
June	83			83				0
July	106			106				0
August	88			88				0
September	73			73		19	95	114
October	127			127	57	67	86	210
November	94			94	6	22	90	118
December	81	75		156	4	22	89	115
Sub total	691	75		766	67	130	360	557
Average	86.4	75.0		161.4	16.8	26.0	72.0	114.8
1992								
January	72	113		185	5	12	120	137
February	95	138		233	14	13	138	165
March	114	124	48	286	9	18	115	142
April	40	106	93	239	5	14	128	147
May	68	96	82	246	8	21	130	159
June	77	138	101	316	16	10	126	152
July	128	157	172	457	22	15	132	169
August	116	159	128	403	8	13	125	146
September	98	146	116	360	3	10	132	145
October	123	144	133	400	4	8	140	152
November	97	137	95	329	3	7	129	139
Sub-total	1,028	1,458	968	3,454	97	141	1,415	1,653
Average	85.7	121.5	96.8	287.8	8.1	11.8	117.9	137.8
Total	1,719	1,533	968	4,220	164	271	1,775	2,210
Average	90.5	127.8	96.8	315.0	10.3	15.9	104.4	130.6
Annual calls	1,086	1,533	1,162	3,780	123	191	1,253	1,567

8.3.5 Service Improvement

The service level of water supply by NCDC is unsatisfactory and needs to be improved. The minimum requirements of water supply are as follows:

- Safe water
- Continuous supply
- Low cost.

For those suffering from water shortage, there are two options for getting water:

- to call NCDC (free but slow)
- to call a private company (fast but expensive)

NCDC is contracting about 20 water carts or trucks for water delivery. NCDC has two water trucks. When someone calls NCDC for water delivery, it will assign one of the trucks. The truck will get water from a fire hydrant or a filling station and deliver it to the caller's house. This delivery is free of charge except for the normal tariff, but is usually very slow. This operation may be subject to corruption. Those who want water urgently call one of private companies for water delivery. They are fast but expensive charging about K400 per tank. There are two problems:

- Low tariff for private companies
- No control for water quality

There is a water tariff for truck delivery but it is quite low. Financial viability is completely ignored. This tariff needs to be increased. A private company cannot assure the water quality.

For both cases, the users have to install a storage tank and additional facility at their own cost, which is a waste of investment or duplication. Keeping the storage tanks clean is usually quite difficult. Water in the tank was a corrosion risk, and may be contaminated by insects and others. The tanks need to be maintained on a regular basis by the owner. But this is very difficult in most cases.

8.3.6 Strengthening of Training

At present NCDC is sending several high level staff overseas mainly to graduate courses, based on funds available from outside. It is also sending some staff to short term courses

organized by universities or academies. However the budget for training is quite small, such as K120,000 for all NCDC staff, for local and overseas training.

There is no training for water supply staff, especially for low level staff. The low level staff also need training. Such training can be provided on-the job or off-the job. It is true that some low level staff are not literate, and they join NCDC on an irregular basis depending upon vacancy, but that is why they need training.

Fundamental problems are as follows:

