Table-10.13 AVERAGE INCREMENTAL COSTS (AIC)

[CHIANGMAI WATERWORKS] x 1,000 BAHT

YEAR	CAPITAL INVESTMENT: FORIGN PORTION	CAPITAL INVESTMENT: LOCAL PORTION: PROCUR.	CAPITAL INVESTMENT: LOCAL PORTION: SKILLED LABOR	CAPITAL INVESTMENT: LOCAL PORTION: UNSKILLED LABOR	CAPITAL INVESTMENT: TOTAL INVESTMENT	ECONOMIC VALUE OF CAPITAL INVESTMENT: FORIGN PORTION	ECONOMIC VALUE OF CAPITAL INVESTMENT: LOCAL PORTION: PROCUR.	ECONOMIC VALUE OF CAPITAL INVESTMENT: LOCAL PORTION: SKILLED LABOR	ECONOMIC VALUE OF CAPITAL INVESTMENT: LOCAL PORTION: UNSKILLED LABOR	ECONOMIC VALUE OF CAPITAL INVESTMENT: TOTAL INVESTMENT	DISCOUNTED AT 10%	SALES VOLUMES (INCREMENTS) 1,000 cm	DISCOUNTED AT 10%	OPERATION AND MAINTENANCE	DISCOUNTED AT 10%
1987	2,347	0	1,565	0	3,912	2,347	0	1,157	0	3,504	3,185	0	0	0	0
1988	13,444	1,110	5,680	1,045	21,279	13,444	888	4,198	291	18,820	15,554	0	0	0	0
1989	10,028	3,610	2,247	1,568	17,453	10,028	2,888	1,661	436	15,012	11,279	2,051	1,541	4,839	3,636
1990	57,319	9,289	13,322	11,886	91,816	57,319	7,431	9,845	3,304	77,899	53,206	2,723	1,860	6,760	4,617
1991	84,448	13,934	18,963	17,829	135,174	84,448	11,147	14,014	4,956	114,565	71,136	3,460	2,148	8,552	5,310
1992												4,237	2,392	12,118	6,840
1993												4,942	2,536	10,851	5,568
1994												5,683	2,651	12,297	5,737
1995												6,311	2,676	13,406	5,686
1996												6,862	2,646	14,382	5,545
1997												7,493	2,626	15,716	5,508
1998												8,117	2,586	17,054	5,434
1999												8,639	2,502	18,145	5,256
2000												9,227	2,430	19,171	5,048
2001												9,227	2,209	19,171	4,589
2002												9,227	2,008	19,171	4,172
2003												9,227	1,826	19,171	3,793
2004												9,227	1,660	19,171	3,448
2005												9,227	1,509	19,171	3,135
2006												9,227	1,372	19,171	2,850
Salvage					-118,956					-95,165	-14,146				
TOTAL					150,678					134,636	140,215	125,107	39,177	268,317	86,172

TOTAL INVEST. DISCNTED		140,215
O&M COST DISCOUNTED	+	86,172
AVERAGE INCREMENTAL COST	=	226,387 / 39,177 = 5.779 (SALES M3 DISCOUNTED)

Table-10.14 AVERAGE INCREMENTAL COSTS (AIC)

[CHIANGMAI WATERWORKS] x 1,000 BAHT

YEAR	CAPITAL INVESTMENT: FORIGN PORTION	CAPITAL INVESTMENT: LOCAL PORTION: PROCUR.	CAPITAL INVESTMENT: LOCAL PORTION: SKILLED LABOR	CAPITAL INVESTMENT: LOCAL PORTION: UNSKILLED LABOR	CAPITAL INVESTMENT: TOTAL INVESTMENT	ECONOMIC VALUE OF CAPITAL INVESTMENT: FORIGN PORTION	ECONOMIC VALUE OF CAPITAL INVESTMENT: LOCAL PORTION: PROCUR.	ECONOMIC VALUE OF CAPITAL INVESTMENT: LOCAL PORTION: SKILLED LABOR	ECONOMIC VALUE OF CAPITAL INVESTMENT: LOCAL PORTION: UNSKILLED LABOR	ECONOMIC VALUE OF CAPITAL INVESTMENT: TOTAL INVESTMENT	DISCOUNTED AT 10%	SALES VOLUMES (INCREMENTS) 1,000 cm	DISCOUNTED AT 10%	OPERATION AND MAINTENANCE *	DISCOUNTED AT 10%
1987	2,347	0	1,565	0	3,912	2,347	0	1,157	0	3,504	3,185	0	0	0	0
1988	13,444	1,110	5,680	1,045	21,279	13,444	888	4,198	291	18,820	15,554	0	0	0	0
1989	10,028	3,610	2,247	1,568	17,453	10,028	2,888	1,661	436	15,012	11,279	2,051	1,541	4,931	3,705
1990	57,319	9,289	13,322	11,886	91,816	57,319	7,431	9,845	3,304	77,899	53,206	2,723	1,860	6,882	4,700
1991	84,448	13,934	18,963	17,829	135,174	84,448	11,147	14,014	4,956	114,565	71,136	3,460	2,148	8,700	5,402
1992												4,237	2,392	12,306	6,946
1993												4,942	2,536	11,061	5,676
1994												5,683	2,651	12,535	5,848
1995												6,311	2,676	13,566	5,796
1996												6,862	2,646	14,561	5,652
1997												7,493	2,626	16,022	5,616
1998												8,117	2,586	17,386	5,540
1999												8,639	2,502	18,498	5,358
2000												9,227	2,430	19,543	5,146
2001												9,227	2,209	19,543	4,678
2002												9,227	2,008	19,543	4,253
2003												9,227	1,826	19,543	3,866
2004												9,227	1,660	19,543	3,515
2005												9,227	1,509	19,543	3,195
2006												9,227	1,372	19,543	2,905
Salvage					-118,956					-95,165	-14,146				
TOTAL					150,678					134,636	140,215	125,107	39,177	273,446	87,797

Note: * Share of Head & Regional Office Overhead Expenses calculated by a new tentative formula based on waterworks surplus.

TOTAL INVEST. DISCNTED 140,215
O&M COST DISCOUNTED + 87,797

AVERAGE INCREMENTAL COST = 228,012 / 39,177 = 5.820
(SALES M3 DISCOUNTED)

Table-10.15 ECONOMIC BENEFITS VS COSTS (INCREMENTAL)

(CHIANGMAI WATERWORKS) x 1,000 BAHT

YEAR	AT 1986 PRICE		DISCOUNTED AT 10% PER ANNUM	
	BENEFITS	COSTS	BENEFITS	COSTS
1987	0	3,504	0	3,185
1988	0	18,820	0	15,554
1989	15,789	19,943	11,862	14,984
1990	20,962	84,781	14,317	57,907
1991	26,636	123,265	16,539	76,538
1992	32,617	12,306	18,412	6,946
1993	38,044	11,061	19,523	5,676
1994	43,749	12,535	20,409	5,848
1995	48,583	13,666	20,604	5,796
1996	52,825	14,661	20,366	5,652
1997	57,682	16,022	20,217	5,616
1998	62,486	17,386	19,910	5,540
1999	66,505	18,498	19,264	5,358
2000	71,031	19,543	18,705	5,146
2001	71,031	19,543	17,004	4,678
2002	71,031	19,543	15,458	4,253
2003	71,031	19,543	14,053	3,866
2004	71,031	19,543	12,776	3,515
2005	71,031	19,543	11,614	3,195
2006	71,031	19,543	10,558	2,905
Salvage		-127,943		-66,836
TOTAL	963,096	375,303	301,592	175,322

BENEFITS/COSTS = 2.56618 BENEFITS/COSTS =1.72022

Note: * Share of Head & Regional Office Overhead Expenses calculated by a new tentative formula based on waterworks surplus.

Table-10.16 ECONOMIC INTERNAL RATE OF RETURN (EIRR)

[CHIANGMAI WATERWORKS] x 1,000 BAHT

YEAR	TOTAL ECONOMIC BENEFITS * AT 1986 PRICE	TOTAL CAPITAL INVESTMENT AT 1986 PRICE	OPERATING COSTS & H.R.O.** AT 1986 PRICE	NET BENEFITS AT 1986 PRICE	CONVERTED ECONOMIC VALUE				NET BENEFITS	
					TOTAL ECONOMIC BENEFITS	TOTAL CAPITAL INVESTMENT	OPERATING COSTS & H.R.O.	NET BENEFITS	DISCOUNTED AT 16%	DISCOUNTED AT 17%
1987	0	3,912	0	-3,912	0	3,504	0	-3,504	-3,020	-2,994
1988	0	21,279	0	-21,279	0	18,820	0	-18,820	-13,986	-13,748
1989	15,789	17,453	6,164	-7,828	15,789	15,012	4,831	-4,154	-2,661	-2,594
1990	20,962	91,816	8,602	-79,456	20,962	77,899	6,882	-63,819	-35,247	-34,057
1991	26,636	135,174	10,875	-119,413	26,636	114,565	8,700	-96,629	-46,007	-44,074
1992	32,617		15,382	17,235	32,617		12,306	20,311	8,337	7,918
1993	38,044		13,826	24,218	38,044		11,061	26,984	9,548	8,991
1994	43,749		15,668	28,080	43,749		12,535	31,214	9,521	8,869
1995	48,583		17,083	31,501	48,583		13,666	34,917	9,182	8,499
1996	52,825		18,326	34,499	52,825		14,661	38,164	8,651	7,940
1997	57,682		20,027	37,655	57,682		16,022	41,661	8,141	7,408
1998	62,486		21,732	40,754	62,486		17,386	45,101	7,598	6,854
1999	66,505		23,122	43,382	66,505		18,498	48,007	6,972	6,236
2000	71,031		24,429	46,603	71,031		19,543	51,488	6,446	5,716
2001	71,031		24,429	46,603	71,031		19,543	51,488	5,557	4,886
2002	71,031		24,429	46,603	71,031		19,543	51,488	4,790	4,176
2003	71,031		24,429	46,603	71,031		19,543	51,488	4,130	3,569
2004	71,031		24,429	46,603	71,031		19,543	51,488	3,560	3,050
2005	71,031		24,429	46,603	71,031		19,543	51,488	3,069	2,607
2006	71,031		24,429	46,603	71,031		19,543	51,488	2,646	2,228
Salvage		-127,943		127,943		-108,954		108,954	5,599	4,715
TOTAL				479,599				568,804	2,824	-3,785

Note : * Average Water Tariff in 1986 used as benefits. (6.90 Baht)

** Share Allocation of Head and Regional Office Overhead Expenses calculated by a new tentative formula based on waterworks surplus.

EIRR = 16+(17-16)x2,824/(2,824+3,785)

= 16.43%

Table-10.17 ECONOMIC INTERNAL RATE OF RETURN (EIRR)

[CHIANGMAI WATERWORKS] x 1,000 BAHT

YEAR	TOTAL ECONOMIC BENEFITS * AT 1986 PRICE	TOTAL CAPITAL INVESTMENT AT 1986 PRICE	OPERATING COSTS & H.R.O.** AT 1986 PRICE	NET BENEFITS AT 1986 PRICE	CONVERTED ECONOMIC VALUE				NET BENEFITS	
					TOTAL ECONOMIC BENEFITS	TOTAL CAPITAL INVESTMENT	OPERATING COSTS & H.R.O.	NET BENEFITS	DISCOUNTED AT 10%	DISCOUNTED AT 11%
1987	0	3,912	0	-3,912	0	3,504	0	-3,504	-3,185	-3,156
1988	0	21,279	0	-21,279	0	18,820	0	-18,820	-15,554	-15,275
1989	11,852	17,453	6,049	-11,650	11,852	15,012	4,839	-8,000	-6,011	-5,850
1990	15,735	91,816	8,450	-84,531	15,735	77,899	6,760	-68,925	-47,076	-45,403
1991	19,994	135,174	10,690	-125,870	19,994	114,565	8,552	-103,123	-64,031	-61,199
1992	24,484		15,147	9,336	24,484		12,118	12,366	6,980	6,611
1993	28,558		13,563	14,994	28,558		10,851	17,707	9,086	8,529
1994	32,839		15,372	17,468	32,839		12,297	20,542	9,583	8,914
1995	36,468		16,758	19,710	36,468		13,406	23,062	9,781	9,015
1996	39,652		17,977	21,675	39,652		14,382	25,271	9,743	8,900
1997	43,299		19,645	23,653	43,299		15,716	27,582	9,667	8,751
1998	46,904		21,318	25,587	46,904		17,054	29,850	9,511	8,532
1999	49,921		22,681	27,240	49,921		18,145	31,776	9,204	8,183
2000	53,319		23,964	29,355	53,319		19,171	34,148	8,992	7,922
2001	53,319		23,964	29,355	53,319		19,171	34,148	8,175	7,137
2002	53,319		23,964	29,355	53,319		19,171	34,148	7,432	6,430
2003	53,319		23,964	29,355	53,319		19,171	34,148	6,756	5,793
2004	53,319		23,964	29,355	53,319		19,171	34,148	6,142	5,219
2005	53,319		23,964	29,355	53,319		19,171	34,148	5,583	4,701
2006	53,319		23,964	29,355	53,319		19,171	34,148	5,076	4,235
Salvage		-127,943		127,943		-108,954		108,954	16,195	13,514
TOTAL				245,950				333,773	2,050	-8,495

Note : * AIC used as benefits. (5.78 Baht)
** Share Allocation of Head and Regional Office Overhead Expenses.

EIRR = 10+(11-10)x2,050/(2,050+8,495)
= 10.19%

Table-10.18 ECONOMIC INTERNAL RATE OF RETURN (EIRR)

(CHIANGMAI WATERWORKS) x 1,000 BAHT

YEAR	TOTAL ECONOMIC BENEFITS * AT 1986 PRICE	TOTAL CAPITAL INVESTMENT AT 1986 PRICE	OPERATING COSTS & H.R.O.** AT 1986 PRICE	NET BENEFITS AT 1986 PRICE	CONVERTED ECONOMIC VALUE				NET BENEFITS	
					TOTAL ECONOMIC BENEFITS	TOTAL CAPITAL INVESTMENT	OPERATING COSTS & H.R.O.	NET BENEFITS	DISCOUNTED AT 10%	DISCOUNTED AT 11%
1987	0	3,912	0	-3,912	0	3,504	0	-3,504	-3,185	-3,156
1988	0	21,279	0	-21,279	0	18,820	0	-18,820	-15,554	-15,275
1989	11,937	17,453	6,164	-11,680	11,937	15,012	4,931	-8,006	-6,015	-5,854
1990	15,848	91,816	8,602	-84,570	15,848	77,899	6,882	-68,933	-47,082	-45,408
1991	20,137	135,174	10,875	-125,911	20,137	114,565	8,700	-103,128	-64,034	-61,201
1992	24,659		15,382	9,277	24,659		12,306	12,354	6,973	6,605
1993	28,763		13,826	14,937	28,763		11,061	17,702	9,084	8,526
1994	33,075		15,668	17,407	33,075		12,535	20,541	9,582	8,913
1995	36,730		17,083	19,648	36,730		13,666	23,064	9,781	9,016
1996	39,937		18,326	21,611	39,937		14,661	25,276	9,745	8,902
1997	43,610		20,027	23,582	43,610		16,022	27,588	9,669	8,753
1998	47,241		21,732	25,509	47,241		17,386	29,856	9,513	8,534
1999	50,279		23,122	27,157	50,279		18,498	31,782	9,206	8,184
2000	53,701		24,429	29,273	53,701		19,543	34,159	8,995	7,925
2001	53,701		24,429	29,273	53,701		19,543	34,159	8,177	7,139
2002	53,701		24,429	29,273	53,701		19,543	34,159	7,434	6,432
2003	53,701		24,429	29,273	53,701		19,543	34,159	6,758	5,794
2004	53,701		24,429	29,273	53,701		19,543	34,159	6,144	5,220
2005	53,701		24,429	29,273	53,701		19,543	34,159	5,585	4,703
2006	53,701		24,429	29,273	53,701		19,543	34,159	5,077	4,237
Salvage		-127,943		127,943		-108,954		108,954	16,195	13,514
TOTAL				244,630				333,835	2,050	-8,497

Note : * AIC used as benefits. [(5.82 Baht)

** Share Allocation of Head and Regional Office Overhead Expenses calculated by a new tentative formula based on waterworks surplus.

