APPENDIX A-3-1

Study on Flow and Pressure Measurement in Distribution System

APPENDIX STUDY ON FLOW AND PRESSURE MEASUREMENTS IN DISTRIBUTION SYSTEM

(1) Introduction

To evaluate the characteristics of the distribution system, pressure and flow measurments were made from August 30, 1988.

(2) Methords and Results

The flow measurements of 24-hours were conducted at the main distribution pipe in the treatment plant using theultrasonic flow meter with pen recorder. The pressure measurements were made by installing pressure gage at 3 house connections in the distribution system.

The results of flow measurement at the Phang Nga Water-works, location of pressure measurement points and the results of pressure measurement are shown in Figures A3-1, A3-2 and A3-3 to A3-5, respectively.

The results of pressure measurements in the existing distribution system show similar pressure conditions with distribution network analysis (refer to section 3.1.3).

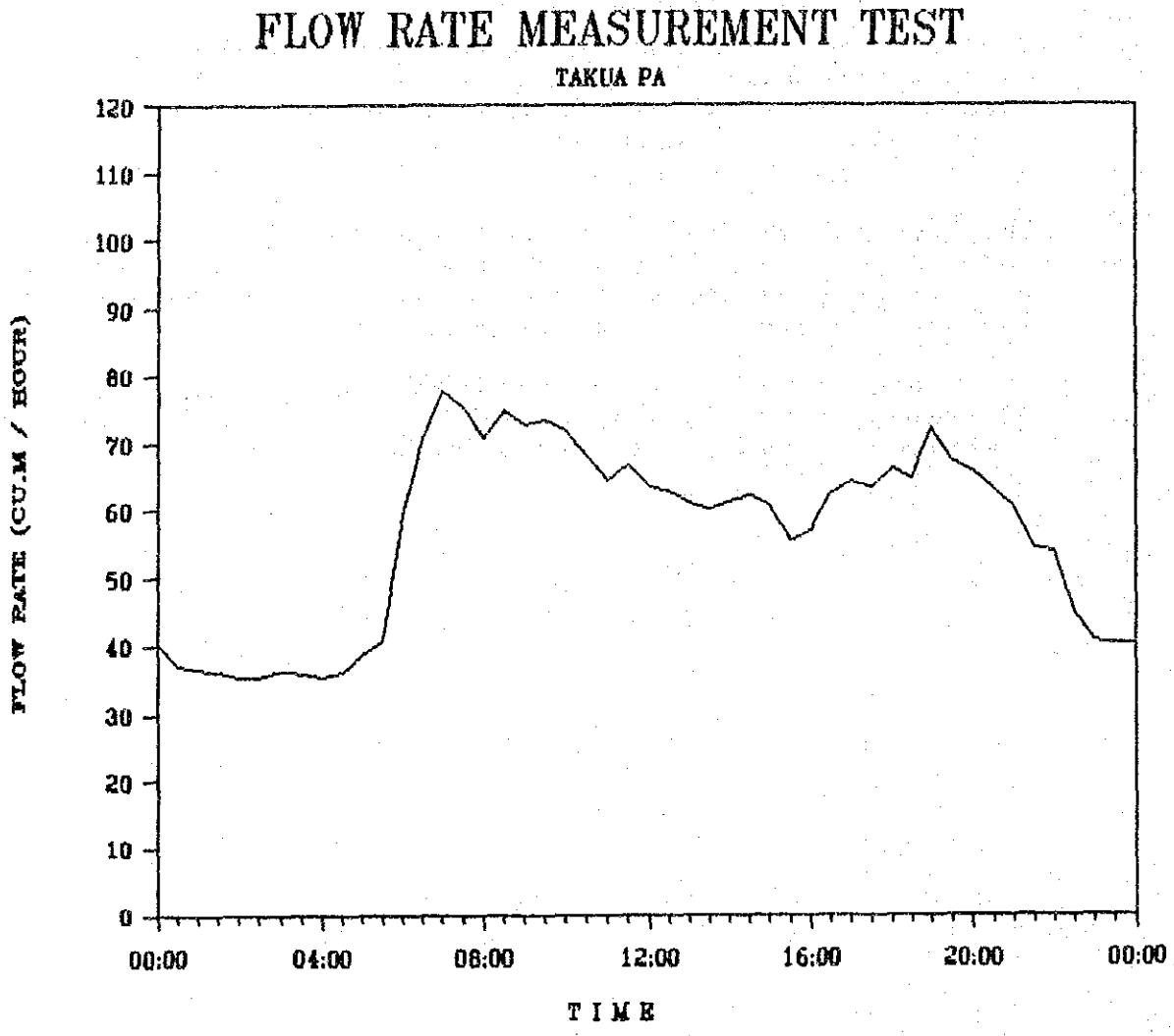


FIGURE A3-1-1

FLOW RATE MEASUREMENT TEST

PRESSURE MEASUREMENT TEST

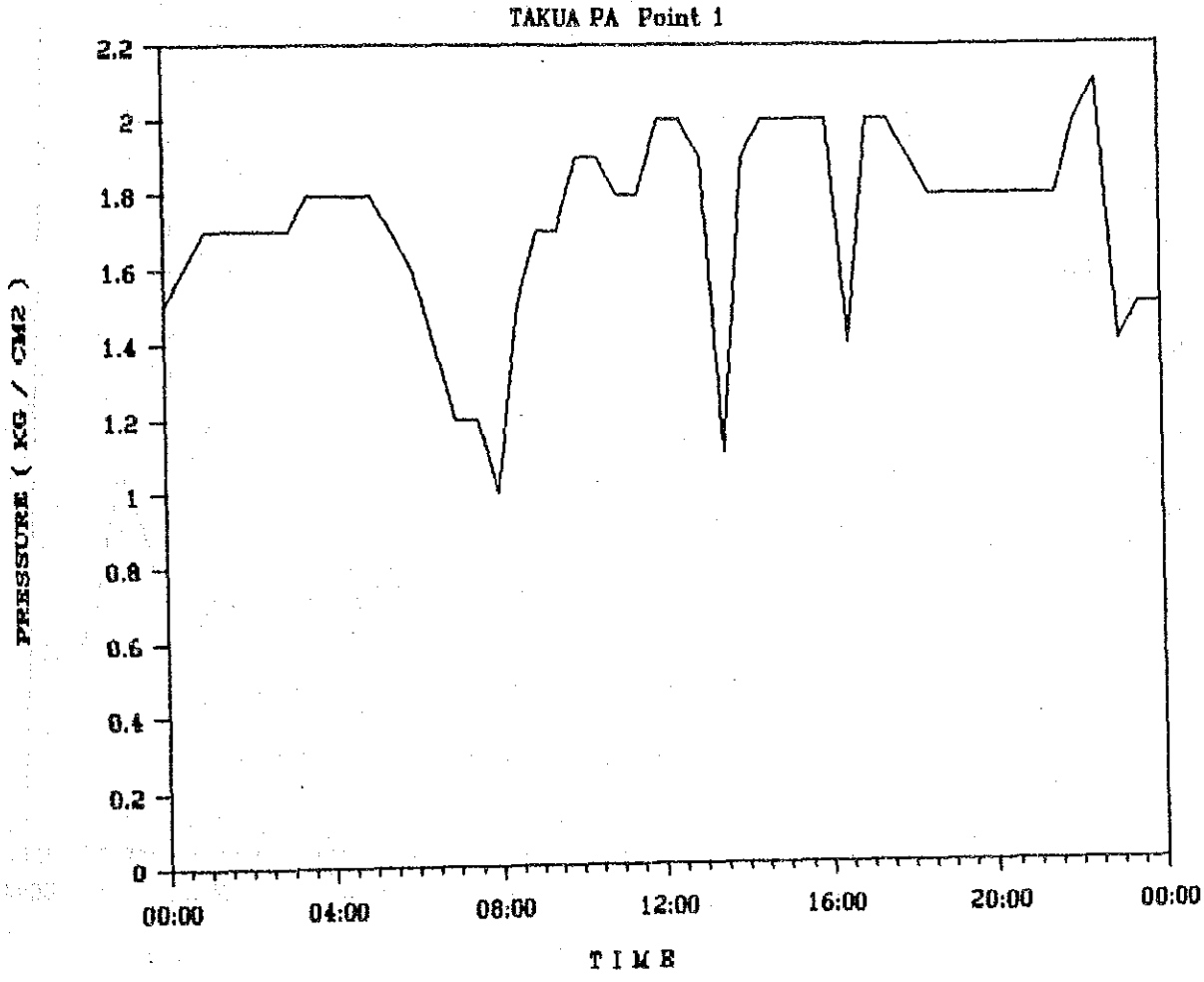


FIGURE A3-1-3

PRESSURE MEASUREMENT TEST
(Point 1)

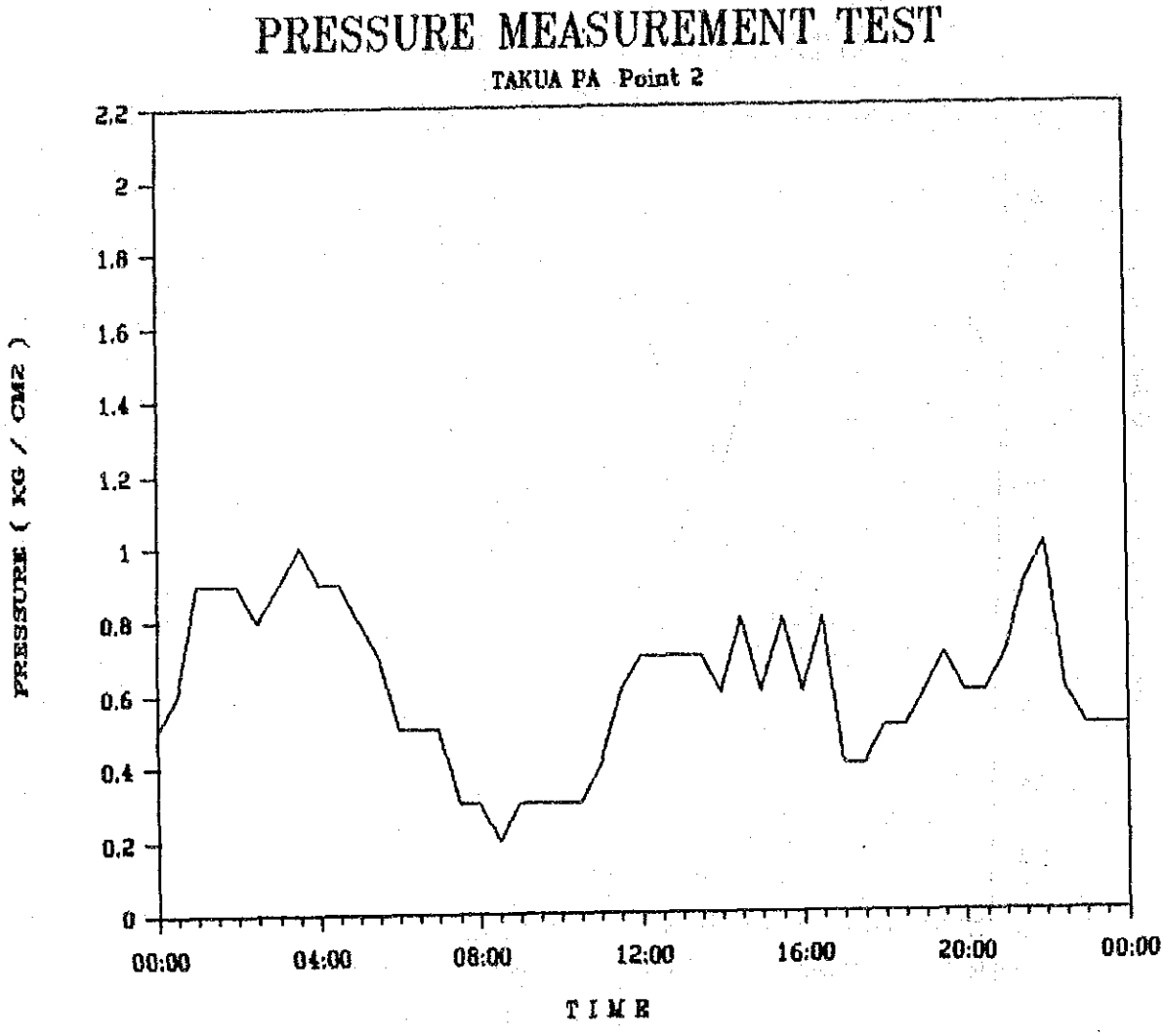


FIGURE A3-1-4

PRESSURE MEASUREMENT TEST
(Point 2)