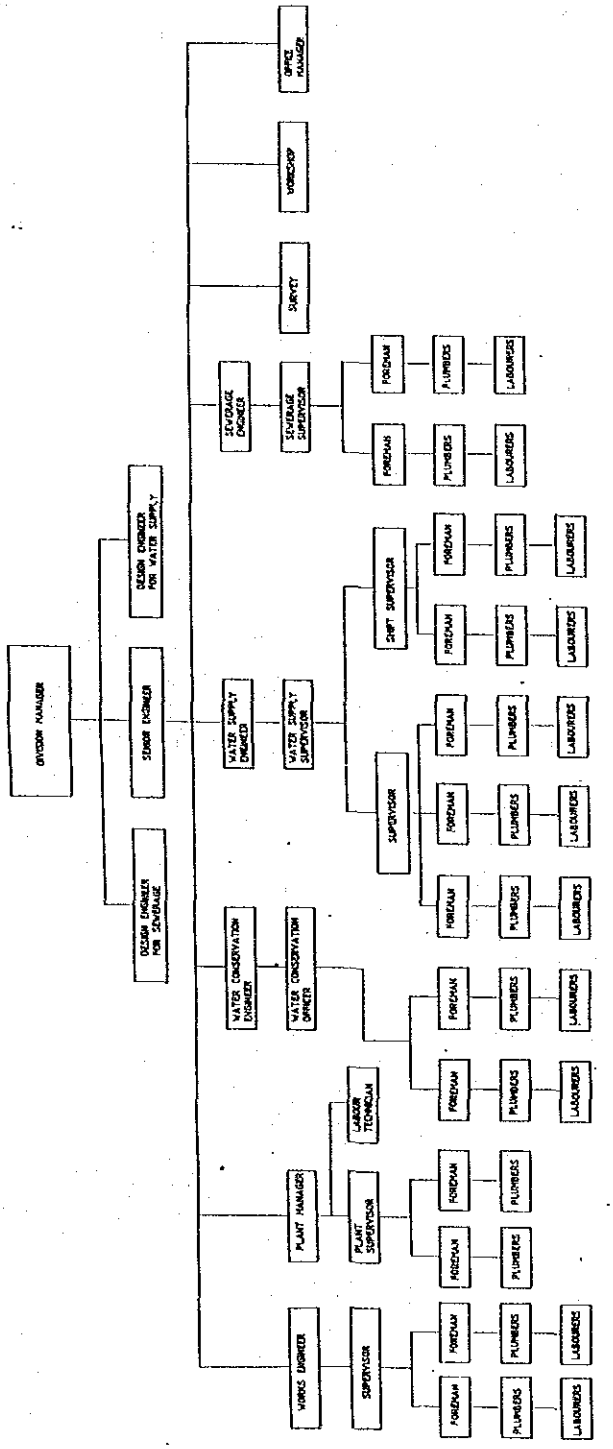
- Insufficient funds
- No lecturers
- No materials
- No facilities

However, the present water supply situation in Port Moresby offers the best place for training high and low level staff :why many people here are suffering from water shortage or why the system is not working well. This report can be used as reference for understanding the overall system.

8.3.7 Development of Maintenance Plan

Any system needs to be maintained properly on a regular basis. This maintenance is called preventive maintenance. But what NCDC has been doing is only 'bandage' maintenance. There is no maintenance plan. Whenever repair is needed, it is carried out temporarily. If the same site again breaks down, the same repairs are repeated without understanding.

Therefore, a maintenance plan should be developed for the long term. For that, a certain budget is necessary. Above all, understanding the system is most important.



