- Completion of the distribution pipe installation for the low zone except the new development area.
- Installation of transmission and distribution pipes.
- Construction of Gerehu service reservoir in the low zone.

Third Phase (2008 - 2015)

- Completion of the 9 mile WTP construction (50,000 m^3/day) The total capacity of the 9 mile WTP will be 200,000 m^3/day.
- Construction of Laloki service reservoir in the low supply zone.
- Completion of installation of distribution pipes in the new development areas.

9.2.4 Complementary Activities

The review of system management has revealed that a number of complementary activities must be undertaken in conjunction with the capital works to improve the operating efficiency of the water supply system.

The implementation of the recommended changes in system management should be given the highest priority and must precede the proposed capital works.

In essence, these activities include the following:

- Implementation of water conservation and leakage control measures
- Update of records for all aspects of water supply
- Implementation of a metering program
- Implementation of measures for preventing illegal consumption
- Formulation of city planning (In particular, new developments and redevelopment)

Details of the recommended program for complementary activities are given in Table 9.8.

Table 9.3 Reservoir works

Reservoir Name	Capacity (m3)	Diameter (m)	Depth (m)	Reservoir capacity 1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Erima	13,000	45.5	8.0				13,000																		
Gerehu	11,000	41.9	8.0									11,000													
Laloki	9,000	35.7	8.0																		9,000				

Note : Depth indicates effective depth

Table 9.4 Transmission pipe works by year

System	Route	Dia. (mm)	Length (m)	Pipe length (m) by year 1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
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																			
Dup. 1	H.M.HW to 7 Mile (along H.M.HW.)	1350	2,000	667	667	666																			
Dup. 2	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	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Low Zone (Nine Mile System)																									
	9 Mile W.T.P. to H.M.HW.	1200	1,280				427	427	426																
Dup. 1	H.M.HW. to 7 Mile	1100	2,000	667	667	666																			
	7 Mile to Erima Res.	700	440				147	147	146																
Dup. 2	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	2,340							213	213	213	213	213	213	213	213	213	213	210					
	subtotal		13,240	1,854	1,854	1,852	1,781	1,781	1,778	213	213	213	213	213	213	213	213	213	213	210	0	0	0	0	0
Total			34,400	6,989	6,989	6,982	3,701	3,701	3,698	213	213	213	213	213	213	213	213	213	213	210	0	0	0	0	0

Note : "Dup. 1 and 2 mean duplication pipe which will be installed at same time and along same route

Table 9.5 Distribution pipe installation works in existing urban area by year

System	Reservoir Block	Route	Stage in F/S (1)	Stage in F/S (2)	Except F/S (3)	Dia. (mm)	Length (m)	Pipe Length (m) by year 1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
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	2,550							159	159	159	159	159	159	159	159	159	159	159	159	159	159	159	165
		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						28,070	6,460	6,460	6,460	2,047	2,047	2,046	159	159	159	159	159	159	159	159	159	159	159	159	159	159	159	165
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	1,050							66	66	66	66	66	66	66	66	66	66	66	66	66	66	66	60
	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	1,100							69	69	69	69	69	69	69	69	69	69	69	69	69	69	69	65
		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						14,540	0	0	0	4,130	4,130	4,130	135	135	135	135	135	135	135	135	135	135	135	135	135	135	135	125
Total							42,610	6,460	6,460	6,460	6,177	6,177	6,176	294	294	294	294	294	294	294	294	294	294	294	294	294	294	294	290

TABLE 9.6 PIPE INSTALLATION WORKS IN NEW DEVELOPMENT AREA BY 5 YEAR INTERVAL

Census Division No.	Name	zone ratio	Dia. (mm)	Pipe Length by 5 Years Interval (meter) 1993	1995 Total	1995 High	1995 Low	2000 Total	2000 High	2000 Low	2005 Total	2005 High	2005 Low	2010 Total	2010 High	2010 Low	2015 Total	2015 High	2015 Low	Total Total	Total High	Total Low
80	Gerehu		100	0	443	0	443	1,070	0	1,070	1,533	0	1,533	2,012	0	2,012	661	0	661	5,719	0	5,719
	High	0	150	0	337	0	337	814	0	814	1,167	0	1,167	1,531	0	1,531	503	0	503	4,352	0	4,352
	Low	1	200	0	96	0	96	233	0	233	333	0	333	437	0	437	144	0	144	1,243	0	1,243
			250	0	87	0	87	209	0	209	300	0	300	394	0	394	129	0	129	1,119	0	1,119
	sub-total			0	963	0	963	2,326	0	2,326	3,333	0	3,333	4,374	0	4,374	1,437	0	1,437	12,433	0	12,433
81	Waigani/University		100	0	528	106	422	1,248	250	998	1,764	353	1,411	2,271	454	1,817	1,608	322	1,286	7,419	1,485	5,934
	High	0.2	150	0	402	80	322	950	190	760	1,342	268	1,074	1,728	346	1,382	1,224	245	979	5,646	1,129	4,517
	Low	0.8	200	0	115	23	92	271	54	217	383	77	306	494	99	395	350	70	280	1,613	323	1,290
			250	0	103	21	82	244	49	195	345	69	276	444	89	355	315	63	252	1,451	291	1,160
	sub-total			0	1,148	230	918	2,713	543	2,170	3,834	767	3,067	4,937	988	3,949	3,497	700	2,797	16,129	3,228	12,901
82	Tokarara/Hohola		100	0	690	345	345	1,689	845	844	2,442	1,221	1,221	1,632	816	816	0	0	0	6,453	3,227	3,226
	High	0.5	150	0	525	263	262	1,285	643	642	1,858	929	929	1,241	621	620	0	0	0	4,909	2,456	2,453
	Low	0.5	200	0	150	75	75	367	184	183	531	266	265	355	178	177	0	0	0	1,403	703	700
			250	0	135	68	67	330	165	165	478	239	239	319	160	159	0	0	0	1,262	632	630
	sub-total			0	1,500	751	749	3,671	1,837	1,834	5,309	2,655	2,654	3,547	1,775	1,772	0	0	0	14,027	7,018	7,009
83	Gordons/Saraga		100	0	299	299	0	808	808	0	92	92	0	0	0	0	0	0	0	1,199	1,199	0
	High	1	150	0	227	227	0	615	615	0	70	70	0	0	0	0	0	0	0	912	912	0
	Low	0	200	0	65	65	0	176	176	0	20	20	0	0	0	0	0	0	0	261	261	0
			250	0	58	58	0	158	158	0	18	18	0	0	0	0	0	0	0	234	234	0
	sub-total			0	649	649	0	1,757	1,757	0	200	200	0	0	0	0	0	0	0	2,606	2,606	0
84	Boroko/Korobosea		100	0	1,393	1,393	0	2,393	2,393	0	0	0	0	0	0	0	0	0	0	3,786	3,786	0
	High	1	150	0	1,060	1,060	0	1,821	1,821	0	0	0	0	0	0	0	0	0	0	2,881	2,881	0
	Low	0	200	0	303	303	0	520	520	0	0	0	0	0	0	0	0	0	0	823	823	0
			250	0	273	273	0	468	468	0	0	0	0	0	0	0	0	0	0	741	741	0
	sub-total			0	3,029	3,029	0	5,202	5,202	0	0	0	0	0	0	0	0	0	0	8,231	8,231	0
87	Laloki/Napanapa		100	0	1,327	159	1,168	6,191	743	5,448	9,861	1,183	8,678	14,044	1,685	12,359	31,946	3,834	28,112	63,369	7,604	55,765
	High	0.12	150	0	1,010	121	889	4,711	565	4,146	7,503	900	6,603	10,686	1,282	9,404	24,307	2,917	21,390	48,217	5,785	42,432
	Low	0.88	200	0	289	35	254	1,346	162	1,184	2,144	257	1,887	3,053	366	2,687	6,945	833	6,112	13,777	1,653	12,124
			250	0	260	31	229	1,211	145	1,066	1,929	231	1,698	2,748	330	2,418	6,250	750	5,500	12,398	1,487	10,911
	sub-total			0	2,886	346	2,540	13,459	1,615	11,844	21,437	2,571	18,866	30,531	3,663	26,868	69,448	8,334	61,114	137,761	16,529	121,232
88	Bomana		100	0	1,928	0	1,928	6,648	0	6,648	8,162	0	8,162	9,324	0	9,324	17,601	0	17,601	43,663	0	43,663
	High	0	150	0	1,467	0	1,467	5,059	0	5,059	6,210	0	6,210	7,094	0	7,094	13,392	0	13,392	33,222	0	33,222
	Low	1	200	0	419	0	419	1,445	0	1,445	1,774	0	1,774	2,027	0	2,027	3,826	0	3,826	9,491	0	9,491
			250	0	377	0	377	1,301	0	1,301	1,597	0	1,597	1,824	0	1,824	3,444	0	3,444	8,543	0	8,543
			300*	0	0	0	0	0	0	0	0	0	0	1,000	0	1,000	0	0	0	1,000	0	1,000
			400*	0	0	0	0	1,400	0	1,400	1,400	0	1,400	1,000	0	1,000	0	0	0	1,000	0	3,800
	sub-total			0	4,191	0	4,191	15,853	0	15,853	19,143	0	19,143	22,269	0	22,269	38,263	0	38,263	99,719	0	99,719
	Total			0	14,366	5,005	9,361	44,981	10,954	34,027	53,256	6,193	47,063	65,658	6,426	59,232	112,645	9,034	103,611	290,906	37,612	253,294

TABLE 9.7 SUMMARY OF DISTRIBUTION PIPE INSTALLATION SCHEDULE

Item	Total Length (m)	Pipe Length (m) by year																					
		1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Mt.Eriama System (High Zone)																							
Urban Area (Improvement)	28,070	6,460	6,460	6,460	2,047	2,047	2,046	159	159	159	159	159	159	159	159	159	159	159	159	159	159	159	165
Development area (New)	37,612	2,503	2,502	2,191	2,191	2,191	2,191	2,190	1,239	1,239	1,239	1,239	1,237	1,285	1,285	1,285	1,285	1,286	1,807	1,807	1,807	1,807	1,806
subtotal	65,682	8,963	8,962	8,651	4,238	4,238	4,237	2,349	1,398	1,398	1,398	1,398	1,396	1,444	1,444	1,444	1,444	1,445	1,966	1,966	1,966	1,966	1,971
Nine (9) Mile System (Low Zone)																							
Urban Area (Improvement)	14,540	0	0	0	4,130	4,130	4,130	135	135	135	135	135	135	135	135	135	135	135	135	135	135	135	125
Development area (New)	253,294	4,681	4,680	6,525	6,525	6,525	6,525	7,927	10,533	9,133	9,133	9,133	9,131	13,446	11,446	11,446	11,446	11,448	20,722	20,722	20,722	20,722	20,723
subtotal	267,834	4,681	4,680	6,525	10,655	10,655	10,655	8,062	10,668	9,268	9,268	9,268	9,266	13,581	11,581	11,581	11,581	11,583	20,857	20,857	20,857	20,857	20,848
total	333,516	13,644	13,642	15,176	14,893	14,893	14,892	10,411	12,066	10,666	10,666	10,666	10,662	15,025	13,025	13,025	13,025	13,028	22,823	22,823	22,823	22,823	22,819

TABLE 9.8 RECOMMENDED COMPLIMENTARY ACTIVITIES

1. Records	(a) Initial Update of all Water Supply Records	
	(b) Annual Updates	
2. Metering	(a) Metering Program Administrative Costs	
		Meter Repair Facility
		Meter Technician
		Training Program
	(b) Metering	
		New Meter Purchase Installation and Repair
		Existing Meter Replacement
3. Water Conservation Measures		
	(a) Education Program	
	(b) Pressure Zoning Equipment	
	(c) Leakage Detection Team Costs	

Cost : Million Kina　　Capacity : mld

Program Item	Total Cost	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
		NCD Water Supply System Works Program																					
Phase		First Phase 200.74							Second Phase 52.65							Third Phase 67.97							
Year		1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Cost	321.36	74.77	53.79	54.30	4.12	4.12	4.09	5.55	2.79	7.25	2.56	15.82	14.66	3.46	2.71	2.71	12.50	10.98	8.37	4.64	4.64	4.63	4.51
Capacity		136	136	136	180	180	180	280	280	280	280	280	280	330	330	330	330	330	380	380	380	380	380
Demand (Daily Max)		192	201	205	209	213	217	221	230	239	249	258	267	277	287	296	306	316	326	336	347	357	367
1. Conveyance System	39.69	39.69							0.00							0.00							
Intake	2.14	■	■																				
Raw Water Main	37.55	■	■	■																			
2. Transmission pipe	37.47	36.01							0.98							0.48							
		■	■	■				■	■	■	■	■	■	■	■	■	■	■					
3. High Zone System	51.99	47.29							1.71							2.99							
(Mt.Eriama W.T.P.)	Capacity	136	136	136	180	180	180	180	180	180	180	180	180	180	180	180	180	180	180	180	180	180	180
W.T.P. & P.S.	36.36	■	■	■																			
Distribution pipe	15.63	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
4. Low Zone System	192.21	77.75							49.96							64.50							
(9 Mile W.T.P.)	Capacity	0	0	0	0	0	0	100	100	100	100	100	100	150	150	150	150	150	200	200	200	200	200
Water Treatment Plant	119.97	■	■	■				■	■	■						■	■	■					
Distribution reservoir	14.84		■							■									■				
Distribution pipe	57.40	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■

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

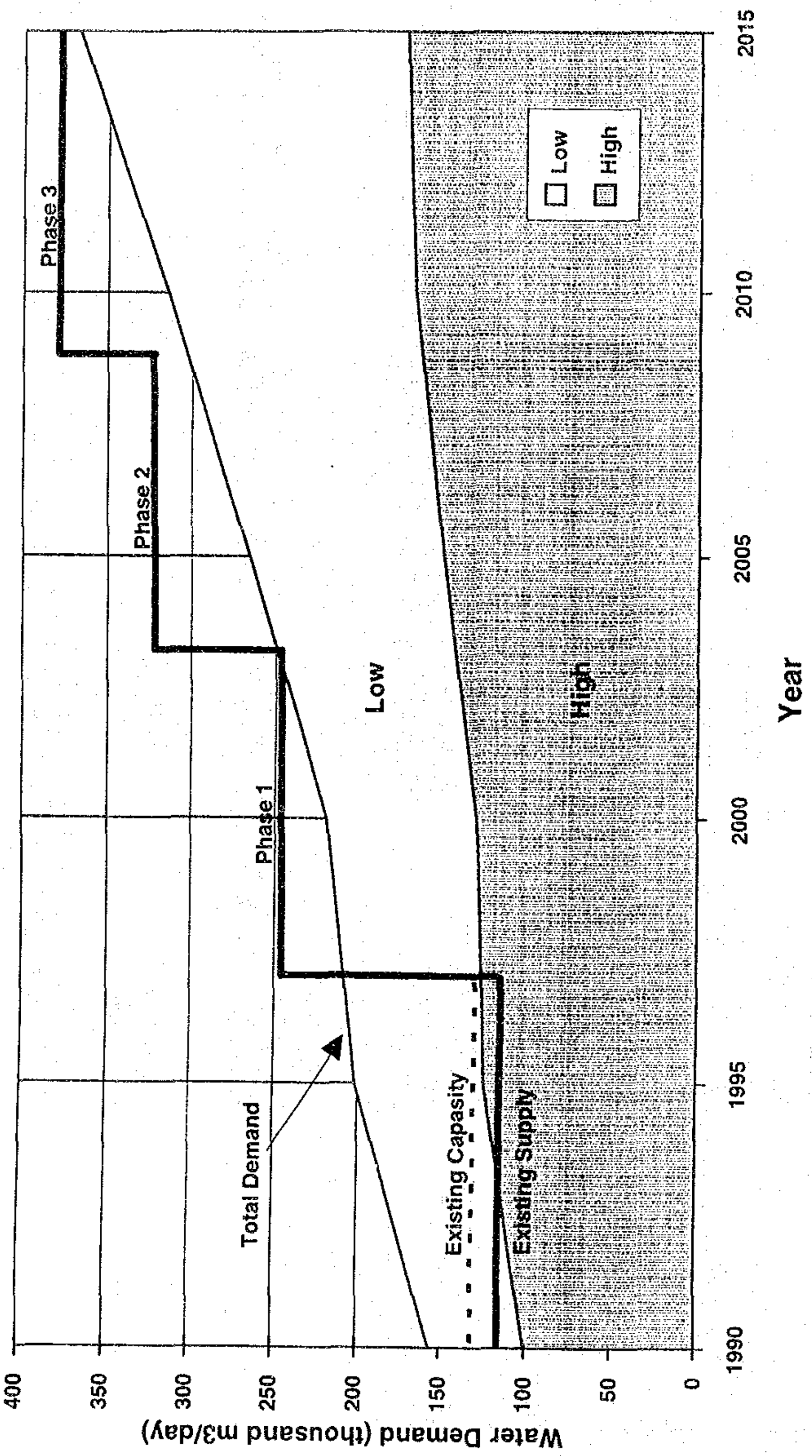
TITLE

IMPLEMENTATION SCHEDULE (OPTION A)

Fig. No. 9.1

PORT MORESBY WATER SUPPLY DEVELOPMENT PLAN

TOKYO ENGINEERING CONSULTANTS in association with PACIFIC CONSULTANTS INTERNATIONAL



TITLE

WATER SUPPLY AND DEMAND (OPTION A)

Fig. No.
9.2

PORT MORESBY WATER SUPPLY DEVELOPMENT PLAN

TOKYO ENGINEERING CONSULTANS in association with PACIFIC CONSULTANTS INTERNATIONAL

Cost : Million Kina Capacity : mld

Program Item	Total Cost	NCD Water Supply System Works Program																					
Phase		First Phase 219.13							Second Phase 49.25							Third Phase 52.98							
Year		1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Cost	321.36	16.93	41.15	59.79	32.02	21.51	45.18	2.55	2.79	7.25	2.56	15.82	14.66	3.46	2.71	2.71	12.50	10.98	8.37	4.64	4.64	4.63	4.51
Capacity		136	136	136	180	180	180	280	280	280	280	280	280	330	330	330	330	330	380	380	380	380	380
Demand (Daily Max)		192	201	205	209	213	217	221	230	239	249	258	267	277	287	296	306	316	326	336	347	357	367
1. Conveyance System	39.69	39.69							0.00							0.00							
Intake	2.14	■	■																				
Raw Water Main	37.55	■	■	■		■	■																
2. Transmission pipe	37.47	36.01							0.98							0.48							
		■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
3. High Zone System	51.99	47.29							1.71							2.99							
(Mt.Eriama W.T.P.)	Capacity	136	136	136	180	180	180	180	180	180	180	180	180	180	180	180	180	180	180	180	180	180	180
W.T.P. & P.S.	36.36	■	■	■																			
Distribution pipe	15.63	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
4. Low Zone System	192.21	96.14							46.56							49.51							
(9 Mile W.T.P.)	Capacity	0	0	0	0	0	0	100	100	100	100	100	100	150	150	150	150	150	200	200	200	200	200
Water Treatment Plant	119.97		■	■	■	■	■				■	■	■				■	■					
Distribution reservoir	14.84				■					■									■				
Distribution pipe	57.40	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■