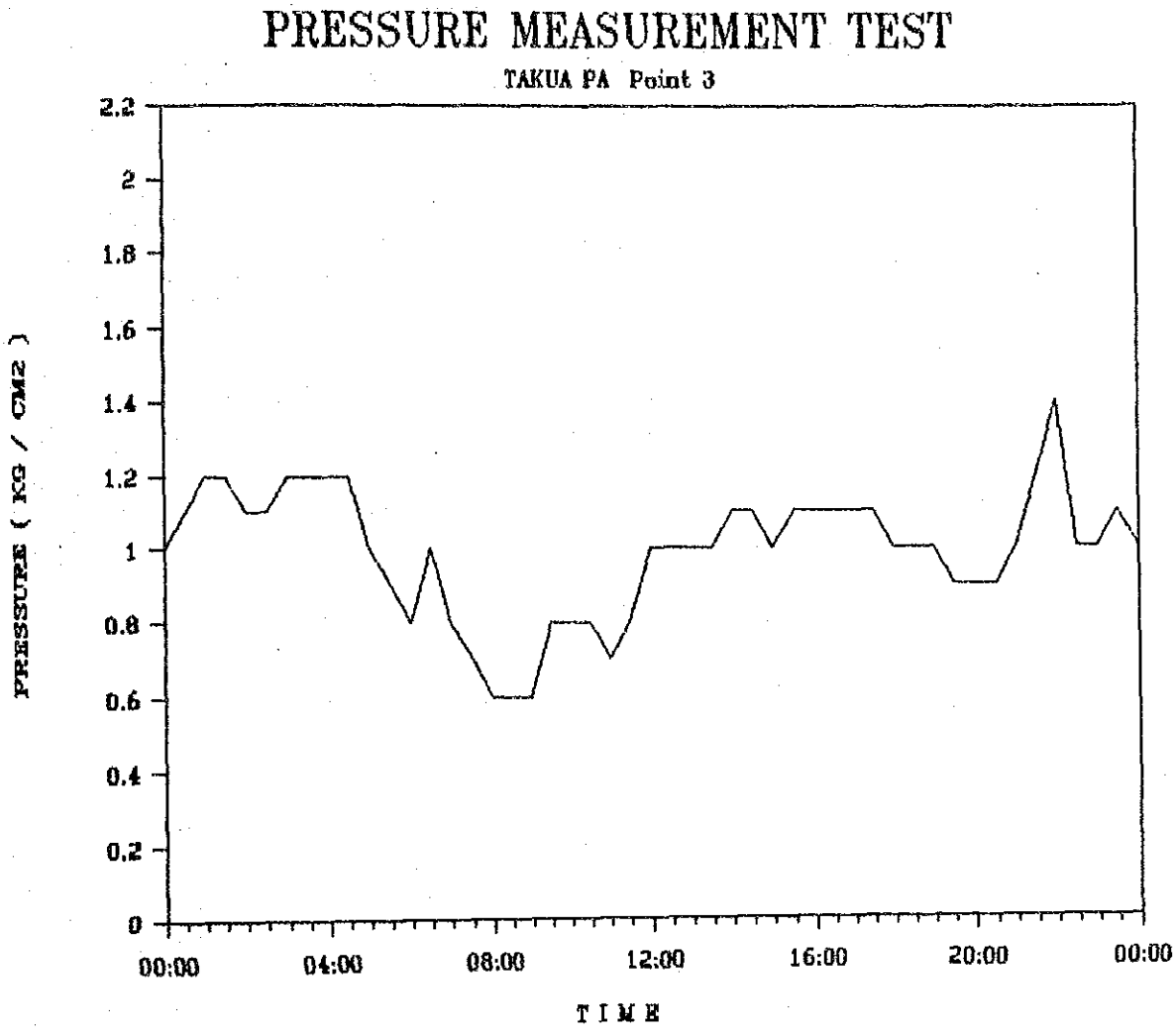


FIGURE A3-1-5

PRESSURE MEASUREMENT TEST
(Point 3)

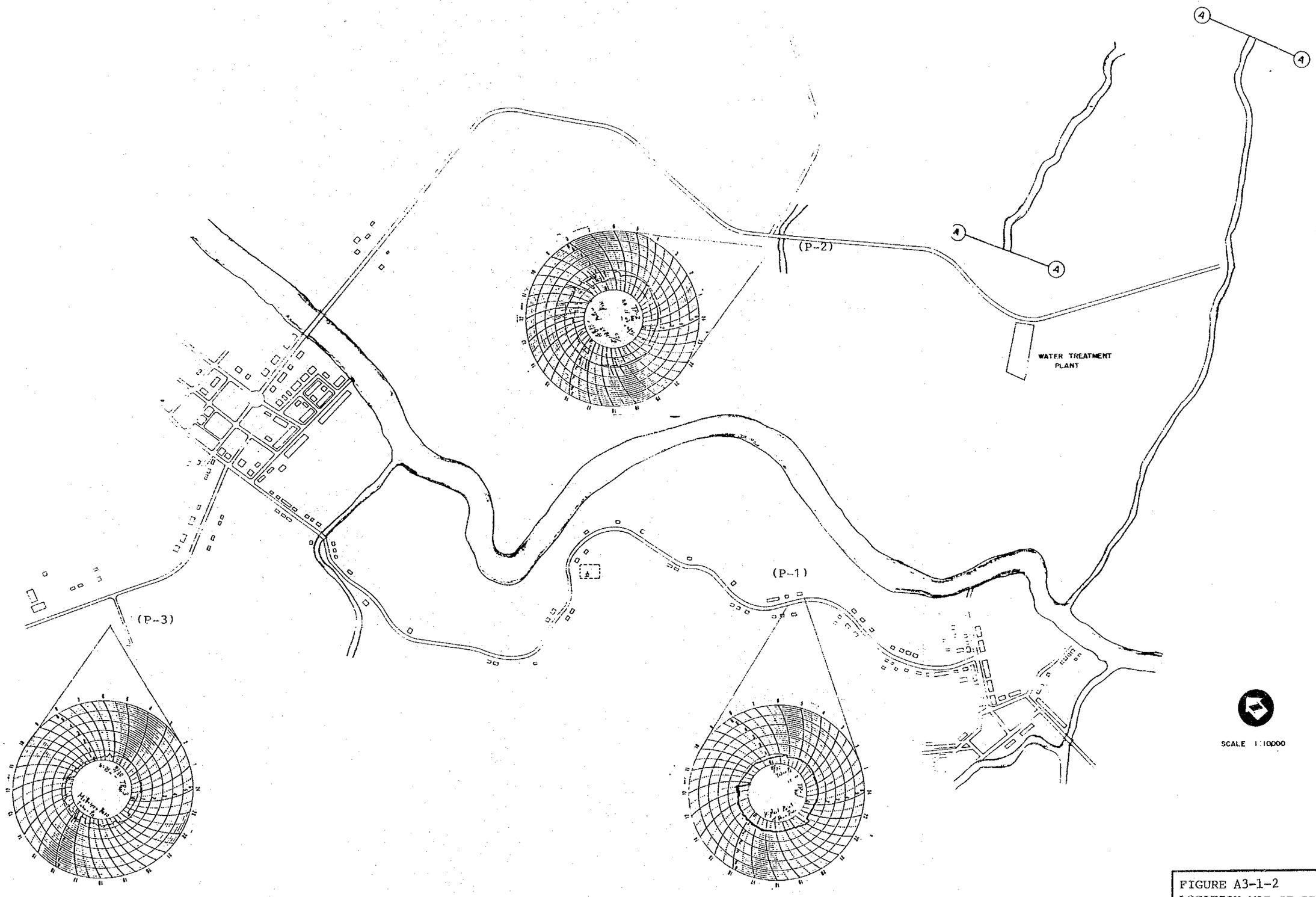


FIGURE A3-1-2
LOCATION MAP OF PRESSURE MEASUREMENT POINTS

APPENDIX A-3-2

Study on Water Quality on Distribution Network

APPENDIX WATER QUALITY ON DISTRIBUTION NETWORK

(1) General

Water quality analysis was conducted along the existing distribution mains by use of a potable water quality analizer. Parameters of the analysis are pH, terperature and conductivity.

The results of the analysis are shown in Table A4-1. Sampling points are indicated in Figure A4-1.

(2) Causes of high pH

Results shows that most of the sampling points except Nos. 1, 3, 6 and 13 have high pH values.

Based on the field investigation, the following causes may result in calcium dissolution from the inner wall of asbestos cement pipes.

a) Pipe are newly installed, about two year old

b) Water is retained long inside pipes due to low water flow.

(3) Countermeasure

Drain-off from hydrants or blow-off pipes should be periodically carried out in those area.