EIRR = 10+(11-10)x2,050/(2,050+8,497)

= 10.19%

Table-10.19 REVENUE AND EXPENDITURE OF CHIANGMAI, MAE RIM AND SAN KAMPHAENG WATERWORKS (x1,000 BAHT)
- FOR PAST TWO YEARS -

	CHIANG MAI		MAE RIM		SAN KAMPHAENG	
	1984	1985	1984	1985	1984	1985
Water Production (x1,000 m3)	12,503	12,418	819	806	498	495
Water Sales (x1,000 m3)	8,260	85,000	653	625	340	356
No. of Connections	14,768	15,669	709	774	1,216	1,329
REVENUE:						
Water Sales	32,048	50,249	2,989	3,760	989	1,735
Service Charge	1,814	1,998	109	124	152	163
Connection Fee	4,799	5,491	252	290	207	403
Others	236	265	29.514	127	6.39	10.099
Total	38,896	58,002	3,380	4,301	1,354	2,311
EXPENDITURE:						
Personnel Cost	6,107	6,651	648	664	814	910
Chemicals	1,603	1,961	105	60	32	29
Material & Maintenance	28	664	33	37	35	60
Oil & Fuel	186	223	19	22	20	30
Office Supplies	80	64	6	8	8	8
Hire & Service	161	161	14	8	9	4
Electricity	6,491	6,869	419	435	299	327
Connection Cost	2,169	2,113	114	112	77	125
Others	656	42	18	40	29	1
Total	17,480	18,748	1,375	1,385	1,322	1,494
REVENUE/EXPENDITURE	2.23	3.09	2.46	3.11	1.02	1.55

Table-10.20 CASH FLOW PROJECTED (x 1,000 Baht) AT CURRENT PRICE. (CHIANGMAI WATERWORKS, EXCLUSIVE OF MAE RIM AND SAN KAMPHAENG WATERWORKS)

Description	Text Ref.	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
(A) Water Production (x1000 m3)		13,211	13,910	14,497	15,107	15,772	16,465	17,409	18,152	18,961	19,564	20,165	20,706	21,288	21,824	22,403
(B) Unaccounted for Water (%)		31	30	29	28	27	26	26	26	26	25	25	24	24	23	23
(C) Water Sales (x1000 m3)		9,089	9,709	10,293	10,877	11,498	12,118	12,848	13,469	14,126	14,673	15,184	15,695	16,243	16,717	17,228
(D) No. of Connections		16,450	17,320	18,190	19,060	19,980	20,780	21,780	22,560	23,210	23,730	24,150	24,560	24,950	25,320	25,680
(E) Average Water Tariff (Baht/m3)**		7.10	7.10	7.10	7.83	7.83	7.83	8.63	8.63	8.63	9.51	9.51	9.51	10.48	10.48	10.48
1. Operating Revenue:																
1.1 Water Sales		64,532	68,934	73,080	85,127	89,987	94,840	110,840	116,197	121,907	139,534	144,400	149,259	170,266	175,194	180,549
1.2 Connection Fees		4,748	5,296	5,296	5,296	5,600	4,870	6,087	4,748	3,957	3,165	2,557	2,496	2,374	2,252	2,191
1.3 Service Charges		2,097	2,208	2,319	2,430	2,547	2,649	2,777	2,876	2,959	3,025	3,079	3,131	3,181	3,228	3,274
1.4 Other Revenue		327	350	370	425	450	469	548	567	590	668	687	710	805	828	852
Total 1.		71,704	76,788	81,065	93,278	98,584	102,828	120,252	124,389	129,413	146,392	150,723	155,596	176,627	181,502	186,867
2. Expenses:																
2.1 Operation & Maintenance																
- Personnel Cost		7,442	8,012	8,939	9,815	10,999	12,152	13,961	15,221	16,287	17,879	19,131	20,897	2,392	2,559	2,738
- Electricity & Fuel Cost		7,985	8,726	9,454	10,322	11,159	12,097	13,887	14,921	16,068	17,120	15,354	19,342	20,588	21,784	23,077
- Chemical Cost		2,061	2,241	2,418	2,695	2,808	3,035	3,309	3,561	3,842	4,098	4,360	4,626	4,922	5,207	5,512
- Connection Cost		2,113	1,961	2,026	2,093	2,286	2,053	2,651	2,136	1,839	1,520	1,268	1,279	1,256	1,231	1,238
- Raw Water Cost		3,095	3,559	4,004	3,846	4,339	4,912	5,624	2,602	3,218	3,735	4,262	4,799	5,410	5,990	6,601
- Other Cost		3,632	3,882	4,194	4,515	4,882	5,254	5,911	6,301	6,676	7,100	7,470	7,909	8,367	8,774	5,438
Sub-total 2.1		26,329	28,381	31,035	33,196	36,473	39,502	45,343	44,743	47,930	51,452	51,844	58,853	42,935	45,545	44,605
2.2 Share of Head & Regional Office Overhead Expenses		8,648	9,542	10,450	11,407	12,457	13,562	14,853	16,085	17,426	18,698	19,988	21,342	22,816	24,257	25,824
2.3 Debt Service		12,050	11,660	12,393	13,338	16,871	22,270	25,489	31,226	32,070	30,798	29,526	36,490	35,055	33,520	26,044
Total 2.		47,026	49,583	53,878	57,933	65,800	75,334	85,685	92,054	97,426	100,948	101,358	116,685	100,807	103,422	96,473
3. Net Cash Flow Surplus:																
3.1 Annual		24,678	27,205	27,187	35,345	32,784	27,494	34,567	32,335	31,988	45,444	49,364	38,911	75,820	78,080	90,394
3.2 Cumulative		24,678	51,883	79,070	114,415	147,200	174,693	209,260	241,595	273,583	319,027	368,391	407,302	483,122	561,202	651,596
4. Unit Cost of Water after Debt Service (Baht/m3)*		4.66	4.58	4.72	4.86	5.22	5.73	6.15	6.38	6.50	6.56	6.40	7.13	5.98	5.97	5.41

Note: * [(Total 2.) x ((1.1 Water Sales) / (Total 1.))] / (3. Water Sales m3)

** Based upon the assumption that the water tariff increases every 3 years at the rate of 3.3 % per annum.

[MAE RIM WATERWORKS] Table-10.21 CASH FLOW PROJECTED (x 1,000 Baht) AT CURRENT PRICE

Description	Text Ref.	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
(A) Water Production (x1000 m3)		1,119	1,157	1,246	1,281	1,315	1,402	1,439	1,481	1,566	1,601	1,627	1,705	1,729	1,758	1,782
(B) Unaccounted for Water (%)		32	31	29	28	27	27	26	26	25	25	25	24	24	23	23
(C) Water Sales (x1000 m3)		763	803	880	920	960	1,029	1,062	1,099	1,168	1,201	1,226	1,292	1,318	1,347	1,372
(D) No. of Connections		810	870	940	1,000	1,050	1,090	1,130	1,170	1,210	1,250	1,280	1,310	1,340	1,370	1,400
(E) Average Water Tariff (Baht/m3) **		7.69	7.69	7.69	8.48	8.48	8.48	9.34	9.34	9.34	10.30	10.30	10.30	11.35	11.35	11.35
1. Operating Revenue:																
1.1 Water Sales		5,866	6,175	6,765	7,797	8,137	8,725	9,925	10,266	10,914	12,369	12,632	13,308	14,960	15,291	15,582
1.2 Connection Fees		179	277	334	296	254	210	217	224	232	239	185	192	198	204	211
1.3 Service Charges		131	145	162	178	193	207	221	237	253	270	286	302	319	337	356
1.4 Other Revenue		28	31	35	42	45	49	58	62	68	79	83	90	105	111	117
Total 1.		6,204	6,627	7,293	8,308	8,624	9,184	10,411	10,776	11,451	12,937	13,163	13,865	15,548	15,905	16,222
2. Expenses:																
2.1 Operation & Maintenance																
- Personnel Cost		712	829	887	949	1,016	1,446	1,643	1,758	1,881	2,013	2,424	2,593	2,775	2,969	3,177
- Electricity & Fuel Cost		487	519	570	606	644	701	745	808	875	926	978	1,055	1,089	1,149	1,213
- Chemical Cost		175	187	205	218	231	253	267	291	315	334	351	379	391	413	436
- Connection Cost		69	103	121	103	86	69	69	69	69	69	52	52	52	52	52
- Other Cost		266	103	309	324	339	420	453	478	504	528	567	619	639	666	695
Sub-total 2.1		1,709	1,742	2,092	2,201	2,316	2,889	3,177	3,405	3,645	3,869	4,391	4,697	4,946	5,249	5,573
2.2 Share of Head & Regional Office Overhead Expenses		1,051	1,143	1,294	1,397	1,506	1,669	1,779	1,901	2,087	2,217	2,339	2,545	2,681	2,831	2,980
2.3 Debt Service		2,147	2,154	2,195	2,236	4,938	5,304	5,382	5,792	5,404	4,948	2,104	3,139	2,995	2,850	1,937
Total 2.		4,907	5,039	5,581	5,834	8,761	9,862	10,338	11,097	11,136	11,034	8,834	10,381	10,622	10,930	10,489
3. Net Cash Flow Surplus:																
3.1 Annual		1,297	1,588	1,712	2,474	-137	-678	73	-321	315	1,903	4,329	3,484	4,925	4,975	5,733
3.2 Cumulative		1,297	2,885	4,597	7,071	6,934	6,256	6,329	6,007	6,322	8,225	12,554	16,038	20,963	25,938	31,671
4. Unit Cost of Water after Debt Service (Baht/m3)*		6.08	5.85	5.88	5.95	8.61	9.10	9.28	9.62	9.09	8.78	6.91	7.71	7.76	7.80	7.34

Note: * [(Total 2.) x {(1.1 Water Sales) / (Total 1.)}] / (3. Water Sales m3)

** Based upon the assumption that the water tariff increases every 3 years at the rate of 3.3% per annum.

[SAN KAMPHAENG WATERWORKS] Table-10.22 CASH FLOW PROJECTED (x 1,000 Baht) AT CURRENT PRICE.

Description	Text Ref.	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
(A) Water Production (x1000 m3)		439	500	507	564	570	632	648	708	724	784	799	867	929	948	1,010
(B) Unaccounted for Water (%)		32	31	29	28	27	27	26	26	25	25	25	24	24	23	23
(C) Water Sales (x1000 m3)		299	347	358	405	416	464	478	526	540	588	602	657	708	726	777
(D) No. of Connections		1,440	1,560	1,680	1,800	1,920	2,030	2,140	2,240	2,350	2,460	2,570	2,680	2,800	2,920	3,030
(E) Average Water Tariff (Baht/m3) **		6.00	6.00	6.00	6.61	6.61	6.61	7.29	7.29	7.29	8.04	8.04	8.04	8.86	8.86	8.86
1. Operating Revenue:																
1.1 Water Sales		1,796	2,081	2,146	2,680	2,752	3,066	3,486	3,832	3,938	4,723	4,840	5,280	6,273	6,434	6,887
1.2 Connection Fees		403	440	440	440	440	403	403	367	403	403	403	403	440	440	447
1.3 Service Charges		176	191	206	220	235	249	262	274	288	301	315	328	343	357	371
1.4 Other Revenue		11	12	13	15	16	17	19	20	21	25	25	28	32	33	35
Total 1.		2,386	2,724	2,805	3,355	3,443	3,735	4,170	4,493	4,651	5,452	5,583	6,039	7,088	7,265	7,740
2. Expenses:																
2.1 Operation & Maintenance																
- Personnel Cost		979	1,129	1,208	1,292	1,383	1,795	1,921	2,055	2,199	2,353	2,518	2,694	2,883	3,085	3,301
- Electricity & Fuel Cost		389	469	485	537	590	648	710	773	841	912	988	1,114	1,198	1,285	1,431
- Chemical cost		10	11	12	13	15	15	17	19	21	23	24	27	30	32	35
- Connection Cost		125	136	136	136	136	125	125	114	125	125	125	125	136	136	125
- Other Cost		242	275	284	300	315	380	400	419	441	462	486	519	542	567	603
Sub-total 2.1		1,745	2,020	2,124	2,279	2,440	2,964	3,172	3,380	3,627	3,875	4,140	4,479	4,788	5,106	5,495
2.2 Share of Head & Regional Office Overhead Expenses		739	884	942	1,102	1,169	1,346	1,434	1,628	1,729	1,943	2,057	2,318	2,580	2,734	3,023
2.3 Debt Service		0	7	42	76	356	930	1,274	1,882	1,864	1,777	1,689	2,512	2,397	2,281	1,552
Total 2.		2,483	2,912	3,108	3,457	3,965	5,240	5,880	6,890	7,219	7,595	7,885	9,309	9,765	10,121	10,070
3. Net Cash Flow Surplus:																
3.1 Annual		-97	-168	-304	-101	-522	-1,505	-1,710	-2,397	-2,569	-2,143	-2,302	-3,270	-2,677	-2,856	-2,329
3.2 Cumulative		-97	-284	-588	-690	-1,212	-2,717	-4,427	-6,824	-9,392	-11,535	-13,837	-17,107	-19,785	-22,640	-24,970
4. Unit Cost of Water after Debt Service (Baht/m3)*		6.24	6.41	6.65	6.81	7.62	9.28	10.28	11.18	11.32	11.20	11.35	12.39	12.20	12.34	11.52

Note: * [(Total 2.) x {(1.1 Water Sales) / (Total 1.)}] / (3. Water Sales m3)

** Based upon the assumption that the water tariff increases every 3 years at the rate of 3.3% per annum.

APPENDIX 11

UNACCOUNTED-FOR WATER STUDY

APPENDIX 11

APPENDIX 11 UNACCOUNTED-FOR WATER STUDY

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APPENDIX 11 UNACCOUNTED-FOR WATER STUDY

11.1 Introduction

Unaccounted-for water is defined as the difference between the volume of produced water (water production) and that of sold water (water sales). The water production is measured as the outflow of treatment plant, while the water sales is calculated as the sum of customer meters' reading.

Included in the water sales are discount rate consumption, bad debt, public use and others.

Discount rate is applied to the consumption by veterans, waterworks staff and hospitals. As the consumption is very small in size, the impact on the whole revenue is almost negligible.

Bad debt is the uncollected credit which should be written off. Although some consumers delay regular payment because of handy money's shortage or unwillingness by reason of their dissatisfaction with the service, payment is made eventually in most cases. Bad debt is also negligibly small.

Regarding the public use, most of the public institutions are paying the normal rate duly, excepting those applied with discount rates.

All of the water sales can be considered revenue-bearing or accounted-for water practically in Thailand.

This study aims for setting up the framework to reduce unaccounted-for water in the future. During the field leakage survey undertaken as a part of the study, some useful and important findings were made, as reported in the Attachment herewith. Some of the essential findings are quoted in the main report.

In the following sections, classification of the unaccounted-for water, existing conditions related to the issue, framework for reduction are discussed.

11.2 Classification of the unaccounted-for water

For the present study, "Unaccounted-for Water" is classified into four categories, as shown below;

1) Illegal Connection
2) Meter Reading Error
3) Metering Loss (Under-sensitivity of Consumer's Meter)
4) Leakage

1) Illegal Connection

Illegal connections are defined as intentional mismanagement of water meters and pipeworks conspired to steal the public supply water. They include breaking or bypassing water meters and making a connection unlawfully. The water consumed through such connection is stolen partly or wholly.

2) Meter Reading Error

Meter reading error occurs in such cases as 1) the meter reader fails to read the meter because of very difficult accessibility, and 2) the meter reader mistakes reading. The part of water guessed for consumption and under-estimated by mistaken reading becomes unaccounted-for water.

3) Metering Loss

Undersensitive or malfunctioning water meters under-register the actual flow. The under-registered part of water becomes the unaccounted-for.

4) Leakage

Water loss caused by leakage from cracks, holes and loose joints of pipes and fittings before flowing into consumers' meter belongs this classification. However, the water loss from the plumbing on the down-stream side of

water meter is not classified herein.

11.3 Approach of the Study

The four categories of unaccounted-for water itemized in the previous section are sorted out into two groups by the way of approach, namely;

Group 1 : Reducible by Institutional Management
- Illegal Connection
- Meter Reading Error

Group 2 : Reducible by Technical Management
- Metering Loss
- Leakage

The following steps will be taken in narrowing down the leakage:

- estimation of the total unaccounted-for water, firstly
- estimation of the metering loss, secondly
- estimation of the illegal connections' loss and meter reading error, thirdly
- deducting the sum of the second and third from the first

The balance calculated by the deduction is designated as the leakage.

11.4 Existing Condition

In this section, to understand the existing conditions concerning unaccounted-for water, information of the itemized categories provided by the PWA Headquarters, Regional Office and Waterworks will be examined.

11.4.1 Total Unaccounted-for Water

The data of water production, water sales and unaccounted-for ratio from 1975 to 1984 are shown in Table-11.1 and plotted in Fig-11.1.

Similar monthly data from January 1985 to May 1986 are shown in Table-11.2 and plotted in Fig-11.2. Table-11.2 lists the number of connections and unaccounted-for water per connection per month also.

The yearly data in 1975-1984 showed noticeable increase of the ratio in 1981, when the Paton Treatment Plant started operation. However after 1981, it decreased gradually, reaching some 30 % in 1984.

The 1985 average of the monthly data was 29 % and the 1985-1986 average of 17 months 28 %.

The result suggests that continuity of the gradual decrease after 1981 has been maintained till 1986, and for this study, assuming 28 % as the present ratio is reasonable.