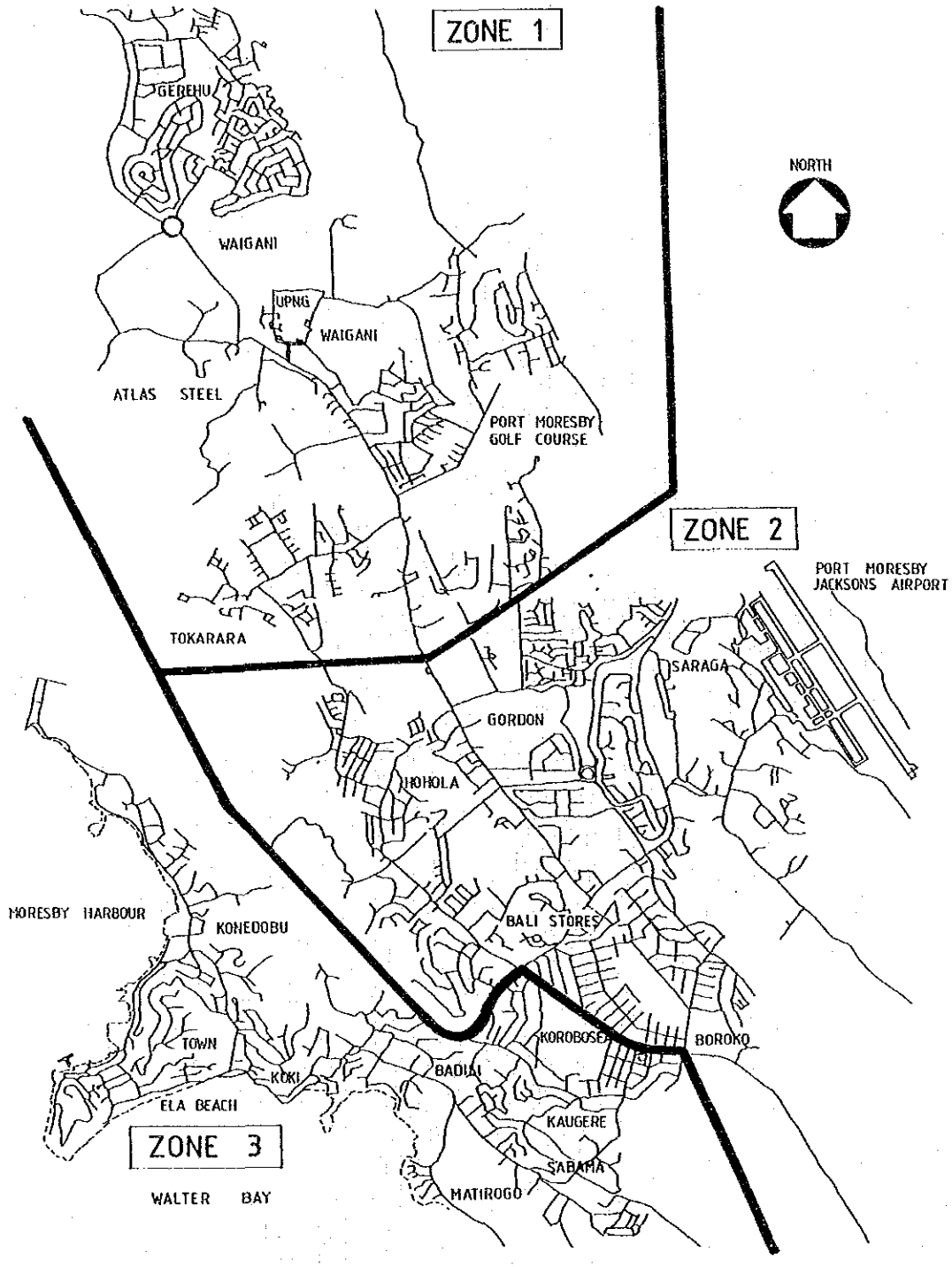
TITLE

EXISTING ORGANIZATION OF WATER SUPPLY AND SEWARAGE DIVISION

Fig. No. **8.1**

PORT MORESBY WATER SUPPLY DEVELOPMENT PLAN

TOKYO ENGINEERING CONSULTANS in association with PACIFIC CONSULTANTS INTERNATIONAL



TITLE

SERVICE ZONES OF WATER SUPPLY IN NCD

Fig. No.
8.2

PORT MORESBY WATER SUPPLY DEVELOPMENT PLAN

TOKYO ENGINEERING CONSULTANS in association with PACIFIC CONSULTANTS INTERNATIONAL

9 COST ESTIMATION AND IMPLEMENTATION PLAN

9.1 Cost Estimation

9.1.1 Project Cost

Project costs for the proposed works in chapter 7 are estimated here. Cost for this scale of construction work may vary significantly, depending on the source of finance, bidding procedure, and contract methods. Therefore, the following conditions are assumed.

(1) Construction period for the first phase of the program for Mt. Eriama WTP is assumed to be 3 years starting from 1994. Since the quantity of water shortage against demand is a big problem in Port Moresby at the moment, the expansion of the existing Mt. Eriama WTP is a high priority task.

(2) Construction period for the first phase of the program for the 9 Mile WTP is considered to be the same as Mt. Eriama's first phase to meet the supply/demand balance at the end of first phase of the program in 2000. The second phase is assumed to be from 2003 to 2005.

(3) Exchange rate is 1 Kina = 115 JY(Japanese Yen). All costs are indicated at the 1993 Kina level.

The Project costs are summarized in Table 9.1, with costs of phasing also. Phasing is explained later in this chapter.

9.1.2 Management, Operation and Maintenance Costs

Management and O/M costs for the long term program is estimated based on the aspects described in chapter 8. Table 9.2 shows items and estimated costs in million Kina.

TABLE 9.1 PROJECT COST

Unit: Million Kina

Work Item	First Phase (1994 - 2000)	Second Phase (2001 - 2007)	Third Phase (2008 - 2015)	Total
Conveyance System				
Intake	2.14	0	0	2.14
Raw Water Main	37.55	0	0	37.55
Sub Total	39.69	0	0	39.69
Transmission Pipe	36.01	0.98	0.48	37.47
High Zone System				
Treatment plant & Pumping station	36.36	0.00	0.00	36.36
Distribution Pipe	10.93	1.71	2.99	15.63
Sub Total	47.29	1.71	2.99	51.99
Low Zone System				
Water Treatment Plant	75.38	26.59	18.00	119.97
Distribution Reservoir	6.03	5.10	3.71	14.84
Distribution Pipe	14.73	14.87	27.80	57.40
Sub Total	96.14	46.56	49.51	192.21
Total	219.13	49.25	52.98	321.36