Table A3-2-1 Results of Water Quality Analysis

Items	Sampling Point 1	2	3	4	5	6	7	8	9	10	11	12	13
pH	7.25	9.22	8.00	9.00	8.40	7.40	9.10	10.35	9.65	9.70	9.98	9.95	7.65
Temp.(°C)	29.0	29.4	29.2	28.7	29.0	28.7	28.9	28.8	28.7	29.0	29.2	30.0	29.7
Conductivity ($5\times10^{2}\mu\mho$)	4.0	5.2	4.1	4.9	4.3	4.5	5.2	7.1	7.0	6.5	6.7	7.2	4.6

Note : *1 Treated Water at Water Treatment Plan

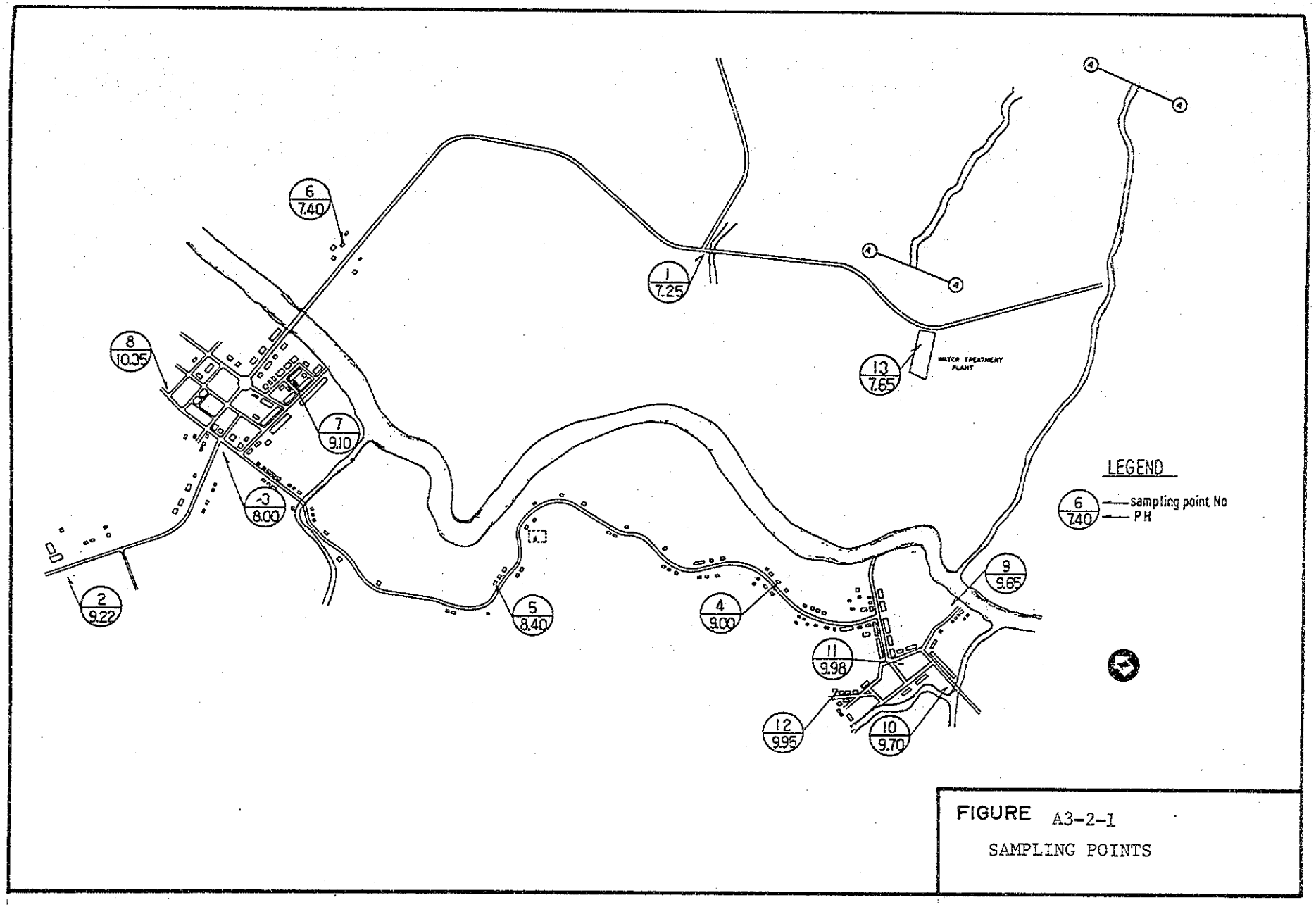


FIGURE A3-2-1

SAMPLING POINTS

APPENDIX A-3-3

Jar Test on Raw Water of the Water Treatment Plant

APPENDIX JAR TEST

1 General

Jar Test was conducted to evaluate the present dosage rate of coagulant and to verify the appropriate dosage rate. The test was conducted on September 1988 for the raw water presently used by the waterworks, which are from water fall and tin mining pit.

2 Coagulant Used

Aluminum sulfate is being used as coagulant at Takua Pa Waterworks as well as the other waterworks. The chemical is a solid type in a package of 25 kg bag, which is dissolved in the coagulant solution tank with an effective volume of about 1.5 cu.m.

According to the operator, they are consuming 20 kg of aluminum sulfate a day. From this amount of consumption, dosage rate is calculated as below:

Dosage rate (R) for daily average flow rate:

R = 20,000 g/1,350 cu.m/day =14.8 mg/l

Concentration of the coagulant in the solution tank is calculated from the amount of chemical dissolved and the volume of the tank as follows:

Concentration of coagulant solution (C)

C = 20,000 g/1.5 cu m = 13,300 mg/l

This solution was diluted 10 times for use of Jar Test; therefore, solution had the concentration of:

13,300 x (1/10) = 1,330 mg/l

3 Test Procedure

Test procedure followed the PWA's regulation for Jar Test. Sequence and time are shown as follows:

a) Coagulant dosed

b) Rapid Mixing, 60 rpm - 7.5 min

c) Flocculation, 40 rpm - 7.5 min

d) Flocculation, 25 rpm - 5.0 min

e) Sedimentation, about 5 min

4 Condition and Results

Jar Test was conducted with a series of six different dosage rates for both waters from waterfall and tin mining pit. The condition and results are as shown in Table A5-1 and 2.

Table A3-3-1 Jar Test Condition and Result (Waterfall)

		1	2	3	4	5	6
1.	Coagulant Solution (ml)	1.85	3.70	7.41	1.11	14.8	18.5
2.	Dosage Rate (mg/l)	2.5	5.0	10	15	20	25
3.	Turbidity after settling	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
4.	pH	7.68	7.58	7.52	7.49	7.45	7.42
5.	Conductivity (micro ohm/cm)	5.0	4.5	4.6	5.0	5.0	5.0
6.	Characteristics of floc	Fine floc	Fine floc	Fine floc	Fine floc	Fine floc	Fine floc

Table A3-3-2 Jar Test Condition and Result (Tin Mining Pit)

		1	2	3	4	5	6
1.	Coagulant Solution (ml)	0.2	0.4	0.75	1.0	1.5	2.0
2.	Dosage Rate (mg/l)	2.5	5.0	10.0	15.0	20.0	25.0
3.	Turbidity after settling	1.5	2.5	1.5	2.5	1.5	2.5
4.	pH	6.05	6.00	5.90	5.92	6.15	5.85
5.	Conductivity (micro ohm/cm)	3.75	4.25	3.5	3.5	4.1	4.0
6.	Characteristics of floc	Fine floc	Fine floc	Fine floc	Fine floc	Fine floc	Fine floc

Since two raw water have quite low turibidity (3.0 and 8.6 for water fall and tin mining pit, respectively), the Jar Test had nearly no effect on the removel of the turbidity.

APPENDIX A-4-1

Study on Water Consumption

APPENDIX STUDY ON WATER CONSUMPTION

1 Data Collection

Present water consumption data was collected from the waterworks' meter reading records for the study of water demand and distribution network analysis. Meter reading records at the waterworks office consist of volumes of cards in PWA's format for each connection. Monthly consumptions from September 1987 to August 1988 of each connection are recorded on this card.

Data collection was made in a manner of copying figures water consumption of each consumer for every month. For distribution network analysis, each consumer was located on the map by interviewing meter readers of the waterworks. When the exact locations were not identified, they were located in some extent of the pipeline. Big consumers were also identified for further analysis.

2 Collected Data

Raw data copied from meter reading books was then summed up by month and by area. The attached sheets hereafter show the summary of water consumption.

WATER SALE OF TAKUA PA WATERWORKS

DAILY AVE. BY MONTH

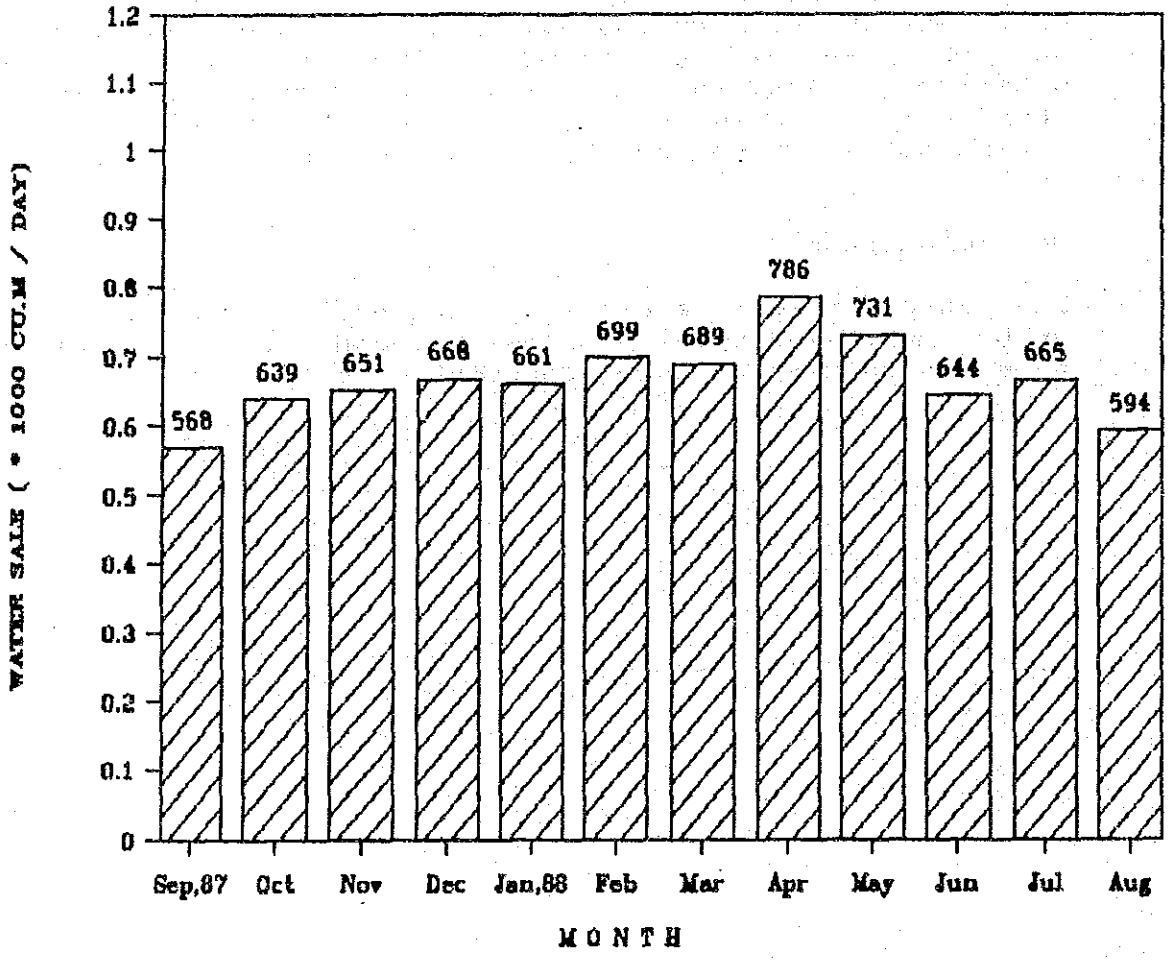


FIGURE
A4 - 1 - 1

Table A4 - 1 - 1
Water Sale of Takua Pa Waterworks

Unit ; Cu.m

Book No.	Sep,87	Oct	Nov	Dec	Jan,88	Feb	Mar	Apr	May	Jun	Jul	Aug	Total	Day Ave.
1-1	1,370	1,792	1,898	1,810	1,949	1,903	1,898	2,271	2,065	1,403	1,775	1,420	21,554	59.05
1-2	1,096	1,388	1,360	1,535	1,295	1,527	1,550	1,844	1,723	1,078	1,637	1,215	17,248	47.25
2	1,496	2,061	1,959	2,410	1,912	2,405	2,166	2,701	2,451	1,949	2,478	1,828	25,816	70.73
3	1,758	1,991	1,994	2,477	2,065	2,244	2,322	2,546	2,250	2,037	2,230	2,048	25,962	71.13
4-1	2,091	2,386	2,486	2,277	2,723	2,507	2,593	2,882	2,846	2,681	2,591	2,317	30,380	83.23
4-2	2,623	2,765	2,608	2,743	2,558	2,525	2,990	2,897	3,062	2,691	2,827	2,386	32,675	89.52
4-3	2,173	2,599	2,604	2,960	3,516	3,410	3,927	4,435	4,593	4,074	3,695	3,474	41,460	113.59
5	4,434	4,834	4,629	4,498	4,460	3,749	3,902	4,009	3,659	3,400	3,370	3,712	48,656	133.30
Total(cu.m/mo)	17,041	19,816	19,538	20,710	20,478	20,270	21,348	23,585	22,649	19,313	20,603	18,400	: 243,751 :	667.81
Total(cu.m/d)	568	639	651	668	661	699	689	786	731	644	665	594		