Table-11.1 PAST UNACCOUNTED-FOR WATER RATIO

YEAR	TOTAL WATER PRODUCTION (cu m/year)	TOTAL WATER SALES (cu m/year)	UNACCOUNTED-FOR WATER RATIO (%)
1975	5,260,420	4,190,546	20.3
1976	5,450,139	4,212,551	22.7
1977	5,282,770	4,241,121	19.7
1978	5,350,395	4,502,844	15.8
1979	10,193,005	8,154,404	20.0
1980	10,862,640	10,330,630	4.9
1981	12,536,300	6,521,400	48.0
1982	12,569,830	7,336,232	41.6
1983	13,706,760	7,538,318	45.0
1984	12,535,590	8,300,252	33.8

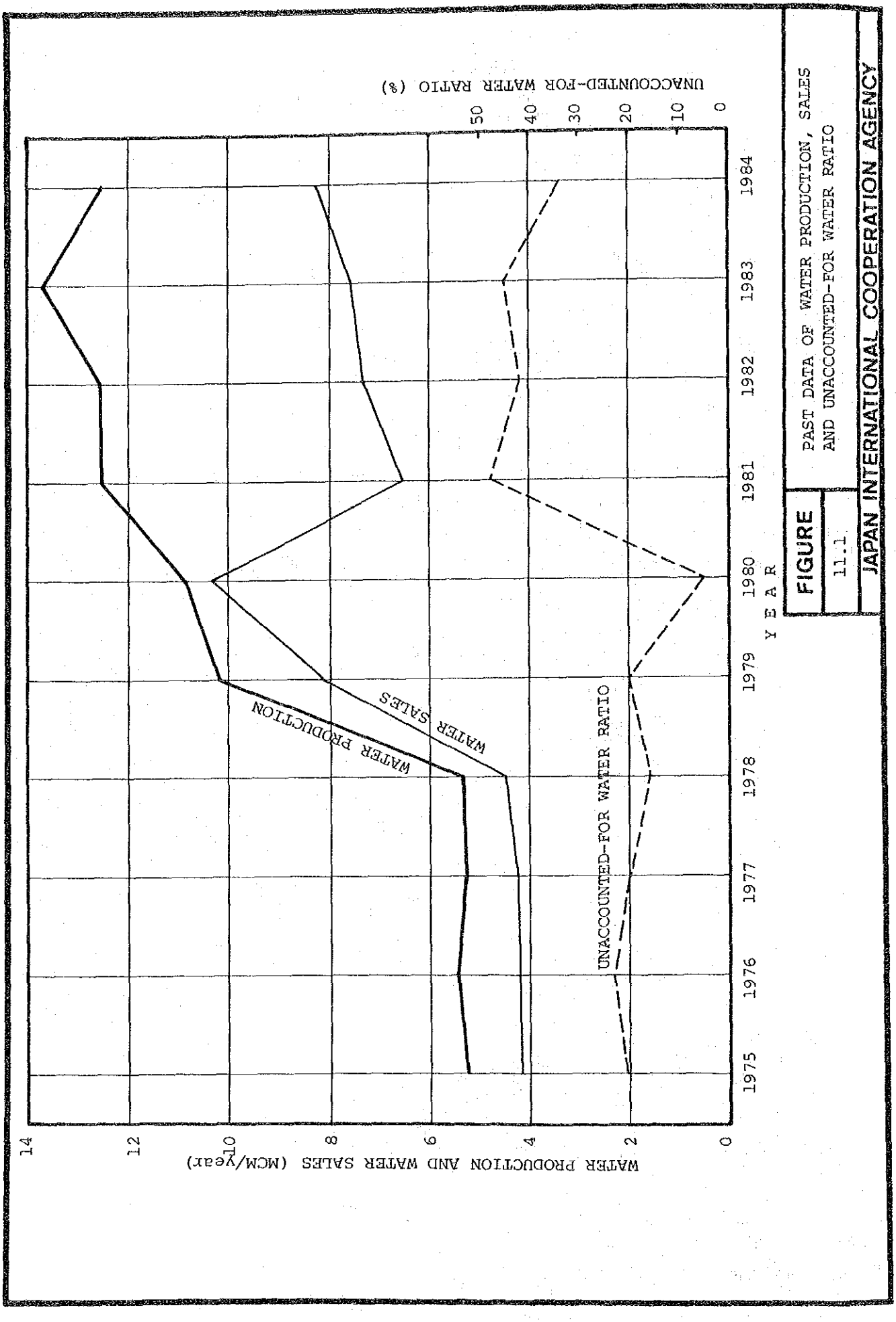

FIGURE 11.1 PAST DATA OF WATER PRODUCTION, SALES AND UNACCOUNTED-FOR WATER RATIO

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Table-11.2 RECENT DATA OF WATER PRODUCTION AND WATER SALE IN CHIANGMAI

	(A) WATER PRODUCTION (cu m/month)	(B) WATER SALES (cu m/month)	(C) UNACCOUNTED -FOR WATER (cu m/month)	D=(C/A)x100 UNACCOUNTED -FOR WATER RATIO (%)	(E) NUMBER OF CONNECTION (number)	(F)=(C)/(E) UNACCOUNTED -FOR WATER PER CONNEC. (m3/conn/mon)
JAN. 1985	1,041,620	667,224	374,396	35.9	14,591	25.7
FEB.	1,058,960	785,389	273,571	25.8	14,715	18.6
MAR.	1,031,300	725,296	306,004	29.7	14,866	20.6
APR.	1,175,310	842,369	332,941	28.3	14,997	22.2
MAY.	996,480	809,706	186,774	18.7	15,169	12.3
JUN.	902,750	666,453	236,297	26.2	15,251	15.5
JUL.	910,850	628,420	282,430	31.0	15,340	18.4
AUG.	1,043,575	778,828	264,747	25.4	15,518	17.1
SEP.	1,001,689	731,283	270,406	27.0	15,669	17.3
OCT.	1,085,800	663,737	422,063	38.9	15,788	26.7
NOV.	1,030,265	729,662	300,603	29.2	15,868	18.9
DEC.	937,375	643,284	294,091	31.4	15,965	18.4
JAN. 1986	936,290	684,361	251,929	26.9	16,033	15.7
FEB.	931,795	710,391	221,404	23.8	16,108	13.7
MAR.	916,695	666,841	249,854	27.3	16,177	15.4
APR.	1,035,600	775,665	259,935	25.1	16,287	16.0
MAY.	1,061,350	798,513	262,837	24.8	16,394	16.0
TOTAL	17,097,704	12,307,422	4,790,282	AVE, 28.0		
TOTAL OF YEAR 1985	12,215,974	8,671,651	3,544,323	AVE, 29.0		

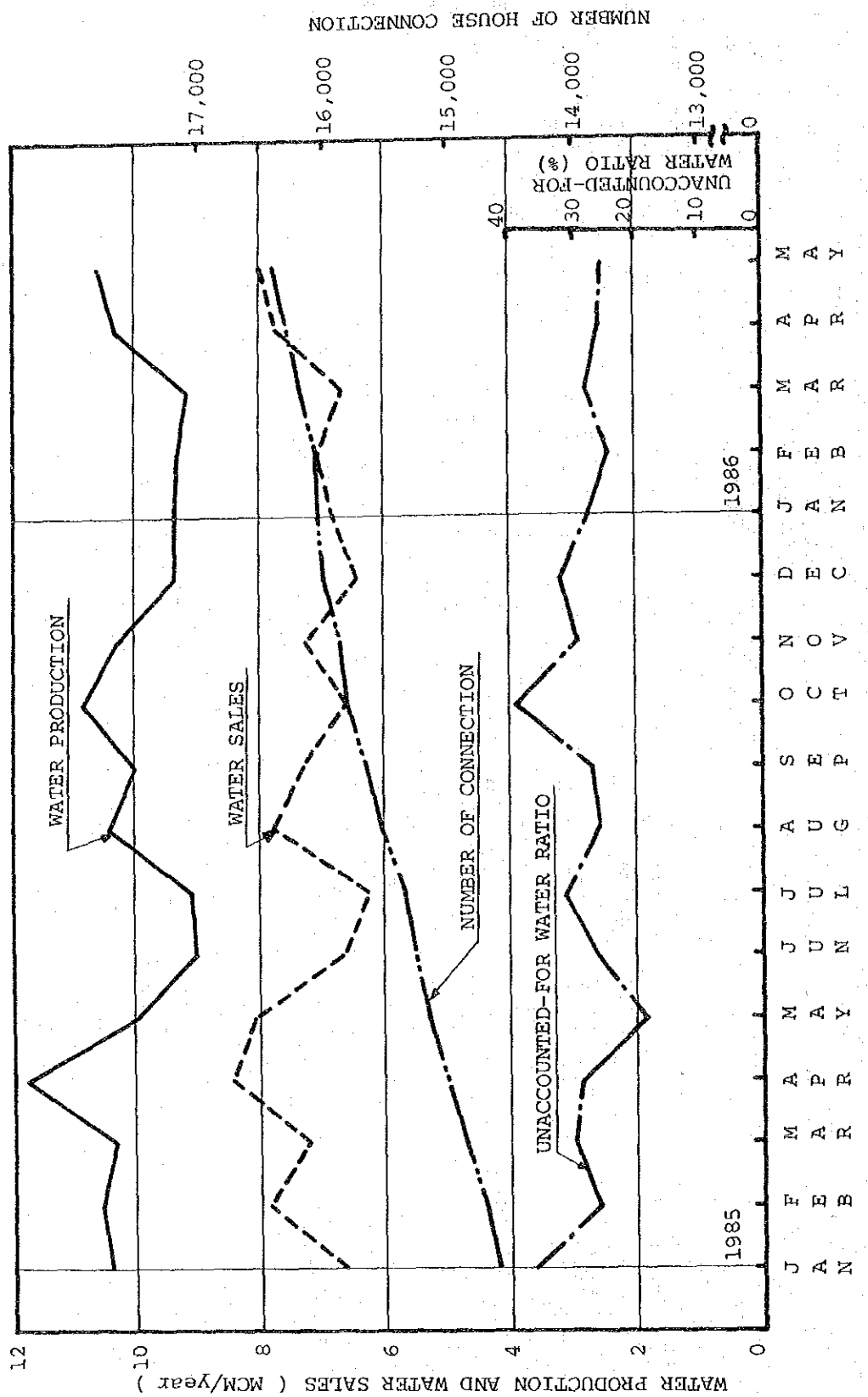

FIGURE 11.2

RECENT DATA OF WATER PRODUCTION, SALES, NUMBER OF CONNECTION, AND UNACCOUNTED-FOR WATER RATIO

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11.4.2 Illegal Connection

Illegal connections are usually uncovered by information from neighboring consumers.

When an illegal connection is uncovered, the consumer must pay, in addition to the penalty fixed under the PWA regulation, the tariff for the stolen water on the estimation by PWA. The penalty for a 1/2 in. illegal connection is ฿5,000.

The informer is awarded with 20 % of the penalty and 50 % of the water tariff paid to PWA by the illegal consumer.

The record of illegal connections uncovered in Chiangmai Waterworks is shown in Table-11.3.

Table-11.3 NUMBER OF ILLEGAL CONNECTION FOUND

YEAR	NUMBER OF ILLEGAL CONNECTION FOUND
1981-1983	NO RECORD
1984	12
1985	12

Data Source: Chiangmai Waterworks

As shown above, 12 illegal connections in total were found in 1985 in Chiangmai. (4 in Pattaya, 13 in Ubon/Warin in the same year, for reference)

The illegal connections' number is less than 0.1 % of the total connections' number of 15,340 in the mid-term of 1985. Even if the illegal consumers use water more wastefully than other consumers, their consumption may be estimated at more or less than 1 % of the produced water.

1 % is counted for the unaccounted-for ratio by illegal connections.

11.4.3 Meter Reading Error

During the field leakage survey, it was found that some water meters were installed at inaccessible spots and a few meters buried underground completely. Very probably those meters had not been read for several months, it seemed.

As no maps of showing the exact location of water meters has been prepared, spotting them shall depend fully on the meter readers' memory or the consumers' guidance.

Presently practiced is that a meter reader, once allocated to an area, is not transferred to other areas. Periodical change of the allocated area together with improvement of preparation of the maps will help decrease the error of meter reading.

So far no check system of preventing or decreasing the meter reading error has been tried and the unaccounted-for volume of water or ratio due to the error has not been made known.

The loss due to meter reading error is not counted herein.

11.4.4 Metering Loss

According to the manufacturers' information, - 5 % error is tolerated for the least flow rate at about 30 l/h in a 1/2 inch meter. The error becomes larger when the flow rate falls lower.

When water is discharged from a tap opened ordinarily under normal pressure, the flow is larger than the said 30 l/h and under-registration is not brought about.

However in Chiangmai, the field survey disclosed that many consumers' taps, slightly opened, were dripping to fill vessels in kitchen and bathroom. The practice might have come from unsteady and unreliable supply condition

in the past. The flow rate, apparently less than 30 l/h, results in under-registering the actual consumption, another cause of the unaccounted-for water.

From the result of meter accuracy test which was carried out for 10 consumers' meters in Pattaya (See Appendix 11 of Pattaya Report), it was learned that the difference between the master meter and the sum of tested consumers' meters was 4 %. The average age of tested meters was 5 years after installation.

Fig-11.3 shows the result, classified by the size and age, of water meters surveyed in Chiangmai.

60 % of all the meters is used in the service for more than 6 years and nearly a half of it for more than 11 years, without being replaced and checked of accuracy of measurement.

Upon consideration of the above, the unaccounted-for ratio due to under-registration of meters is assumed as 5 %.

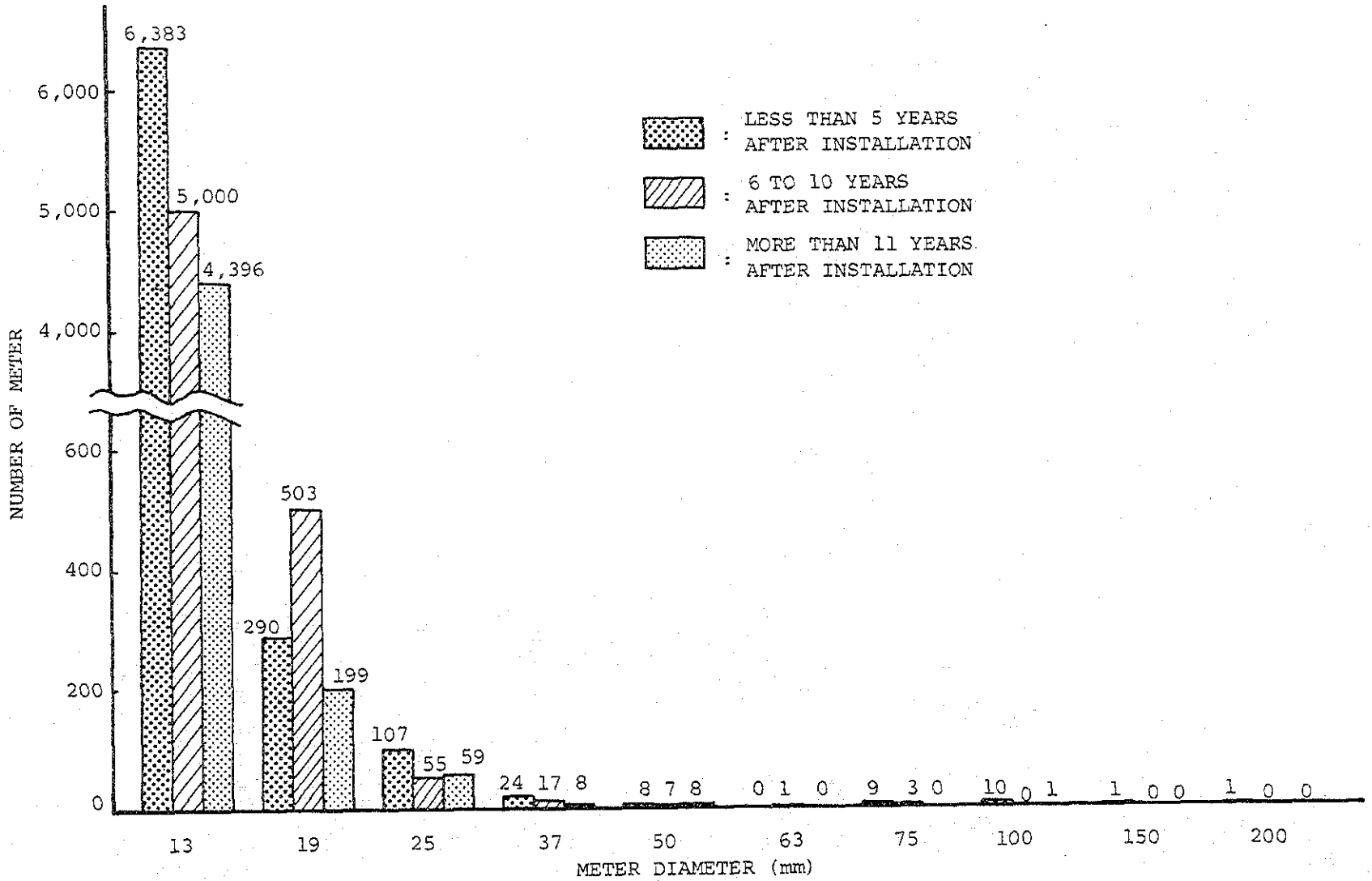

FIGURE	CONSUMER METER CLASSIFICATION BY METER SIZE AND YEARS AFTER INSTALLATION
11.3	

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11.4.5 Leakage

In the foregoing subsections estimated were: 28 % for the total unaccounted-for ratio, 1 % for illegal connections, nil for meter reading error and 5 % for meter loss (under-registration).