W.T.P. : Water Treatment Plant

P.S. : Pumping Station

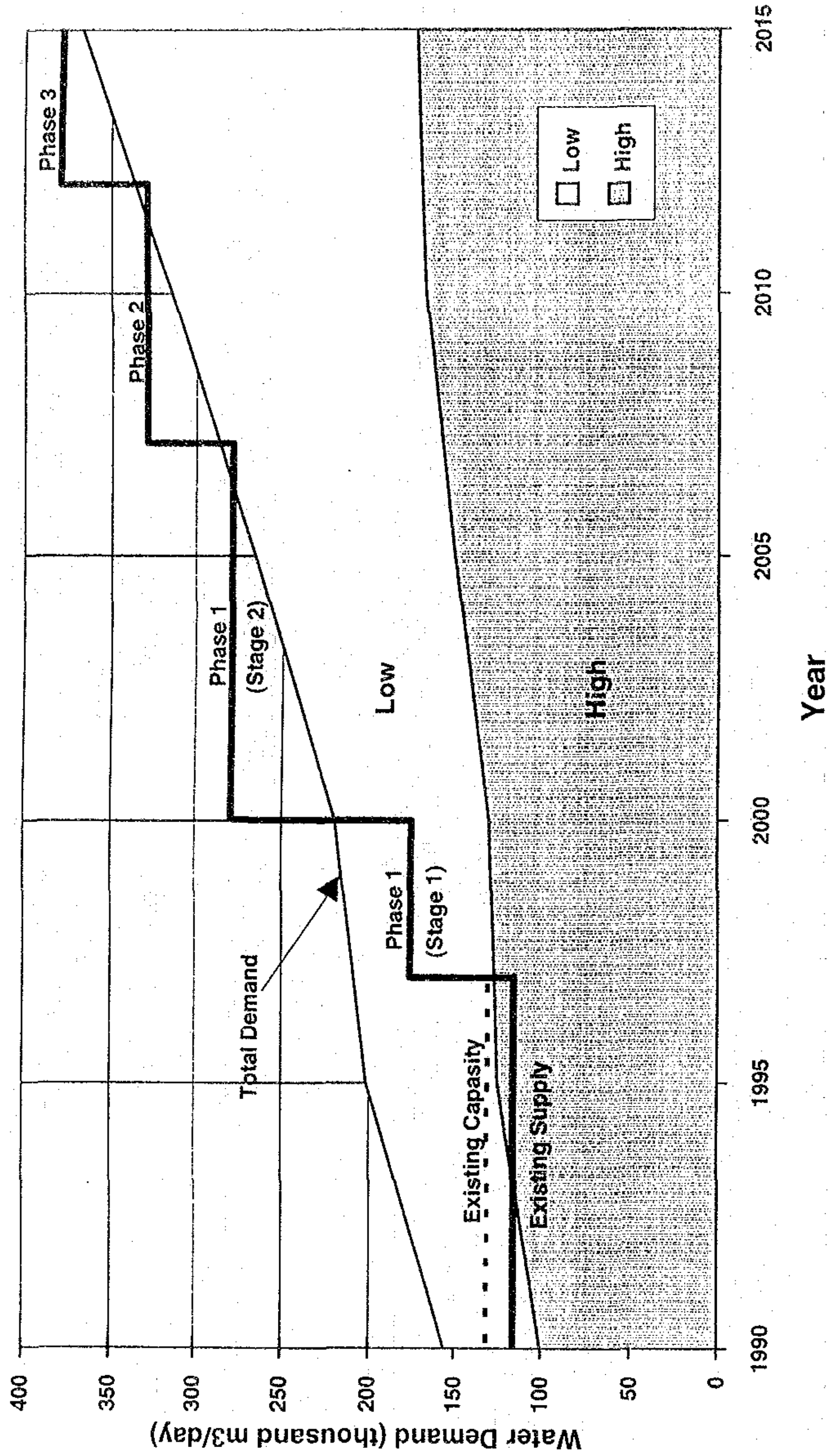
TITLE

IMPLEMENTATION SCHEDULE (OPTION B)

Fig. No.
9.3

PORT MORESBY WATER SUPPLY DEVELOPMENT PLAN

TOKYO ENGINEERING CONSULTANTS in association with PACIFIC CONSULTANTS INTERNATIONAL



TITLE

WATER SUPPLY AND DEMAND (OPTION B)

Fig. No. 9.4

PORT MORESBY WATER SUPPLY DEVELOPMENT PLAN

TOKYO ENGINEERING CONSULTANS in association with PACIFIC CONSULTANTS INTERNATIONAL

Cost : Million Kina   Capacity : mld

Program Item	Total Cost	NCD Water Supply System Works Program																					
Phase		First Phase 219.13 kina							Second Phase 49.25 kina							Third Phase 52.98 kina							
		Stage 1 117.87			Stage 2 101.26																		
Year		1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Cost	321.36	16.93	41.15	59.79	32.02	21.51	45.18	2.55	2.79	7.25	2.56	15.82	14.66	3.46	2.71	2.71	12.50	10.98	8.37	4.64	4.64	4.63	4.51
Capacity		115	115	115	180	180	180	280	280	280	280	280	280	330	330	330	330	330	330	380	380	380	380
Demand (Daily Max)		192	201	205	209	213	217	221	230	239	249	258	267	277	287	296	306	316	326	336	347	357	367
1. Conveyance System	39.69	2.32	14.26	14.29	0.00	0.69	8.13	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	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	37.47	8.79	8.79	8.81	3.16	3.16	3.16	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.20					
3. High Zone System	51.99	4.96	16.62	22.74	0.84	0.84	0.82	0.47	0.23	0.23	0.23	0.23	0.23	0.28	0.28	0.28	0.28	0.28	0.45	0.45	0.45	0.44	0.36
(Mt.Eriama W.T.P.)	Capacity	125	125	125	180	180	180	180	180	180	180	180	180	180	180	180	180	180	180	180	180	180	180
W.T.P. & P.S.	36.36	2.29	13.95	20.12																			
Distribution pipe	15.63	2.67	2.67	2.62	0.84	0.84	0.82	0.47	0.23	0.23	0.23	0.23	0.23	0.28	0.28	0.28	0.28	0.28	0.45	0.45	0.45	0.44	0.36
4. Low Zone System	192.21	0.86	1.48	13.95	28.02	16.82	33.07	1.94	2.42	6.88	2.19	15.45	14.29	3.04	2.29	2.29	12.08	10.50	7.92	4.19	4.19	4.19	4.15
(9 Mile W.T.P.)	Capacity	0	0	0	0	0	0	100	100	100	100	100	100	150	150	150	150	150	200	200	200	200	200
Water Treatment Plant	119.97		0.62	12.71	18.71	13.54	29.80				0.41	13.67	12.51				9.79	8.21					
Distribution reservoir	14.84				6.03					5.10									3.71				
Distribution pipe	57.40	0.86	0.86	1.24	3.28	3.28	3.27	1.94	2.42	1.78	1.78	1.78	1.78	3.04	2.29	2.29	2.29	2.29	4.21	4.19	4.19	4.19	4.15

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

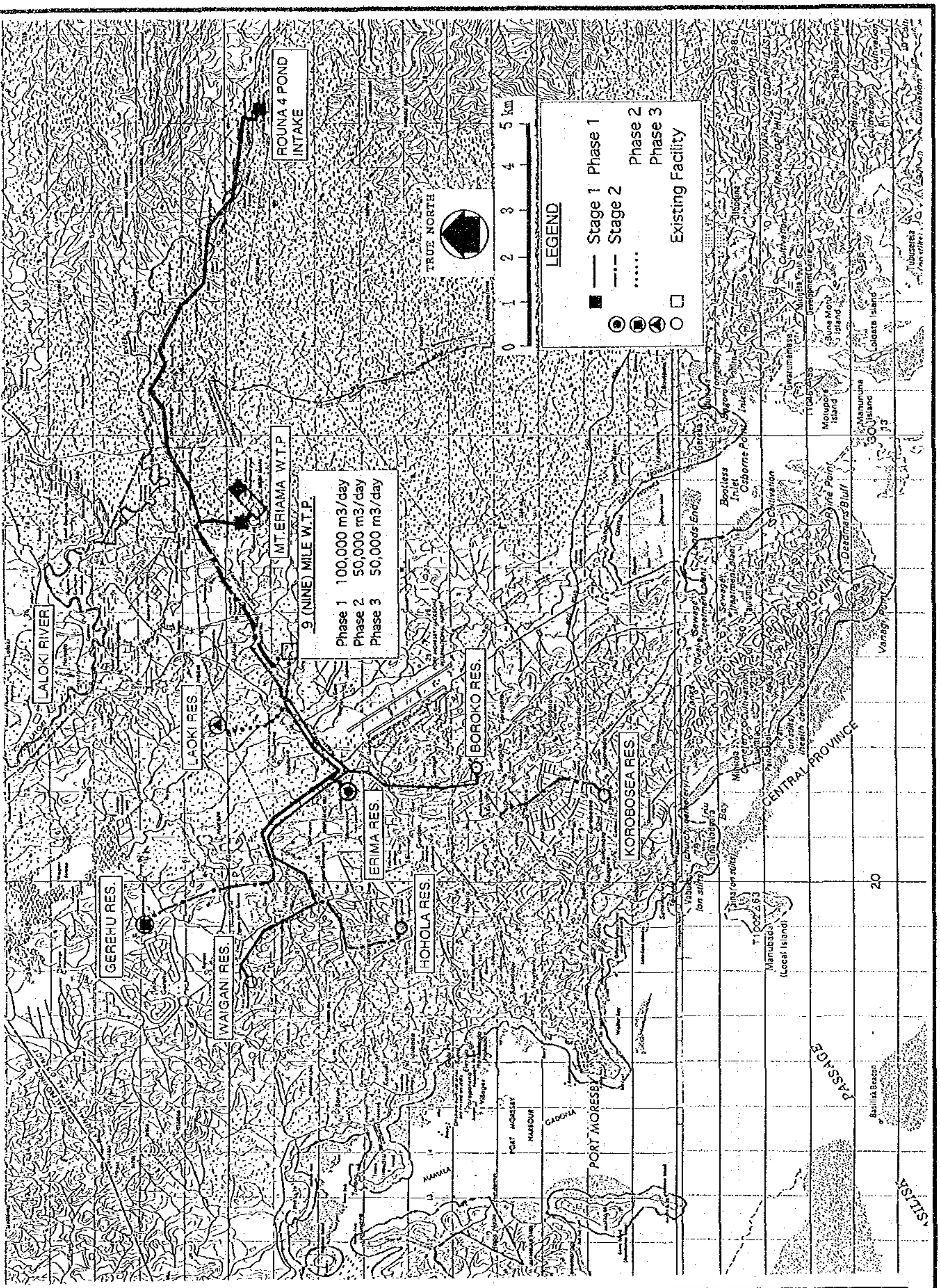
TITLE

IMPLEMENTATION SCHEDULE

Fig. No. 9.5

PORT MORESBY WATER SUPPLY DEVELOPMENT PLAN

TOKYO ENGINEERING CONSULTANS in association with PACIFIC CONSULTANTS INTERNATIONAL



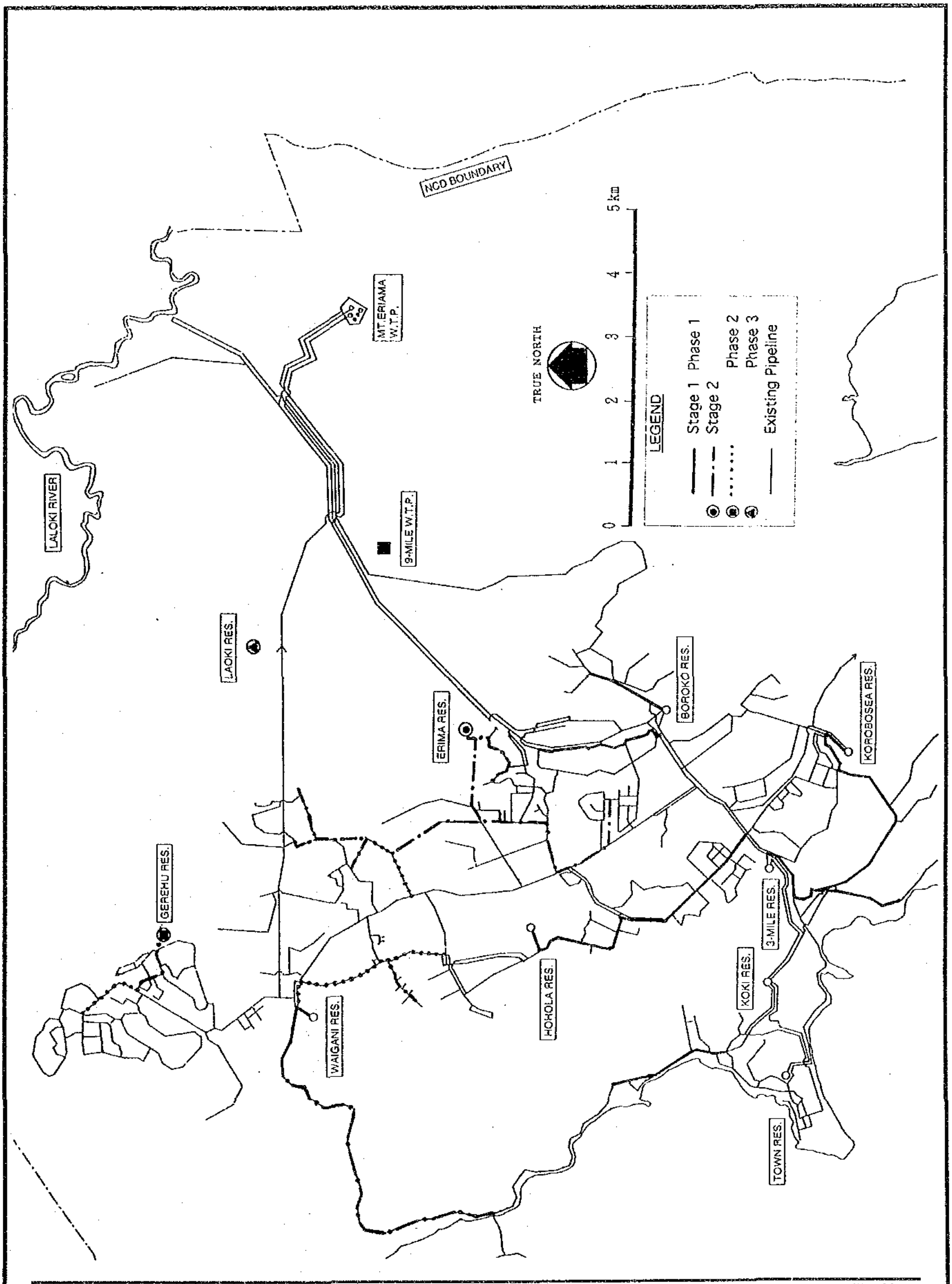
TITLE

IMPLEMENTATION SCHEDULE (MAJOIR FACILITY)

Fig. No. **9.6**

PORT MORESBY WATER SUPPLY DEVELOPMENT PLAN

TOKYO ENGINEERING CONSULTANS in association with PACIFIC CONSULTANTS INTERNATIONAL



TITLE

IMPLEMENTATION SCHEDULE (DISTRIBUTION)

Fig. No. **9.7**

PORT MORESBY WATER SUPPLY DEVELOPMENT PLAN

TOKYO ENGINEERING CONSULTANS in association with PACIFIC CONSULTANTS INTERNATIONAL

10 PROJECT EVALUATION

10.1 Financial Evaluation

10.1.1 General

The major function of the master plan is to determine the outline of the first phase of the capital investment plan. The period of this master plan is until 2015, and consists of three construction phases, namely, expansion of the system in phase one (increase of water volume: 144 mld in two stages), phase two (increase of water volume: 50 mld) and phase three (increase of water volume: 50 mld).

According to the expansion plan, the service area would be divided into two parts, the high-altitude area and the low-altitude area. The volume of water supplied in the first phase, which is the theme of the latter part of this study, would be able to meet the demand in the high zone until 2015, and that of the lower zone until 2005. The second phase would be able to cope with the demand in the low-altitude zone up to the year 2011, while the third phase would cope with the demand in the low-altitude zone up to the year 2015.

Financial implications in the project formation have been studied in 10.1.2 and 10.1.3.

10.1.2 Fund Requirements

(1) Introduction

The reserve fund of WS & S of NCDC is nominal, and current assets consist of only debtors. Income does not cover costs if income from supporting activities is counted. So, the cash position of the NCDC is always tight and it depends on a large overdraft. Internal financing for even a portion of this investment program is, therefore, out of the question at the moment.

The NCDC has been repaying long term government loans regularly, but it has not been paying its interest regularly. So, the sum of principal and interest arrears to be paid has been increasing.

The NCDC must show its willingness to improve the present financial situation before it approaches the government or a foreign donor to draw grants or long-term loans from them. Again, it requires some money to do so. In the following investment plan, the costs of strengthening management capability and upgrading operation/maintenance standards are included.

(2) Proposed Scale and Schedule of Investment

Table 10.1 gives an overall investment schedule for the rehabilitation and expansion of the system. Their breakdowns are given in the appropriate chapters of this report.

TABLE 10.1 INVESTMENT SCHEDULE

million Kina (1993 price)

	Capital Investment	Training for Management, O&M		Capital Investment	Training for Management, O&M
1994	17	0.4	2006	3	
1995	41	0.4	2007	3	
1996	60	0.4	2008	3	
1997	32	0.3	2009	13	
1998	22	0.3	2010	11	
1999	45	0.3	2011	8	
2000	3	0.3	2012	5	
2001	3		2013	5	
2002	7		2014	4	
2003	3		2015	4	
2004	16				
2005	15		TOTAL	321	2.4

C= Capital Investment, T= Training for Management

(3) Proposed Financial Sources

Costs of strengthening management capability and upgrading operation/maintenance standards are to be covered by the NCDC, if it complies with the preconditions described in the third paragraph of 10.1.2 (1). NCDC has been subsidizing about half the costs of administration, such as costs for those of supporting activities.

A mixture of government grant and that from a foreign donor may be suitable for the fund for this portion of investment, 20 percent of which may be shared by the federal government, for example. A long-term loan allocated for building of social infrastructure would be appropriate for investments in the priority project that is the first part of expansion program of the water supply system. Its terms and conditions are reasonable. An example of the loan provided by the OECF is given below.

Interest Rate: 2.7 percent pa,
Period: 30 years with a 10-year grace period.

The financial plan of the Water Supply Sub-Division for the period of the master plan is studied in the next section.

10.1.3 Financial Plan

Effective financial management of the WS & S presupposes an adequate understanding of cost structure of the operation, on which the whole financial plan is built up. We have tried to incorporate the costs of supporting activities into the cost structure. This is reflected in the proposed marginal cost, though the figure is rather conservative.

We have not combined the future flow of financial statements with the expansions works, as the level of uncertainty could not be minimized with the available data. We only deal with the latter here. A summarized consolidated financial statement of the water supply service is given in Table 10.2.

Our plan covers the master plan period from 1994 to 2015. The units used in the table is million Kina as in 1993. The water supply after the first phase of the expansion will start from 1997, the third year after the commencement of the works. The water supply by the second phase will begin from 2006. Repayment of the first installment of the loan will start from 2004, the 11th year.

Terms and conditions of the loan used in our calculation are according to the sample given in 10.1.2 (3). (at 2.7 percent interest pa for a period of 30 years with a 10-year grace period.)

The following are other assumptions used in the table:

1. The monetary unit used is Kina as of 1993.

2. Benefit is derived directly from the sale of water. Unit price is set at 0.72 Kina* per cubic meter per month.

3. Efficiency of distribution of water for the new system is assumed as 80 per cent, and efficiency of the existing system would increase from 70 per cent in 1994 to 80 percent in 2000, which is the target of physical planning.

4. Efficiency of bill collection would increase from 60 per cent in 1994 to 80 percent in 2000. We will rely on the results of training for better management.

* The basis of the assumption is as follows:
The average unit price of 28 per cent of the total volume of water used is set at 0.24 Kina , the lowest category in the proposed water rate, and that of 72 per cent is set at 0.91 Kina, a 40 per cent increase from 0.65 Kina, the average of the middle and the highest categories in the proposed water rate.

Costs of operation and its supporting activities are based on the calculations in Table 4.5 (A) and (B) of the master plan. The total cost structure is inclusive of costs for improving maintenance. Decrease of electricity use after 1997 when Bomana pumping station ceases to function, is also considered.

The central government will be requested to support the NCDC by paying the interest incurred between 1994 and 1996 when there will be no revenue from the new supply system. During 1994 and 1997 a total of 1.5 million Kina shall be covered by the NCDC general account for the cost of training. (Another 0.4 million Kina would be repaid from the water supply account itself.) The money borrowed from the both sources would be returned between 2000 and 2002. After the fourth year, cash inflow will continue , and on the 22nd year the amount of reserve funds will reach 130 per cent of the accumulated depreciation.