APPENDIX A-4-2

Questionnaire Survey for Residents

APPENDIX QUESTIONNAIRE SURVEY IN TAKUA PA

1 Objective

The door-to-door questionnaire survey was conducted to obtain the basic information on the resident's living conditions, water use patterns, responses to the municipal system and/or their own water sources and willingness for house-connection supply, and covered the area served or unserved by the municipal water supply system.

2 Survey Area

The survey area was divided into 6 blocks taking into account the munipality's characteristics as shown in Figure A1-2-1. Block 6 was ban Muang presently unserved by the municipal system.

3 Survey Item

The form used for the questionnaire survey was originally written by Thai and included the following items.

1. General
   - 1.1 Address
   - 1.2 Type of House
   - 1.3 No. of Persons in Family
   - 1.4 No. of Employees
   - 1.5 Average Monthly Income
   - 1.6 Average Monthly Medical Expense
2. Type of Water Supply
3. Conditions in case of Municipal System
   - 3.1 Pressure
   - 3.2 Quantity
4. Other Sources than Municipal System
   - 4.1 Type of Source
   - 4.2 Conditions in case of Groundwater
5. Potability
6. Water Quality in case of Municipal System
   - 6.1 Color
   - 6.2 Smell
   - 6.3 Turbidity
7. Average Monthly Water Consumption
8. Average Monthly Water Charge

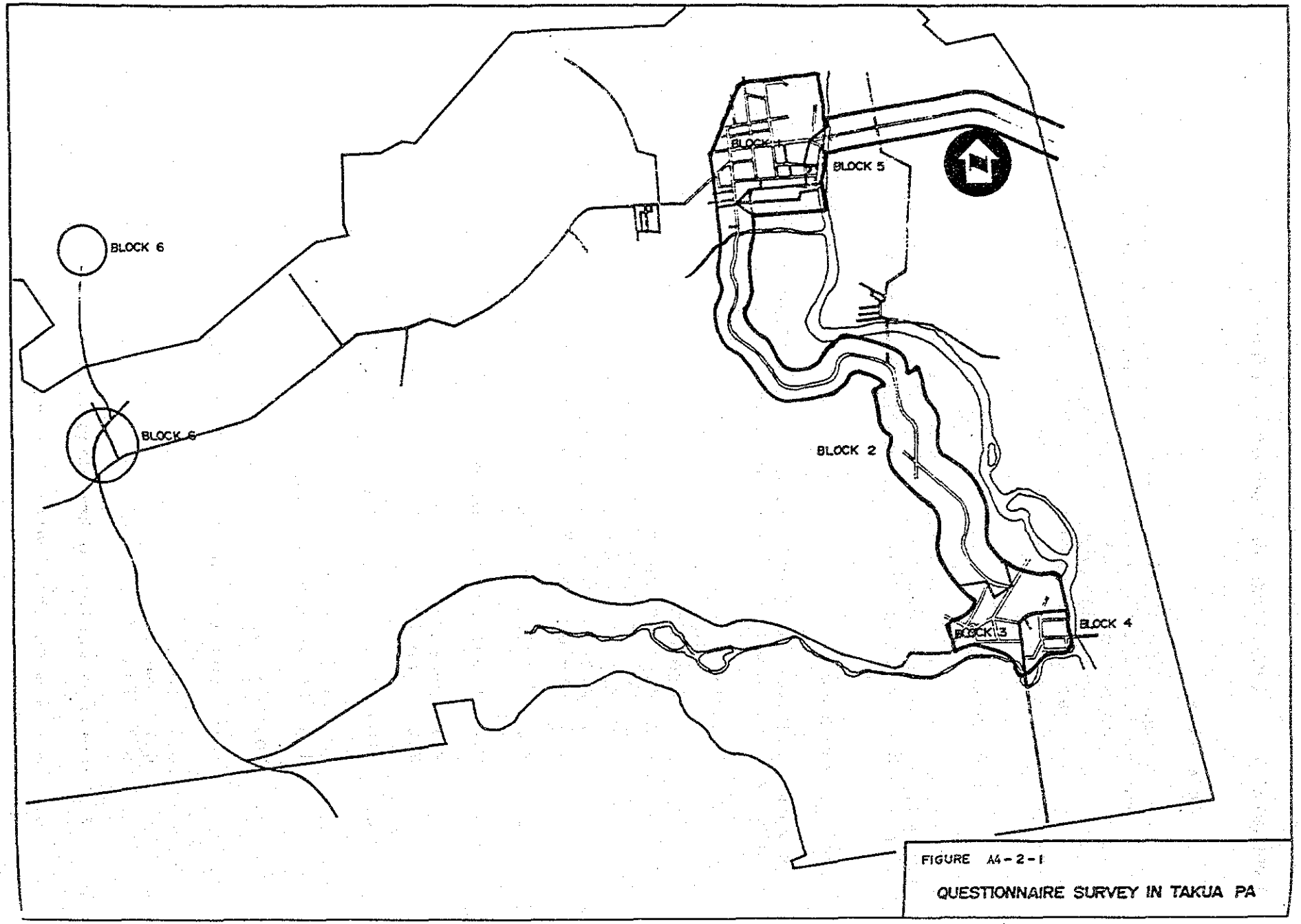


FIGURE A4-2-1

QUESTIONNAIRE SURVEY IN TAKUA PA

9. Willingness to Pay for Water Charge

10. Water Quality in case of Other Source

    10.1 Color
    10.2 Smell
    10.3 Turbidity

11. Willingness to Connect to the Municipal System

12. Willingness to Pay for Connection Fee

13. Willingness to Pay for Water Charge

4 Survey Method

Senior high school students were employed as interviewers and were engaged in the questionnaire survey with the guidance of the PWA Head Office staff. The survey was conducted to 158 residents on September 1, 1988.

5 Survey Results

The results of the questionnaire survey are summarized in Table A1-5-1.

1) General

57.0% of the respondents lived in residential houses while 43.0% in commercial buildings.

The total numbers of persons in families and employees were 781 and 339, respectively. Accordingly, one household is composed of 4.94 family members and 2.15 employees on an average with a total of 7.09 persons.

Regarding the average monthly income, 72.8% respondents was in the up-to-4,500 Baht bracket, or 32.3% in the up-to-2,000 Baht, 26.6% in the 2,001-3,000 Baht and 13.9% in the 3,001-4,500 Baht brackets, respectively. The average in respondents weighted by the number of persons and the median in each income bracket was approximately 3,660 Baht, but the number of persons was biggest in the up-to-2,000 Baht bracket.

As to the average monthly medical expense, 39.9% was in the up-to-50 Baht bracket and 22.1%, 12.7% and 15.2% were in the 51-100, 101-200 and 201-500 Baht brackets, respectively. The average in respondents calculated by the same method as the above is 200 Baht, but the number of persons was biggest in the the up-to-50 Baht bracket.

2) Type of Water Supply

25.3 % used the municipal system only, 60.8% the other source than the municipal system and 13.9% the combined system of the municipal system and other source(s).

87.3% or 103 out of 118 other sources was groundwater.

Block No.	1	2	3	4	5	6	Total
Municipal System Only	13	1	7	7	12	-	40
plus Rain/River	-	-	-	2	-	-	2
plus Water Vendor	-	-	-	5	-	-	5
plus Well	2	4	4	3	1	-	14
plus Others	1*	-	-	-	-	-	1
Well Only	17	16	11	9	12	19	84
plus Rain	-	-	-	-	-	1	1
plus Pond/Reservoir	-	-	-	-	-	1	1
plus Water Vendor	-	-	-	-	-	2	2
Water Vendor Only	-	-	-	-	-	7	7
Others	-	-	-	1**	-	-	1
Total	33	21	22	27	25	30	158

* Rain/River and Well
** Rain/River and Watr Vendor

3) Response to Municipal System

The reputation of the PWA waterworks among 62 respondents using the municipal system was not so good, that is to say, 38.7% complained of low pressure, 8.1% of insufficient water, 51.6% of color, 66.1% of smell and 59.7% of turbidity. However there were big gaps in response by the block. Though the low pressure took place in all served blocks except for Block 2, the respondents in Blocks 2, 3 and 5 took sufficient water. The complaint of color, smell and turbidity occured in all served 6 blocks.

4) Potability

This question was originally intended to know the potability of tap water, but the answer seemed to be made not only for the tap water but also for other source water, since the question followed that on other sources.

Accordingly, the evaluation was made extracting the data from respondents using tap water or well water only.

	Tap Water	Well Water
Drinking	23 (57.5%)	64 (76.2%)
Not Drinking	13 (32.5%)	12 (14.3%)
Both	2 (5.0%)	5 (5.9%)
Unknown	2 (5.0%)	3 (3.6%)
Total	40 (100%)	84 (100%)

57.5% used well water for drinking and 5.0% for drinking and not-drinking in spite of their complaints of its water quality, while 76.2% used well water for drinking and 5.9% for drinking and not-drinking.

The doubt as to the kind of water the respondents (who answered that they didn't use only one source for drinking) used for drinking is remained. They may use the water vendor, although this is not expressed clearly in the survey.

5) Water Quality of Other Sources

As mentioned above, the main water source was the groundwater. 11.9% complained of color, 11.0% of smell and 15.2% of turbidity. Scrutinizing the data block by block, such complaints mostly took place in unserved Block 6 (Ban Muang). Compared with those in tap water, the complaint of water quality was rather less in well water.

6) Conditions of Wells

The well depth distribution is shown below. Between 2 and 14 m and 89.3% wells had depths of not more than 10 m. The wells with depths of more than 10 m were located in Blocks 1 and 6.