The leakage ratio, deducting the sum of 1 % and 5 % from 28 %, is calculated as 22 % therefore.

Detection of leakage in Chiangmai is mostly made accidentally by the consumers, passers-by and waterworks staff. Receiving information from them, the waterworks send personnel to repair the leaking spots.

Fig-11.4 shows the numbers of repair works made in 1985. On the average, five leaking spots were repaired in a day. In spite of such efforts of the waterworks, presumably undetected and or uninformed leakage is taking place, because the detection of leakage is done in passive way as mentioned above.

The leakage ratio resulted from the field survey was 17.8 % for the big block which covered 2.9 % of the whole distribution pipes in the system. The estimated leakage ratio 22 % can be considered reasonable.

11.4.6 Conclusions

In Chiangmai, the leakage loss is largest of the several factors affecting unaccounted-for ratio, and there is much hope in it to reduce unaccounted-for water ratio.

But efforts to lower not only leakage but each factor of the unaccounted-for ratio are worth making, as described in the following sections.

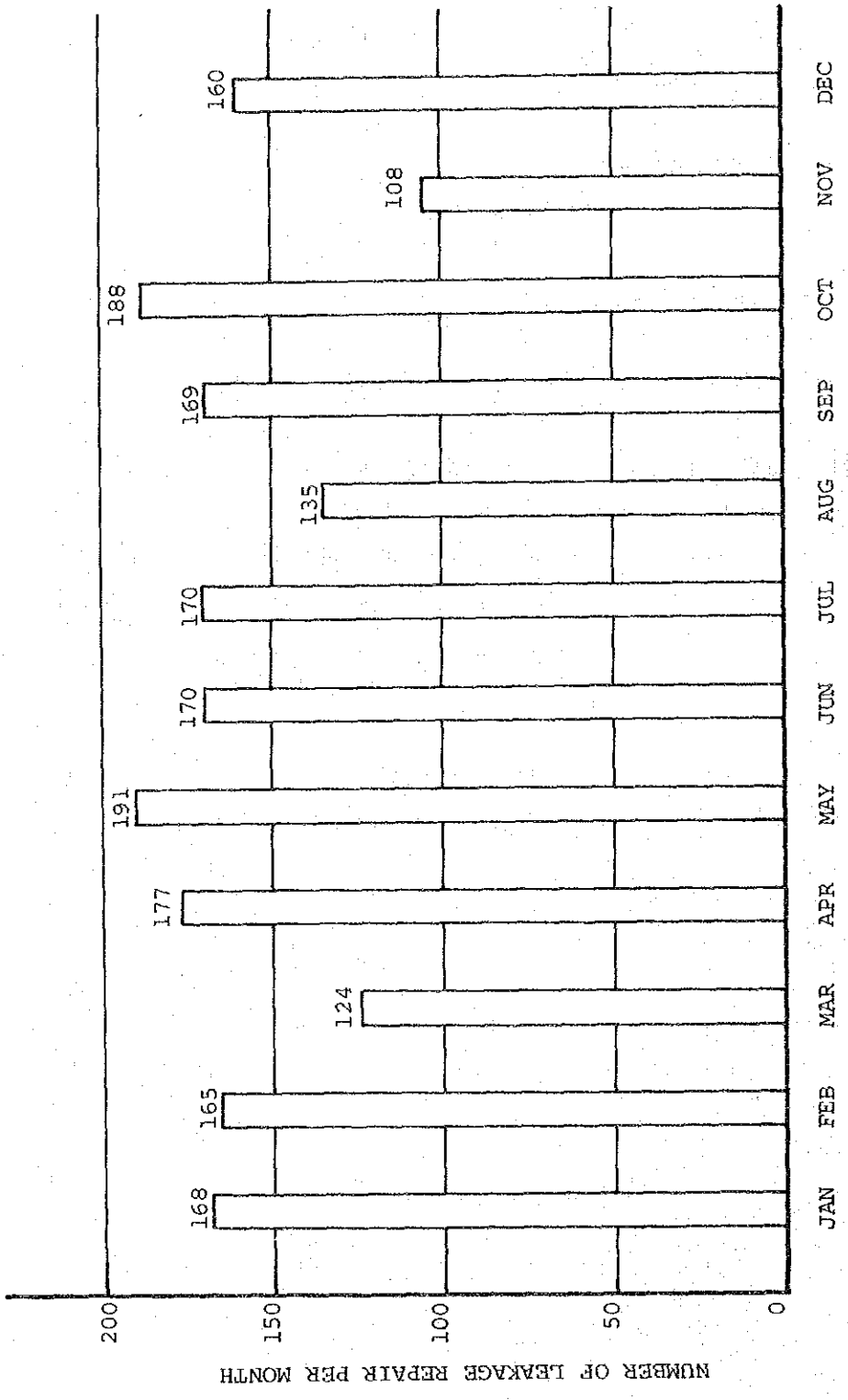

FIGURE 11.4 NUMBER OF LEAKAGE REPAIR PER MONTH IN 1985

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11.5 Reduction of Unaccounted-for water

11.5.1 Illegal Connections

The present situation of illegal connection, estimated at 1 % of the total unaccounted-for water, is very satisfactory. The PWA regulation which imposes penalty upon the unlawful consumers and awarding the informers seems to be effective.

In fact however, no assurance is given whether all illegal connections have been uncovered and such connections will not be made any more in future.

Desirable approaches will be promoting public relations to stimulate the public-mindedness of people against such illegality and encourage meter readers and bill collectors to find illegal connections.

11.5.2 Meter Reading Error

Estimating the error made in reading water meters is most difficult and it was counted out of the unaccounted-for water estimation.

However, some ways of preventing and decreasing can be discussed herein.

It is necessary to make a guideline or manual for installing meters in rightful ways. Basic considerations will be that the meters are safe from accidental damage, inundation and suchlike and easy for connection, disconnection and reading. The existing meters installed wrongly shall be relocated.

Also necessitated is that the ledgers and maps of recording every house connection in the distribution system shall be prepared and filed, so that they are made available to any waterworks official.

As suggested previously in 11.4.3, rotating the allocated areas of meter readers are worth trying.

11.5.3 Metering Loss

Metering loss, or the loss due to under-registration of meters, in Chiangmai was assumed as 5 % in the ratio.

The figure was established partly on the manufacturers' information and the observation of the manner of water consumption, backed up by the result of field leakage test.

The following measures are recommended for reducing the loss:

1) Maintaining Accuracy

Overhaul at regular intervals, say 6 years, changing parts and checking accuracy, is to be practiced and records of the overhaul be kept in file.

2) Checking Meter Size

Over- or under-sized meters register inaccurate consumption. A meter size shall be checked periodically of its suitableness for consumption especially for large consumers.

11.5.4 Leakage

To prevent future occurrence of leakage, much consideration is to be given in selecting pipe material and class, pipeline route and alignment, burying and joining methods of new pipelines. When rehabilitation and repair works are made on existing pipelines, unreliable parts of pipeline shall be thoroughly replaced, abandoned parts be cut off from living parts completely.

Of distribution pipelines, maps recording exact alignment, depth, location of valves, fittings, service connections shall be prepared and filed. In case any change is made on existing conditions, like by road improvement and urban renewal, the maps shall be updated immediately.

Of every service connection, a ledger and map shall be made and filed. In them, length, size, material of service pipes, location of service connection, stop valve, meter shall be recorded. They are subject to updating when necessary, too.

Availability of those maps and ledgers is indispensable for successful execution of leakage control.

Fig-11.5 shows a case of leakage control program drawn schematically.

PREPARATORY WORKS

Preparatory works are the works to be done in preparation of execution of the leakage control program.

Training of staff in detection and repair of leakage control is to be given at all the levels of PWA, Head Office, Regional Office and waterworks.

In Regional Office and waterworks organization, a team assigned to leakage control is formed by the trained staff.

The team selects areas for the leakage survey plan, upon consideration of various factors like the past occurrence of leakage, consumption in the area, etc.

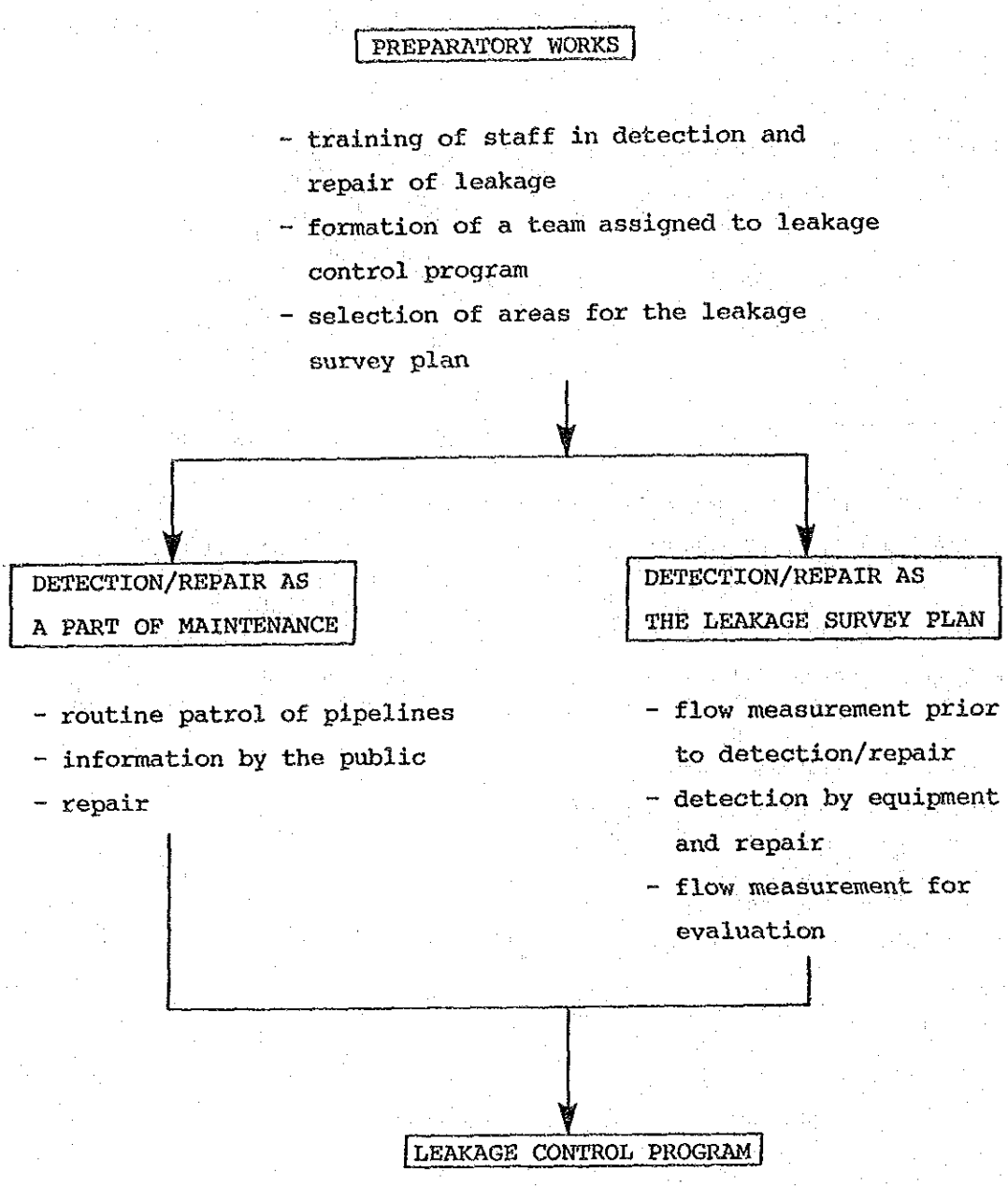

FIGURE	LEAKAGE CONTROL PROGRAM
11.5	

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DETECTION/REPAIR AS A PART OF MAINTENANCE

Patrol of pipelines to detect leakage, under a plan, is practiced as a routine work of the maintenance.

Information given by the public of leakage is responded with gratitude.

Leakage detected by the patrol and reported by the public is repaired by the maintenance staff, as a routine work also.

DETECTION/REPAIR AS THE LEAKAGE SURVEY PLAN

The inflow to the selected area is measured before and after the detection and repair works. The pre-measurement is to gain informations of existing pressure/flow conditions affected by the consumption and leakage. The post-measurement is to evaluate the detection/repair works' effectiveness.

The leakage survey plan carried out for the Chiangmai waterworks is reported in the attached paper.

LEAKAGE CONTROL PROGRAM

Informations of the distribution pipework and service connections gained in the leakage survey plan's implementation shall be used for updating the existing maps and ledgers.

The result of the leakage survey plan is to be used for controlling the pressure in the surveyed area, as overpressurization is found to affect adversely on leakage sometimes.

Overall evaluation of leakage reduction works shall be made under the coordination of engineers, administrative and financial managers. The effectiveness of implementation of the leakage control program shall be studied from the angles like cost performance, working conditions of personnel, organization re-structuring as well as technical improvement.

The leakage control program shall be executed at regular intervals. Because the leakage ratio of Chiangmai estimated at 22 % presently shall be lowered to realize the planned unaccounted-for ratio in 2010, 20 %.

ATTACHMENT

FIELD LEAKAGE SURVEY

ATTACHMENT

FIELD LEAKAGE SURVEY

TABLE OF CONTENTS

1. Introduction

The field leakage survey in Chiangmai was carried out from Aug. 9 to Aug. 22 in 1986, and covered 2.9 % of the distribution pipes of whole length of the network as shown in Fig-11.6. The field leakage survey aimed the following goals.

1) to identify the preparatory works necessitated for effective execution of a leakage abatement program in future

2) to transfer practical know-hows of handling the instruments used for leakage survey and to introduce the methodology of leakage survey to the counterparts

3) to study major causes of leakage

4) to recommend a leakage abatement program prepared based on all findings of the leakage survey

2. Method of Leakage Survey

In this leakage survey, a certain area was isolated from the rest of distribution areas by closing appropriate valves, and then measurement of the inflow to the area was made for 24 hours continuously and sound detection of leakage within the area was carried out at midnight when the background noise was lowest. The advantage of 24 hours' measurement was that it could study about the minimum flow at midnight as well as the flow pattern in the area.

A flow meter of the portable ultra-sonic type, made by Tokyo Keiki in Japan, was installed on an inflow pipe to the area, a closed system without connection to other distribution areas.

Two ways of the midnight measurement were carried out. One was named the direct measurement and another the indirect measurement.