10.1.4 FIRR

Table 10.3 gives the flows of costs and benefits during the period of the master plan, then the FIRR of the master plan is calculated.

The following is an assumption used in the table in addition to assumptions made in Table 10.2.

1. The project life is set at 52 years after the implementation of the works, i.e., 30 years after the completion of the works.

The FIRR of the master plan is calculated as 8.65 per cent. This figure exceeds the prevailing interest rate with reference to the long term loan for the BHN infrastructure development project. So, the master plan is financially feasible.

10.1.5 Sensitivity Analysis

1. A ten percent increase in costs throughout the construction period gets the FIRR to reduce itself to 8.43 per cent.

2. A year's delay in the first construction phase* gets the FIRR to reduce itself to 8.55 per cent.

   * The first phase :1994-96=>>94-97, the rest of the phases 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 case 2) gets the FIRR to reduce itself to 7.73 per cent.

10.1.6 Other Benefits

Benefits of health and sanitation, and other value added benefits to land are easily recognizable. We only mention them as their values are not easy to calculate.

TABLE 10.2 FINANCIAL STATEMENTS OF WATER SUPPLY ENTERPRISE: M/P

BALANCE SHEET

Unit: Mil. Kina 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	221.92	229.17	231.73	247.55	262.21	265.67	268.38	271.09	283.59	294.57	302.94	307.58	312.22	316.85	321.36
Depreciation	0.42	1.45	2.95	3.75	4.29	5.41	5.48	5.55	5.73	5.79	6.19	6.56	6.64	6.71	6.78	7.09	7.36	7.57	7.69	7.81	7.92	8.03
(-)Accum. Depreciation	0.42	1.88	4.82	8.57	12.85	18.27	23.75	29.29	35.02	40.82	47.01	53.56	60.20	66.91	73.69	80.78	88.14	95.72	103.41	111.21	119.13	127.17
Assets: net	16.51	56.20	113.05	141.32	158.55	198.31	195.38	192.63	194.15	190.91	200.54	208.65	205.47	201.47	197.40	202.81	206.43	207.22	204.17	201.01	197.72	194.19
Current Assets	0.00	0.00	0.02	1.02	1.15	0.35	3.42	7.76	11.92	20.89	30.07	36.85	39.05	45.11	51.94	56.48	60.91	63.64	72.61	82.22	91.27	99.85
TOTAL ASSETS	16.51	56.20	113.07	142.34	159.69	198.67	198.81	200.39	206.06	211.80	230.62	245.49	244.52	246.58	249.34	259.29	267.34	270.86	276.79	283.23	288.99	294.04
Long Term Loan	16.93	41.14	59.80	32.02	21.51	45.18	2.55	2.79	7.25	2.56	15.82	14.66	3.46	2.71	2.71	12.50	10.98	8.37	4.64	4.64	4.63	4.51
Loan : Cumulative	16.93	58.07	117.87	149.89	171.40	216.58	219.13	221.92	229.17	231.73	246.70	258.46	256.03	251.24	245.38	247.05	247.08	244.35	237.53	230.59	222.84	214.24
[(-)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	11.10	11.46	11.59	12.38	13.11
Reserved Fund	-0.42	-1.87	-4.80	-7.55	-11.71	-17.91	-20.32	-21.53	-23.11	-19.93	-16.09	-12.97	-11.51	-4.67	3.96	12.24	20.26	26.51	39.26	52.64	66.15	79.80
TOTAL LIABIL. & CAPITAL	16.51	56.20	113.07	142.34	159.69	198.67	198.81	200.39	206.06	211.80	230.62	245.49	244.52	246.58	249.34	259.29	267.34	270.86	276.79	283.23	288.99	294.04

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	0.00	0.01	6.58	6.88	7.19	15.30	17.46	19.08	20.69	21.85	21.81	21.84	27.16	28.85	28.86	28.88	28.91	35.33	35.91	35.93	35.95
From NCDC	0.40	0.40	0.40	0.30	0.00	0.00	-0.40	-0.40	-0.40	-0.30	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	1.97	3.60	6.88	6.88	7.19	14.44	15.49	15.50	20.39	21.85	21.81	21.84	27.16	28.85	28.86	28.88	28.91	35.33	35.91	35.93	35.95
O/M Costs	0.40	0.40	0.40	1.83	2.13	2.13	5.46	5.16	5.16	5.16	5.16	5.16	6.82	6.82	6.82	6.82	6.82	8.49	8.49	8.49	8.49	8.49
Depreciation	0.42	1.45	2.95	3.75	4.29	5.41	5.48	5.55	5.73	5.79	6.19	6.56	6.64	6.71	6.78	7.09	7.36	7.57	7.69	7.81	7.92	8.03
Interest Payment : 2.7%	0.46	1.57	3.18	4.05	4.63	5.85	5.92	5.99	6.19	6.26	6.66	6.98	6.91	6.78	6.63	6.67	6.67	6.60	6.41	6.23	6.02	5.78
Expenditure	1.28	3.42	6.53	9.62	11.04	13.39	16.85	16.70	17.07	17.21	18.01	18.69	20.38	20.31	20.22	20.58	20.86	22.66	22.59	22.52	22.42	22.30
BALANCE	-0.42	-1.45	-2.93	-2.74	-4.16	-6.21	-2.41	-1.21	-1.58	3.18	3.84	3.12	1.46	6.84	8.63	8.28	8.03	6.25	12.74	13.39	13.51	13.65

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	2.79	7.25	2.56	15.82	14.66	3.46	2.71	2.71	12.50	10.98	8.37	4.64	4.64	4.63	4.51
Income	0.00	0.00	0.01	6.58	6.88	7.19	15.30	17.46	19.08	20.69	21.85	21.81	21.84	27.16	28.85	28.86	28.88	28.91	35.33	35.91	35.93	35.95
Gov.Contribution+NCDC	0.86	1.97	3.58	0.30	0.00	0.00	-0.86	-1.97	-3.58	-0.30	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	43.11	63.40	38.90	28.39	52.37	16.99	18.28	22.75	22.95	37.67	36.47	25.30	29.87	31.56	41.36	39.86	37.28	39.97	40.55	40.56	40.46
Investment	16.93	41.14	59.80	32.02	21.51	45.18	2.55	2.79	7.25	2.56	15.82	14.66	3.46	2.71	2.71	12.50	10.98	8.37	4.64	4.64	4.63	4.51
O/M Costs	0.40	0.40	0.40	1.83	2.13	2.13	5.46	5.16	5.16	5.16	5.16	5.16	6.82	6.82	6.82	6.82	6.82	8.49	8.49	8.49	8.49	8.49
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	11.10	11.46	11.59	12.38	13.11
Interest Payment : 2.7%	0.46	1.57	3.18	4.05	4.63	5.85	5.92	5.99	6.19	6.26	6.66	6.98	6.91	6.78	6.63	6.67	6.67	6.60	6.41	6.23	6.02	5.78
Total Outflow	17.79	43.11	63.38	37.90	28.27	53.16	13.92	13.94	18.60	13.97	28.49	29.70	23.09	23.81	24.73	36.82	35.43	34.55	31.00	30.94	31.51	31.89
Net Cash Inflow	0.00	0.00	0.01	1.01	0.12	-0.79	3.07	4.34	4.15	8.98	9.18	6.77	2.21	6.06	6.83	4.54	4.43	2.73	8.97	9.61	9.05	8.57
Cash Balance	0.00	0.00	0.02	1.02	1.15	0.35	3.42	7.76	11.92	20.89	30.07	36.85	39.05	45.11	51.94	56.48	60.91	63.64	72.61	82.22	91.27	99.85

TABLE 10.3 FIRR : M/P

		COST						BENEFIT					
	year	invest.	o/m	train	TOTAL	Q	Q'+	sale1	sale2	TOTAL	balance	ef:f	ef:ph
1	1994	16.93	0.00	0.4	17.33				0.00	0.00	-17.33	0.60	0.70
2	1995	41.14	0.00	0.4	41.54		3		0.76	0.76	-40.78	0.63	0.70
3	1996	59.80	0.00	0.4	60.20		6		1.52	1.52	-58.68	0.66	0.71
4	1997	32.02	1.46	0.3	33.78	44	9	7.93	2.29	10.22	-23.56	0.69	0.71
5	1998	21.51	1.46	0.3	23.27	44	12	8.26	3.07	11.33	-11.94	0.71	0.72
6	1999	45.18	1.46	0.3	46.94	44	15	8.59	3.87	12.46	-34.49	0.74	0.72
7	2000	2.55	1.87	0.3	4.72	45	18	9.15	4.68	13.83	9.10	0.77	0.73
8	2001	2.79	2.16		4.95	52	21	10.92	5.47	16.39	11.44	0.80	0.73
9	2002	7.25	2.45		9.70	59	21	12.37	5.60	17.97	8.27	0.80	0.74
10	2003	2.56	2.77		5.33	67	22	13.99	5.73	19.71	14.39	0.80	0.74
11	2004	15.82	3.06		18.88	73	22	15.49	5.87	21.35	2.48	0.80	0.75
12	2005	14.66	3.34		18.00	80	23	16.90	5.98	22.88	4.87	0.80	0.75
13	2006	3.46	3.66		7.12	88	23	18.52	6.10	24.62	17.49	0.80	0.76
14	2007	2.71	3.98		6.69	96	24	20.13	6.23	26.36	19.67	0.80	0.76
15	2008	2.71	4.27		6.98	103	24	21.65	6.37	28.02	21.04	0.80	0.77
16	2009	12.50	4.59		17.09	110	25	23.21	6.48	29.68	12.59	0.80	0.77
17	2010	10.98	4.91		15.89	118	25	24.82	6.60	31.43	15.53	0.80	0.78
18	2011	8.37	5.23		13.60	126	26	26.44	6.73	33.17	19.57	0.80	0.78
19	2012	4.64	5.55		10.19	133	26	28.14	6.87	35.01	24.81	0.80	0.79
20	2013	4.64	5.90		10.54	142	27	29.84	6.98	36.81	26.27	0.80	0.79
21	2014	4.63	6.22		10.85	150	27	31.46	7.10	38.56	27.70	0.80	0.80
22	2015	4.51	6.54		11.05	157	28	33.16	7.23	40.39	29.34	0.80	0.80
23	2016		6.86		6.86	165	28	34.78	7.25	42.03	35.17	0.80	0.80
24	2017		7.18		7.18	173	28	36.31	7.23	43.53	36.35	0.80	0.80
25	2018		7.50		7.50	180	28	37.92	7.23	45.15	37.65	0.80	0.80
26	2019		7.82		7.82	188	28	39.54	7.23	46.77	38.95	0.80	0.80
27	2020		8.14		8.14	196	28	41.27	7.25	48.52	40.38	0.80	0.80
28	2021		8.46		8.46	203	28	42.78	7.23	50.00	41.54	0.80	0.80
29	2022		8.49		8.49	204	28	42.89	7.23	50.12	41.63	0.80	0.80
30	2023		8.49		8.49	204	28	42.89	7.23	50.12	41.63	0.80	0.80
31	2024		8.49		8.49	204	28	43.01	7.25	50.25	41.77	0.80	0.80
32	2025		8.49		8.49	204	28	42.89	7.23	50.12	41.63	0.80	0.80
33	2026		8.49		8.49	204	28	42.89	7.23	50.12	41.63	0.80	0.80
34	2027		8.49		8.49	204	28	42.89	7.23	50.12	41.63	0.80	0.80
35	2028		8.49		8.49	204	28	43.01	7.25	50.25	41.77	0.80	0.80
36	2029		8.49		8.49	204	28	42.89	7.23	50.12	41.63	0.80	0.80
37	2030		8.49		8.49	204	28	42.89	7.23	50.12	41.63	0.80	0.80
38	2031		8.49		8.49	204	28	42.89	7.23	50.12	41.63	0.80	0.80
39	2032		8.49		8.49	204	28	43.01	7.25	50.25	41.77	0.80	0.80
40	2033		8.49		8.49	204	28	42.89	7.23	50.12	41.63	0.80	0.80
41	2034		8.49		8.49	204	28	42.89	7.23	50.12	41.63	0.80	0.80
42	2035		8.49		8.49	204	28	42.89	7.23	50.12	41.63	0.80	0.80
43	2036		8.49		8.49	204	28	43.01	7.25	50.25	41.77	0.80	0.80
44	2037		8.49		8.49	204	28	42.89	7.23	50.12	41.63	0.80	0.80
45	2038		8.49		8.49	204	28	42.89	7.23	50.12	41.63	0.80	0.80
46	2039		8.49		8.49	204	28	42.89	7.23	50.12	41.63	0.80	0.80
47	2040		8.49		8.49	204	28	43.01	7.25	50.25	41.77	0.80	0.80
48	2041		8.49		8.49	204	28	42.89	7.23	50.12	41.63	0.80	0.80
49	2042		8.49		8.49	204	28	42.89	7.23	50.12	41.63	0.80	0.80
50	2043		8.49		8.49	204	28	42.89	7.23	50.12	41.63	0.80	0.80
51	2044		8.49		8.49	204	28	43.01	7.25	50.25	41.77	0.80	0.80
52	2045		8.49		8.49	204	28	42.89	7.23	50.12	41.63	0.80	0.80
		321.4		2.4							8.65%		

10.2 Environmental Aspects

The important environmental aspects and potential long term negative impacts of this potable water supply master plan are related to the following three (3) activity elements.

1. Surface water intake of raw water abstraction for potable use

2. Water treatment plant for treating the abstracted water

3. Waste water generated during the supply of treated water

The existing water supply facility that draws its entire raw water from the Laloki river using a conventional water treatment plant of capacity 136 mld at Mt.Eriama, is illustrated in Chapter 3, and the facility in the proposed master plan until the year 2015 is given in Chapter 7.

The baseline environmental conditions with respect to the above three aspects consequent to the existing water supply facilities, and the future implications of this proposed water supply master plan were evaluated on a preliminary basis and are described in Appendix-J. They are given in brief in subsequent sections.

The proposed plan is an environmental improvement plan for providing potable water supply, a basic human need to NCD residents. The beneficial effects are not discussed here.

10.2.1 Existing condition

1) Surface Water Intake

Rouna 1/3 pond in the Laloki river reaches, is a major gravity intake accounting for 85% of the total raw water abstraction of $1.2m^3/s$ for potable water supply. Bomana pump intake, a source of noise nuisance, though not significant at present, accounts for the remaining 15% of raw water.

The reduction in river discharge downstream of the Rouna 1/3 pond is not significant due to the above raw water abstraction, and accounts for only a 10% of normal dry weather flow of $10m^3/s$.

2) Water treatment Plant

The existing sole conventional water treatment plant of capacity 136 mld at Mt.Eriama is operated and maintained satisfactorily to produce fine treated water for distribution, and conforms to the potable water quality standards (ref. Chapter 5 and Appendix-B).

Gravity settling in earthen basins, located at the base of Mt.Eriama is used to clarify the raw water sludge produced during the water treatment process. The clarified effluent is apparently very clear and is used for irrigation.

The overall performance of the treatment plant is very satisfactory.

3) Waste water Generation

The existing potable water service area of NCD has a system to collect and dispose the sewage/waste water generated.

The waste water collected from the coastal service areas is discharged into the sea without treatment, as ocean outfall. While waste water collected from the inland service areas, constituting the major portion of collected waste water, is treated in lagoon systems (oxidation ponds) at three (3) locations - Waigani, Morata and Gerehu. Among these lagoons, Waigani Lagoon is the largest treatment system (ref., Fig. J.1 and Fig. J.2 of Appendix-J).

All treated effluents of these three lagoon systems are discharged into the vast wetland and lake area, known as Waigani Swamp, that stretches for an area of about 500 ha.

Most ocean outfalls are not satisfactory even from sanitary aspects, as their final disposal locations are near the coast. This results in a potential public health hazard as well as coastal pollution.

The treatment efficiency of the largest Waigani Lagoon is also unsatisfactory. This is evident from both extensive generation of foam in the treated effluent and hyper-eutrophication in the final receiving body, the Waigani Swamp.

Accordingly, the existing sewerage system is evaluated as unsatisfactory and requires rehabilitation.

10.2.2 Future Condition

1) Surface Water Intake

The total future (2015) raw water requirement of about 4.4m^3/s (380 mld) for potable water supply will be abstracted from the Rouna 1/3 and Rouna 4 head ponds. The termination of Bomana pump intake will not only economize the operation. This in an environmental improvement around Bomana pump facility in comparison to existing condition.

The raw water abstraction of 4.4m^3/s is a significant 43% of the normal dry weather flow of 10m^3/s in Laloki river. A 15 km reach of Laloki river between the Rouna 1/3 intake and its confluence with Goldie river will not, however, be subjected to this reduction in natural river flow because the raw water will be converted from the amount currently used for hydropower generation.

Therefore, no adverse effects on river ecology, including adverse effects on aquatic flora and fauna are anticipated, due to the reduction in river flow. However, future abstraction for other beneficial uses in the above reduction river flow reach of 15 km need by the Bureau of Water Resources (BWR).

2)Treatment Plant

The future (2015) potable water demand of 380 mld will be met by two (2) separate treatment plants. The existing treatment capacity of Mt. Eriama plant will be expanded from 136 mld to 180 mld. A new treatment plant located on a hill near the Airport at Nine Mile will meet the remaining capacity requirement of 200 mld.

Both plants will distribute the treated water through gravity to two (2) independent service areas.

Very similar hill topography of both plants in turn facilitates similar design, operation, and maintenance of both plants, including raw water sludge management.

Accordingly, operation and maintenance skill acquired at the Mt.Eriama plant can be used for both plants in future. No significant adverse effects to the surroundings of both plants, and the existing Eriama plants, are anticipated even in future.

The hill at the Nine Mile location of the new treatment plant, is an uninhabited open area belonging to the Government of PNG. Hence, no social issues such as land acquisition, house compensation and resettlement, are involved.

3) Waste water Generation

Increased waste water generation due to increased potable water supply will require expansion of the existing sewerage system. This has to be addressed by future sewerage development programs.

10.2.3 Conclusion

The environmental effects of the proposed master plan, in comparison to the existing conditions, are summarized in Table 10.2.1.

All potential negative environmental effects are evaluated as manageable and insignificant.

Waste water generated, as a consequence of the water supply, and its subsequent disposal in a sanitarily and environmentally acceptable manner, is a major concern requiring appropriate management. This is not just due to the anticipated future increase in waste water generation, but due more to the deficiency in the existing waste water management system.

A master plan study of sewerage rehabilitation and development in NCD area, must be implemented by NCDC as a follow-up to this water supply rehabilitation and development master plan.

PART 2 FEASIBILITY STUDY

1 INTRODUCTION

As a result of a study of the master plan, the framework of the feasibility study was finalized as follows:

a) Target Year	: 2000
b) Projected Population in the year 2000	: 314,300
c) Projected Demand in the Year 2000	: 220,000 m^3/day (Daily Maximum)
d) Proposed Water Production in the year 2000	: 280,000 m^3/day (including the existing 136,000 m^3/day capacity)
e) Proposed Works	: 1) Intake Facilities at Rouna 4 Head Pond 2) Raw Water Mains to Mt. Eriama and 9 Mile WTP 3) Mt. Eriama Pumping Station 4) Expansion (44,000 m^3/day) of the Mt. Eriama WTP 5) New 9 Mile WTP (100,000 m^3/day) 6) Related Transmission and Distribution lines 7) Erima Service Reservoir

This report mainly presents the details of the feasibility study (the study) and consists of six chapters. Chapter 2 mentions the engineering details of the proposed work (hardware aspects of the study). Chapters 3 and 4 describe the study from the view points of management and operation/maintenance (software aspects of the study). Chapter 5 presents the cost of the study and its implementation schedule. Finally, project evaluations from three different angles, namely, financial, economic, and environmental aspects are presented in Chapter 6, to demonstrate the feasibility of the proposed work.

2 ENGINEERING DESIGN

2.1 Major Works

The following facilities are fully considered and designed in the feasibility study.