Block No.	<5m	>5m <10m	>10m <15m	Unknown	Total
1	3	16	1	-	20
2	11	9	-	-	20
3	8	5	-	2	15
4	4	6	-	2	12
5	6	2	-	5	13
6	15	7	1	-	23
Total	47	45	2	9	103
Well Depth (m)	4.1 (47)	7.7 (45)	12.5 (2)		
Water Depth (m)	2.2 (47)	3.7 (45)	6.0 (2)		
Operation Time (h/d)	1.8 (28)	1.6 (32)	2.0 (2)		
No.of Fetching Time (1/d)	8.9 (16)	9.4 (9)	- (-)		

The figures in parentheses show the number of wells used for the average calculation.

7) Average Monthly Water Consumption, Water Charge and Willingness-to-Pay

Regarding the average monthly water consumption, 38.7% of the respondents belonged to the up-to-15 cu m bracket and 24.2% and 8.1% to the 16-30 cu m and 31-50 cu m brackets, respectively. However, 21.0% belonged to the unknown bracket.

35.5% paid for the water charge in the up-to-50 Baht bracket and 27.4% in the 51-100 Baht bracket, while, according to the result on the willingness-to-pay for water charge, 75.8% wanted that the water charge would be in the up-to-50 Baht bracket and 17.8% in the 51-100 Baht bracket. The expectant amount was rather less than the actual payment.

8) Willingness-to-Connect

Out of 158 respondents, 96 didn't use the municipal system at present. However, 38.5% was willing to connect to the municipal system. Such people mainly lived in Blocks 1 and 6. When excluding the data in unserved Block 6, the rate the willingness-to-connect decreased to 21.2%. They wanted that the connection fee would be less than 2,500 Baht (100%)

and the water charge less than 100 Baht (97.3%). The response to the water charge of the possible consumers was almost equal to that of the existing consumers.

Reasons for unwillingness-to-connect were summarized below

Block No.	1	2	3	4	5	6	Total
There is a well	-	8	8	9	8	1	34
Well water is enough	8	2	1	-	-	5	16
Well water is clean	-	-	1	-	-	1	2
Well water is convenient	1	-	-	-	-	-	1
Don't use much water	-	1	-	-	-	-	1
Lack of money	-	-	1	-	1	-	2
Others	1	2	-	-	-	-	3
Total	10	13	11	9	9	7	59

Contents of others were as follows:

- I will transfer to the new house.
- Tap water is unstable.
- Tap water is not potable due to the chlorine smell.

Most people who were unwilling to connect to the municipal system thought that they already had wells and those were enough or clean. The wells were very close and indispensable to their living.

Table A4-2-1 SUMMARY OF QUESTIONNAIRE SURVEY IN TAKUA PA

Block No.	1	2	3	4	5	6	Total	Rate (%)
No. of Samples	33	21	22	27	25	30	158	
1. General								
1.1 Address								
1.2 Type of House							90	57.0
Residential	16	21	15	15	14	9	68	43.0
Commercial	17	-	7	12	11	21	-	-
Residential/Commercial	-	-	-	-	-	-	-	-
Unknown	-	-	-	-	-	-	781	
1.3 No.of Persons in Family	153	111	120	129	125	143	-	
Unknown (No. of Samples)	-	-	-	-	-	-	339	
1.4 No.of Employees	76	33	62	64	44	60	-	
Unknown (No. of Samples)	-	-	-	-	-	-		
1.5 Ave. Monthly Income								
Baht								
up to 2,000	8	5	5	1	25	7	51	32.3
2,001-3,000	8	7	10	4	-	13	42	26.6
3,001-4,500	3	3	2	10	-	4	22	13.9
4,501-6,000	8	4	4	4	-	2	22	13.9
6,001-7,500	-	-	1	2	-	2	5	3.2
7,501-10,000	3	-	-	1	-	2	6	3.8
10,001-15,000	2	2	-	1	-	-	5	3.2
15,001-50,000	1	-	-	1	-	-	2	1.2
Over 50,000	-	-	-	-	-	-	-	-
Unknown	-	-	-	3	-	-	3	1.9
1.6 Ave. Monthly Medical Expense								
Baht								
up to 50	7	8	12	11	18	7	63	39.9
51-100	6	5	6	7	5	6	35	22.1
101-200	12	1	-	2	-	5	20	12.7
201-500	5	5	2	3	1	8	24	15.2
501-1,000	2	1	2	-	1	2	8	5.1
1,001-2,000	1	1	-	-	-	2	4	2.5
2,001-5,000	-	-	-	1	-	-	1	0.6
Over 5,000	-	-	-	-	-	-	-	-
Unknown	-	-	-	3	-	-	3	1.9
2. Type of Water Supply								
Municipal System	13	1	7	7	12	-	40	25.3
Combined	3	4	4	10	1	-	22	13.9
Other Sources	17	16	11	10	12	30	96	60.8
Unknown	-	-	-	-	-	-	-	-
3. Municipal System								
3.1 Pressure								
Low	8	-	5	4	7	-	24	38.7
High	7	5	6	13	6	-	37	59.7
Unknown	1	-	-	-	-	-	1	1.6
3.2 Quantity								
Sufficient	13	5	11	8	12	-	49	79.0
Not Sufficient	3	-	-	2	-	-	5	8.1
Unknown	-	-	-	7	1	-	8	12.9

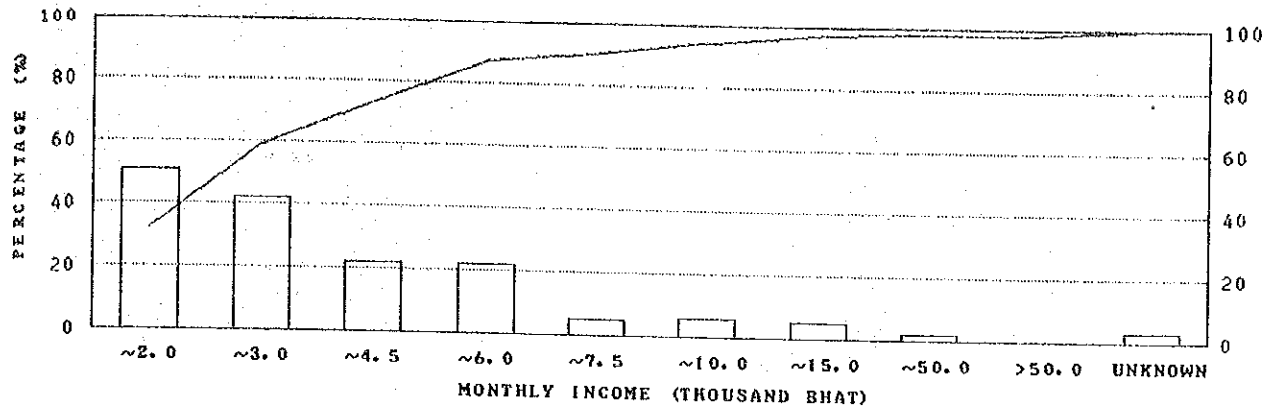
Table A4-2-1 SUMMARY OF QUESTIONNAIRE SURVEY IN TAKUA PA (CONT'D)

Block No.	1	2	3	4	5	6	Total	Rate (%)
4. Other Sources								
Rain/River	1	-	-	3	-	1	5	
Pond/Reservoir	-	-	-	-	-	2	1	
Water Vendor	-	-	-	6	-	9	15	
Groundwater-Shallow Well	20	20	15	12	13	23	103	
-Deep Well	-	-	-	-	-	-	-	
Unknown	-	-	-	-	-	-	-	
5. Potability								
Drinking	12	18	19	18	21	24	112	70.9
Hot Drinking	17	-	-	4	3	6	30	19.0
Both	4	3	-	4	-	-	11	6.9
Unknown	-	-	3	1	1	-	5	3.2
6. Water Quality (Municipal System)								
6.1 Color								
Yes	10	3	4	9	6	-	32	51.6
No	5	1	7	8	6	-	27	43.6
Unknown	1	1	-	-	1	-	3	4.8
6.2 Smell								
Yes	12	3	3	13	10	-	41	66.1
No	3	1	8	4	2	-	18	29.0
Unknown	1	1	-	-	1	-	3	4.9
6.3 Turbidity								
Yes	11	3	5	10	8	-	37	59.7
No	4	1	6	7	5	-	23	37.1
Unknown	1	1	-	-	-	-	2	3.2
7. Ave. Monthly Water Consumption								
Up to 15 cu m	7	2	3	3	9	-	24	38.7
16-30 cu m	5	2	4	1	3	-	15	24.2
31-50 cu m	1	-	3	-	1	-	5	8.1
51-75 cu m	2	-	-	-	-	-	2	3.2
76-100 cu m	1	1	-	-	-	-	2	3.2
101-150 cu m	-	-	-	-	-	-	-	-
151-200 cu m	-	-	1	-	-	-	1	1.6
201-300 cu m	-	-	-	-	-	-	-	-
Over 300 cu m	-	-	-	-	-	-	-	-
Unknown	-	-	-	13	-	-	13	21.0
8. Ave. Monthly Water Charge		-						
Baht		-						
Up to 50	6	2	3	5	6	-	22	35.5
51-100	4	-	3	6	4	-	17	27.4
101-150	2	2	4	1	2	-	11	17.8
151-200	-	-	-	-	1	-	1	1.6
201-300	2	-	-	3	-	-	5	8.1
301-500	1	-	1	1	-	-	3	4.8
501-1,000	1	1	-	-	-	-	2	3.2
Over 1,000	-	-	-	-	-	-	-	-
Unknown	-	-	-	1	-	-	1	1.6

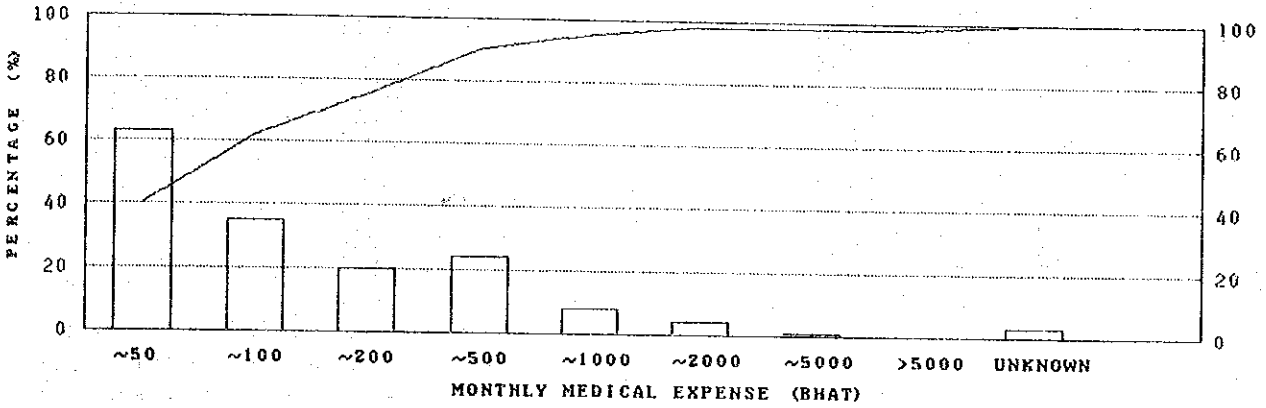
Table A4-2-1 SUMMARY OF QUESTIONNAIRE SURVEY IN TAKUA PA (CONT'D)