The direct measurement was measuring the inflow, after all consumers' taps were ensured to have been closed. The reading indicated the leakage loss

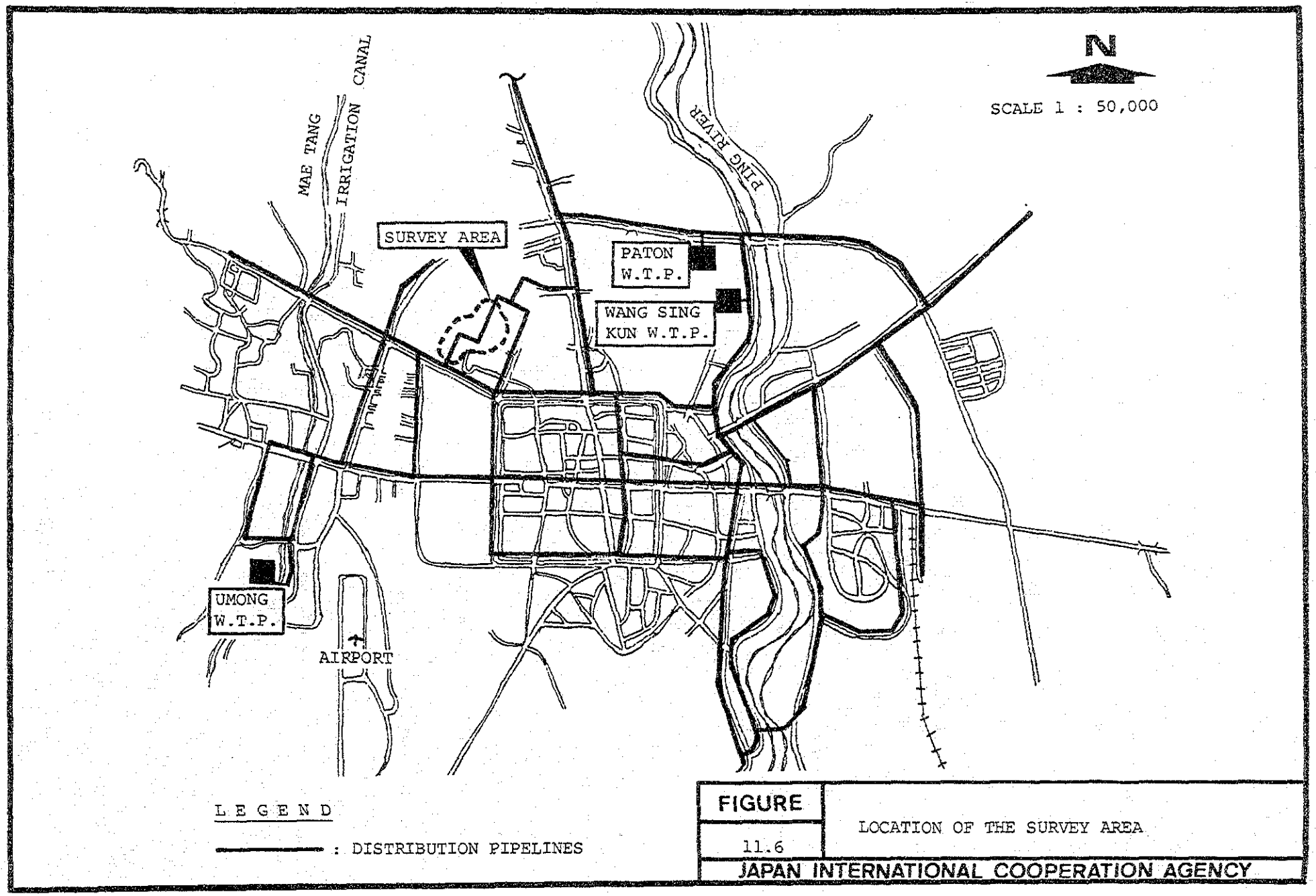

FIGURE 11.6 LOCATION OF THE SURVEY AREA

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presumably.

The indirect measurement was measuring the inflow without any assurance of the consumers' tap condition. The reading can be approximate to the leakage loss, as the consumption at midnight would be small negligibly.

To train the PWA counterparts on the methodology and technology described above, two areas, named "Big Block" and "Small Block" because of their size, were selected as the pilot area of survey. The direct measurement was made on the Small Block and the indirect measurement on the Big Block.

In selecting the survey area (block), the following matters were considered:

(1) the survey block is not a newly developed one
(2) leakage in the block seems to be highly probable, according to the waterworks' experience
(3) pipelines in the block are made of the so-called Class 15 Asbestos Cement Pipe manufactured years ago for low pressure service
(4) service pressure in the block is relatively high
(5) the block is entirely of residential use and does not contain any consumers like factories, hotels, hospitals and facilities which use water for 24 hours continuously
(6) the inflow pipe is conveniently conditioned for installation of the flow meter

Details of the steps taken in the leakage survey is shown in Figs-11.7 and 11.8 schematically.

To ask the consumers' cooperation for closing their taps during the midnight survey, from 1:00 to 4:00 a.m. on the appointed date, announcement was made by distributing handbills to every consumer in the area, prior to "Measurement Procedure" shown in Fig-11.8 for the survey of the Small Block.

PREPARATION PROCEDURE

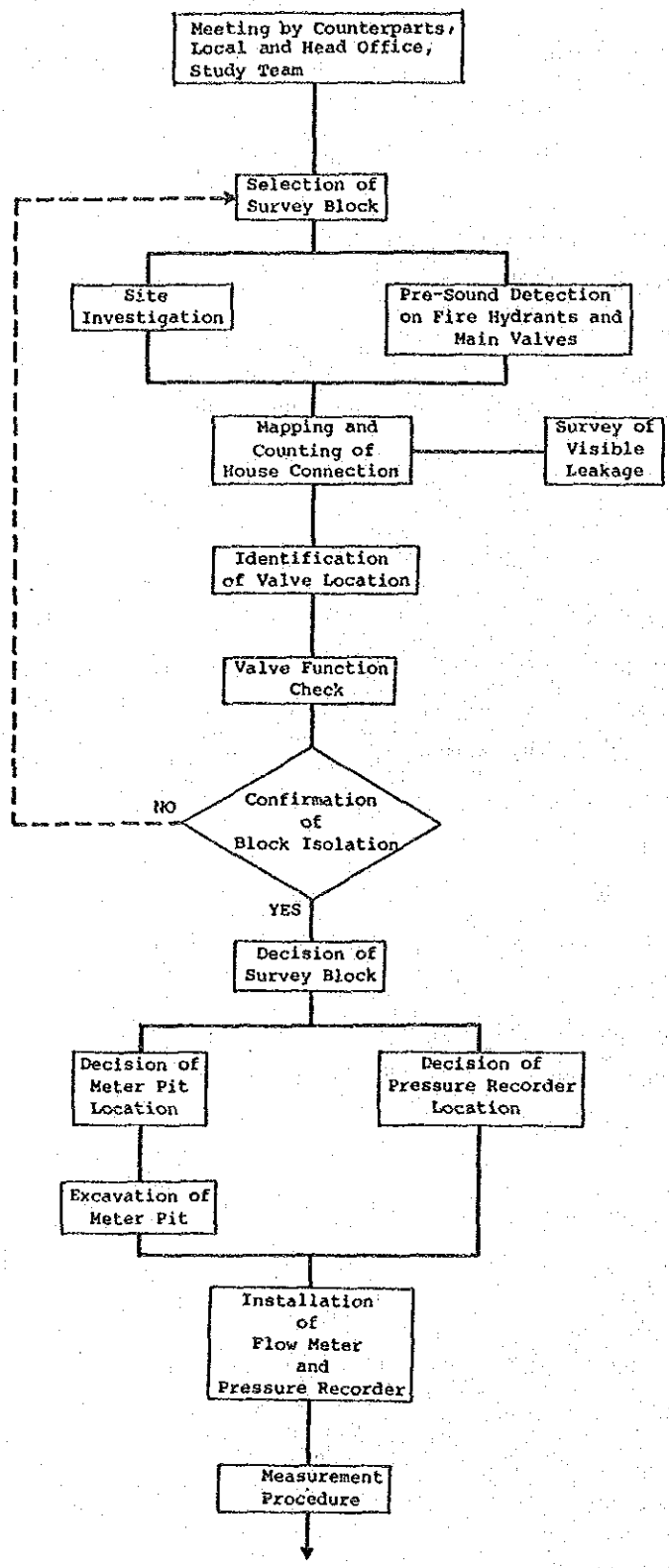

FIGURE	PREPARATION PROCEDURE FOR LEAKAGE SURVEY
11.7	

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MEASUREMENT PROCEDURE

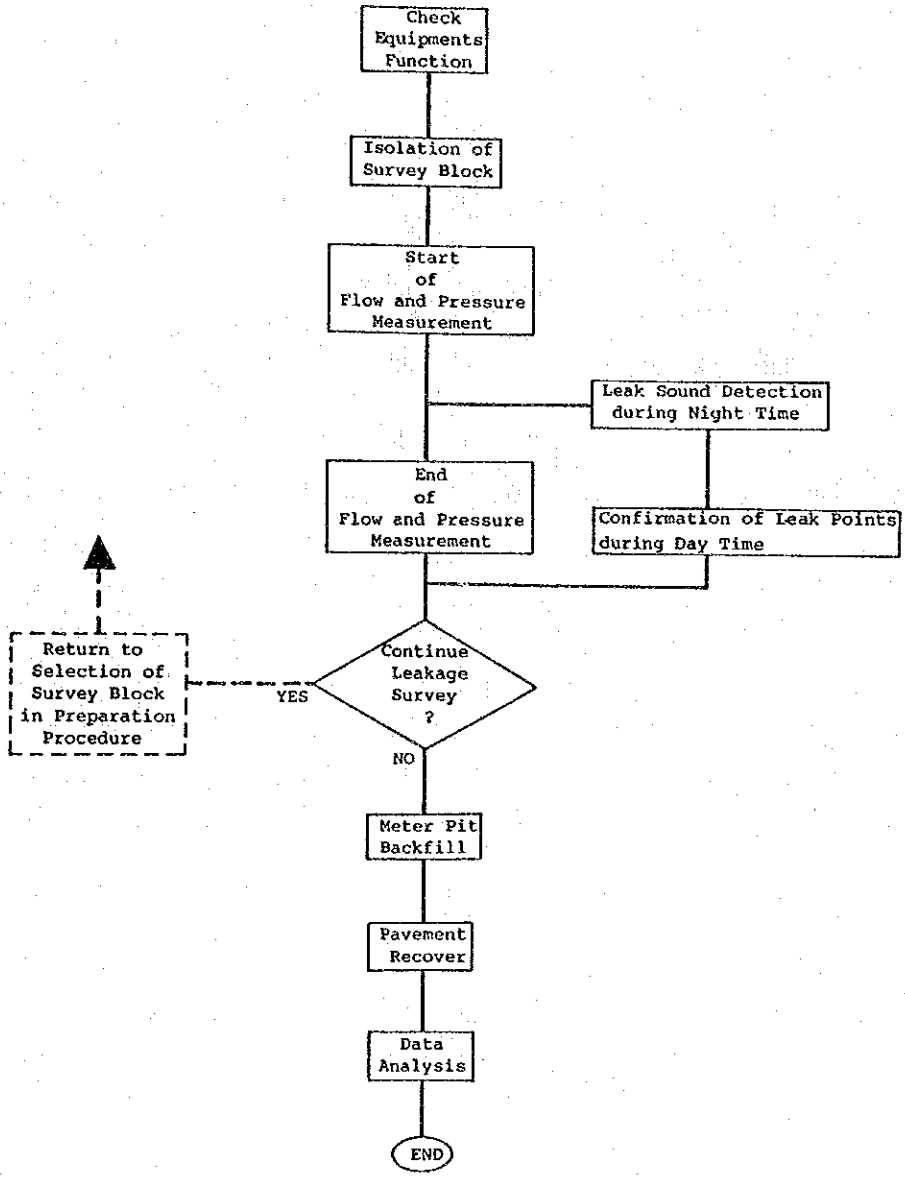

FIGURE	MEASUREMENT PROCEDURE FOR LEAKAGE SURVEY
11.8	

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3. Activities of Leakage Survey Team

Twelve counterparts from the PWA Head Quarters, Chiangmai Regional Office and Chiangmai Waterworks worked willingly with the Study Team. The activities of the Study Team and the counterparts are summarized below.

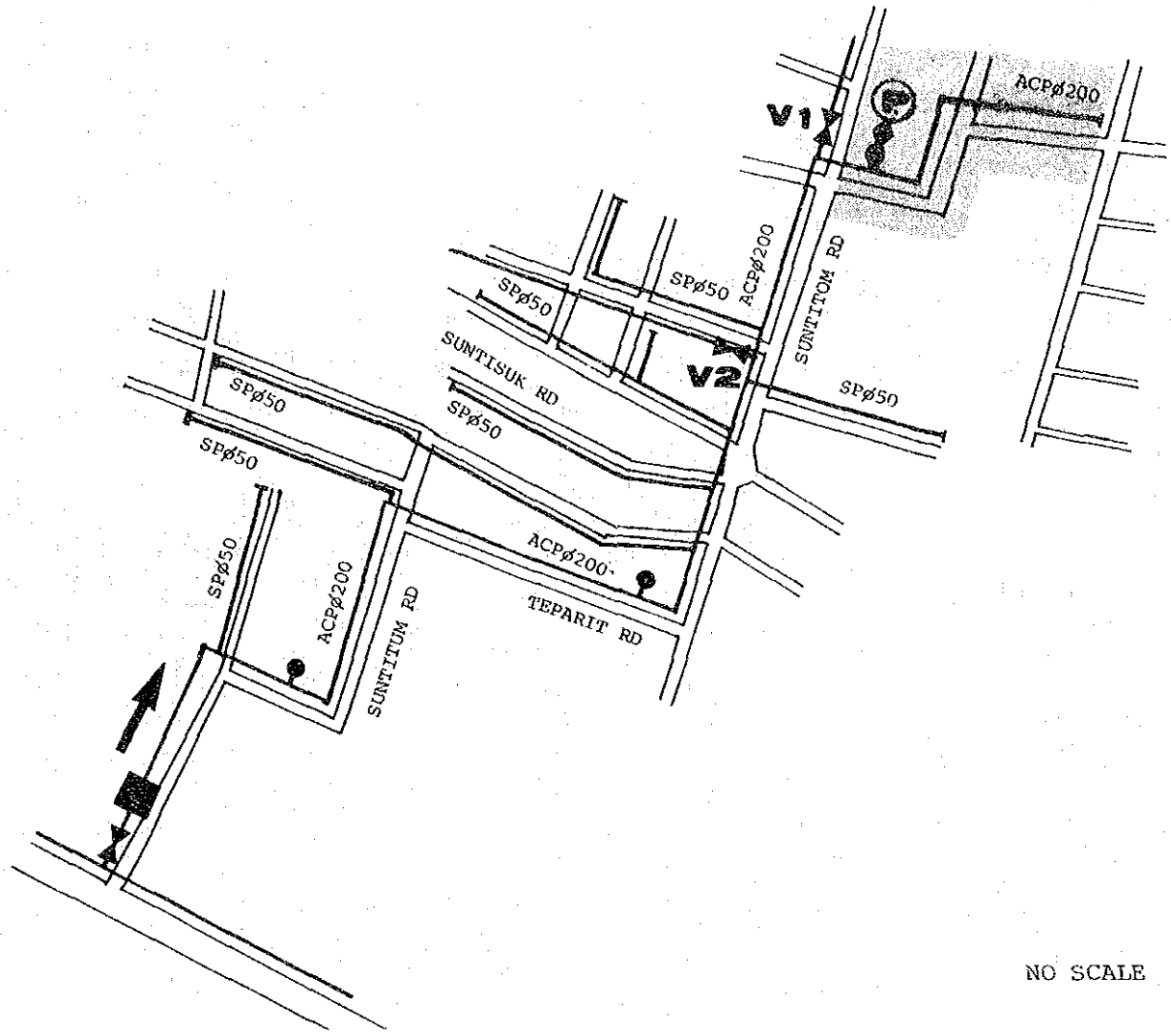
3.1 Big Block Survey

The area, of which the total length of distribution pipes is 3.0 km and the number of house connections 176, was selected as a Big Block. Materials of the distribution pipes in the survey block were of ACP Class 15, ACP Class 20 and SP. Most of the service pipes were of SP and PVC pipes are used for some connections.

Regarding the Big Block, the Study Team intended to select an area which covered at least 500 house connections but after site investigation, it was found that necessary valves for block isolation were missing under pavement, or inoperatable because of deterioration even when located with a metal locator. During the confirmation work of the block isolation, it was also found that dozens of connections in the block were connected with a distribution pipe which was out of the survey block and was not shown on the map. Eventually, the requirement of connection number were found unrealistic.

The Study Team selected the 176 connections area as a Big Block. The plan of the Big Block survey is shown in Fig-11.9. A pit was excavated to install the flow meter on the inflow pipe (ACP, ϕ200) to the survey block, and a pressure recorder was set on a fire hydrant at the other end of the block.

24 hours' measurement of the flow and pressure was carried out from August 18 to August 19, 1986. During the 24 hours' measurement, locating leaking spots was tried by detecting sound with stethoscopic bars and sound detectors. Several spots of leakage, invisible but detectable by sound, were located and confirmed of leakage on the next day, after digging the ground. The leakages were repaired immediately by the service section of the waterworks.



NO SCALE

Length of Distribution Pipe : 3.0 km
Number of House connection in Big Block : 176

L E G E N D

: FLOW METER
V1 : CLOSED VALVES FOR BLOCK ISOLATION
: PRESSURE RECORDER
: DIRECTION OF FLOW
: DISTRIBUTION PIPE
: FIRE HYDRANT
: SMALL BLOCK

FIGURE	PLAN OF THE BIG BLOCK SURVEY (INCLUDING THE SMALL BLOCK)
11.9	

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3.2 Small Block Survey

A section of the Big Block was selected as the Small Block. The total length of distribution pipes was 0.25 km and the number of house connections was 40 in the block. The plan of the Small Block is shown in Fig-11.10.

The Small Block was a downstream section of the Big Block. A pit was excavated to expose the inflow pipe (ACP ϕ200) into the survey area for the flow meter installation. As to the pressure measuring point, a fire hydrant, which was just upstream from the flow measuring point, was used as shown in Fig 11.10.

Most of the distribution pipes were ACP. SP was used mostly and PVS partly for service connections.