1) Rouna 4 intake :	New intake facilities at Rouna 4 head pond, land owned by ELCOM. Design intake amount is 293,400 m^3/day. (380,000 X 1.03 - 98,000 = 293,400 m^3/day)
2) Raw Water Main :	Rouna 4 to Mt. Eriama water treatment plant and 9 Mile water treatment plant. Design Capacity is 293,400 m^3/day.
3) Mt. Eriama Pumping Station:	Boost the water from raw water main to Mt. Eriama water treatment plant. Design capacity is 87,400 m^3/day.
4) Mt. Eriama water treatment plant :	Total design capacity is 180,000 m^3/day. An expansion of 44,000 m^3/day is proposed.
5) 9 Mile water treatment plant :	New Water Treatment Plant near 9 Mile. Design capacity is 100,000 m^3/day.
6) Erima Reservoir :	New reservoir at Erima district. Design capacity is 13,000 m^3.
7) Transmission & Distribution Pipes :	Lay new pipes or replace lines for the proposed facilities.

Fig. 2.1 shows the schematic drawings of the above facilities.

Before discussing the engineering details, it should be noted that land issue in PNG is a major hindrance to development. Therefore, in this study, Government-owned land (9 mile water treatment plant, Mt. Eriama pumping station, Erima reservoir) or road easements (raw water main, transmission lines) were chosen for the proposed facilities. However, the actual land owners with titles must be identified and the detailed documentation for the land acquisition for the project must be checked before starting the construction work.

2.2 Intake Facility

2.2.1 Rouna 4 Head Pond

The pond is owned by ELCOM for hydroelectric generation purpose. This consists of an inflow open channel, outflow pipe for the generators, and spillway with the pond, as shown in Fig. 2.2.

After several discussions with ELCOM representatives, the following were confirmed:

1) Rouna 4 head pond is maintained by desludging every 5 years. At that time, the pond is emptied for 4 to 5 days.

   Desludging pumps can be used to prevent the pond from being emptied, but these pumps do not work efficiently, from past experiences at another pond (Rouna 1-3 pond). Thus, raw water can not be taken directly from the pond.

2) Inflow water is estimated between 4.5 m^3/sec to 22.0 m^3/sec.

2.2.2 Design

Due to the previously mentioned restrictions, the following points may be noted. Firstly the intake point should be at the inflow channel. Secondly, a means to prevent the water from flowing into the pond during the desludging process are necessary. Thirdly, the design has to cope with the range of inflow volume (4.5 m^3/sec to 22.0 m^3/sec). Therefore, the weir and intake mouth are designed here.

It was agreed that all intake facilities should be set up in ELCOM owned land.

(1) Intake Weir

Design Considerations

a) The designed intake water level at the intake mouth has to be guaranteed all the time.

b) At the weir, the expected maximum flow (22.0 m^3/sec) has to be ensured.

c) It should be possible for the weir to move the sludge accumulated in it.

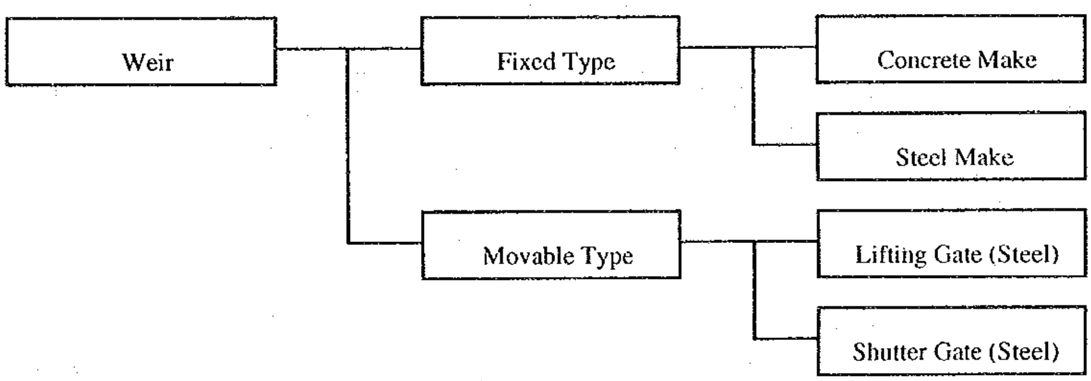
d) The construction period must be within 4 to 5 days, since the period must preferably be during ELCOM's desludging process.

It is recommended that the location of the weir be at a point near the pond from the design consideration given in c).

The height is calculated as 1.0 m from the point a) (with the assumption of inflow and velocity at the intake mouth). On the other hand, since the expected maximum flow is 22.0 m^3/sec, the depth of overflow at the weir (1.0 m height) from b), is calculated as 1.5 m. The expected maximum depth is 2.5 m at the weir, which is below the surface of inflow channel by 0.2 m. Hence, the height of the weir is 1.0 m.

Type of Weir

Generally, the weirs are categorized as below,



A movable type weir is recommended for handling the accumulated sludge. Since the cross-section of the inflow channel is a trapezoid, a partially movable weir is recommended for dispersing the sludge. The part around the center of the weir must be movable and the other part should be fixed (partially movable on the fixed type, see Fig. 2.2). The material of the fixed type of weir must be steel because of the restriction given in d), i.e., construction period must be within 4 to 5 days. Regarding the gate of the movable part, the shutter gate must have base construction at the bottom of the inflow channel. This violates the restriction on the construction period. However, the lifting gate clears the restrictions c) (sludge consideration) and d) (construction period). Hence, a lifting gate is proposed for the design.

(2) Intake Mouth

Design Considerations

a) It should cope with the spillway level of the pond.

b) It should be free from sand and soil accumulation and convenient for maintenance and care.

c) It should have sufficient capacity to divert the flow to the headpond during ELCOM's desludging process. In other words, it must prevent water from flowing into the pond.

d) Construction period should be within 4 to 5 days (same reason as specified before).

The intake can be located at the inflow channel,. However in this case, it is difficult to satisfy the restriction on construction period. Thus, access track to the inflow channel as shown in Fig. 2.2 is selected as the location, from the ease of construction and economical aspects.

To meet the requirement b), screen and desludge pit are recommended. A stop log for the desludging process is also preferable. To get the required amount of water, a two-parallel intake mouth structure is recommended.

For drainage of water during desludging works, a drain pipe from the intake to the bottom of the spillway (around 200 m) is considered.

2.3 Raw Water Main

The route and the number of lines (single or double) of the raw water main has a considerable impact on the cost and maintenance.

Due to the location (elevation) of Rouna 4 Head Pond, a pumping station is required to boost the raw water to Mt. Eriama WTP. The following section compares three alternatives of raw water main systems, viz., routes of raw water main with a pumping station.

2.3.1 Alternatives

To minimize the land acquisition problem, the two routes mentionede below are considered for the raw water main.

- Road easement of the Rouna Road
- Easement of the existing raw water main (from Rouna 1-3 Head Pond to Mt. Eriama water treatment plant)

Two locations for the pumping station along the proposed routes are considered here.

Location 1: Point I in Fig. 2.3. Usage of the existing 750 mm raw water main to Mt. Eriama (see Alternative C).

Location 2: Just before the Mt. Eriama WTP along the proposed line (see Fig. 2.3).

Accordingly, the next three alternative routes with pumping station are considered (see Fig. 2.3). The route from the branch (point IV) to Mt. Eriama WTP is along the existing access road to the WTP.

Alternative A : Along the road easement of Rouna Road (from Rouna 4 Head Pond to 9 mile water treatment plant)
Pumping station is at Location 2, lifting 87.4 mld.

Alternative B : Rouna 4 Head Pond to the point I - Road easement of Rouna Road
Point I to Point III - Existing raw water main route
Point III to 9 Mile water treatment plant - Road easement of Rouna Road (through point V)
The location of pumping station, lifting 87.4 mld, same as alternative A.

Alternative C : Rouna 4 Head Pond to the point I.
The existing 750 mm line is used from point I to Mt. Eriama WTP through a pumping station, lifting 87.4 mld plus 98.0 mld. The latter comes from the Rouna 1/3 head pond.

Points I to V are shown in Fig. 2.3 and points II, III, and V are decided, based on hydraulic conditions and the length of the routes.

Table 2.1 shows comparison of costs of the alternatives (A, B and C). Mild Steel Pipe with inner cement lining (MSCL) is selected considering cost performance. The cost consists of pipe installation and pumping station costs.

The Rouna Road has undulations or zigzags in parts, which can affect construction considerations. However, in alternative A, the access road is unnecessary. This may relate to the overall construction period or ease of execution. Alternative C has smaller pipe cost due to utilization of existing 750 mm line, but needs large pumps, which increases the running cost. The cost of alternative A is the lowest among the alternatives.

Table 2.2 shows the result of the comparison, based on Net Present Value (NPV).

Table 2.1 COST COMPARISON OF THE ALTERNATIVES

Unit ; 1000 Kina

	Alternative A	Alternative B	Alternative C
Rouna 4 to Branch *	1600 mm 11.2 km	1600 mm 11.5 km	1600 mm 4.0 km
Cost	21,029	23,253	8,090
Branch * to Mt. Eriama	900 mm 2.0 km	900 mm 1.3 km	Use existing 750 mm pipe
Cost	2,054	1,335	0
Branch * to 9 Mile	1350 mm 4.6 km	1350 mm 4.5 km	1350 mm 11.8 km
Cost	9,012	7,510	19,690
Cost of Pipes	32,095	32,998[1]	27,780
Pumping Station (PS) Location Flow Total Power Total Head	 Location 2 87,400 m^3/day 1120 kW 50 m	 Location 2 87,400 m^3/day 1120 kW 50 m	 Location 1 185,400 m^3/day 6500 kW 185 m
Cost of Pumping Station	3,320	3,320	15,000
TOTAL COST	35,415	36,318	42,780

* Branch: Branch IV (Fig. 2.3) in alternative A
Branch III (Fig. 2.3) in alternative B
Branch I (Fig. 2.3) in alternative C

Even if the running cost is not considered, alternative C gives a high cost. In this comparison, also, alternative A shows the lowest value. Hence, Alternative A is selected for raw water main system from technical and economical aspects.

2.3.2 Cost Comparison (Double and Single Line)

Generally, there are double or single line systems for raw water main. Obviously, each system has advantages and disadvantages from the technical and economical viewpoints.

From the field survey along the proposed route (Rouna Road), the only existing underground line is the telephone cable, which was laid in the southern road easement. The single line can be laid on the other side of the easement (northern one). For the double line, the road way have to be crossed and will require more time for obtaining permission from

[1] The access road (6 km) cost is included.

the landowners. It has been found by surveys that the center of the road is not consistent with the center of the road easement in some parts, which means the width at the edge of the road is not the equal on both sides. This may have an impact on the selection of routes, in the case of the double line. Therefore, from the construction point of view, a single line is advantageous. Other factors governing this choice are economical aspects and system reliability.

Table 2.2 COMPARISON IN NPV

Unit: Thousand Kina

		A	B	C
1	1995	13,201.50	14,854.00	7500.00
2	1996	13,201.50	13,954.00	15590.00
3	1997			
4	1998			9845.00
5	1999	9,012.00	7,510.00	9845.00
6	2000			
	TOTAL	35,415.00	36,318.00	42,780.00
	NPV	28,507.44	29,698.99	32,539.72

Note: 10 % of discount rate is used for calculation.

Table 2.3 shows the cost comparison. The cost of double line is naturally more than the single line by about 10 million Kina. Table 2.4 shows the cost on a Net Present Value base. Discount rate was considered as 10 %, which is the standard rate at the moment in Port Moresby. The assumptions made for calculating the NPV are :

a) Expansion of the Mt. Eriama treatment plant is implemented in 1995 and 1996,

b) First stage of the Nine Mile treatment plant would be in 1999 and

c) Second stage of the Nine Mile treatment plant would be from 2002 to 2005.

The above is derived from a balance between demand and supply.

In the NPV base, the single line costs less than a double line by about 1 million Kina. Though the double line system has more reliability, in this situation single line is preferable. In case of system failure on the single line, some amount of water can be transferred from the existing 750 mm raw water main. It is estimated that about 25 percent of the new single line capacity will be covered by transfer, in this situation.

From the above discussion, a single line for the raw water main is chosen.

Table 2.3 COST COMPARISON (SINGLE OR DOUBLE LINE)

Unit: 1000 Kina

	Single	Double
Rouna 4 to Branch	1600 mm 10.4 km 21,029	1200 mm 20.8 km 27,960
Branch to Mt. Eriama	900 mm 2.0 km 2,054	900 mm 2.0 km 2,054
Branch to 9 Mile	1350 mm 5.4 km 9,012	1100 mm 10.8 km 13,534
	32,095	43,548[2]

Table 2.4 COST COMPARISON IN NPV

Unit: 1,000 Kina

	Year	Single	Double
1	1995	11,541.50	7,503.50
2	1996	11,541.50	7,503.50
3	1997		
4	1998		
5	1999	9,012.00	6,767.00
6	2000		
7	2001		
8	2002		10,887.00
9	2003		10,887.00
10	2004		
	TOTAL	32,095.00	43,548.00
	NPV	25,626.45	26,920.39

[2] The pavement cost is included only for one line.

2.3.3 Others

There are two types of installation methods for the raw water main, namely, laying under or above the ground. Laying under the ground is definitely safer than laying above the ground but it is difficult to execute, especially when the ground is rocky. Since the existing raw water main was laid under the ground, except for the rocky parts[3], no major problems will be encountered in laying the proposed raw water main under the ground (the soil structure is the same in the area around the existing main and proposed main routes).

As far as pipe attachments are concerned, sluice valves should be installed at the points where the pipe branches out or water flows in or out from the facility. Moreover, a distance of 3 km between the sluice valves is recommended which will enable a quick response to in case of accident in the raw water main. The air valves should be installed in a convex part of the pipeline. Drainage facilities are also recommended for the hollow part of the pipeline, or in the vicinity of a river.

For the raw water main, the material chosen was mild steel pipe with cement inner lining.

2.4 Pumping Station

2.4.1 Location Of Pumping Station

Since the raw water main to Mt. Eriama water treatment plant will be installed along the existing access road from Rouna Road to the water treatment plant, the location of the pumping station will be around the proposed raw water main line.

The ground level of the access road rises from 40 m at the base of the road to 160 m at the Mt. Eriama water treatment plant. On the other hand, an appropriate height of the pumping station would be about 90 to 110 m (GL), from the following considerations,

a) Required suction head is 5 to 10 m.
b) A smaller discharge head is better.
c) Should meet Hydraulic conditions.

A field survey around the area indicated that NCDC is planning to build a chemical shed at point A in Fig. 2.4, and the land for the chemical shed is already under the name of NCDC. It was agreed that the pumping station would be built just south of the chemical shed, where

[3] The existing pipes are laid under ground for the section particularly between around the Rouna 4 head pond and the Mt. Eriama treatment plant

there is adequate empty space. This location is about 30 m higher from the access road and is at a ground level of 93 m, which satisfies the above mentioned conditions.

2.4.2 Pump Specification

The design of the pumping station is based on the daily maximum rate (87,400 m^3/day) and the total head is 50 m (to reach a level of 170 m at the treatment plant from the level of 90 m at the pumping station, 80 m head is required at the pumping station. Using the remaining head of 30 m in the raw water main, a 50 m head pump is required). A booster pump was selected considering economic aspects. Accordingly, the type of pump to be used is a horizontal axis pump. For a horizontal axis pump, since the pump and electromotor are aligned horizontally, pump maintenance is easier compared to the vertical axis type.

The total number of pumps is four, including one standby pump.

Countermeasures for water hammer usually require installing surge tank or flywheel. The flywheel is chosen here for economic reasons.

Power service line to the pumping station is the responsibility of NCDC.

The summary of specifications of the pumping station are given below,

a) Size of pumping station 18 m in width and 30 m in length

b) Pump

Type:	Horizontal axis, double-suction volute pump
No. :	4 pumps including 1 standby pump
Discharge Volume:	20.2 m^3/min./unit
Head:	50 meters
Diameter:	400 mm for suction side
	300 mm for discharge side
Electromotor :	Three phase, 415 V
	280 kW/unit

c) Electric equipment

- Incoming power receiving panel
- Pump starter panel
- Auxiliary relay panel
- Monitoring & control panel

2.5 Mt. Eriama Expansion Works

2.5.1 Introduction

From the investigations for the master plan, it was found that the existing Mt. Eriama water treatment plant has an advantage in its elevation enabling it to supply water by gravity to the 'high supply zone' (basically, area above 60 m elevation) in the future. Thus, the expansion work of Mt. Eriama is designed to meet the future demand.

The Mt. Eriama water treatment plant was constructed in the following stages:

Stage	Year	Design Capacity
Stage 1	1964-1965	27,000 m^3/day
Stage 2	1967-1968	41,000 m^3/day
Stage 3	1976-1977	68,000 m^3/day

The total design capacity is 136,000 m^3/day,. However, present capacity is below this level, mainly due to the aging and broken equipment. From our field survey, the following main problems were observed:

a) Mass balance of water is unknown because the outflow meter is out of order.
b) Water wastage at the filter. This could be caused by forced manual operation in the backwashing process. Valves, measuring instruments, and control panel for back-washing are out of order.
c) Monitoring system is out of order.

A part of the rehabilitation work for the existing water treatment plant was planned by NCDC and was finished in December, 1993. This work has been considered in our design as well. Our proposed total design capacity is 180,000 m^3/day.

Proposed expansion works are summarized below and shown in Fig. 2.5.
a) Construction of receiving well
b) Construction of a sedimentation tank (circular clarifier, same as the existing type)
c) Construction of filter basins (same as the existing type)
d) Expansion of drainage system
e) Expansion of chemical dosing equipment

Service reservoirs will not be expanded because the existing capacity is adequate even for the year 2015.

2.5.2 Receiving Well

The existing dividing well (flow splitter) is only for No.1 and No.2 clarifiers[4], However, the receiving well is recommended here for the following reasons:

a) To stabilize the level of raw water
b) To regulate and monitor the amount so that the subsequent purifying processes (4 clarifiers in future) of chemical feeding, settling, and filtration can be implemented with precision.

The common practice is to have a modest size and the capacity of the receiving well for economical reasons, so long as the objectives are attained. For this, a design detention time of 1.5 minutes and a depth of 5.0 m are recommended.

2.5.3 Circular Clarifier

The design of the proposed clarifier is the same as the existing one, namely, the high rate coagulo-sedimentation basin.

The total design capacity is 180,000 m^3/day as described already and the existing designed capacity is 136,000 m^3/day. Hence, the required capacity for sedimentation is 44,000 m^3/day.

2.5.4 Filter Basin

A gravity type filter basin is chosen, which is same as the existing one.

The required capacity of the filter basin is 62,000 m^3/day, including 10 percent extra capacity for washing and maintenance purposes.
(180,000 m^3/day x 1.1 - 136,000 m^3/day = 62,000 m^3/day)

The existing filters (No.3 to No.6) are relatively old.[5] No.3 & 4 are 25 years old and No.5 & 6 are 16 years old. Moreover, it is difficult to check and maintain the filter medias, as floc carry-over was observed in the sedimentation tanks. Therefore, it is highly likely that the filter media have mud balls or clogging. Considering these conditions and the fact that the existing filter capacity is below the designed capacity, the proposed works include

[4] No.3 clarifier recieves water directly from the raw water main.
[5] Nos. 1 and 2 were rehabilitated some 5 years ago.

rehabilitation of existing filters (No.3 to No.6), viz., rehabilitation of the filter media and underdrain systems.

2.5.5 Drainage System

In the current system, all waste water (drain and overflow water from sedimentation tanks, washing water from the filter basins) from the plant is drained to lagoons, which are located down to the east of the plant. From the field survey, the ratio of waste water was estimated as about 3 % (waste water amount / clear water amount).

A method for reducing this waste water ratio is by using a closed system, namely, by returning the waste water to the receiving well. However, it was chosen not for converting the existing system to a closed system, but for expanding the existing system for the reasons given below:

a) In a closed system, extra drain pumps and reservoirs will be needed.

b) Due to the expansion of the filter basin, the waste water ratio is expected to be reduced from 3 % to around 1.5 %.

c) The water at lagoons is being utilized for irrigation purposes.