Block No.	1	2	3	4	5	6	Total	Rate (%)
9. Willingness to Pay								
Baht								
Up to 50	11	2	7	17	10	-	47	75.8
51-100	3	2	3	-	3	-	11	17.8
101-200	1	1	1	-	-	-	3	4.8
201-500	1	-	-	-	-	-	1	1.6
501-1,000	-	-	-	-	-	-	-	-
Over 1,000	-	-	-	-	-	-	-	-
Unknown	-	-	-	-	-	-	-	-
10. Water Quality (Other Source)								
10.1 Color								
Yes	2	-	2	-	2	8	14	11.9
No	18	19	13	19	9	22	100	84.7
Unknown	-	1	-	1	2	-	4	3.4
10.2 Smell								
Yes	3	-	1	1	2	6	13	11.0
No	17	19	14	18	9	-	77	65.3
Unknown	-	1	-	1	2	24	28	23.7
10.3 Turbidity								
Yes	3	-	1	-	-	14	18	15.2
No	17	19	14	19	11	16	96	81.4
Unknown	-	1	-	1	2	-	4	3.4
11. Willingness to Connect								
Yes	7	3	-	1	3	23	37	38.5
No	10	13	11	9	9	7	59	61.5
Unknown	-	-	-	-	-	-	-	-
12. Willingness to Pay for Connection Fee								
Baht								
Up to 1,000	2	1	-	1	-	13	17	46.0
1,001-2,000	5	-	-	-	-	9	14	37.8
2,001-2,500	-	2	-	-	3	1	6	16.2
2,501-3,000	-	-	-	-	-	-	-	-
3,001-4,000	-	-	-	-	-	-	-	-
4,001-5,000	-	-	-	-	-	-	-	-
5,001-6,000	-	-	-	-	-	-	-	-
Over 6,000	-	-	-	-	-	-	-	-
Unknown	-	-	-	-	-	-	-	-
13. Willingness to Pay for Water Charge								
Baht								
Up to 50	3	1	-	-	-	6	10	27.0
51-100	4	2	-	1	3	16	26	70.3
101-200	-	-	-	-	-	-	-	-
201-500	-	-	-	-	-	1	1	2.7
501-1,000	-	-	-	-	-	-	-	-
Over 1,000	-	-	-	-	-	-	-	-
Unknown	-	-	-	-	-	-	-	-

MONTHLY INCOME DISTRIBUTION



MONTHLY MEDICAL EXPENSE DISTRIBUTION



TYPE OF WATER SOURCE & WILLINGNESS-TO-CONNECT

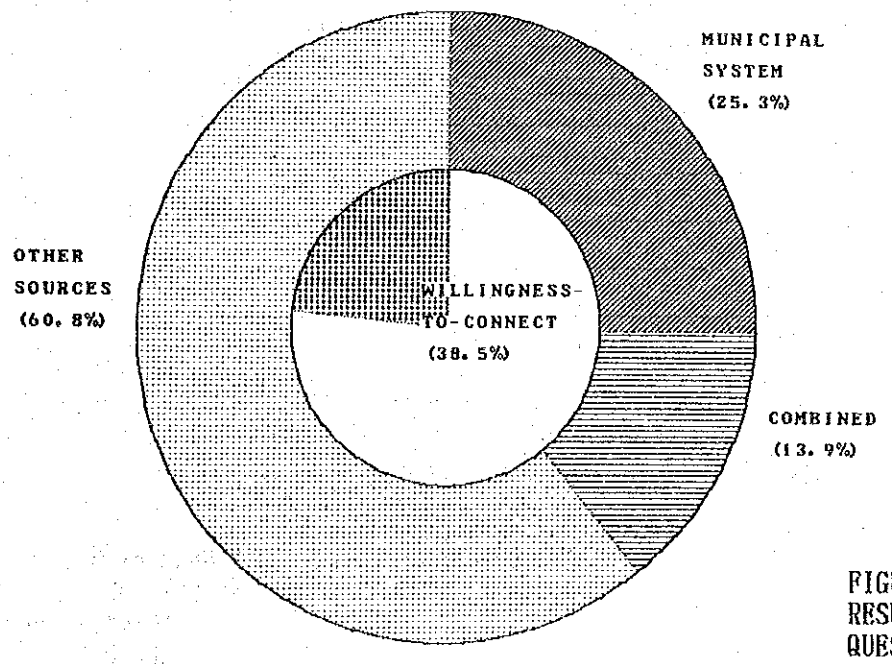
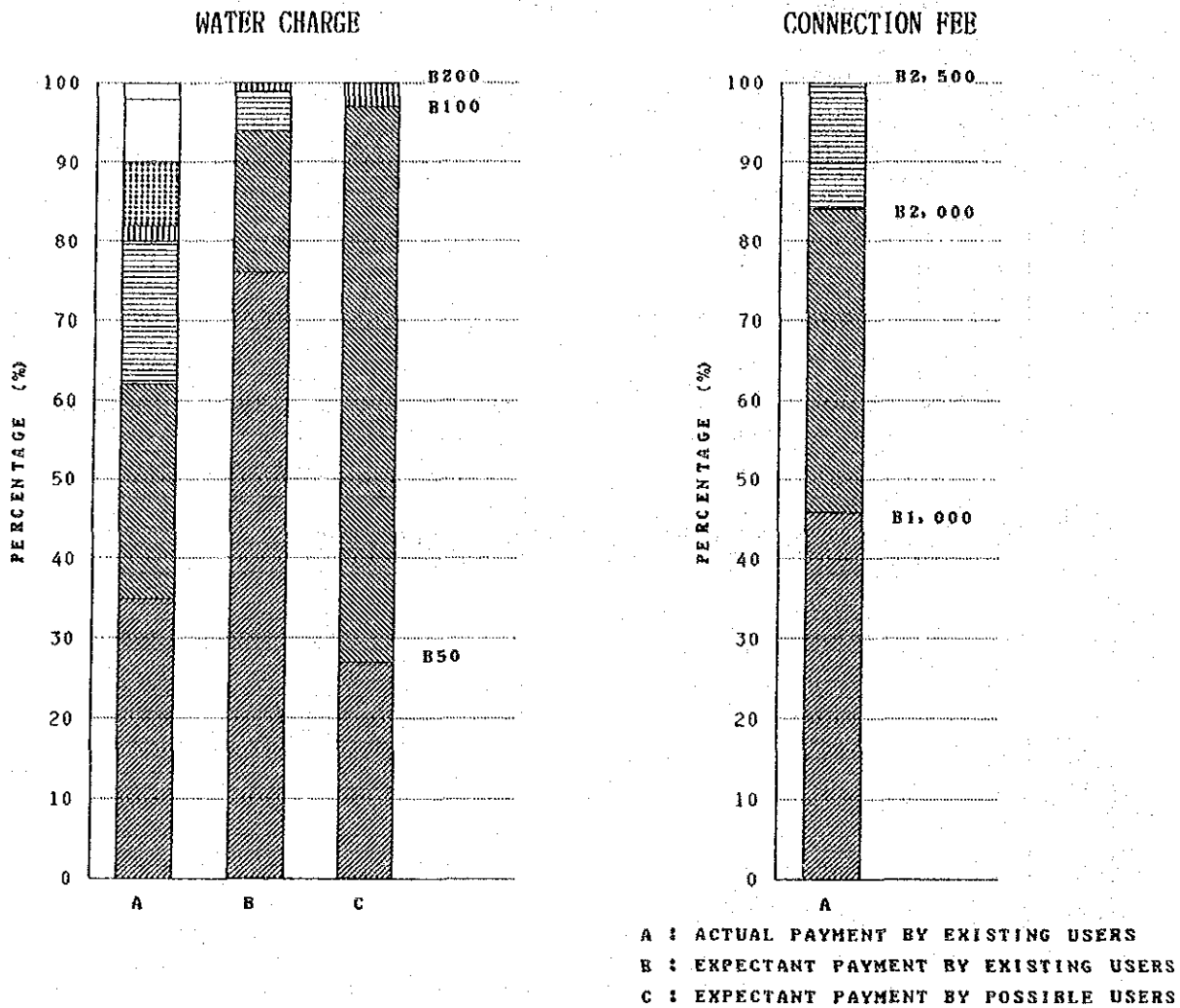


FIGURE A1-5-2
RESULTS OF
QUESTIONNAIRE SURVEY (1)
(TAKUA PA)

WILLINGNESS-TO-PAY



COMPLAINTS OF RESPONDENTS

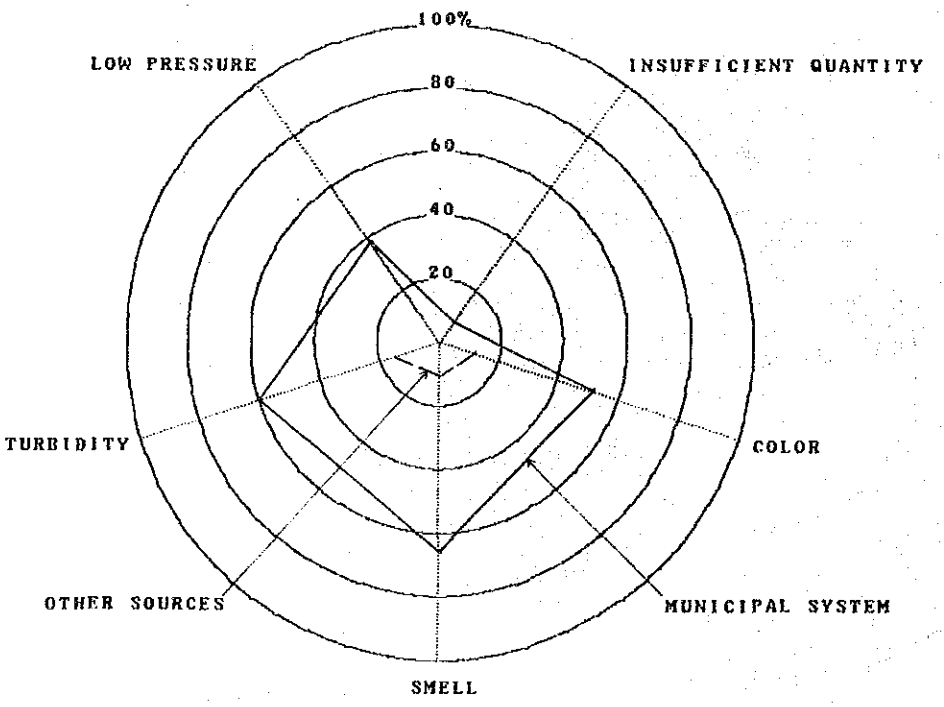


FIGURE A1-5-2
RESULTS OF
QUESTIONNAIRE SURVEY (2)
(TAKUA PA)