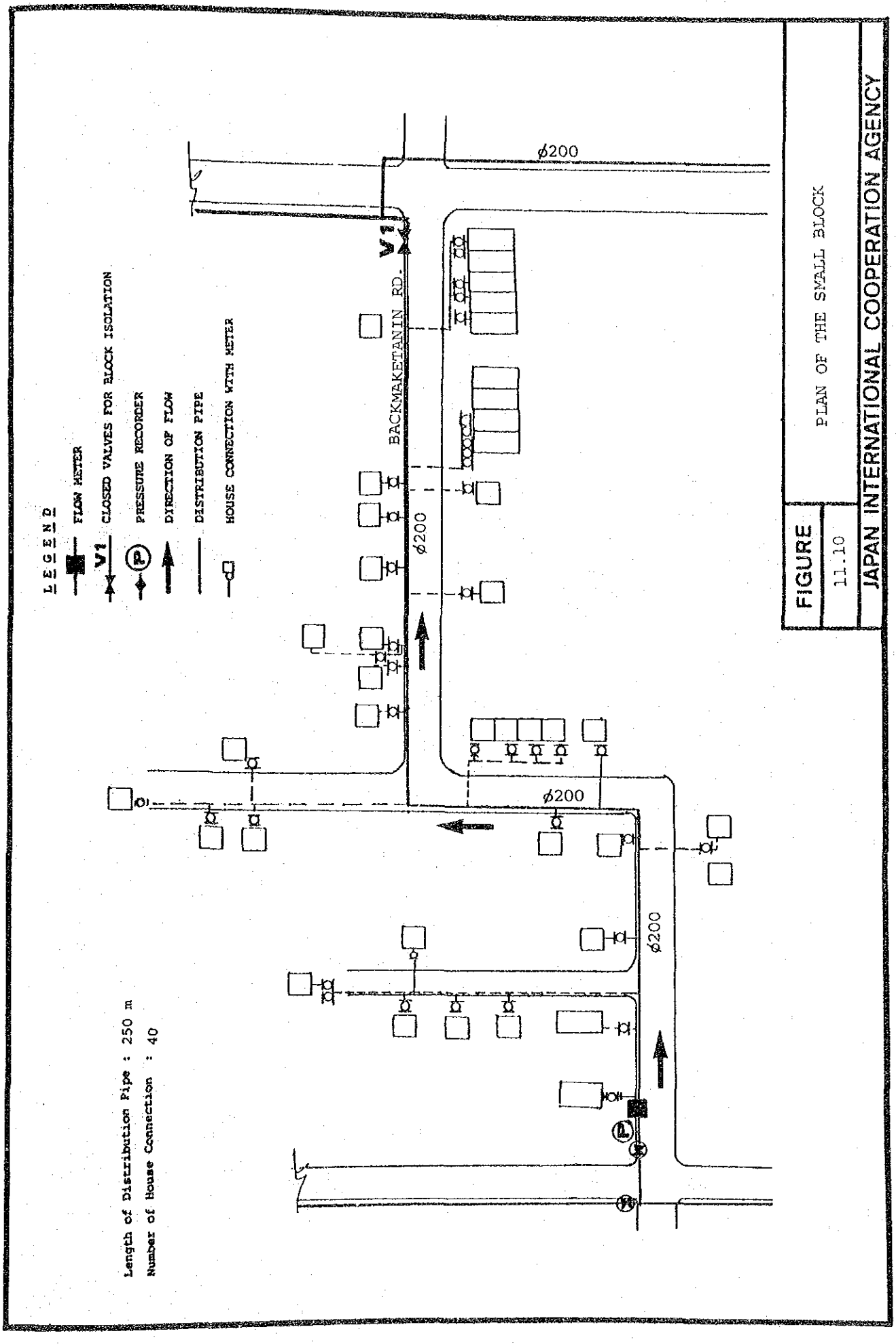
24 hour's measurement of the flow and pressure was started on June 19, 1986.

But the flow meter stopped functioning in the midnight. Checking the measuring equipments and operation process, neither mechanical defect nor mishandling was found.

By the experience of similar surveys on Pattaya, Ubon/Warin and Suphanburi made previously, it was leaned that attaching the sensor to the pipe was most principal.

Measurement by the ultra sonic flow meter is made by measuring the ultra sonic signals transmitted across the water flow in the pipe. The transmitter attached to a side of the pipe sends signals which are received by the receiver attached on the opposite side or the same-side downstream position. The received signals are converted to be indicated in the meter.

As the sensor, a pair of transmitter and receiver, is a key component of the system, the skillfulness of attaching the sensor, like correct positioning and disturbance-free conditioning, and the fitness of the pipe, concerning material, surface and inside conditions, are most important for successful operation.


LEGEND
FLOW METER
V1 CLOSED VALVES FOR BLOCK ISOLATION
P PRESSURE RECORDER
DIRECTION OF FLOW
DISTRIBUTION PIPE
HOUSE CONNECTION WITH METER
BACKMAKETANIN RD.
V1
φ200
φ200
φ200
φ200
Length of Distribution Pipe : 250 m
Number of House Connection : 40
FIGURE
11.10
PLAN OF THE SMALL BLOCK
JAPAN INTERNATIONAL COOPERATION AGENCY

In setting the sensor, trials are repeated until normal functioning of transmission and reception is confirmed and the sensor is fixed.

The trials were made in this case before the setting. However, groundwater seepage filled the excavated pit, submerging the set sensor afterward.

The failure was probably caused by a slight displacement of the sensor's positioning under the changed condition.

Consequently 24 hours' measurement of the flow was abandoned, and only sound detection of leakage at midnight was carried out for the Small Block Survey.

3.3 Technology Transfer of Leakage Survey to the Counterparts

Two counterparts of the Planning Section of PWA Head Quarters, two counterparts of the O & M Department of PWA Head Quarters, three counterparts of the Chiangmai Regional Office and five counterparts of the Chiangmai Waterworks were assigned to work closely with the Study Team, throughout the survey period. The manager and the assistant manager of the waterworks also attended to the sound detection of leakage at midnight.

One of the objectives of this leakage survey was to transfer the know-hows of handling instruments, as well as the methodology of leakage survey to the counterparts, so that they would be able to prepare a similar program in future.

Chiangmai Regional Office and Chiangmai Waterworks were found in possession of main instruments used widely in leakage survey, as listed in Table-11.4. They were the same ones the Study Team intended to demonstrate and fortunately some of the counterparts had used them before. So the demonstration and instruction of handling the instruments were smoothly understood by the counterparts.

Though the instruments were familiar, practical lessons of using them in the field survey had not been given by experienced leakage survey experts before, it seemed. Skillful use of the instruments is essential in bearing effective results, especially with leak sound detectors and stethoscopic bars, as many kinds of sound, resembling leakage sound, disturb right judgment.

In this survey, however, an experienced leakage expert of the Study Team could give practical know-hows to be used in searching for and locating leakage spots to the counterparts, through the field work.

The ultrasonic flow meter used in this survey was promised for donation to PWA after the completion of the study and familiarization with the meter was thought to be important. Practical method of installation and operation was demonstrated in details by the Study Team. The counterparts tried hard in learning them with positive willingness.

In addition to the practical know-hows of field survey, the methods of

planning like selecting a survey area in the distribution network were learned by the counterparts.

All of the counterparts, while gaining practical experience, became aware of existing problems of obstacles to be tacked by themselves. Those problems discussed during the survey by the Study Team and counterparts are raised and summarized in Chapter 5.

Table-11.4 INVENTORY OF THE INSTRUMENTS FOR LEAKAGE SURVEY

Chiangmai Regional Office

1.	Water Leak Detector (Fuji WL-200)	2 sets
2.	Electric Sound Detector (Fuji FSB-4L)	1 set
3.	Metal Locator (Fuji F-80)	1 set

Chiangmai Waterworks

1.	Water Leak Detector (Fuji WL-200)	1 set
2.	Electric Sound Detector (Fuji FSB-4L)	1 set
3.	Metal Locator (Fuji F-80)	1 set

4. Survey Result

4.1 Big Block Survey

4.1.1 Flow and Water Pressure

24 hours' flow and pressure patterns measured in the Big Block are shown on Fig-11.11. The minimum flow was 2.0 cu m/hr and the maximum flow 17.0 cu m/hr. The minimum pressure observed was 0.5 kg/sq cm in the evening and the maximum pressure 1.6 kg/sq cm at midnight. The flow and the pressure were correlated reasonably.

The 24 hours' flow into the Big Block was 213 cu m/day, when integrated mathematically.

4.1.2 Leakage Detected

Ten leaking spots were found in the Big Block survey. Three underground leakages were detected by sound during the night and confirmed by digging the next day. Some of seven leaks on exposed pipes were sound-detected initially and tracked out while the others were detected visually.

The cause of leakage were considered to be as follows:

a) Poor Workmanship of Service Pipe Laying

The buried depth is too shallow, indicating that PWA standards are not observed strictly. In backfilling, rough-edged crushed stones and bricks, damaging to the pipes, are often used seemingly.

b) Poor Workmanship of Joint

Visible leakage is seen often on the joints of service pipes. Poor workmanship is suspected of causing it.

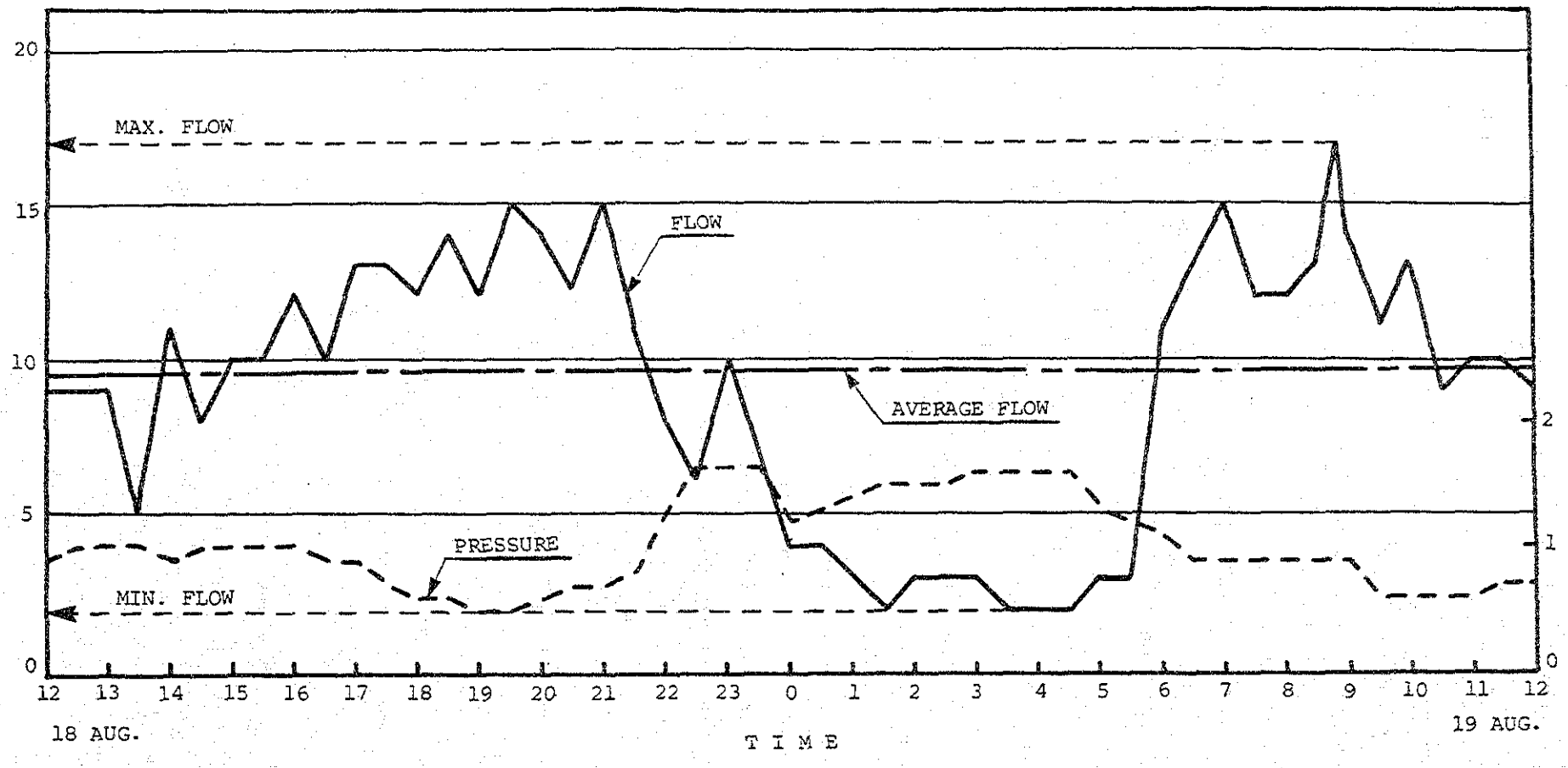


FIGURE	FLOW AND PRESSURE PATTERNS DURING BIG BLOCK SURVEY IN CHIANGMAI
11.11	

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c) Corrosion of pipe

Leakages caused by corrosion were found on some old service pipes.

4.1.3 Leakage Ratio Estimation

Leakage ratio in the surveyed area was calculated, although it was not the sole purpose of this leakage survey.

The minimum flow at midnight was modified upon consideration of the difference of pressure, at midnight and average in the daytime, and it was designated as the leakage loss. The leakage ratio was 17.8 %. Under the average daytime pressure, the leakage per unit pipe length per day was calculated as 12.6 cu m/km/day.

4.2 Small Block Survey

4.2.1 Leakage Detected

Two leaking spots were found in the Small Block survey. One underground leakages were detected by sound during the night and confirmed by digging the next day. One leakage on exposed pipes were tracked out.

4.3 Summary of Survey Results

The results of Big Block Survey are summarized in Table-11.5.

5. Finding and Conclusion

Major findings of the survey are described as follows:

1) The existing drawings are not prepared satisfactorily. It doesn't show actual pipelines and location of valves. Some valves (specially old ones) are not shown and the recently laid pipes are not shown, too. It is recommended to prepare complete drawings not only for leakage survey but also routine maintenance and future expansion plan.

2) Some valves shown in the drawings are missing, probably because of road construction work made later.

3) Some valves are deteriorated. Leakage was observed at the gland of valves when they were operated.

4) Twelve leak spots were found in the Big and Small Block Surveys and their causes are considered to be as follows:

Table-11.6 SUMMARY OF SURVEY RESULTS IN CHIANGMAI

ITEM	DESCRIPTION	UNIT	BIG BLOCK
A	LENGTH OF DISTRIBUTION PIPE	(km)	3.0
B	NUMBER OF HOUSE CONNECTION	(number)	176.0
C	MAXIMUM FLOW	(cu m/hr)	17.0
D	MINIMUM FLOW	(cu m/hr)	2.0
E	AVERAGE FLOW	(cu m/hr)	8.9
F	ACCUMULATED FLOW	(cu m/hr)	213.0
G	MAXIMUM PRESSURE	(kg/sq cm)	1.6
H	MINIMUM PRESSURE	(kg/sq cm)	0.5
I	AVERAGE PRESSURE	(kg/sq cm)	1.0
J	AVERAGE WATER FLOW PER HOUR PER UNIT PIPE LENGTH	(cu m/hr/km)	3.0
	* * * ASUMING : MINIMUM FLOW = LEAKAGE * * *		
K	MODIFIED LEAKAGE BY AVERAGE PRESSURE	(cu m/hr)	1.6
L	LEAKAGE AMOUNT PER DAY	(cu m/day)	37.9
M	ESTIMATED LEAKAGE RATIO	(%)	17.8
N	LEAKAGE PER PIPE LENGTH	(cu m/day/km)	12.6
O	LEAKAGE PER HOUSE CONNECTION	(cu m/day/con.)	0.2

NOTE : F = E x 24
J = E / A
K = D x (I / G)^0.5
L = K x 24
M = (L / F) x 100
N = L / A
O = L / B

Cause	Case
Defected gland of service valve	4
Loose or inappropriate joint	3
Corrosion of service pipe	3
Defected water meter	1
Deteriorated rubber packing of saddle	1

5) In Table-11.5, Item J designates the average water flow per hour per unit pipe length. When the value is larger, the probability of occurrence of leakage is considered to be higher.

For the Big Block, the value was 3.0.

Another indicator is the number of connections per unit pipe length, calculated by dividing Item B by Item A in the table and expressed in the unit of number/km. Again, the larger value suggests the higher probability.

For the Big Block, the value was 59.

Collecting such data of various waterworks will be helpful in studying leakage problems comparatively and in making a guideline in future.

6) The leak volume calculated by the following formula is indicative of a pipeline's leakage condition:

$$Q = (Q_m / L) \times (P_s / P)^{1/2}$$

where, Q = Leak volume per hour per unit pipe length, (cu m/hr/km)

Q_m: Measured minimum flow per hour, (cu m/hr)

L : Distribution pipe length in the surveyed area, (km)

P_s: Standard water pressure, (2 kg/sq cm)

P : Water pressure when the minimum flow is recorded, (kg/sq cm)

After Q_m and P are measured, Q is calculated with the given L and P_s.

Q value was 0.77 and 15.9 for the Big Block. In case of the water-works in Japan, the value from 0.5 to 1.2 is seen often and considered as acceptable.