2.5.6 Chemical Dosing Equipment

The chemicals for dosing are same used presently - aluminum sulfate (solid) as coagulant, slaked lime as alkaline agent and liquid chlorine as disinfectant. The locations for feeding these chemicals are summarized below.

a) Alum is added at the receiving well.

b) Slaked lime is added at the receiving well to enhance coagulation effect. Also, for the purpose of pH adjustment, the slaked lime should be fed to the existing filtered water duct.

c) Liquid chlorine should be fed to the existing filtered water duct. Also, pre-chlorination (feeding at receiving well) or intermediate-chlorination (feeding at collecting channels of the sedimentation tanks) facilities are provided for future possible use.

2.5.7 Electrical Equipment

For the expansion schemes previously mentioned, the following equipment are considered. These include a part of the equipment needed for rehabilitation of the existing facilities.

The following is the list of the panels to be installed at the new administrative building:

1	: Incoming power receiving panel
2,3	: Motor control center for sedimentation tank
4-12	: Motor control center for filters
13	: Motor control center for chemical dosing
14	: Motor control center for miscellaneous equipment
15	: Spare panel
16	: Lighting power receiving panel
17,18	: Motor control center for sampling pump
19 -21	: Auxiliary relay panel
22	: Uninterrupted power supply unit
23	: Battery
24	: Generator panel
25	: Supervisory panel
26	: Operation desk
27-29	: Telemetering unit
30	: Printer

The required instrumentation is described below.

1) Monitoring of incoming power line
2) Instantaneous flow rate of raw water
3) Accumulated flow of 2)
4) Water level of receiving well
5) Instantaneous flow rate of filtered water
6) Accumulated flow of 5)
7) Instantaneous flow rate of backwash water
8) Accumulated flow of 7)
9) Head loss of filter
10) Water level of clear water storage tank
11) Instantaneous flow rate of clear water
12) Accumulated flow of 11)
13) Instantaneous feed rate of chemicals

14) Accumulated flow of 13)
15) Instantaneous feed rate of chlorine
16) Accumulated flow of 15)
17) Telemetering unit

2.5.8 Administrative Building

The existing building does not have the facilities given below, which are required.

a) Office work space : business office, conference rooms, etc.
b) Public space : rest and recreation room, etc.

Also, the existing control room and water quality analysis room do not have adequate space. For these reasons, the new administrative building will be two stories high with about 10 m width and 20 m length for renewing equipment and observation of the plant. The existing buiding can be used exclusively for chemical dosing purposes.

2.5.9 Arrangement of Proposed Facilities

According to the stage 4 plan, which was planned in the past by NCDC, the proposed location of stage 4 clarifier was south of the existing No.1 and No.2 clarifiers, and the stage 4 filter basin was planned for construction east of the existing No.5 and No.6 filter basins.

In this plan, the water flow is unified in the north-south direction and the same facilities are integrated in the space with some benefits in maintenance. Hence, the locations of the proposed clarifier and the filter basins are based on the above criteria. The proposed receiving well can be located in the space between the No.3 and 4 clarifiers as shown in Fig. 2.6.

2.6 9 Mile water treatment plant

2.6.1 Introduction

The new 9 Mile water treatment plant was designed, based on the following concepts.

1) Designed capacity is 100,000 m^3/day for the feasibility study scheme (200,000 m^3/day in total under the master plan). However, the three facilities (receiving well, administrative building and chemical dosing building) are constructed for a capacity of 200,000 m^3/day.

2) Each facility is compactl at the same time the required water quality is satisfied.

3) Simplification of structure of facilities.

4) Design of parallel systematic water process with each series connected to each other, for safety during failure.

5) Redundant system adopted for electrical & mechanical equipment, and integrated in the available space.

From the above concepts, 2) is chosen mainly from economical aspects, 3) and 4) are related to the safety, control, and administration of the system.

In terms of 4) (concept of series process), sedimentation basins and filter basins are divided into 4 series for the master plan design capacity (200,000 m^3/day).
Thus each series will have a capacity of 50,000 m^3/day. Two of these series are to be constructed (total is 100,000 m^3/day) in the scope of the feasibility study.

The location of the water treatment plant is discussed in the master plan study.

2.6.2 Proposed Facilities

In the feasibility study, the facilities given below are designed. The plant flow is shown in Fig. 2.7.

1) Receiving Well
2) Rapid Mixing Chamber
3) Flocculation Basin
4) Sedimentation Basin
5) Filter Basin
6) Chemical (Alum, Lime and Chlorine) Dosing Equipment
7) Clear Water Reservoir
8) Drainage System
9) Electric Equipment
10) Administrative Building

The sections given below describe design criteria for each of the facilities.

2.6.3 Receiving Well

The receiving well is designed to stabilize the water level and know the amount of water so that the subsequent purifying process can be executed with precision and ease. The detention time is selected as 1.5 minutes of the design capacity in the master plan scheme (200,000 m^3/day). A depth of 4 m is selected.

2.6.4 Rapid Mixing Chamber

In practice, colloidal particles do not settle because of the filtering mechanism of the rapid sand filter. Therefore, it is necessary to flocculate the colloidal particles and change their conditions for chemical settling and rapid filtration. The coagulation process consists of two stages. The first stage consists of coagulating the particles in tiny flocs by rapid stirring after adding coagulants, the second stage is slow stirring, forming the flocs to facilitate the subsequent settling and filtration.

A detention time of two minutes is designed for the rapid mixing chamber considering economic and the required chemical processes.

Flush mixer is one of the most commonly utilized equipment for mixing. It consists of a rotating vertical axis with several wings. The advantages of this type are reduced energy consumption and small head loss. Hence, the flush mixer was adopted here.

2.6.5 Flocculation Basin

The following were considered in the design.

1) Flocculation must be achieved by adequate stirring to grow the coagulated flocs to larger ones.

2) Stirring in the flocculation basin must be regulated for slow down as it goes downstream.

3) Detention time is 20 minutes to the design flow.

There are two types of stirring methods - mechanical flocculation and baffling.

a) Baffling [6] Vertical baffling type

[6] Use only water flow energy.

Horizontal baffling type
Mix of the two types mentioned above

b) Mechanical — Paddle type.

The baffling type has more head loss than the mechanical type. However, mechanical and electrical equipment are not necessary in the baffling type, which results in smaller initial and running costs. Moreover, in the baffling type, less maintenance work is required. Therefore, the baffling type is recommended.

As described above, there are three type of baffling methods. Since vertical baffling has less short circuits, it is considered as a basic method. The horizontal baffling type is also partially used in bends. (Mixed type was adopted here).

2.6.6 Sedimentation Basin

The types of sedimentation basins are,

1) High rate coagulo-sedimentation type (same as Mt. Eriama water treatment plant)
2) Conventional horizontal flow type

Generally, it is difficult to use high rate coagulo-sedimentation type in slurry control in the drainage process, especially when there is a large change in raw water quality scale. At Mt. Eriama water treatment plant, floc carry-over occurred and resulted in malfunction of the plant.

The conventional horizontal flow type comprises of a rectangular shaped sedimentation basin and a rake for desludging. This system has advantages because of its relatively simple mechanism and ease of maintenance. Due to this, the conventional horizontal flow type was designed with 30 mm/minutes of outflow rate.

2.6.7 Filter Basin

Filter basins are categorized as follows,

Rapid Sand Filter — Pressure Type
Gravity Type (single or multi-layer filter)

Slow Sand Filter

The slow sand filter has advantages such as ease of maintenance and steady effluent water quality. However, the raw water turbidity should be less than 10. Since the filtration rate of the slow sand filter is about 4 - 5 m/day, it needs 30 to 40 times larger area than a rapid sand filter. Thus, slow sand filter is not recommended.

Considering the rapid sand filter, the existing pressure-type facilities of Mt. Eriama water treatment plant have not been functioning satisfactorily as noted before. Especially, there is difficulty in directly observing filter media. Hence, the gravity type is designed.

As far as filter material layers are concerned, there are single-material layers and multi-material layers. The multi-material layer has a higher filtration rate than a single-material layer. However, a single-material layer is designed here, considering ease of its maintenance. The depth of the layer is 60 cm, the filtration area per basin is 100 m^2 and the spare basin is designed with 10 % capacity for backwashing, changing filter material, and maintenance purposes. The filtration rate is designed as 150 m/day.

Backwashing and surface washing are other possible washing methods. The water for backwashing is designed to be stored at a tank (washing tank) for the sake of minimizing pump equipment for backwashing. The surface washing is carried out by washing pumps directly.

2.6.8 Chemical Dosing Equipment

The chemicals used are aluminum sulfate (solid), slaked lime and liquid chlorine, same as the Mt. Eriama water treatment plant. The feeding points are,

Aluminum Sulfate :	Mixing chamber
Slaked Lime :	Mixing chamber and chlorination chamber
Chlorine :	Mixing chamber, effluents of sedimentation basin, and chlorination chamber

The chlorination chamber is designed for a capacity of 5 minutes detention time of the designed capacity (of the feasibility study). The method for mixing is the the same as the one proposed for the flocculation basin. The chlorination chamber is located just after the filter basins.

2.6.9 Clear Water Reservoir

Effective capacity of the clear water reservoir is one hour storage of the planned quantity of filtrate plus the proposed capacity of a service reservoir (6 hours of the daily maximum demand) for the area directly delivered from the 9 mile water treatment plant. The required total capacity is 24,000 m^3 in the master plan scheme (2015). In the feasibility work, half the capacity is to be constructed (see Fig. 2.8).

2.6.10 Drainage System

As previously mentioned in the Mt. Eriama system, a lagoon type of drainage system is proposed here for the same reasons as before. A box culvert is designed for drainage.

2.6.11 Electrical Equipment

The power supply is 3-phase, 415 V, same as Mt. Eriama. It was agreed that the power line to the water treatment plant wll be the responsibility of NCDC.

The proposed loads (master plan schemes) for each equipment are as follows,

Mechanical equipment :	300 KVA
Chemical Dosing :	20 KVA
Power for Buildings :	100 KVA
Control Equipment :	50 KVA

The installation of these equipment is divided into three phases. In the first phase (1994 - 2000, feasibility study period), 80 % of these facilities are to be completed. Power receiving facilities are to be completed in phase one.

The power generator has a capacity of 150 KVA & 180 HP. The design criteria for the power generator is as follows,

- Power to lush mixer, sludge collector, chemical feeding system, and chlorination system are to be supplied by generator. In addition, at least the load of filter facilities for one basin should be covered by the generator.
- The capacity of the generator itself should be 90 kW.
- Gas turbine engine is recommended.

2.6.12 Administrative Building

The administrative building is designed to cayer to the following functions:

- Control & Operation rooms
- Water analysis laboratory
- Mechanical & electrical rooms
- Office space
- Public space

Since the chemical dosing facility is located in the administrative building at the existing Mt. Eriama water treatment plant, the chemical dosing building is designed separately for the 9 Mile water treatment plant.

The building will have two storeys and have a size of 30 m x 40 m.

2.6.13 Arrangement of Proposed Facilities

The following points are considered in the arrangement of proposed facilities at the site (leveled hill).

1) The direction of flow should be one-way, preferably from the water resource side to the distribution area.

2) To guarantee the stability of the structure, relatively large scale structures such as sedimentation basins, filter basins, and clear water reservoirs should be built on the cut area, not on the banking area.

3) For ease of control, the administrative building and the chemical feed building, rapid sand filter basins, and tanks or pumps for washing should be close to each other.

The proposed arrangement of the facilities is as shown in Fig. 2.8. In the figure, the shaded facilities are proposed for the feasibility study.

2.7 SERVICE RESERVOIR AND TRANSMISSION & DISTRIBUTION PIPES

2.7.1 New Water Supply System

The general explanations of proposed works for reservoirs and transmission & distribution pipes are fully explained in part one of the main report (master plan). As described in the master plan, zone, area, and block supply systems are proposed and their implementation schedules are given, including the area supply system (4 areas) to be completed in the feasibility study. The names of four areas are coastal south, coastal north, inland urban, and inland suburban areas. In the master plan, these areas are further divided into small blocks (block supply system). The corresponding zones (2), areas (4), and blocks (11) are summarized below.

Zone Name	Area Name	Block Name
High Zone	Coastal South	Boroko, Korobosea, 3 mile, Koki, and Town
	Coastal North	Waigani, and Hohola
Low Zone	Inland Urban	Gerehu, Erima
	Inland Suburban	9 Mile, Laloki

2.7.2 Service Reservoirs

There are 7 existing service reservoirs in the system with required capacity in the master plan scheme , which are assigned to High Zone. Thus there is no new reservoir planned for the High Zone. Additional 4 new reservoirs are proposed for the Low Zone in the master plan (Gerehu, Erima, Laloki, 9 Mile reservoirs). The 9 Mile reservoir is actually a clear water reservoir at 9 Mile WTP. Table 2.5 shows the required capacity (6 hours storage of the daily maximum demand) of new reservoirs by 5-year intervals.

Table 2.5 REQUIRED CAPACITY BY YEAR

Unit: m^3

Name	Total Capacity	1990	1995	2000	2005	2010	2015
Gerehu	11,000	3,821	4,829	5,190	6,655	8,728	10,806
Erima	13,000	7,484	9,484	10,087	11,197	12,400	12,763
9 Mile	24,000[7]	4,601	7,256	9,448	13,047	16,821	23,331
Laloki	9,000	65	410	932	2,029	4,030	8,714

In the feasibility study scheme, one service reservoir (Erima reservoir) is proposed for construction in 1997 to minimize the initial cost, except 9 Mile reservoir with 12,000 m^3. The designed capacity is 13,000 m^3. Fig. 2.9 shows the schematic layout of the future water supply system (zoning system). Fig. 2.10 describes the future system in terms of elevation.

7 Includes 1 hour storage (8000 m^3) of the planned quantity of filtered water.

2.7.3 Transmission and Distribution Pipes

The transmission lines to existing reservoirs (7 in total) and Erima reservoir are planned for construction by the year 2000. Zone distribution service (high and low zones) will start after the completion of the 9 Mile WTP. The proposed transmission (Fig. 2.11) and distribution pipes (Fig. 2.12) to be completed by the year 2000 (Phase 1) are summarized in the following three tables (Table 2.6(A),(B),(C)) .

Table 2.6 (A) Proposed Transmission Pipe

(meter)

Sys. Route	Dia. (mm)	Length (m)	Sys. Route	Dia. (mm)	Length (m)
High Zone (Mt. Eriama System)			Low Zone (Nine Mile System)		
Mt. Eriama Res. to Dia.1000 pipe	1000	20	9 Mile W.T.P. to H.M.HW.	1200	1,280
9 Mile to Hubert Murray Highway.	1350	2,180	H.M.HW. to 7 Mile	1100	2,000
H.M.HW to 7 Mile (along H.M.HW.)	1350	2,000	7 Mile to Erima Res.	700	440
7 Mile to Mokaraha Rd.	1000	3,560	7 Mile to Mokaraha Rd.	1000	3,560
Mokaraha Rd. to Waigani Drive	1000	1,400	Mokaraha Rd. to Gerehu Res.	800	3,620
Waigani Drive to Waigani Res.	800	2,940	H.M.HW. to Laloki Res.	600	213
Waigani Drive to Hohola Res.	600	3,000	subtotal		11,113
7 Mile to Boroko res.	900	3,300			
H.M.HW to Korobosea Res.	400	2,760			
subtotal		21,160	Total		32,273

Table 2.6 (B) Proposed Distribution Pipe
- Existing Urban Area -

(meter)

Reservoir Block	Route	Dia. (mm)	Leng -th(m)	Reserv. Block	Route	Dia. (mm)	Leng -th(m)
High Zone (Mt. Eriama System)				Low Zone (Nine Mile System)			
Boroko	H.M. HW. to Gordons	300	2,230	Gerehu	Gerehu res. to Gerehu drive	600	1,280
	near Boroko res. to Air port	250	570		Gerehu Drive to Tauramana Ave.	400	66
Korobosea	Korobosea res. to Horse cmp	300	2,400	Erima	Erima res. to B.P.Sogeri rd.	800	1,430
	Pari rd. to Pari	200	4,000		B.P. Sogeri rd. to Waigani Drive	450	2,260
3 Mile	3 Mile res. to Scratchley rd.	300	1,130		Waigani Drive	400	1,330
	Scratchley rd. to Horse camp	150	810		Waigani Drv. to Spring Garden rd	250	500
	Scratchley rd. to Gabutu	200	960		Erima	200	1,030
Koki	Konedobu to Hanuabada	250	1,620		B.P. Sogeri rd. to Mokaraha rd.	500	1,800
Waigani	Waigani res. to Waigani Drv.	500	250		Mokaraha rd. to Waigani rd.	350	69
	Waigani Drive to Sivari rd.	450	1,100		Mokaraha rd. to Curlew St..	300	600
	Sivari rd. to mountain pass	300	1,540		mokaraha rd. to Morata	300	960
	mountain pass to Tatana	150	3,620		Morata	150	1,200
	Waigani Drive to Koura way	500	159	subtotal			12,525
	June valley	150	980				
Hohola	Hohola res. to H.M. HW.	600	2,250				
	Ward rd. to H.M. HW.	400	2,060				
subtotal			25,679	Total			38,204

Table 2.6 (C) Proposed Distribution Pipes
- Development Area -

(meter)

	Zone	High					Low							Ratio	
	Diameter (mm)	100	150	200	250	total	100	150	200	250	300	400	total	High	Low
80	Gerehu	0	0	0	0		1,513	1,151	329	296			3,289	0.00	1.00
81	Waigani/University	356	270	77	70	773	1,420	1,082	309	277			3,088	0.20	0.80
82	Tokarara/Hohola	1,190	906	259	233	2,588	1,189	904	258	232			2,583	0.50	0.50
83	Gordons/Saraga	1107	842	241	216	2,406	0	0	0	0			0	1.00	0.00
84	Boroko/Korobosea	3,786	2,881	823	741	8,231	0	0	0	0			0	1.00	0.00
87	Laloki/Napanapa	902	686	197	176	1,961	6,616	5,035	1,438	1,295			14,384	0.12	0.88
88	Bomana	0	0	0	0	0	8,576	6,526	1,864	1,678	0	1,400	20,044	0.00	1.00
	Total	7,341	5,585	1597	1436	15,959	19314	14,698	4,198	3,778	0	1,400	43,388		

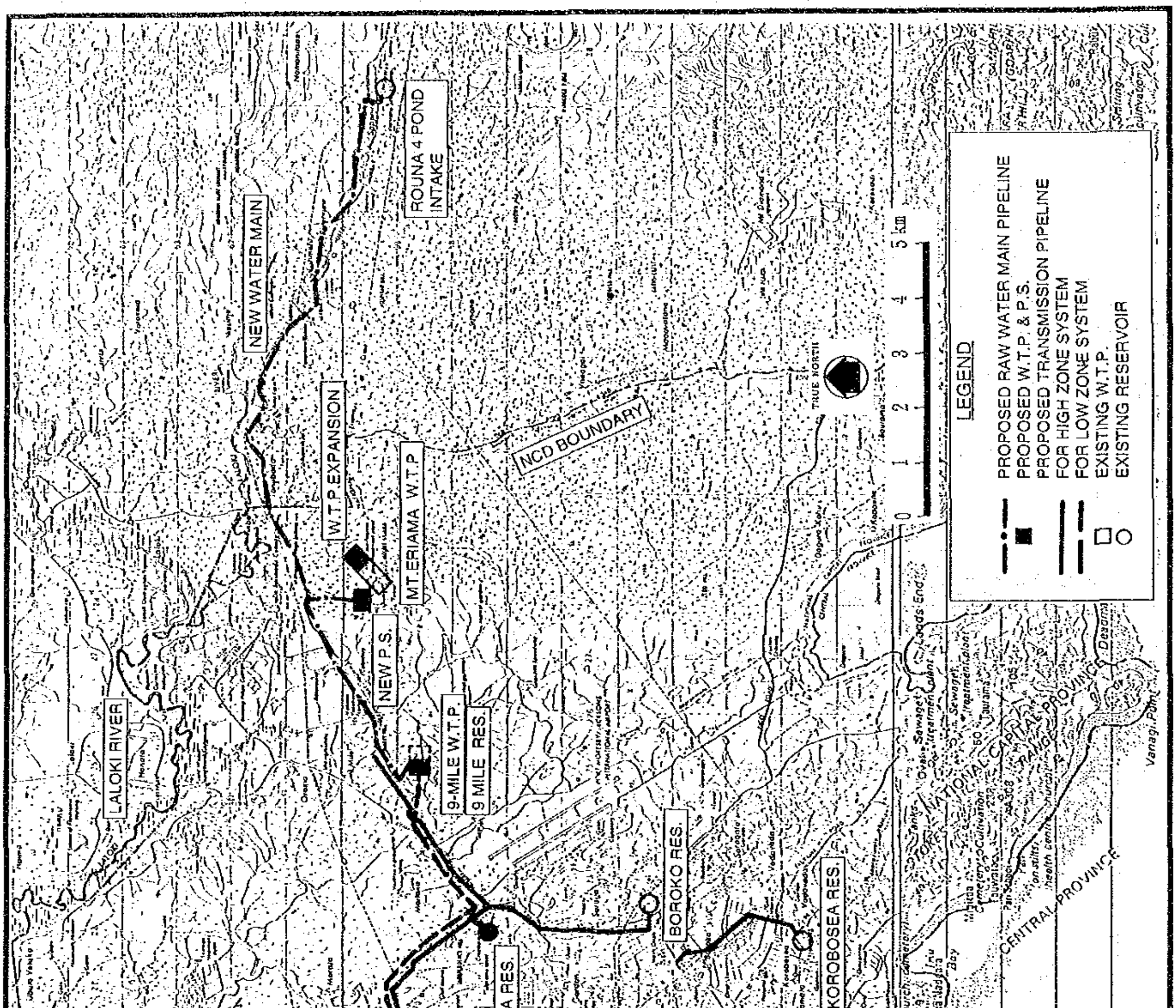
2.8 SUMMARY OF PROPOSED FACILITIES

Table 2.7 gives a summary of proposed facilities under the scope of the feasibility study.