APPENDIX A-6-1

Construction Unit Cost

Unit Cost

Pipeline

Item	Material	Fitting	Labor	SubTotal	Transprt (<800km)	Profit etc.(21%)	Total 1 (w/10%cont)	Pavement	Total 2
	(**********			P W A 's	Unit Rate (1987)		**********		)
a. A/C Pipe(Normal Tytpe)		(25%)							
100 mm	85	21	56	162	6	35	224	140	364
150 mm	142	36	77	255	11	56	353	154	507
200 mm	255	64	90	409	19	90	569	166	735
250 mm	352	88	126	566	29	125	792	179	971
300 mm	507	127	167	801	40	177	1119	223	1342
400 mm	970	243	248	1461	80	324	2050	248	2298
500 mm	1362	341	278	1981	132	444	2812	283	3095
600 mm	1761	440	354	2555	161	570	3615	319	3934
b. Steel Pipe		(35%)							
150 mm	545	191	99	835	12	178	1127	140	1267
200 mm	720	252	111	1083	22	232	1471	154	1625
250 mm	1080	378	153	1611	38	346	2195	166	2361
300 mm	1330	465	202	1998	58	432	2736	179	2915
400 mm	1420	497	250	2167	80	472	2991	223	3214
500 mm	1785	625	361	2771	160	615	3901	248	4149
600 mm	2140	749	468	3357	264	760	4820	283	5103
700 mm	2495	873	582	3950	322	897	5686	319	6005

Unit Cost

For Transmission Pipeline (Transportation < 800 km)

Item	Material	Fitting (10%)	Labor	SubTotal	Transprt (<800km)	Profit etc.(21%)	Total 1 (w/10%cont)	Pavement	Total 2	PNA Price (1987)	Ratio	Adopted (1988)
	(****** Unit Rate Based on Pipe Material Cost as of December,1988								******)			
a. A/C Pipe (Class 20 Normal type)		(10 %)										
100 mm	115	12	63	190	7	41	261	153	414	364	1.14	410
150 mm	189	19	87	295	12	64	408	168	577	507	1.14	580
200 mm	328	33	101	462	21	101	643	181	824	735	1.12	820
250 mm	454	45	142	641	32	141	895	196	1091	971	1.12	1,090
300 mm	643	64	188	895	44	197	1249	244	1493	1342	1.11	1,490
400 mm	1217	122	279	1618	87	358	2270	271	2541	2298	1.11	2,540
500 mm	1699	170	313	2182	144	488	3096	309	3405	3095	1.10	3,410
600 mm	2187	219	398	2804	176	626	3967	349	4315	3934	1.10	4,320
b. Steel Pipe		(15 %)										
150 mm	550	83	111	744	13	159	1008	168	1176	1267	0.93	1,270
200 mm	908	136	125	1168	24	250	1587	181	1769	1625	1.09	1,770
250 mm	1210	182	172	1564	42	337	2136	196	2332	2361	0.99	2,360
300 mm	1507	226	227	1960	63	425	2693	244	2937	2915	1.01	2,940
400 mm	1887	283	281	2451	87	533	3378	271	3649	3214	1.14	3,650
500 mm	2261	339	406	3006	175	668	4233	309	4542	4149	1.09	4,540
600 mm	2723	408	526	3657	288	829	5252	349	5600	5103	1.10	5,600
700 mm	3179	477	655	4311	352	979	6206	407	6612	6005	1.10	6,610
800 mm	4527	679	932	6138	460	1385	8781	465	9246			9,250
900 mm	5104	766	1051	6921	582	1575	9986	523	10508			10,510
1000 mm	6804	1021	1401	9225	718	2088	13234	581	13815			13,820
1100 mm	7926	1189	1632	10746	869	2439	15460	639	16099			16,100
1200 mm	9048	1357	1863	12268	1034	2793	17705	697	18402			18,400
1350 mm	11000	1650	2265	14915	1309	3407	21594	784	22378			22,380
1500 mm	12953	1943	2667	17563	1616	4027	25526	871	26398			26,400

*** Note: Pipe material prices are estimated from the contractor's purchasing price as of Dec.1988

Unit Cost

For Distribution Pipeline (Transportation < 800 km)

Item	Material	Fitting	Labor	SubTotal	Transprt (<800km)	Profit etc.(21%)	Total 1 (w/10%cont)	Pavement	Total 2	PWA Price (1987)	Ratio	Adopted (1988)
	(****** Unit Rate Based on Pipe Material Cost as of December,1988								******)			
a. A/C Pipe (Class 20 Normal type)		(25 %)										
100 mm	115	29	63	207	7	45	284	153	437	364	1.20	440
150 mm	189	47	87	323	12	70	446	168	614	507	1.21	610
200 mm	328	82	101	511	21	112	708	181	890	735	1.21	890
250 mm	454	113	142	709	32	155	986	196	1181	971	1.22	1,180
300 mm	643	161	188	991	44	217	1378	244	1621	1342	1.21	1,620
400 mm	1217	304	279	1801	87	397	2513	271	2784	2298	1.21	2,780
500 mm	1699	425	313	2437	144	542	3435	309	3744	3095	1.21	3,740
600 mm	2187	547	398	3132	176	695	4403	349	4752	3934	1.21	4,750
b. Steel Pipe		(35 %)										
150 mm	550	193	111	854	13	182	1154	168	1322	1267	1.04	1,320
200 mm	908	318	125	1350	24	289	1829	181	2010	1625	1.24	2,010
250 mm	1210	424	172	1806	42	388	2459	196	2654	2361	1.12	2,650
300 mm	1507	527	227	2262	63	488	3095	244	3338	2915	1.15	3,340
400 mm	1887	660	281	2828	87	612	3880	271	4151	3214	1.29	4,150
500 mm	2261	791	406	3458	175	763	4835	309	5144	4149	1.24	5,140
600 mm	2725	953	526	4202	288	943	5977	349	6325	5103	1.24	6,330
700 mm	3179	1113	655	4946	352	1113	7052	407	7459	6005	1.24	7,460
800 mm	4527	1584	932	7043	460	1576	9986	465	10451			10,450
900 mm	5104	1786	1051	7941	582	1790	11344	523	11867			11,870
1000 mm	6804	2381	1401	10586	718	2374	15045	581	15626			15,630
1100 mm	7926	2774	1632	12332	869	2772	17570	639	18209			18,210
1200 mm	9048	3167	1863	14077	1034	3173	20113	697	20810			20,810
1350 mm	11000	3850	2265	17115	1309	3869	24522	784	25307			25,310
1500 mm	12953	4533	2667	20153	1616	4571	28974	871	29846			29,850

*** Note: Pipe material prices are estimated from the contractor's purchasing price as of Dec.1988

For Transmission Pipeline (Transportation >= 800 km)

Item	Material	Fitting (10%)	Labor	SubTotal	Transprt (>=800km)	Profit etc.(21%)	Total 1	Pavement (w/10%cont)	Total 2			Adopted (1988)
(****** Unit Rate Based on Pipe Material Cost as of December,1988 ******)												
a. A/C Pipe (Class 20 Normal type)		(10 %)										
100 mm	115	12	63	190	13	43	270	153	423	364	1.16	420
150 mm	189	19	87	295	24	67	424	168	593	507	1.17	590
200 mm	328	33	101	462	42	106	670	181	852	735	1.16	850
250 mm	454	45	142	641	63	148	937	196	1133	971	1.17	1,130
300 mm	643	64	188	895	87	206	1308	244	1551	1342	1.16	1,550
400 mm	1217	122	279	1618	175	377	2387	271	2658	2298	1.16	2,660
500 mm	1699	170	313	2182	288	519	3288	309	3597	3095	1.16	3,600
600 mm	2187	219	398	2804	352	663	4201	349	4549	3934	1.16	4,550
b. Steel Pipe		(15 %)										
150 mm	550	83	111	744	26	162	1025	168	1193	1267	0.94	1,270
200 mm	908	136	125	1168	48	255	1619	181	1801	1625	1.11	1,800
250 mm	1210	182	172	1564	83	346	2192	196	2387	2361	1.01	2,390
300 mm	1507	226	227	1960	127	438	2778	244	3022	2915	1.04	3,020
400 mm	1887	283	281	2451	175	551	3495	271	3766	3214	1.17	3,770
500 mm	2261	339	406	3006	350	705	4466	309	4775	4149	1.15	4,780
600 mm	2723	408	526	3657	577	889	5636	349	5984	5103	1.17	5,980
700 mm	3179	477	655	4311	704	1053	6674	407	7081	6005	1.18	7,080
800 mm	4527	679	932	6138	919	1482	9393	465	9857			9,860
900 mm	5104	766	1051	6921	1163	1698	10760	523	11283			11,280
1000 mm	6804	1021	1401	9225	1436	2239	14190	581	14771			14,770
1100 mm	7926	1189	1632	10746	1738	2622	16616	639	17256			17,260
1200 mm	9048	1357	1863	12268	2068	3011	19081	697	19778			19,780
1350 mm	11000	1650	2265	14915	2617	3682	23336	784	24120			24,120
1500 mm	12953	1943	2667	17563	3231	4367	27677	871	28548			28,550

*** Note: Pipe material prices are estimated from the contractor's purchasing price as of Dec.1988

Unit Cost

For Distribution Pipeline (Transportation >= 800 km)

Item	Material	Fitting	Labor	SubTotal	Transprt (>=800km)	Profit etc.(21%)	Total 1	Pavement (w/10%cont)	Total 2			Adopted (1988)
(****** Unit Rate Based on Pipe Material Cost as of December,1988 ******)												
a. A/C Pipe (Class 20 Normal type)		(25 %)										
100 mm	115	29	63	207	13	46	293	153	446	364	1.23	450
150 mm	189	47	87	323	24	73	462	168	630	507	1.24	630
200 mm	328	82	101	511	42	116	736	181	917	735	1.25	920
250 mm	454	113	142	709	63	162	1028	196	1223	971	1.26	1,220
300 mm	643	161	188	991	87	227	1436	244	1680	1342	1.25	1,680
400 mm	1217	304	279	1801	175	415	2630	271	2901	2298	1.26	2,900
500 mm	1699	425	313	2437	288	572	3627	309	3936	3095	1.27	3,940
600 mm	2187	547	398	3132	352	732	4637	349	4986	3934	1.27	4,990
b. Steel Pipe		(35 %)										
150 mm	550	193	111	854	26	185	1171	168	1340	1267	1.06	1,340
200 mm	908	318	125	1350	48	294	1861	181	2042	1625	1.26	2,040
250 mm	1210	424	172	1806	83	397	2514	196	2709	2361	1.15	2,710
300 mm	1507	527	227	2262	127	502	3179	244	3423	2915	1.17	3,420
400 mm	1887	660	281	2828	175	631	3997	271	4268	3214	1.33	4,270
500 mm	2261	791	406	3458	350	800	5068	309	5377	4149	1.30	5,380
600 mm	2723	953	526	4202	577	1004	6361	349	6709	5103	1.31	6,710
700 mm	3179	1113	655	4946	704	1187	7520	407	7927	6005	1.32	7,930
800 mm	4527	1584	932	7043	919	1672	10598	465	11062			11,060
900 mm	5104	1786	1051	7941	1163	1912	12118	523	12641			12,640
1000 mm	6804	2381	1401	10586	1436	2525	16001	581	16582			16,580
1100 mm	7926	2774	1632	12332	1738	2955	18726	639	19365			19,370
1200 mm	9048	3167	1863	14077	2068	3391	21490	697	22187			22,190
1350 mm	11000	3850	2265	17115	2617	4144	26264	784	27049			27,050
1500 mm	12953	4533	2667	20153	3231	4911	31125	871	31996			32,000