There is technical and economical limits in reducing leakage. Setting up its own indicator as calculated above is realistic for each water-works, upon consideration of existing management, technical level of detection and repair of leakage, staff's availability and capability, benefit of leakage reduction for conservation or development of water sources, future expansion plan, etc.

APPENDIX 12

OPERATION AND MAINTENANCE OF THE SYSTEM

APPENDIX 12

APPENDIX 12 OPERATION AND MAINTENANCE OF THE SYSTEM

12.1 Introduction

The raison d'etre of the water supply service is supplying clean and low-price water in abundance to consumers, in order to improve the public hygiene and promote the living environments. Operation and maintenance of the water supply system aim to realize the reason of the existence.

The water supply service shall manage a public enterprise, by utilizing water sources, a natural and national resource, and supplying potable water to the general public. The service, therefore, has responsibility for utilizing the resource effectively and managing the enterprise soundly.

As for to the service, the people shall pay attention to maintaining cleanness of the water sources and normality of water supply facilities as well as supporting the waterworks management.

Looking as above, cooperation of the supply service and consumers is essential.

12.2 Software and Hardware of Water Supply Service

The water supply service shall be looked into of the two sides, software and hardware. The software is institutional matters such as laws, acts and regulations, while the hardware is physical matters like facilities and equipments.

For the improvement of operation and maintenance, good establishment of the software and hardware is essential.

12.3 Laws

In order to develop the water supply service in a country, the following laws, among others, shall be legistrated and enforced:

For protection and conservation of water sources to be used by the service, laws of Water Pollution Control, Groundwater Control and Natural Environment Protection are needed.

Corresponding with advancement of a country, systematic and organized development of water resources becomes essential. For it, Water Resources Development Law will be effective.

To establish the position of water supply service, Water Supply Service Law is to be legistrated.

To secure employment of competent personnel for the service, a law concerning Status of Public Servants will have to established in coordination with Labor Law.

In Criminal Law stipulation of the crimes of damaging waterworks' facilities, pollution or poisoning water source and stealing water is necessary.

In some countries, illegality concerning the service can be corrected only by means of judicial action. On the part of the service, it is too complicated and troublesome. Instead, the service shall be authorized to take administrative actions like compulsory investigation and penalization. Details of such actions empowered to the service shall be determined and legalized.

Legally and administratively and on both the national and local levels, the water supply service shall be coordinated to other public services such as city planning, road maintenance and housing. Legal and administrative adjustment between the water supply and other services is needed.

12.4 Hardware-oriented Software

Industrial Standards ruling the materials and products used widely and commonly shall be established. The water supply service will benefit by it, as they are used also by the service.

Waterworks Standards applicable to materials and products used by the water supply service are to be prepared.

Design Criteria shall be revised and updated periodically, not only by the staff assigned to the design department/section but also participated by the staff to the departments/sections of procurement, planning and construction, as well as operation and maintenance.

Regarding the above mentioned Industrial Standards, Waterworks Standards and Design Criteria, academic fields' people are to be asked to give advice and private sectors' involvement, by manufacturers, suppliers and contractors, are to be welcomed.

12.5 Organization

A water supply system consists, by the widely accepted concepts, raw water intake and transmission, treatment, distribution and service, following the flow of water.

Usually the waterworks organization is formed after the above division. Upon the local conditions, two or three divisions can be merged to one, for instance, a system using well water may have a division managing intake/transmission/distribution or another system, small sized, will have a division handling distribution/service.

In a large city where it is divided into a number of reasonably-sized districts, the water supply service may have the district office. For such a setup, the district office deals with meter-reading and tariff-collecting, as well as taking technical care of service facilities.

In whatever way a waterworks is organized, a few essential matters are to be considered.

12.5.1 Personnel Management

Assigning the right persons to the right positions is most essential for any organization.

In every aspects of personnel management, fairness is to be regarded. In recruitment, promotion and reshuffle, selection based on the qualification

and past performance of capability and personality shall be made on competitive basis. Favoritism and nepotism shall be avoided by any means.

Aside from the responsible department/division for the matters of personnel, a committee making selection or decision or recruitment, promotion and reshuffle is to be formed in the organization.

In operation and maintenance of a water supply system, the knowledge learned by experience is as valuable as the theoretical technology learned in school. Therefore, experienced technicians shall be given a fair share of opportunities of being promoted to certain levels. When this kind of promotion is realized often, it will help activate young aspiring technicians and even skilled labors.

This promotion system will also influence favorably the success of training of personnel.

12.5.2 Training

Training courses for all levels and different fields of occupation are to be planned and carried out. Participation in the training course followed by accumulation of experience on the job shall be regarded fairly as a qualification. The qualified persons shall be encouraged to attend to higher level of the training course.

To evaluate and improve the effectiveness of a training course, making examination of the participants shall be practiced. Each one's achievement will be used for awarding a license or qualification which can be referred to in the occasions of promotion or assignment of a new promising position.

In low level training courses, the instructors are to be appointed from not only high officials but also persons who have been promoted from lower rank on the merit as suggested above.

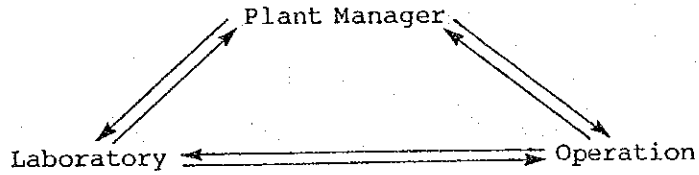
12.5.3 Internal Coordination

In any organization, internal coordination is essential in functioning the whole efficiently and smoothly.

The first point to be stressed is reporting-back or feeding-back of information. In a treatment plant for instance, optimum dosage is determined by the laboratory and reported to the plant manager. The results of actual application of the dosage shall be sent back to the laboratory with comments by the operator, so that, the laboratory is to be learn the difference of mechanical and hydraulic conditions between jar testing and plant performance.

Regarding the whole system, internal feed-back between the divisions of intake/transmission, treatment, distribution and service is to be routinized.

The second point is, so to speak, horizontal coordination as shown below.



From the rule of organization, the plant manager is the coordinator. When different or conflicting information is reported to him from below, he has to adjust, harmonize and decide. However on the daily routine matters, difference can be settled between the interested parties by themselves, partly contradicting the rule of organizational functioning.

In the operation and maintenance of treatment plant and whole supply system, such horizontal coordination or exchange of information is speedy and efficient, and it accords with the first point mentioned before.

As shown above, the way of thinking will make three channels of two-way communication in the picture. Generally speaking, multi-channel, vertical and horizontal two-way communication is to be activated.

12.5.4 Recording and Record Processing

The procedures of recording and record processing shall be ruled within an organization.

Operation and maintenance records, for each of intake/transmission, treatment, distribution and service, are to be made in specified formats, regarding the daily routine works.

Formats of reporting accidental matters are to be prepared also.

Record processing means creating higher-level information by coordinating and integrating the collected records. In the beginning, the methodologies shall be agreed by the participants from different departments/divisions and the aims of using the higher-level information shall be clarified.

12.5.5 Checklists for Preventive Maintenance

Preventive maintenance is most essential. Sensing and correcting abnormality of facilities and equipments, at earlier stages, will certainly end in saving substantial cost of maintenance.

It shall be perceived and tried into everyday's works, by all staff from the top to the bottom. Especially the senior and middle level personnel are expected to contribute, as they are experienced and knowledgeable.

Formats of checklists on the facilities, equipments and machineries which need periodical checking are to be prepared.

12.6 Hardwares for Operation and Maintenance

Hardwares needed in the operation and maintenance are outlined.

12.6.1 Manuals

Manuals covering the following subjects, among others, are needed*

- pipeline
- valve and valve operation
- pumps and appurtenance
- water treatment machinery
- chemical system and operation
- filter operation
- clear water reservoir operation
- leakage survey and repair
- consumers' meter

12.6.2 Maps, Drawings and Ledgers

Maps of pipelines including the location of valves, air valves, drain valves, hydrants and others, are to be kept, in sufficient number and good order and, when any modification works are made on the pipelines, the maps shall be revised immediately. The location of auxiliaries is often found lost when looked for and detailed maps showing the location, relative to permanent structures, are to be attached. The approximate depth of pipes and auxiliaries is to be filled in these maps preferably, when opportunities of finding them occur.

Drawings of the major facilities are also to be revised when modification is made on them.

In principle, materials and devices, design and installation works of private plumbing systems shall be, all of them, under the control of the waterworks authority, For each plumbing system, a ledger shall kept in file.

The documents are to be made in duplicate or triplicate, depending on the importance of them, and to be kept in file in the waterworks, regional office and head office.

12.6.3 Vehicles

Considering the work volume and number of personnel engaged in various tasks of operation and maintenance, vehicles like bicycles, motorbikes, vans, trucks and sedans are to be allocated for the use of waterworks.

Mobility is a key matter in operation and maintenance works.

12.6.4 Communication system

Communication system between the waterworks office, treatment plant, pumping station, operation/maintenance chief's office and the field staff team is to be made immediately when need arises. Public telephone system shall be fully utilized for the communication and a radio system between a mobile station and fixed station will be effective.

For a large plant or where offices are set apart in a large site, an in-plant telephone system is to be installed, because frequent exchange of information is preferable, as mentioned in 12.5.3 previously.

Assuming various cases of emergency, communication plan shall be prepared well beforehand.

12.6.5 Meters and Meter Management System

a service meter is said to become inaccurate after about 6 years of service. It will mean that 16 % of existing meters is to be replaced by new or renewed ones. If additional requirement for new customers is counted, about 20 % of the presently installed number shall be kept ready for use in the warehouse.

A meter management system is to be established, as well as the stockpiling

of meters. As the hardware parts of the system, warehouse, repair shop and meter-testing shop will be needed.

12.6.6 Simple Monitoring system

A simple monitoring system, by a number of testing devices and with the help of the waterworks personnel and citizens, is to be formed.

The devices are portable pressure gauges, residual chlorine testers and hand-made turbidity meters consisting of pre-made test tubes of standard turbidity.

The portable pressure gauge is a model which is inserted to the household tap, pushed and held by hand for measuring pressure.

The residual chlorine tester is the widely used kit, containing chemical, small test tube and rotating disc of color comparison.

The turbidity meter consists of a few test tubes. To each of them, a set of standard turbidity, for example, 1,2,4,8 and 16 ppm, is prepared by laboratory, contained and sealed. A sample of unknown turbidity is compared with them for rough estimation of turbidity.

Selecting the participants of the monitoring system shall be made on the location of their houses, points of collecting informative data, and capability in handling the testers. The participants will be the laboratory workers of knowledge and experience, engineers of the waterworks, citizens such as school teachers of chemistry and engineering, and well learned persons working in the fields of science and engineering.

The participants are to test water of their taps on the pre-fixed timing periodically. The collected data showing various spots' water quality and pressure are to be plotted on the map, to overview the service area's condition.

The kind of citizens participation will help promoting the public relations.

12.7 Public Relation

In the foregoing sections, the issues related to improve operation and maintenance of the waterworks have been discussed, mostly from the standpoints of water supply service.

Some of the issues cannot be achieved without the support and cooperation of the pubic.

12.7.1 Legal and Administrative Issues

In 12.3 the following laws were named and explained of the necessity:

- Water Pollution Control
- Groundwater Control
- Natural Environment Protection
- Water Resources Development
- Water Supply Service

Also discussed in 12.3 was that the water supply service shall be empowered administratively to make compulsory investigation and penalizing actions against illegality concerning the water source and supply service.

Regarding the above, strong support of the public is necessary.

12.7.2 Public Enlightenment

The water supply service shall be positive in enlightening the public on the necessity of clean water, taking opportunities of involving in school education, civilian and women groups' activities.

As a form of excursion, the primary and secondary school children can visit the water intake and treatment plant to learn about water supply service. For higher educational institutions, sending the waterworks staff to give lectures on the subject like waterworks engineering, water pollution control and others will be fruitful.

On the occasions of festival and recreational events, the waterworks shall take advantage of them for campaigning its cause and activities.

12.7.3 Personnel in the Front

The meter readers, tariff collectors, service system repairmen and receptionists in the office make direct contacts with the customers.

They shall be nice and kind so that customers can speak out opinion on the supply service freely. Some of the customers viewpoints will be helpful for improvement of the service and these well-intended people shall be asked for more help in future.

Like awarding the informers of illegal connection, awarding the people detecting leakage on the public pipeline is worth studying, as it will save the works of operation and maintenance staff. The same can be applied to the case of finding faulty meters.

The customers are to be taught of making simple repairs by themselves. It will also save inefficient input of manpower on the part of waterworks.

In case of accidents needing major repair works, the damages inflicted on the private property shall be immediately compensated. Delayed action on such matters will damage the public relation as well as the waterworks image.

12.7.4 Advance Notice

The date of the meter readers' and tariff collectors' visit to the consumers shall be noticed in advance. Or, more preferably, a certain date is fixed on each specific section of the service area.

Advance notices are also needed in the case of pipeline works which cause failure or shortfall of supply to consumers. The purpose, date, time and duration of the works and foreseeable inconvenience shall be informed.

APPENDIX 13

SCOPE OF WORK

APPENDIX 13

Minutes of Meeting

SCOPE OF WORK
FOR
MASTER PLAN
AND
FEASIBILITY STUDY
ON
PROVINCIAL WATER SUPPLY PROJECTS
IN
THE KINGDOM OF THAILAND
AGREED UPON BETWEEN
PROVINCIAL WATERWORKS AUTHORITY
AND
JAPAN INTERNATIONAL COOPERATION AGENCY

BANGKOK, 1985

細田三朗

Saburo HOSODA
Leader
JICA Preliminary Study Team

Dr. Tawat Wichaidit
The Governor
Provincial Waterworks
Authority

I. INTRODUCTION

In response to the request of the Government of Thailand, the Government of Japan decided to implement a Master Plan and a Feasibility Study on Provincial Water Supply Projects (Chiangmai, Ubon-Ratchathani, Suphanburi and Pattaya) in Thailand (hereinafter referred to as "the Study") within the general framework of technical cooperation between Japan and Thailand, which is set forth in the Agreement on Technical Cooperation between the Government of Japan and the Government of Thailand, signed on November, 1981.

Accordingly, the Japan International Cooperation Agency (hereinafter referred to as "JICA"), the official agency responsible for the implementation of the technical cooperation programme of the Government of Japan, will undertake the study, in accordance with the relevant laws and regulations in force in Japan and in close cooperation with the authorities of Thailand. The Provincial Waterworks Authority (hereinafter referred to as "PWA") shall act as counter agency to the Japanese Study Team and also as a coordinating body in relation with other relevant organizations for the smooth implementation of the study. The present document sets forth the Scope of Work for the study.

II. OBJECTIVE OF THE STUDY

The objective of the study is to prepare a Master Plan (long term basic plan) for the Provincial water supply projects in Chiangmai Municipality and its Surrounding Communities Sansai, San-Kamphaeng, Saraphi and Hang Dong, Ubon-Ratchathani Municipality, Warin Chamrap Municipality Suphanburi, and Pattaya up to the next 20 years, (2006) and to carry out a feasibility study (short term development plan) for a project selected from the result of the Master Plan study.

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III. OUTLINE OF THE STUDY

The Study will be composed of field surveys and data collection in Thailand and of analysis works in both Thailand and Japan.

The items to be covered by the Study are as follows:

(i) Phase I; Master Plan Study (Long term basic plan)

a. Data collection and analysis
b. Delineation of served areas for planning
c. Projection (estimation of population and Water demand etc.)
d. Study of existing water supply system (facilities, Management, and Organization etc)
e. Study of water sources (based on the available data)
f. Planning of appropriate water supply system (Organization, Operation and Management Plan)
g. Rough estimation of cost for construction, operation and maintenance
h. Preparation of implementation program
i. Identification of the project including immediate improvement and rehabilitation for the Feasibility Study.

(ii) Phase II; Feasibility Study (Short term development plan)

a. Delineation of project area
b. Estimation of population to be served
c. Estimation of water demand
d. Study of improvement of existing facilities
e. Study of water sources
f. Layout of facilities
g. Study for alternative plans

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h. Preliminary design (including design criteria)
i. Study of construction materials and labour force
j. Estimation of costs of construction, operation and maintenance
k. Preparation of Construction method and procurement method of materials and equipments
l. Study of Tariff System
m. Estimation of benefits
n. Economic Studies and Financial analysis
o. Study of organization, operation and management plan
p. Preparation of implementation schedule.

IV WORK SCHEDULE

The study will be conducted in accordance with the tentative schedule as shown in the Annex I herewith attached.

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V. REPORTS

JICA shall prepare and submit the following reports in English to the Government of Thailand.