Table 2.7 SUMMARY OF PROPOSED FACILITIES

	Type	Detention Time	Specifications
Intake			(Capacity 293,400 m^3/day)
Intake Weir	Partially Movable		W 5.5mxL 1.0mxH 1.0m
Intake Mouth			W 6.0mxL 14.0mxH 7.0m
Raw Water Main			(Capacity 293,400 m^3/day)
Pipe	Mild Steel with cement lining		1600 mm L=11.2 km
			1350 mm L= 4.6 km
			900 mm L= 2.0 km
			(Total L=17.8 km)
Pumping Station			(Capacity 87,400 m^3/day)
Pump	Horizontal Axis Double Suction Volute Pump		Discharge Volume 20.2 m^3/min.
			Head 50 m
			Electromotor 280 kW
			No. of Pumps 4 (1 standby)
Building			W 18.0 m x L 30.0 m S=1 A=540m^2
Mt. Eriama water treatment plant			(capacity 44,000 m^3/day)
Receiving Well		1.5 min.	D 7.0m x H 5.0m V= 192 m^3
Circular Clarifier	Clarifier	40 mm/min.	D 41.2m x H 6.4m A=1160 m^3
Filter basin	Pressure	194 m/day	W 3.82m x L 3.82m 12 cells/basin 2basins A=350m^2
Drainage System	Lagoon		W 12.5m x L 80.0m 4 basins A=4000m^2
Chemical Dosing Equipment	Alum,Lime, Chlorine		
Electrical Equipment			
Administrative Building			W10.0m x L20.0m S=2 A=400m^2
9 Mile water treatment plant			(capacity 100,000 m^3/day)
Receiving Well		1.5 min.	W4.5mx L6.0m x H4.0m 2 basins V=216m^3
Rapid Mixing Chamber	Flush Mixer	2 min.	W4.0mx L4.0m x H5.0m 2 basins V=160m^3
Flocculation Basin	Baffling	20 min.	W1.15mxL153.0mxH4.0m 2 basins V=1410m^3
Sedimentation Basin	conventional horizontal flow	30 mm/min.	W25.3mxL46.0m xH4.0m 2 basins A=2330m^2
Filter Basin	Gravity,Backwashing-tank	150 m/day	W 9.6m x L 10.0m 8 basins A=768m^2
Chlorination Chamber	Baffling	5 min.	W1.65m x L42.2mxH2.6m 2 basins V=362m^3
Clear Water Reservoir		1 hrs (6 hrs)[8]	W20.0mxL50.0mxH6.0m 2 basins V=12000m^3
Drainage System	Lagoon		W12.5m x L80.0m 5 basins A=5000m^2
Chemical Dosing Equipment	Alum,Lime,Chlorine		W12.0xL25.0m S=3 A=900m^2
Administrative Building			W30.0mxL40.0m S=2 A=2400m^2
Transmission Pipes	Mild Steel Pipe (D>700mm) Ductile Cast Iron Pipe		500 mm to 1350 mm 32.3 km
Distribution Pipes	Ductile Cast Iron Pipe		100 mm to 400 mm 97.6 km
Erima Reservoir		6 hrs	D 46.0m x h 8.0m V=13000 m^3

8 See section 2.6.9.



TITLE

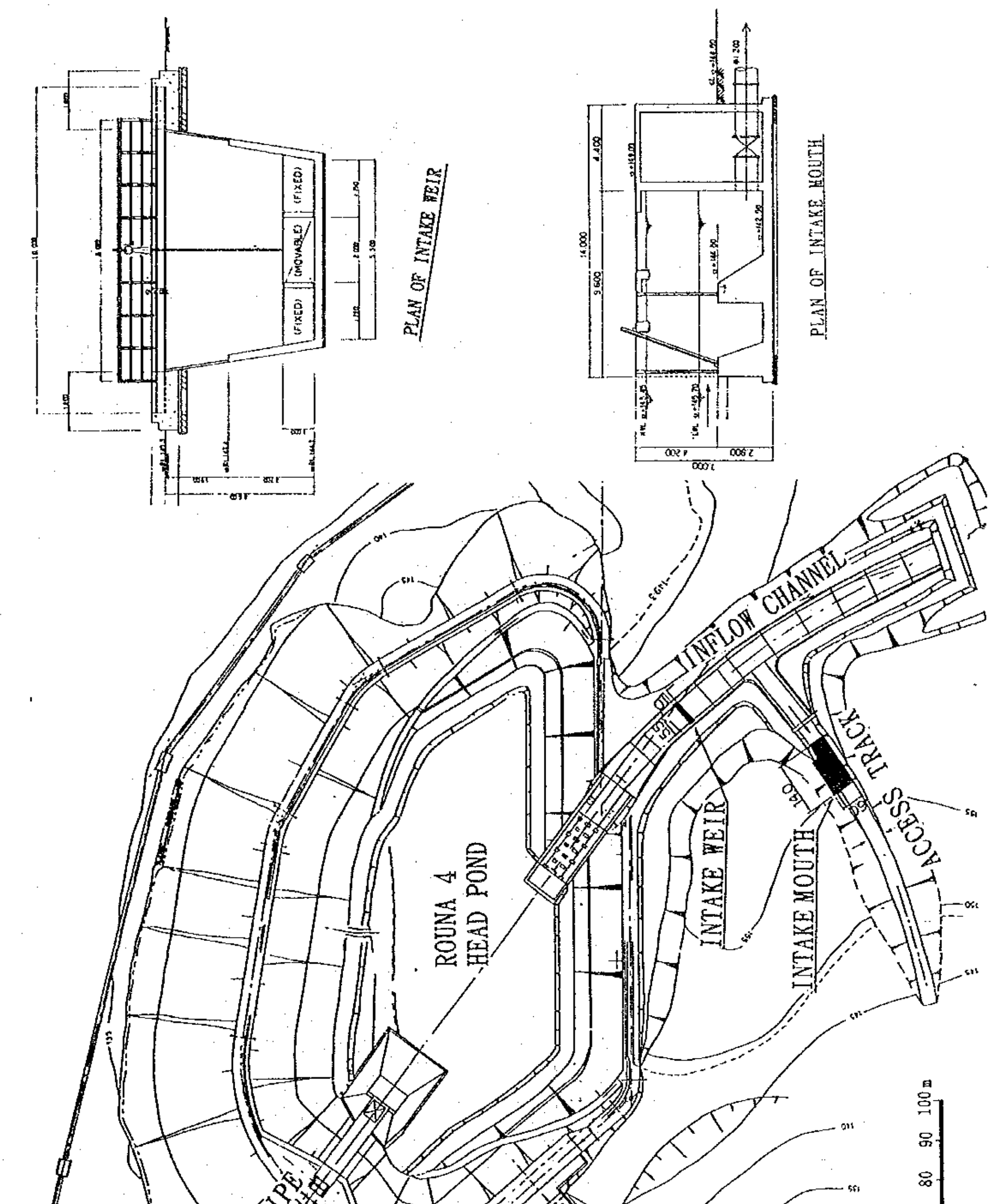
PROPOSED FACILITIES

Fig. No.

2.1

PORT MORESBY WATER SUPPLY DEVELOPMENT PLAN

TOKYO ENGINEERING CONSULTANTS in association with PACIFIC CONSULTANTS INTERNATIONAL



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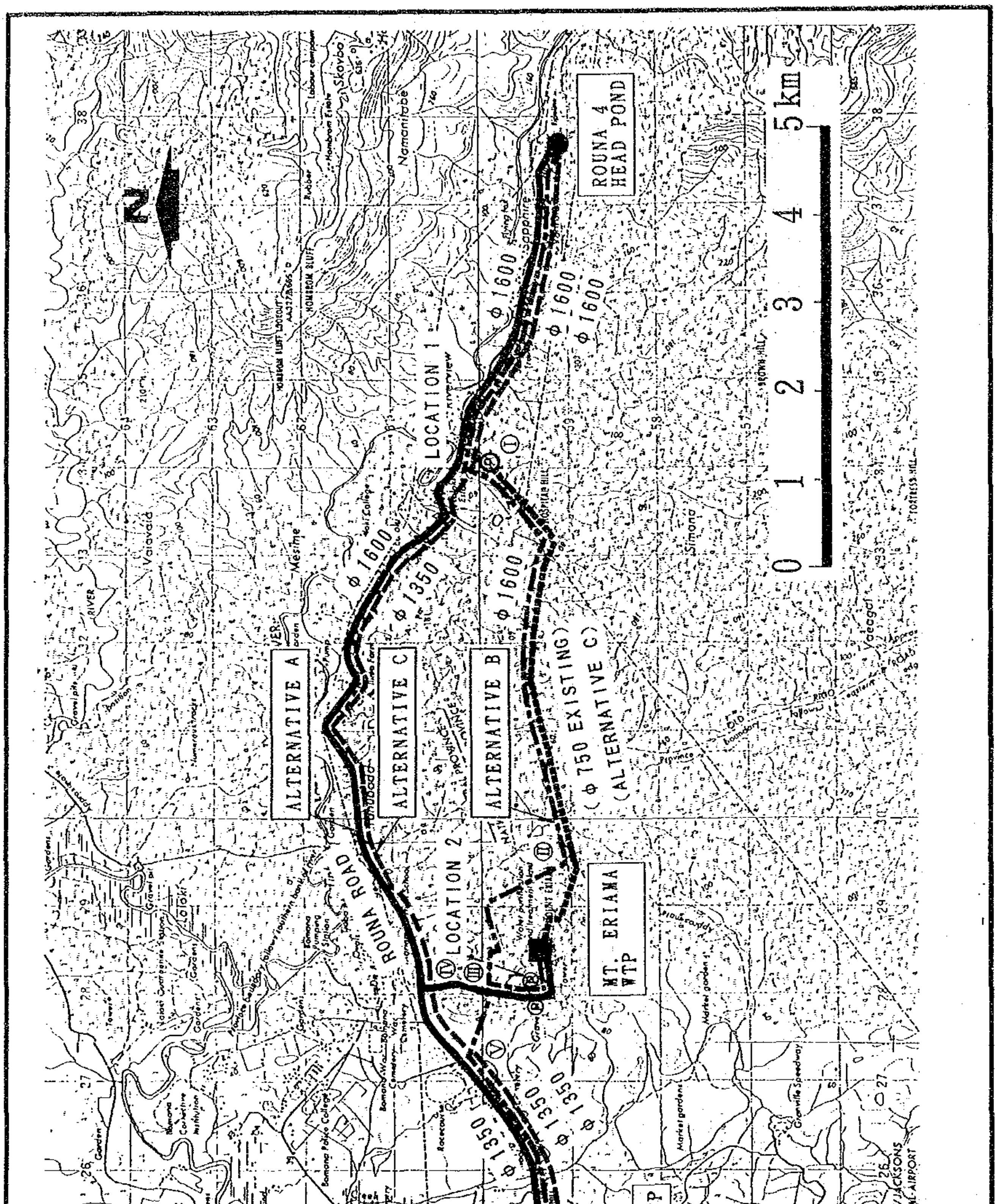
ROUNA 4 HEAD POND

Fig. No.
2.2

PORT MORESBY WATER SUPPLY DEVELOPMENT PLAN

TOKYO ENGINEERING CONSULTANTS in association with PACIFIC CONSULTANTS INTERNATIONAL



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ALTERNATIVE ROUTES OF THE RAW WATER MAIN

Fig. No. **2.3**

PORT MORESBY WATER SUPPLY DEVELOPMENT PLAN

TOKYO ENGINEERING CONSULTANTS in association with PACIFIC CONSULTANTS INTERNATIONAL

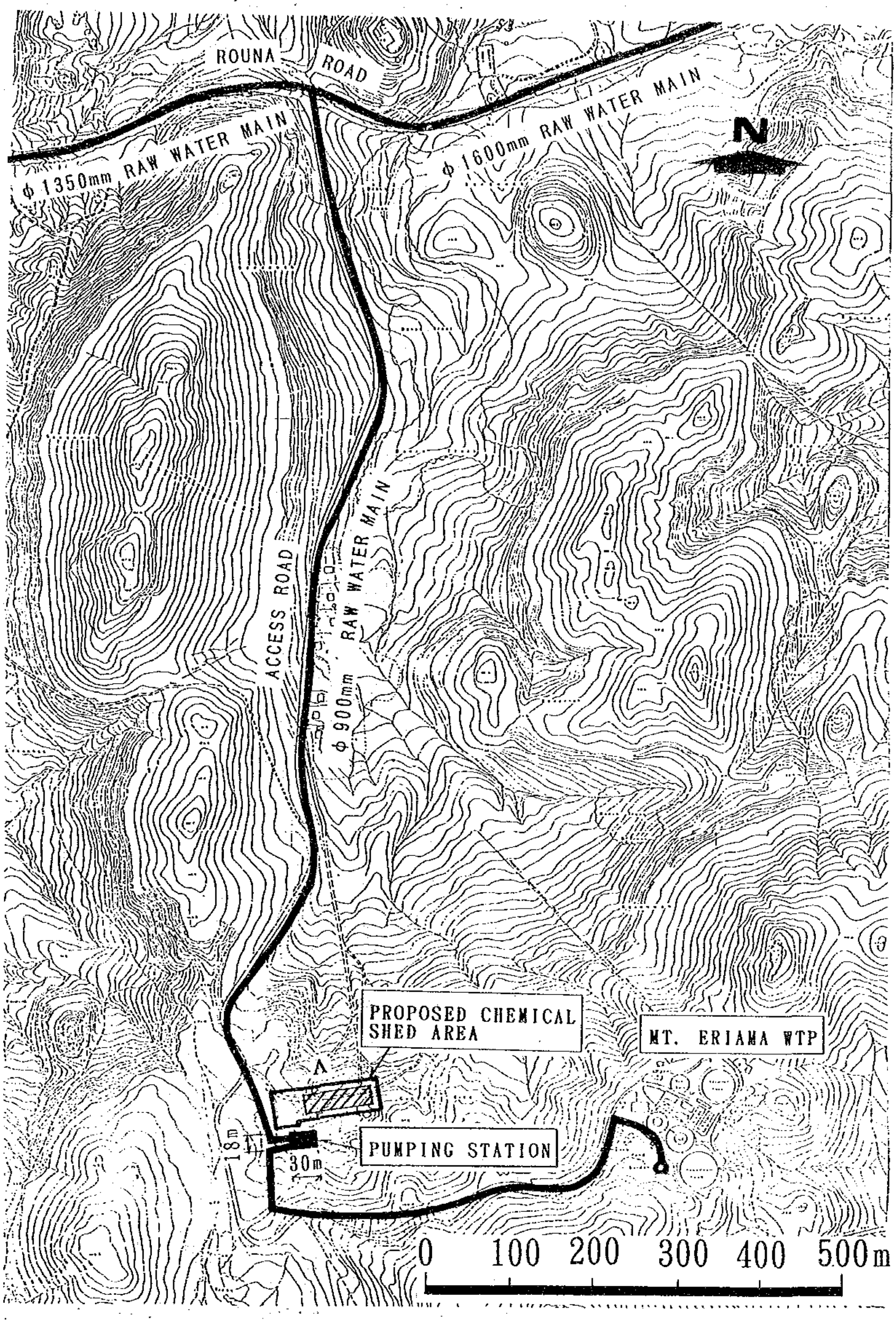

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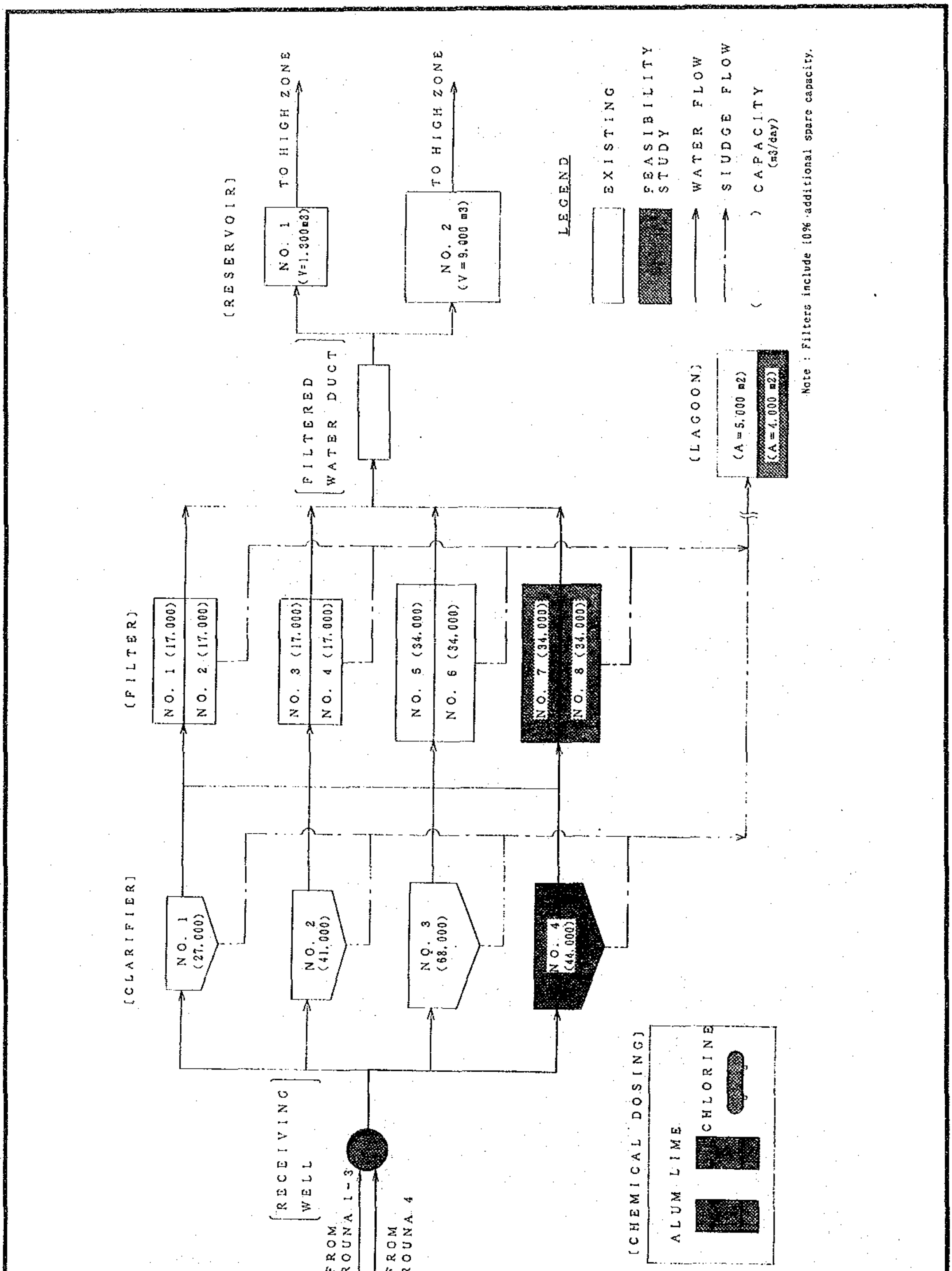
Fig. No. 2.4