TABLE 9.2 COST ESTIMATES FOR MANAGEMENT AND O/M

Unit : million Kina

Item	Cost	Year							
		1994	1995	1996	1997	1998	1999	2000	Total
I. Management									
a) Institutional reorganization	No								
b) Increased meter reading	No								
c) Improved record keeping	No								
d) Network updating	Yes	0.5	0.5						1.0
e) Strengthening Training	Yes	0.6	0.4	0.4	0.4	0.4	0.4	0.4	3.0
II. Operation and Maintenance									
a) Metering of all connections	Yes	0.5	0.5	0.5	0.5				2.0
b) Illegal connection	No								
c) Stand pipes	No								
d) Water pricing	Yes	0.4	0.3						0.7
e) Asset registration	Yes	0.4	0.4	0.4					1.2
f) Bill collection	No								
g) Meter correction	Yes	0.4	0.3	0.3					1.0
h) PR intensification	No								
i) Maintenance plan	Yes	0.2							0.2
j) Leakage prevention	Yes	0.4	0.4	0.4	0.4	0.4			2.0
Total		3.4	3.0	2.0	1.3	0.8	0.4	0.4	11.3

Note: Costs included in urgent remedial measures and priority projects.

9.2 Implementation Schedule

9.2.1 General

An investment program has been developed. This program was prepared following the assessment of the present system and projected future water demands. The program includes not only capital works but also system management tasks like leakage reduction and water control measures. The latter measures, already proposed as early as 1980, are economical but would require vigorous efforts from NCDC. Therefore, only a few measures have been implemented. However, it is emphasized that, although implementation of the capital works only, would solve the water shortage, their effects are temporary. All measures must be implemented in parallel, from easy to difficult measures.

Work requirements were established by observation of the existing system performance and analysis of the system under the estimated maximum daily demand conditions. These demands include an allowance for reduced per capita consumption to account for leakage reduction and water conservation measures.

In developing the program, priority was given to increasing supply (from intake to treatment plant) over improving the distribution to poorly supplied areas. This is because the current demand exceeds the supply capacity and because the trunk mains leading to Town area, the worst affected place, are scheduled to be constructed under the immediate remedial measures.

Major capital expenditure is unlikely in the 1993-1994 financial year due to the lead time required to design the facilities recommended for immediate construction and to organize parallel programs.

9.2.2 Implementation Program Constraints

The draft final report was submitted in December, 1993. It is envisaged that the design, documentation, tendering and construction phases for even the most urgent facilities will be completed by the middle of 1994.

Large capital works are required immediately since the gap between demand and supply has become increased as a result of no capital investments since 1980. Normally, the work schedule is planned to satisfy the demand. Fig. 9.1 shows such an

implementation schedule. As seen from the figure, both expansion of Mt. Eriama treatment plant, and the first stage of the new 9 mile treatment plant are scheduled between 1994 and 1996. In addition, conveyance system and the distribution system are scheduled. It costs as much as 223 million Kina. Even though the supply capacity will increase to 247 mld in 1997 according to this schedule and it will meet the demand, as is shown in Fig. 9.2, it is difficult to implement this schedule. After discussions with the NCDC officials, a more feasible schedule has been developed, which is shown in Figs. 9.3 and 9.4.

In this schedule, the works will firstly concentrate on the expansion of the Mt. Eriama treatment plant and conveyance system. After the expansion in 1996, construction of the 9 mile treatment plant will start, and it will be completed in 1999. This schedule is recommended from the viewpoints of the magnitude of the work and costs involved.

9.2.3 Implementation Program

Details of the recommended capital works program are given in chapter 7.3. The recommended capital works are shown on Fig. 9.5. This schedule still requires tremendous efforts from the NCDC. It should complete survey, design, and financial arrangement for the first stage works in 1994 within one year. Further, the construction should be completed within two years, during 1995 and 1996.

The long term program is divided into three phases as shown below. The works for reservoirs, transmission pipes and distribution pipes are shown in Tables 9.3 to 9.7 and Fig. 9.6 and Fig. 9.7, respectively .

First Phase (1994 - 2000)

- Completion of the Mt. Eriama WTP expansion (44,000 m^3/day)
- Completion of Phase One of 9 Mile WTP (100,000 m^3/day)
- Total supply from both WTP is 280,000 m^3/day at the end of First Phase. The estimated demand at daily maximum base in 2000 is 221,000 m^3/day.
- Construction of two service reservoirs (Erima and 9 mile) for low supply zone.
- Installing transmission pipes and distribution pipes.

Second Phase (2001 - 2007)

- Construction of the 9 mile WTP construction (50,000 m^3/day) The total capacity of the 9 mile WTP will be 150,000 m^3/day.