1) Inception Report
   - Copies 30
   . at the beginning of the Field Survey (Master Plan Study)

2) Progress Report
   - Copies 30
   . at the end of Field Survey (feasibility study)

3) Interim Report
   - Copies 30 each
   . within 3 months from the beginning of the Master Plan Study
   . within 7 months from the beginning of the Feasibility study

4) Draft Final Report
   - Copies 30
   . within 10 months from the beginning of the feasibility study

5) Final Report with summaries
   - Copies 50 each
   . within 16 months from the beginning of the Master Plan study
   . within 13 months from the beginning of the Feasibility study

The PWA shall submit her comments to JICA within one month after the receipt of Draft Final Report.

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VI. UNDERTAKING OF THE GOVERNMENT OF THE KINGDOM OF THAILAND

1. In accordance with the Agreement on Technical Cooperation between the Government of Japan and the Government of the Kingdom of Thailand dated November 5, 1981, the Government of the Kingdom of Thailand shall accord benefits to the Japanese study team as follows:-

(1) to permit the members of the Japanese study team to enter, leave and sojourn in Thailand for the duration of their assignment therein and exempt them from alien registration requirements and consular fees,

(2) to exempt the members of the Japanese study team from taxes, duties and any other charges on equipment, machinery and other materials brought into Thailand for the conduct of the Study,

(3) to exempt the members of the Japanese study team from income taxes and charges of any kind imposed on or in connection with any emolument or allowance paid to the members of the Japanese study team for their services in connection with the implementation of the Study,

(4) to bear claims, if any arises against the members of the Japanese study team resulting from, occuring in the course of, or otherwise connected with the discharge of their duties in the implementation of the Study, except when such claims arise from gross negligence or willful misconduct on the part of the members of the Japanese study team.

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2. To facilitate smooth conduct of the Study, PWA shall take necessary measures in cooperation with other relevant organization;

(1) to secure permission for entry into private properties or restricted areas for the conduct of the Study,

(2) to secure permission for the study team to take all data and documents (including photographs) related to the Study out of Thailand to Japan.

(3) to provide the medical services as needed (Its expenses will be chargeable on members of the Japanese study team),

(4) to ensure the safety of the members of the Japanese study team when and as it is required in the course of the Study.

3. PWA shall, at its own expense, provide the Japanese study team with the followings:

(1) available data and information related to the Study,

(2) counterpart personnel,

(3) suitable office space with necessary equipment,

(4) credentials or identification cards.

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VII. UNDERTAKING OF JICA

For the implementation of the Study, JICA shall take the following measures,

(1) to dispatch, at its own expense, study teams to Thailand,

(2) to pursue technology transfer to the Thai counterpart personnel in the course of the Study.

VIII. JICA and PWA shall consult with each other in respect of any matter that may arise from or in connection with the Study.

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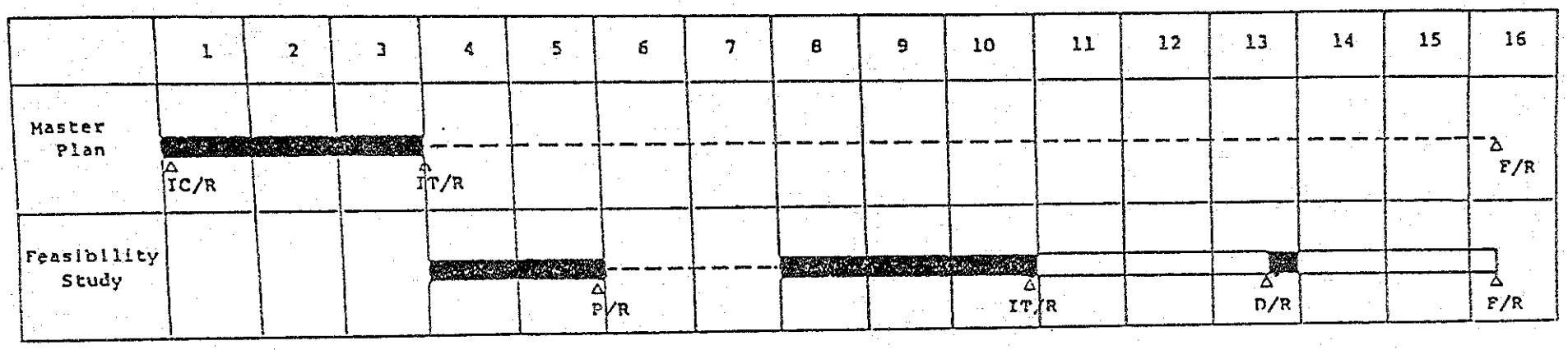
ANNEX I

Tentative Schedule for Master Plan, Feasibility Study



* Remarks

in Thailand

in Japan

IC/R Inception Report
P/R Progress Report
IT/R Interim Report
D/R Draft Final Report
F/R Final Report

MINUTES OF MEETING

ON

THE SCOPE OF WORK FOR THE MASTER PLAN

AND

FEASIBILITY STUDY

ON

PROVINCIAL WATER SUPPLY PROJECTS

AUG. 13, 1985

BANGKOK, THAILAND

細田三朗

Saburo HOSODA
Leader
JICA Preliminary Study Team

DR. TAWAT Wichaidit
The Governor
Provincial Waterworks Authority

MINUTES OF MEETING

The Japanese Preliminary Study Team and the Thai counterpart of PWA held a series of discussions during July 30 - August 13, 1985 concerning the Scope of Work.

The present minutes were prepared to confirm the main issues discussed and matters agreed upon both parties.

A. Both parties confirmed the followings :-

1. Scope of Work

The Japanese Study Team (hereinafter referred to as "the Study Team") shall implement a Master Plan and a Feasibility Study of Provincial Water Supply Projects in Thailand based on available data which the Study Team will study in cooperation with PWA, whose items are shown in Annex I.

(1) The Master Plan will be selected by optimal solution by technical and economical evaluation.

(2) Delineation of served areas for planning will be implemented in consideration of such as economic, geographical and related aspects.

(3) Estimation of water demand will be implemented not only in terms of total demand but also divided in categories such as domestic, institutiona commercial and industrial demand.

(4) The Study Team will implement the water sources studying on hydrological, hydrogeological, geophysical survey etc., based on such available data.
The Study Team will evaluate to determine the availability of alternative water sources.

(5) In Feasibility Study, "Study for alternative plans" will include the selection of optimal plan.

(6) Estimation of benefits of optimal plan will be implemented not only in direct but also indirect aspects such as improvement of human health etc., in general terms.

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(7) Water leakage detection concerning preparation of drawings and systematic detection of pipe bursts, etc., will be surveyed, studied and prepared in "Study of organization, operation and management plan" so that the Water Leakage Detection Program will be implemented by PWA.

2. Undertaking of PWA

PWA shall, at its own expense, provide the Study Team with the followings :-

- Counterpart personnel : 3 Engineers, during the study period
  Non-technical personnel : 1 Clerk (Full Time), 1 Clerk (Part Time)
- Main Office : Space (10 personnels occupied) with necessary equipment
  (Desk, Chair, Locker, Telephone (1) (local use), Air Conditioning, in PWA H.Q.)
  Field Office : Suitable office space with Desk, Chair, etc. at Chiangmai, Ubon-Ratchathani, Suphanburi, Pattaya in PWA Regional Offices

3. Technical Training

PWA requested that her counterparts will be invited to Japan for technical training, Japanese side promised to take the request for favorable consideration.

B : Attendants of the discussions :

1. PWA Side (Corporate Planning Department)
   - Mr. PRAKIT Chanurai
     Acting Chief, Planning Division
   - Miss. ORAPIN Assavanig
     Chief, International Cooperation Section
   - Mr. PRAPON Chanakitjanukit , Engineer
   - Mr. JAROON Upanan , Engineer
   - Mr. SUTHEE Asawapichaid , Engineer

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2. Japanese Side

- Mr. Saburo HOSODA
  Director of Riverhead Forestory Office, Bureau of Waterworks, TOKYO METROPOLITAN GOVERNMENT
- Mr. Yoichi SEKI
  Special Advisor to the Director, Social Department, JAPAN INTERNATIONAL COOPERATION AGENCY
- Mr. Tsutomu NAGASAKA
  Engineer, Atsuta Office, NAGOYA WATERWORKS BUREAU
- Mr. Masuji IDE
  Engineer, Northern Water Control Center, YOKOHAMA WATERWORKS BUREAU
- Mr. Hajime NISHIKAWA
  Engineer, Water Supply Division, MINISTRY OF HEALTH AND WELFARE

5, 4

Annex I

I. Importance of the Project

(1) Relationship between the budget and the Relevant Development Plan.
(2) Utilization Plan of technical transfer
(3) Priority, urgency of the Project
(4) Advantageous effect
(5) Solved problem

II. Outline of four cities

(1) Data
- Hydrology
- Climate
- Geography

(2) Type of cities
(3) The movement of population and economics
(4) Order of importance of the cities
(5) Arrangement of electricity supply, water supply and drainage situation
(6) Characteristics
(7) Public health

III. References

PWA

(1) Laws and regulations
(2) Purpose of activity
(3) Organization
(4) Management situation
(5) Budget plan

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(6) Future plan
(7) Outline of PWA's undertaking
(8) Process of decision making of budget and policy

Four cities

IV. Outline of four cities's waterworks
(1) Statistics of facilities
(2) Statistics of population and water demand
(3) Served area
(4) Present situation of the waterworks facilities
  a. Intake facilities
  b. Conveyance, water transmission, distribution and service installation
  c. Purification facilities
  d. Maintenance of facilities
  e. Water sources
(5) Prospects of future water works facilities (in details)
(6) Technical Standard
(7) Water rate system
(8) Budget plan
(9) Technique period, cost of construction

V. Present evalution of waterworks (including analyses of causes)
(1) Technique (man-power)
(2) Management system waterworks
(3) Stock of equipment, existance of repair works factory
(4) Situation of finance
(5) Management plans for improvement

VI. Relation with other administrative organizations

VII. Adjustment of map drawing in projected area
(1) Map of topography, etc.
(2) Drawing of facilities
(3) Drawing of piping
(4) Process chart for facilities

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VIII. Existing problem in PWA

IX. Technical and economical cooperation by foreign countries or international organizations in recent years in relation with waterworks

X. Others

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APPENDIX 14

OFFICIALS CONCERNED IN THAILAND

APPENDIX 14

APPENDIX 14 OFFICIALS CONCERNED IN THAILAND

Provincial Waterworks Authority

Dr. Tawat Wichaidit	Governor
Mr. Sawasdi Orvichian	Deputy Governor
Mr. Anant Tantidhamma	Deputy Governor
Dr. Wanchai Ghooprasert	Assistant Governor

Corporate Planning Department (CPD)

Mr. Chatpong Chucharoen	Director
Mr. Sukhon Sitthilertpisan	Acting Chief, Planning Division
Miss Orapin Assavanig	Chief, International Cooperation Section
Mr. Prakit Chanurai	Acting Chief, Policy and Planning Work
Dr. Sarawoot Chayovan	Chief, Water Resources Development Project
Mr. Wanchai Lowatanatrakul	Project Coordinator, Corporate Planning Division
Mr. Thaworn Nitipavachon	Water Resources Development Project
Mrs. Pinporn Phongsri	Corporate Planning Division
Miss Wirawan Kaeopradith	Corporate Planning Division
Mr. Jaroon Upanan	Corporate Planning Division
Mr. Somkriat Piriyakakul	Water Resources Development Project
Mr. Udomsak Siriaksorn	Water Resources Development Project
Mr. Sanit Kitchawan	Corporate Planning Division
Mr. Suthee Asawapichaid	Corporate Planning Division
Mr. Pisit Hongvanishkul	Corporate Planning Division
Mr. Piray Satayasunhusakul	Corporate Planning Division
Mr. Nived vachiraanan	Corporate Planning Division
Mr. Prathom Khoysomboon	Corporate Planning Division
Mrs. Anu Songsakchai	Corporate Planning Division
Mrs. Bussara Rasamiamornwiwat	Corporate Planning Division
Mr. Prapon Chanakitjanukit	Corporate Planning Division

Operation and Maintenance I

Mr. Virusah Mahakkapong	Director
Mr. Wiroon Pungronothanin	Chief, Water Production Section
Mr. Veerapun Henprasert	
Mr. Pichai Pirapaemakul	
Mr. Sombun Kheawchalua	
Mr. Sommai Tossila	
Mr. Phichai Pirapatanakul	

Operation and Maintenance II

Mr. Sitthichai Pissathanporn	Director
Mr. Wuthichai Usaha	Chief, Water Distribution Section
Mr. Prasong Nimwattana	
Mr. Surachai Jarikhuan	
Mr. Chuer Panyasiri	
Mr. Ruthai Intarapalit	

Accounting and Finance Department

Mrs. Virayu Amornlectrakul	Director
Mrs. Vanida Taechasaen	Chief, Accounting Division
Miss Sompis Amornrodjanawong	Head, Loan Account
Miss Chantira Chulothok	Head, General Ledger
Mrs. Somsong Pantaranontaka	Acting Director, Budget Division

Analysis and Evaluation Department

Miss Chindarat Suwanabhat	Chief, Data Collection and Reporting Section

Engineering Department

Mr. Anunt Sahasak	

Central Laboratory

Mrs. Chitra Tritham	Head, Chemical Section

Chiangmai

Mr. Manit Padungtin	Director, Regional Office No.9
Mr. Somsak Sawatdirak	Manager, Chiangmai Waterworks
Mr. Kamol Hason	Assistant Manager, Chiangmai Waterworks
Mr. Bundit Suwanavut	Regional Office No.9
Mr. Niyom Khuntitarangkun	Regional Office No.9
Miss Ladda Keovara	Head, Laboratory, Regional Office No.9
Mr. Chatree Kunchatchai	Chief, Cost Estimation and Design Work, Regional Office No.9
Mr. Vitaya Tipchumnong	Head, Service Section, Chiangmai Waterworks
Mr. Wanchat Tatsanasuvun	Chinagmai Waterworks
Mr. Samphan Tenyam	Regional Office No.9
Mr. Thongyou Khunpon	Chiangmai Waterworks
Mr. Sawat Luangjai	Chiangmai Waterworks
Mr. Sanguan Chaita	Chiangmai Waterworks
Miss Rapiparn Wirachon	Regional Office No.9
Mr. Nipan Nakisathit	Manager, San Kamphaeng Waterworks
Mr. Chot Intaraksa	Formerly Manager, San Kamphaeng Waterworks
Mr. Chalong Kongcharoen	Chief, Production Section, San Kamphaeng Waterworks
Mr. Somanus Chaites	Manager, Mae Rim Waterworks

Embassy of Japan

Mr. Yasunobu Takayama	First Secretary

JICA Bangkok Office

Mr. Motonori Gotoh	Representative
Mr. Shin-ichi Suzuki	Deputy Director
Mr. Takahito Hino	Assistant Resident Representative

JICA Expert

Mr. Masaru Tanaka	Provincial Waterworks Authority
Mr. Kumpei Igarashi	Provincial Waterworks Authority

APPENDIX 15

MEMBER LIST OF ADVISORY COMMITTEE AND STUDY TEAM

APPENDIX 15

APPENDIX 15 MEMBER LIST OF ADVISORY COMMITTEE AND STUDY TEAM

Advisory Committee

Mr. Saburo Hosoda (Chairman)	Director, Riverhead Forestry Office, Bureau of Waterworks, Tokyo Metropolitan Government
Mr. Tsutomu Nagasaka	Nagoya Waterworks Bureau
Mr. Masuji Ide	Yokohama Waterworks Bureau
Mr. Hajime Nishikawa	Kobe Waterworks Bureau

Ministry of Foreign Affairs

Mr. Teruyoshi Kumashiro	Development Cooperation Division
Mr. Takeo Sato	Development Cooperation Division

Ministry of Health and Welfare

Mr. Syuhei Kato	Water Supply and Environmental Sanitation Department
Mr. Hiroyuki Endo	Water Supply and Environmental Sanitation Department
Mr. Tsutomu Sakagawa	Water Supply and Environmental Sanitation Department

JICA

Mr. Hiroyoshi Ihara	Social Development Cooperation Department
Mr. Shozo Matsuura	Social Development Cooperation Department
Mr. Yoichi Seki	Social Development Cooperation Department, Coordinator

Study Team

Mr. Osamu Wakamoto (Team Leader)	General Director, Overseas Service Department, Nihon Suido Consultants Co., Ltd.
Mr. Hiroshi Machida (Co-Team Leader)	Director, Overseas Service Department Nihon Suido Consultants Co., Ltd.
Mr. Tatsuya Samukawa	Advisor, Overseas Service Department Nihon Suido Consultants Co., Ltd.
Mr. Shigeyoshi Kagawa	Nihon Suido Consultants Co., Ltd.
Mr. Hideki Kondo	Nihon Suido Consultants Co., Ltd.
Mr. Hideki Asada	Nihon Suido Consultants Co., Ltd.
Mr. Toshio Yamada	Nihon Suido Consultants Co., Ltd.
Mr. Masakazu Inamiya	Nihon Suido Consultants Co., Ltd.
Mr. Takemasa Mamiya	Nihon Suido Consultants Co., Ltd.