PROPOSED LOCATION OF PUMPING STATION

PORT MORESBY WATER SUPPLY DEVELOPMENT PLAN

TOKYO ENGINEERING CONSULTANTS in association with PACIFIC CONSULTANTS INTERNATIONAL



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EXPANSION WORKS

Fig. No. **2.5**

PORT MORESBY WATER SUPPLY DEVELOPMENT PLAN

TOKYO ENGINEERING CONSULTANTS in association with PACIFIC CONSULTANTS INTERNATIONAL

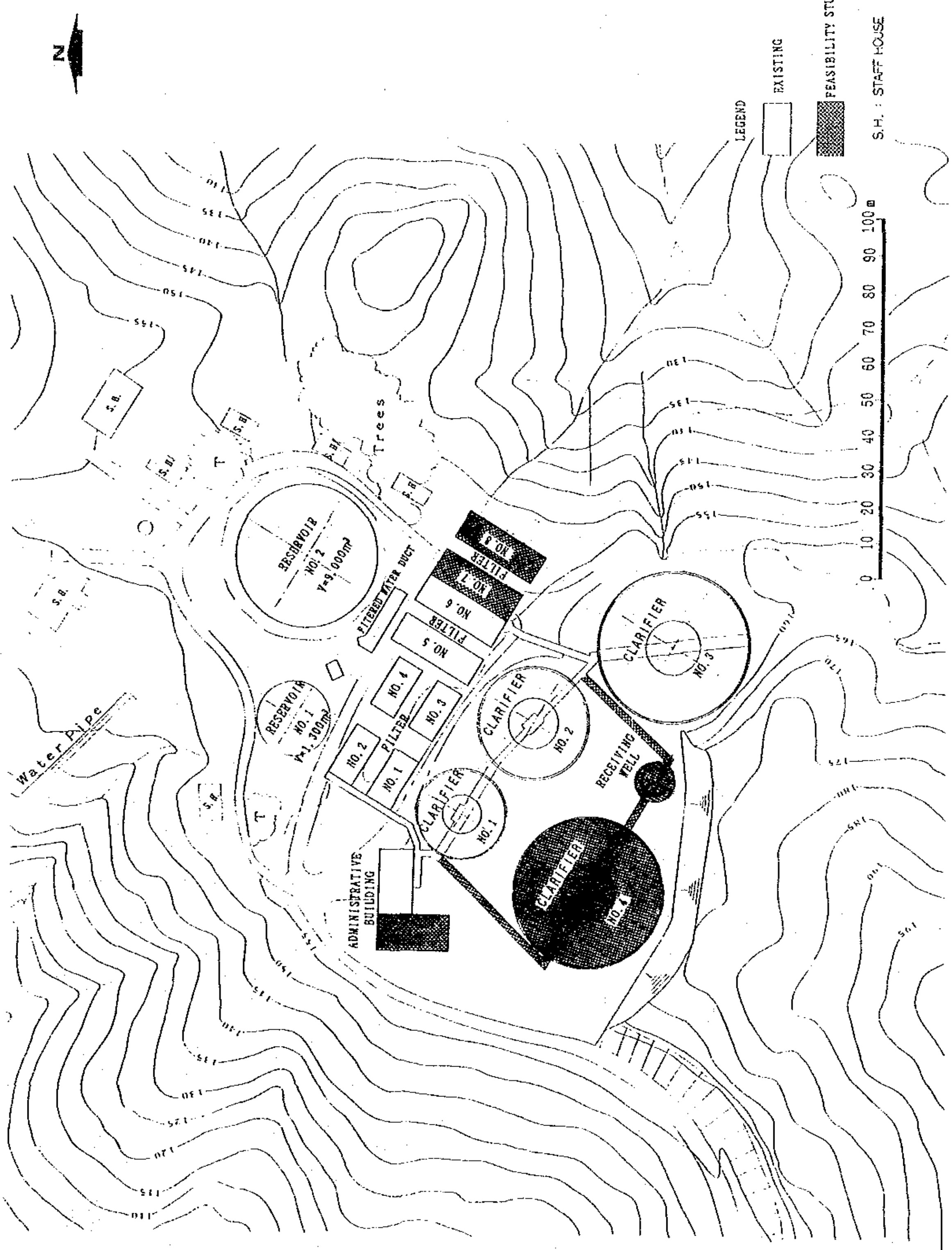

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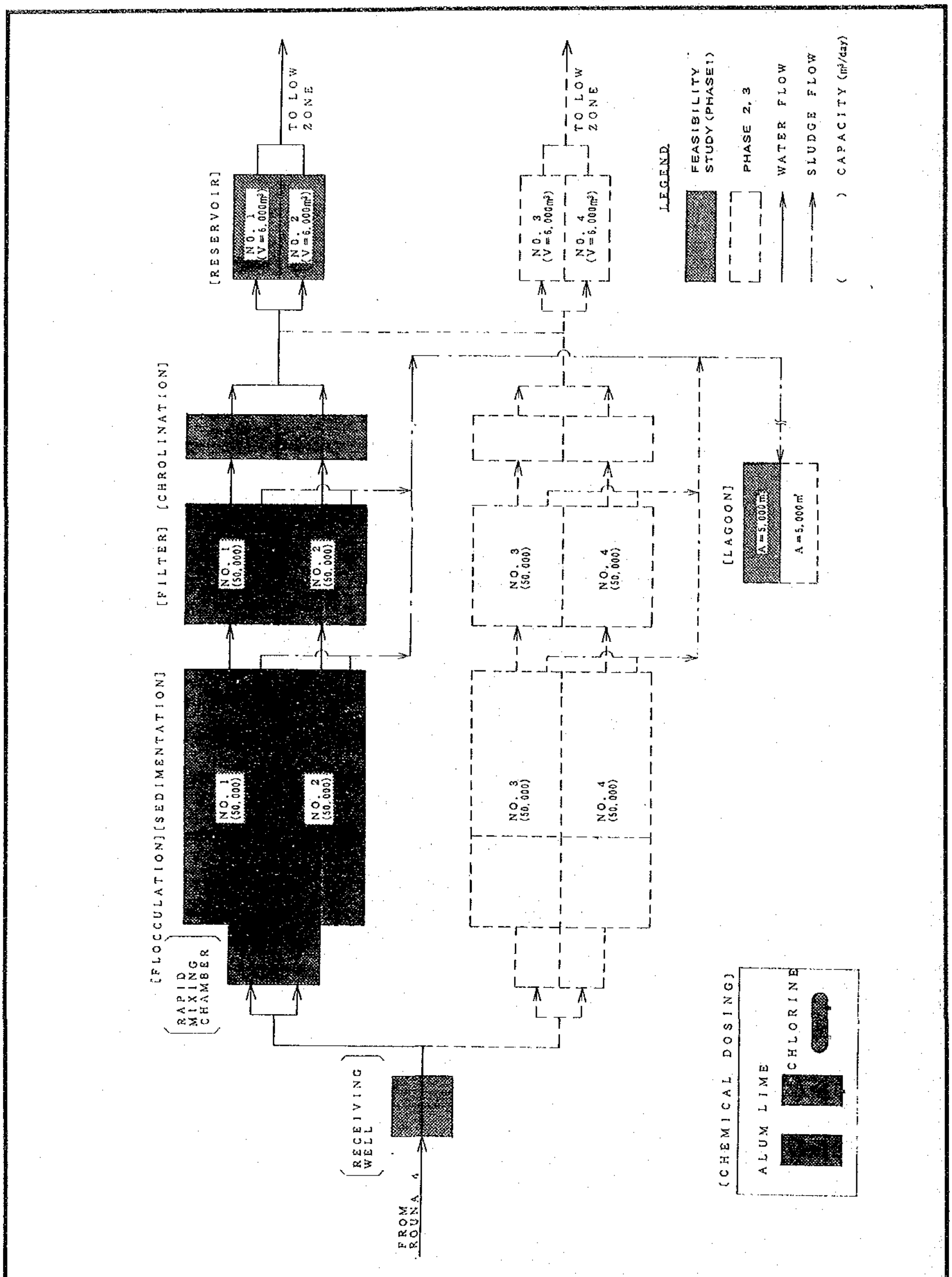
Fig. No.

PROPOSED FACILITIES FOR MT. ERIAMA TREATMENT PLANT **2.6**

PORT MORESBY WATER SUPPLY DEVELOPMENT PLAN

TOKYO ENGINEERING CONSULTANTS in association with PACIFIC CONSULTANTS INTERNATIONAL



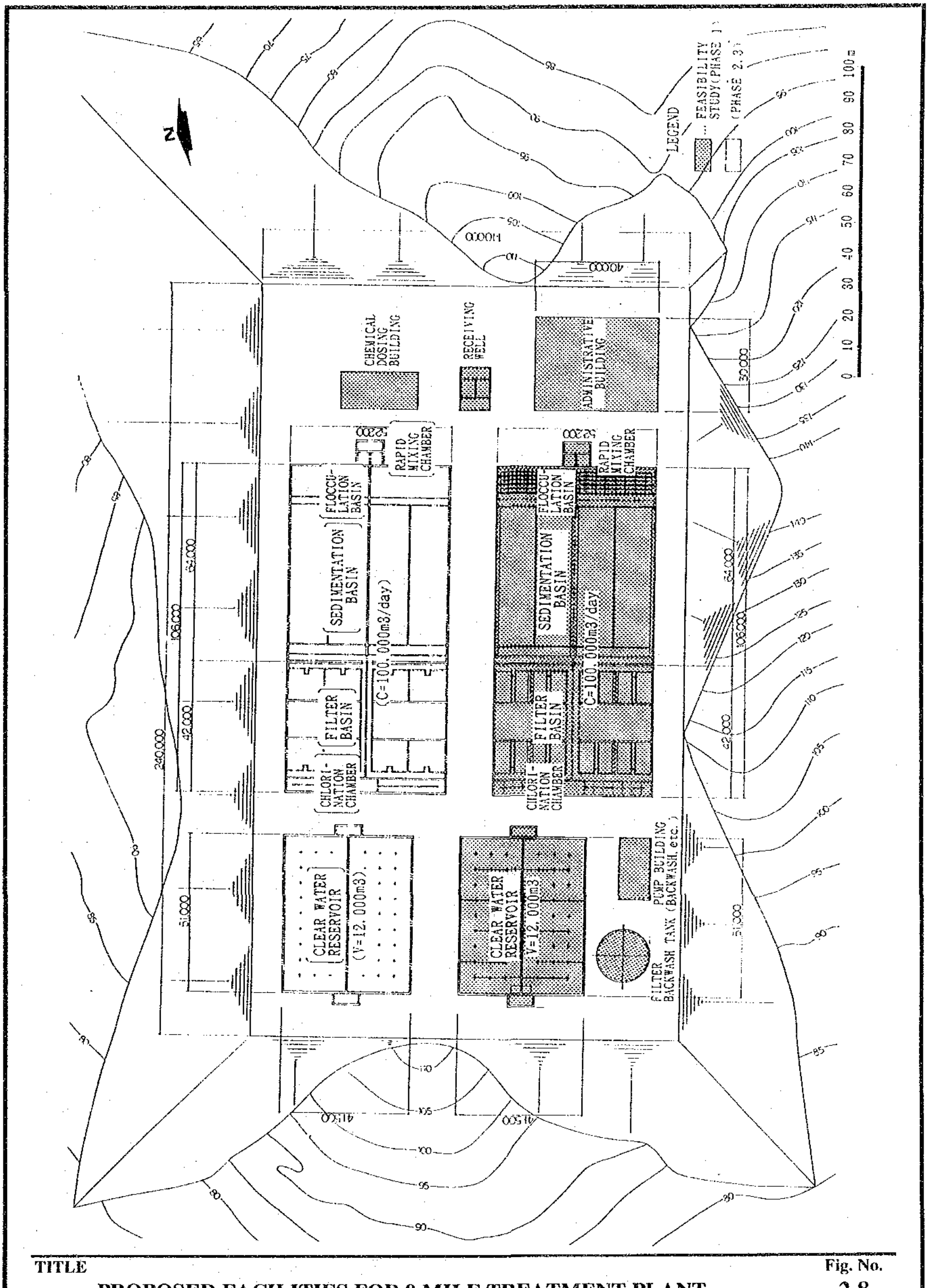
TITLE

PLANT FLOW OF 9 MILE TREATMENT PLANT

Fig. No. 2.7

PORT MORESBY WATER SUPPLY DEVELOPMENT PLAN

TOKYO ENGINEERING CONSULTANTS in association with PACIFIC CONSULTANTS INTERNATIONAL



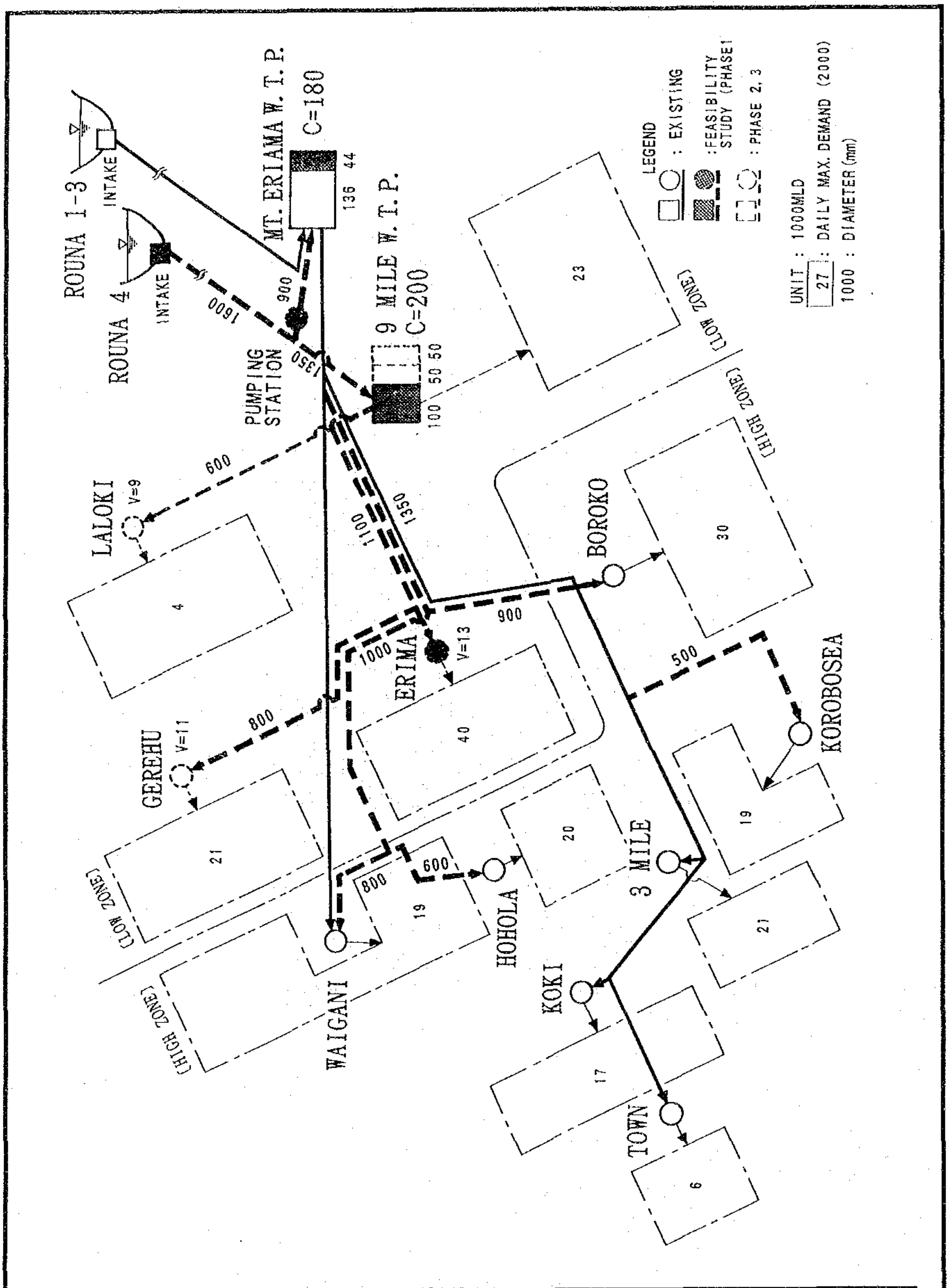
TITLE

PROPOSED FACILITIES FOR 9 MILE TREATMENT PLANT

Fig. No. **2.8**

PORT MORESBY WATER SUPPLY DEVELOPMENT PLAN

TOKYO ENGINEERING CONSULTANTS in association with PACIFIC CONSULTANTS INTERNATIONAL



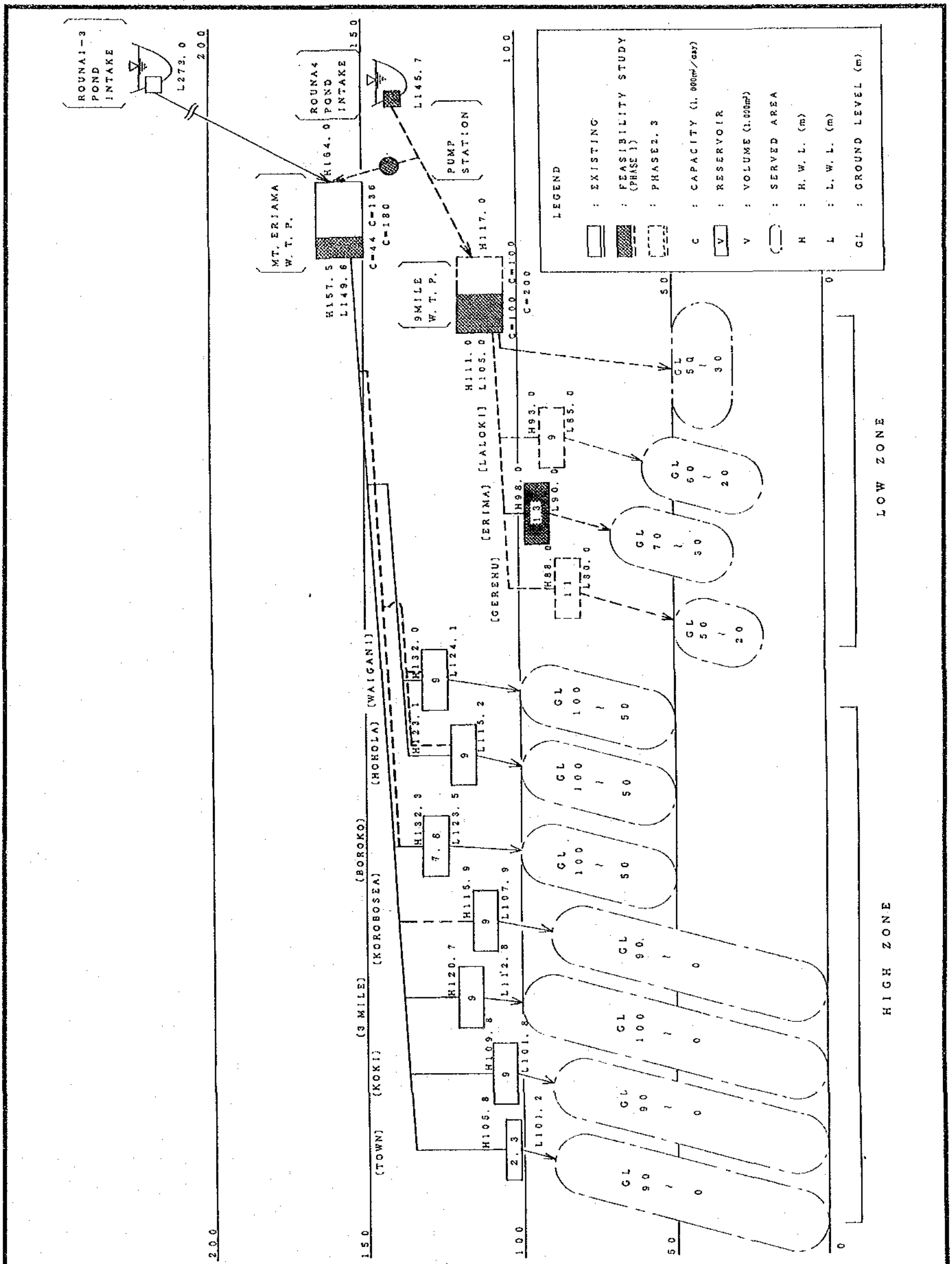
TITLE

SCHEMATIC LAYOUT OF THE FUTURE WATER SUPPLY SYSTEM

Fig. No. **2.9**

PORT MORESBY WATER SUPPLY DEVELOPMENT PLAN

TOKYO ENGINEERING CONSULTANTS in association with PACIFIC CONSULTANTS INTERNATIONAL



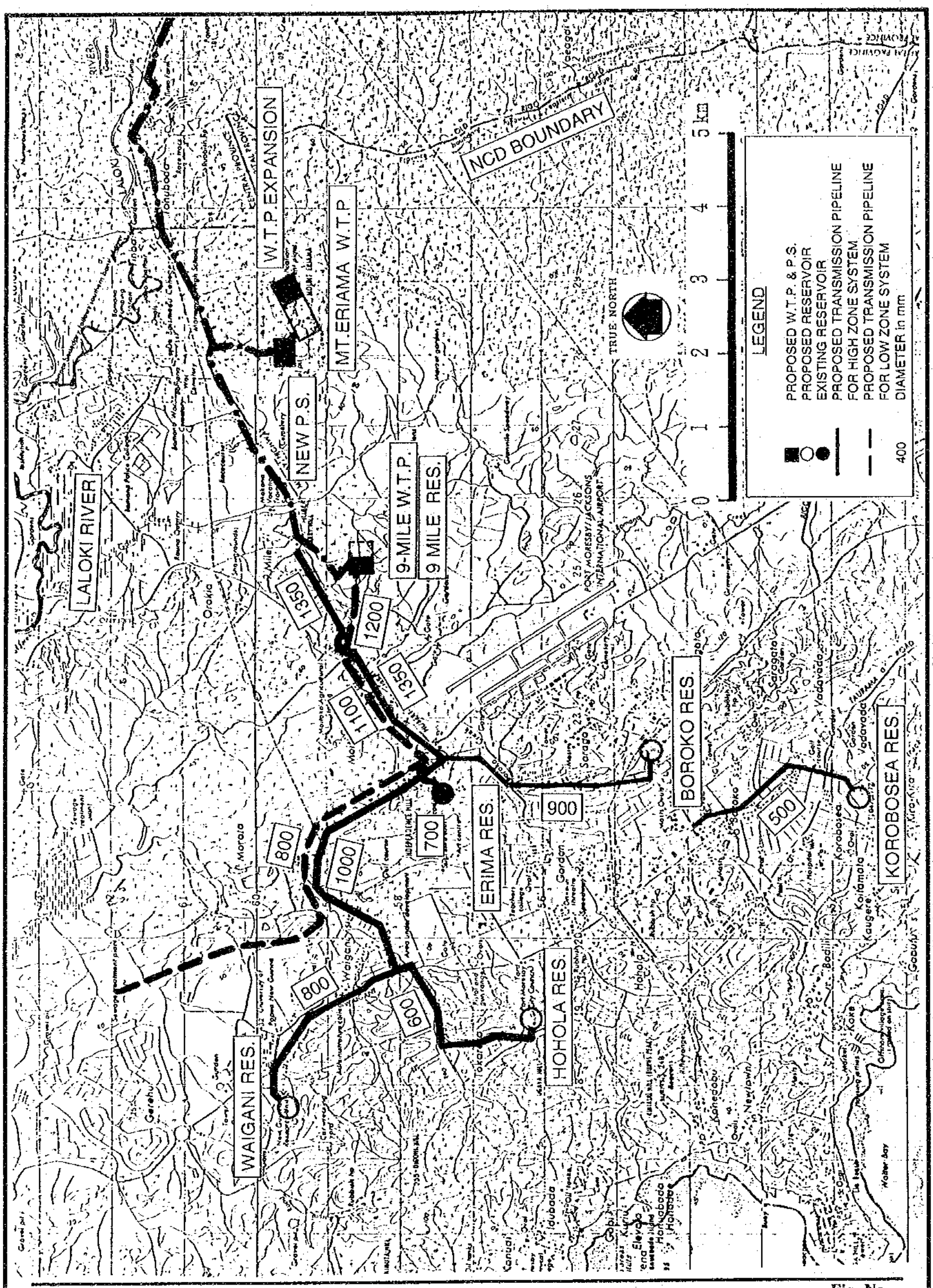
TITLE

FUTURE WATER SUPPLY SYSTEM WITH ELEVATION

Fig. No. **2.10**

PORT MORESBY WATER SUPPLY DEVELOPMENT PLAN

TOKYO ENGINEERING CONSULTANTS in association with PACIFIC CONSULTANTS INTERNATIONAL



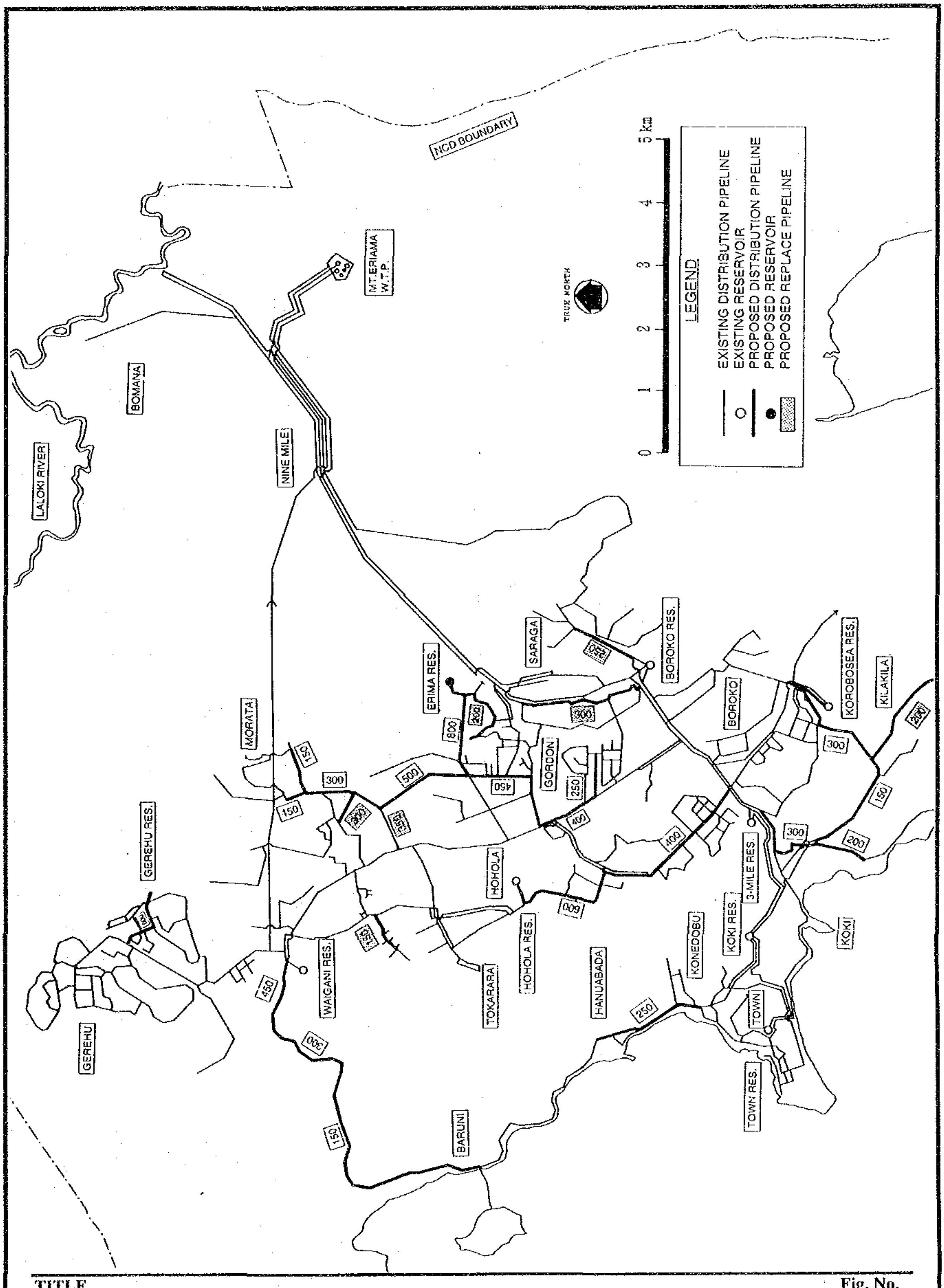
TITLE

Fig. No.

PROPOSED TRANSMISSION LINES FOR THE FEASIBILITY STUDY **2.11**

PORT MORESBY WATER SUPPLY DEVELOPMENT PLAN

TOKYO ENGINEERING CONSULTANTS in association with PACIFIC CONSULTANTS INTERNATIONAL



TITLE

PROPOSED DISTRIBUTION LINES FOR THE FEASIBILITY STUDY

Fig. No. **2.12**

PORT MORESBY WATER SUPPLY DEVELOPMENT PLAN

TOKYO ENGINEERING CONSULTANTS in association with PACIFIC CONSULTANTS INTERNATIONAL

3 Management

3.1 Introduction

It is estimated that there are now a total of over 200,000 residents living in Port Moresby, also called the National Capital District (NCD). The annual increase in the population was estimated by the JICA study team as 3.2 to 5.3% per year between now and the target year of 2015. Based on this estimate, the future population in 2000 is expected to reach about 314,000. Therefore, the study team estimated the future water demand as about 220,000 m^3 per day.

NCDC is now planning to reorganize the governmental system under the chairmanship of Hon David Unagi, MP. The basic concept of the organization will not change greatly by the reorganization, but there are some unique characteristics related to water supply management. The existing Water Supply and Sewerage division will be divided into independent divisions in 1993. This seems to be good for management, because the management system was too complicated previously.

3.2 New Organization of NCDC

The Special Commission of NCDC was held on 12 July, 1993 to approve the structure of its organization and to appoint the top level managers. Now these top-level managers of departments and divisions are in the process of establishing their organizational set ups.

The new NCDC organization is shown in Fig. 3.1. There are some changes in the names of the positions: for example, the previous General Manager was renamed City Manager, who is assisted by the Deputy City Manager. The previous Deputy General Managers of the three Departments were also renamed as City Engineer, Financial Controller, etc.
The previous organization of NCDC had three departments :

Dep of Finance and Administration
Dep of Technical and Engineering
Dep of Community Services

The new organization has five departments :

Dep of Administration (headed by Chief Administrative Officer)
Dep of Personnel (headed by Personnel Manager)

Dep of Finance (headed by Financial Controller)
Dep of Health/Social Services (headed by Director of H/SS)
Dep of Engineering (headed by City Engineer)

This reorganization does not necessarily mean that the obligations and duties of NCDC have increased, but the new administration of Mr. Unagi defined clearly the assignments which were unclear. The previously heavily burdened Finance/Adm. Dep was divided into three Departments - Administration, Personnel and Finance. This will increase the efficiency of the new management.

However, the fundamental concepts of city management remain unchanged, especially regarding water supply. Pros and cons of the new direction for water supply management will be discussed later in this section. We will make proposals on short and long terms, reflecting the local situation of PNG and Port Moresby.

The JICA study team explained in the Interim Report issued in March 1993, that the NCDC organization would encounter fundamental problems in fulfilling the functions of water supply because of organizational fragmentation. In other words, if the water supply management is more unified, with clear-cut duties and assignments, higher efficiency could be expected. But it is also true that such a reorganization would take a long time to evolve.

The process will require a certain amount of education and training. This chapter details the problems faced by NCDC and proposes improvement measures.

3.3 Management Issues

As mentioned above, the existing and new management for water supply is too largely separated to work as a united body. Here we review the basic functions required for total water supply management. The points are summarized in Table 3.1. Fig. 3.2 summarizes the new organization for water supply management.

As shown in Table 3.1 and Fig. 3.2, the management for water supply is fragmented even in the new organization. The previous management for Water Supply and Sewerage was divided into two divisions: water supply and sewerage. This is a good step in the right direction of improvement, though minor disadvantages such as work forces, storage and equipment will exist.

Table 3.1 Basic Functions of Water Supply

	Basic Function	NCDC Section (New)
1	General Administration	Dep of Administration
2	Recruitment	Dep of Personnel
3	Retirement	Dep of Personnel
4	Budgeting/Planning	Dep of Finance
5	Purchasing	Dep of Finance
6	House Connection	Dep of Finance
7	Meter Reading	Dep of Finance
8	Planning	Dep of Engineering (Plan)
9	Designing	Dep of Engineering (Design)
10	Construction	Dep of Engineering (Const.)
11	Operation for Water Supply	Dep of Engineering (W/S)
12	Maintenance for Water Supply	Dep of Engineering (W/S)

The proposed Water Supply division will be responsible only for operation and maintenance of the water supply system. But it is important that the O/M manager for water supply should understand financial and planning/design aspects. He should be aware of metering and connection matters for routine maintenance. On the other hand, the financial and planning/design managers should understand the daily on-going operations. The present system cannot guarantee two-way communications for improvement. They would certainly need the feed-back from the other side. This is essential for efficient management of water supply. It is also true that it will take some time to achieve the goal. But the organizational set-up should be in the right direction.

The JICA study team suggests that water supply organization, in general, should be balanced with respect to the following functions. This is shown in Fig. 3.3:

(1) Administration and finance,
(2) Engineering (planning and construction)
(3) Operation and maintenance

Currently financing (planning and budgeting) functions are controlled by the Finance Dep. Meter reading is also handled by the same dep. The work related to connections, namely new connections, reconnection and disconnection, is also done by the same dep. The water bills are sent by this dep., which also collects the bills, because the water bills are to be paid by the users. They are like taxes.

However, this sort of arrangement makes it almost impossible for the Water Supply division to control costs and restrict them, including the costs for minor repair works, storage of fittings, and others. It is true, however, that the division does not have qualified staff to look after both technical and financial matters.

The engineering functions are controlled by the Deputy City Engineers (planning, design & construction). That is why the Water Supply division does not maintain proper drawings of the existing system. Nevertheless it is conducting minor repair works without proper drawings for the repair site. These repairs are not recorded properly, and relevant drawings are not updated. The workers repair the existing pipes when leakages are observed above the ground. However, without proper records, they tend to repair the same spot several times. They do not have a renewal program for the existing system, in spite of using old pipes, including asbestos pipes even now. Asbestos cement pipes are considered health-hazardous and cause cancer. These pipes must be eliminated, as soon as possible.

Personnel matters such as recruitment, retirement programs and training are controlled by the Personnel Dep. Though affairs are conducted in consultation with the water division, management is unsatisfactory and needs to be improved with financial support.

3.4 New Organization of Water Supply Division

3.4.1 General

A new organization is proposed for the Water Supply division headed by a senior engineer. In this section of the report, gradual improvements are recommended based on the existing system, because full-fledged management for water supply will require a time to mature

The existing water supply system consists of :

a) Intake facilities at Rouna 1/3 and Bomana
b) Conveyance system
c) Treatment plant at Mt. Eriama
d) Transmission system
e) Reservoirs
f) Distribution system

3.4.2 Service System

The NCDC service is spread over a relatively large area, especially along the North-South direction. It is currently divided into three zones for operation, as shown in Table 3.2. This zoning is functioning well and should be maintained in the future, though further improvements will be required. If the service area is divided into many zones, management and control will be very complicated. Again if there is only a single zone in a large area, the access distance is too large and service response will be too slow.

Table 3.2 Water Service Zones of NCDC

Zone	Name of Area
No.1	Gerehu, University, Waigani, Morata, Ensisi Valley, Tokalala, Waigani Government Offices
No.2	Hohola, Gordons 5, Gordons, Eriama, Boroko, Sagara/Airport, Bomana, 8 Mile Settlement, 9 Mile Settlement
No.3	Korobosea, Sabama, Kaugere, Kilakila/Vabukori, Gabutu, Badili/Koki, Town, Hanuabada, Baruni/Tatana, Idubada

The water supply service operates continuously round the clock. Though most repair work can be done during day time, all the working facilities must be operated and monitored all the time. Besides, some emergency work should be done in the night also.

The existing operating system of the treatment plant is working well, and can be continued in the future. Some improvements may be needed as the system expands. Table 3.3 shows one example of shifting at Mt. Eriama WTP. Practical shifting should be decided on the basis of fairness and efficiency, and in consultation with the operators.

Table 3.3 Operators' Duty Roster for Plant and P/S

Operator	< 1st Pay Period >														< 2nd Pay Period >														Total
	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	(days)
	Off	N	N	N	N	N	N	N	Off	Off	D	D	Off	D	D	D	D	A	A	A	Off	A	A	A	Off	Off	D	A	
Mr. A		Lab	Lab	Lab	Lab	Lab	Plt	Plt			Plt	Plt		Plt	Lab	Lab	Lab	Lab	Lab	Plt		Plt	Plt	Plt			Plt	Plt	21
Mr. B		Plt	Plt	Plt	Plt	Plt	Lab	Lab			Lab	Lab		Lab	Plt	Plt	Plt	Plt	Plt	Lab		Lab	Lab	Lab			Lab	Lab	21
	N	Off	Off	D	D	Off	D	D	D	D	A	A	A	Off	A	A	A	Off	Off	D	A	Off	N	N	N	N	N	N	
Mr. C	Lab			Lab	Lab		Lab	Lab	Plt	Plt	Plt	Plt	Plt		Lab	Lab	Lab			Lab	Lab	Plt	Plt	Plt	Plt	Plt	Plt	Plt	21
Mr. D	Plt			Plt	Plt		Plt	Plt	Plt	Lab	Lab	Lab	Lab		Plt	Plt	Plt			Plt	Plt		Lab	Lab	Lab	Lab	Lab	Lab	21
	D	D	D	A	A	A	Off	A	A	A	Off	Off	D	A	Off	N	N	N	N	N	N	N	Off	Off	D	D	Off	D	
Mr. E	Lab	Lab	Lab	Lab	Lab	Plt		Plt	Plt	Plt			Plt	Plt		Lab	Lab	Lab	Lab	Lab	Plt	Plt			Plt	Plt		Plt	21
Mr. F	Plt	Plt	Plt	Plt	Plt	Lab		Lab	Lab	Lab			Lab	Lab		Plt	Plt	Plt	Plt	Plt	Lab	Lab			Lab	Lab		Lab	21
	A	A	A	Off	Off	D	A	Off	N	N	N	N	N	N	N	Off	Off	D	D	Off	D	D	D	D	A	A	A	Off	
Mr. G	Lab	Lab	Lab			Lab	Lab		Plt	Plt	Plt	Plt	Plt	Plt	Lab			Lab	Lab		Lab	Lab	Plt	Plt	Plt	Plt	Plt		21
Mr. H	Plt	Plt	Plt			Plt	Plt		Lab	Lab	Lab	Lab	Lab	Lab	Plt			Plt	Plt		Plt	Plt	Lab	Lab	Lab	Lab	Lab		21
Total Nr																													
Lab	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	
Plt	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	

Note : Shift Hours

D 7.45 am - 4.00 pm

A 3.45 pm - 12.00 m/n

N 11.45 pm - 8.00 am