*** Note: Pipe material prices are estimated from the contractor's purchasing price as of Dec.1988

Unit Cost

Construction Works	Price in 3 Lowest Tenders (1988) (A)	Estimated Cost (A)*1.35	PWA's Unit Cost (for 1987)	Adopted Cost (1988)
Concrete Work (incl.Form Work,Scafolding)	Baht 2,200 /cu m	Baht 2,970 /cu m	-	
Re-Bar	Baht 18 /kg	Baht 24 /kg	-	
Unit Concrete Cost (incl.Form Work,Scafolding, Re-Bar(100kg/cu m concrete)})		Baht 5,370 /cu m	-	5,400
Earth Work				
Excavation (with Backfill)	55 /cu m	79 /cu m	-	80
Soil Fill	53 /cu m	76		120 (From PWA Cost)
Architectural Works				
Administration Bldg.	4,516 /sq m	6,451 /sq m		
Head Quarter Bldg.	3,612	5,160		5,000
Chlorination House	Baht 2,830 /sq m	Baht 4,043 /sq m	3610 - 4300	3,800
Pump House (excl.pump pit)	Baht 1,860 /sq m	Baht 2,657 /sq m	3540 - 4200	3,600

Unit Cost

Construction Works	PWA's Cost (for 1987) (Baht 1000)	Unit Cost (Baht/cu m/h) (A)	Estimated Cost (for 1989) (A)*1.30	Adopted Cost (1988)
Treatment Facilities			Unit Cost (Baht/cu m/h)	Unit Cost (Baht/cu m/h)
Sedimentation Basin				
50 cu m/hr	1,310	26,200	34,100	34,000
100 cu m/hr	1,633	16,330	21,200	21,000
200 cu m/hr	3,136	15,680	20,400	20,000
250 cu m/hr	5,133	20,532	26,700	27,000
500 cu m/hr	7,708	15,416	20,000	20,000
1000 cu m/hr	17,723	17,723	23,000	23,000
Filters				
50 cu m/hr	588	11,760	15,300	15,000
100 cu m/hr	1,044	10,440	13,600	14,000
200 cu m/hr	2,227	11,135	14,500	15,000
250 cu m/hr	2,337	9,348	12,200	12,000
500 cu m/hr	4,674	9,348	12,200	12,000
1000 cu m/hr	11,356	11,356	14,800	15,000
Clear Water Reservoir			Unit Cost (Baht/cu m)	Unit Cost (Baht/cu m)
500 cu m	887	1,774	2,300	2,300
1000 cu m	1,628	1,628	2,100	2,100
1500 cu m	2,699	1,799	2,300	2,300
2000 cu m	2,803	1,402	1,800	1,800
2250 cu m	3,282	1,459	1,900	1,900
3000 cu m	6,633	2,211	2,900	2,900
3300 cu m	6,603	2,001	2,600	2,600
4000 cu m	7,730	1,933	2,500	2,500
5800 cu m	10,809	1,864	2,400	2,400
Elevated Tank			Cost (Baht 1000)	Cost (Baht 1000)
50 cu m	722		940	900
120 cu m	1,146		1,490	1,500
259 cu m	1,394		1,810	1,800

APPENDIX A-8-1

Capacity Calculation of the Water Treatment Plant

Capacity Calculation for Treatment Plant

Item		Total System (for 2011)
Planned Flow (Daily Max)	Q=	4,300 cu m/d
	=	179 cu m/hr
	=	3.0 cu m/min
	=	0.050 cu m/sec
No. of Treatment Line		2 Lines
		2,150 cu m/d x 2 lines
(1) Receiving Well		
Criteria	T=	1.5 min
	d=	2.0 m
No.		1 unit
Dimension	Circular	
	Dia	1.8 m
	v=	5 cu m
	t=	1.7 min
(2) Mixing Tank		
Criteria	T=	1.0 min
Dimension	Square	x 2 units
	L m x	W m x D m x units
	1.2	1.0 1.2 2
	v =	2.88 cu m
	t =	1.0 min
Mixer	Mechanical Flush Mixer	

Capacity Calculation for Treatment Plant

Item	Total System (for 2011)
(3) Coagulant Mixing	
Coagulant	Solid Aluminum Sulphate (Al2(SO4)3) containing 15 % Al2-O3
	Dosage Rate : 10-25 mg-solid alum/l Average 10 mg/l
	Coagulant Solution : 5 % solution
	Dosage Amount : 43 kg-Alum/day
	Coagulant Solution (5 % solution) = 1 cu m/day
No. of Mixer	2 units
Type	Batch Type Mixing
Capacity	0.4 cu m/unit
Dimension	Square x 2 units (1 stand by) L m x W m x D m x units 1.0 1.0 1.0 1
	v = 1.0 cu m/unit
	Total V = 1.0 cu m

Capacity Calculation for Treatment Plant

Item	Total System (for 2011)
(4) Flocculator	
Type	Hydraulic Flocculation
No.	N = 2 lines x 2 units
	= 4 units
Unit Flow	q = 0.75 cu m/min/unit
Criteria	T = 30 min
Dimension	W m x L m x D m x n lines
	1.0 12.0 2.0 2
	v = 24 cu m/unit
	t = 32.1 min

Capacity Calculation for Treatment Plant

Item	Total System (for 2011)
(5) Sedimentation Basin	
Type	Rectanglar, Horizontal Flow
No.	N = 2 line x 1 basins
	= 2 basins
Unit Flow	q = 89.6 cu m/hr/basin
Criteria	Retention Time
	T = 4 hours
Dimension	W m x L m x D m x N
	5 25 4.0 2
	v = 500 cu m/basin
	t = 5.6 hours
Flow velocity	v = 7.5 cm/min
Surface Load	a = 17.2 m3/m2/day
Sludge Removal	Mechanical Scraper
Sludge Amount	
Solid Amount (ton-DS)	So = Q(K(T1-T2)+0.16xB)x10^-6 where So:Sludge dry weight(ton) Q :Treated water amount(m3/d) K :Coefficient converting turbidity to SS (0.8-1.5 ->>1.2) T1 :Turbidity in raw water (ave=20) T2 :Turbidity after Sedimentation (ave = 7) B :Alum dosage rate (ave.= 10 mg/l)
	So = 0.07 ton-DS/day
	Water Contents of Drained Sludge
	w = 99.5 %
	Sludge Volume
	v = 15 cu m/d

Capacity Calculation for Treatment Plant

Item	Total System (for 2011)
(6) Rapid Sand Filter	
Type	Down Flow, Single Media
No.	N = 2 lines x 2 units = 4 units
Unit Flow	q = 1,075 cu m/day/unit
Criteria	Surface Load 120 - 150 m3/m2/day
Dimension	W m x L m x N units 2.5 3.5 4
	a = 9 sq m/unit
Surface Load	La = 122.9 m3/m2/day
Filter Washing Frequency	Once a day for each filter
Rate	Surface Washing 0.2 m3/m2/min x 5 min Backwashing 0.6 m3/m2/min x 10 min
Water Amount required	Surface Washing v = 9 sq m/unit x 4 units x 0.2 m3/m2/min x 5 min = 35 cu m/day Backwashing v = 9 sq m/unit x 4 units x 0.6 m3/m2/min x 10 min = 210 cu m/day
Total q=	245 cu m/day

Capacity Calculation for Treatment Plant

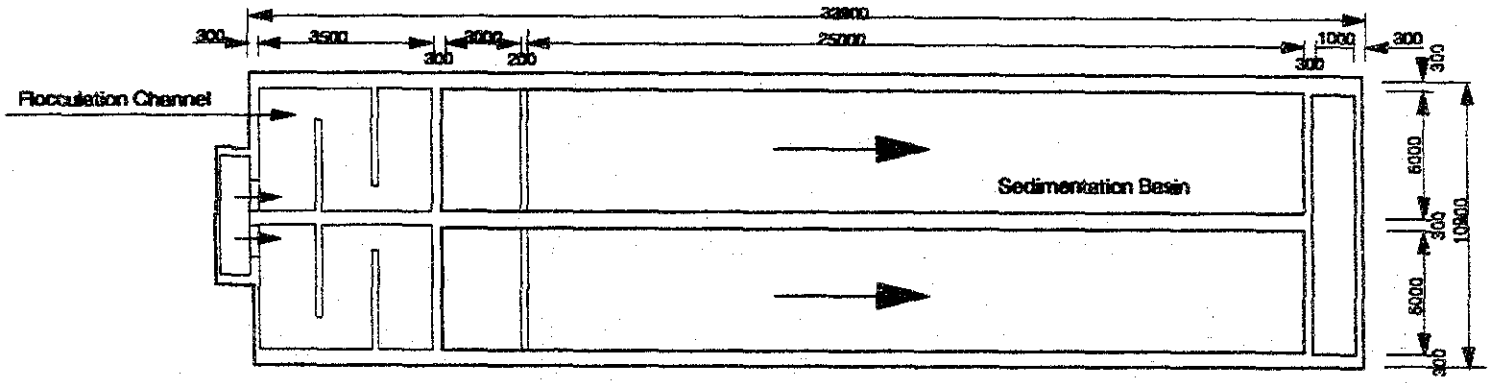
Item	Total System (for 2011)
Solid Amount in Wastewater	
Solid Amount (ton-DS)	So = Q*K*(T1-T2)*10^-6 where So:Sludge dry weight(ton) Q :Treated water amount(m3/d) K :Coefficient converting turbidity to SS (0.8-1.5 ->>1.2) T1 :Turbidity before filter(ave= 7) T2 :Turbidity after filter(ave = 0) So = 0.04 ton-DS/day
SS Contents	s = 147 mg/l

(7)
Clear Water Reservoir

No.	N = 1 units
Criteria	Retention Time
	T = 8 hours
Required Volume	V = 1,433 cu m
Dimension	L m x W m x D m x N units 18 20 4 1
	Total Volume
	v = 1,440 cu m
Retention Time	t = 8.0 hours

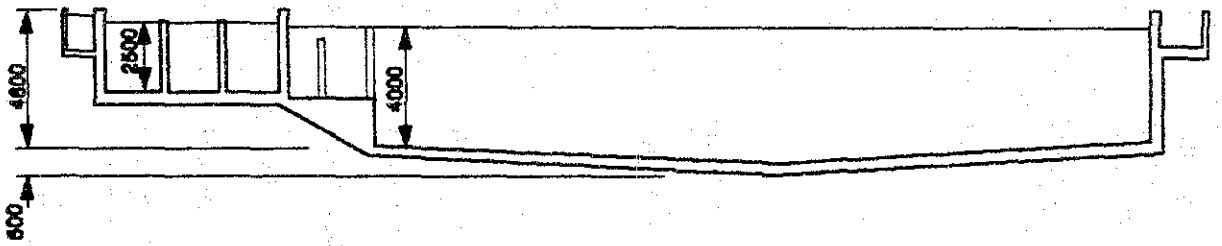
Capacity Calculation for Treatment Plant

Item	Total System (for 2011)
(8) Chlorination Equipment	
Injection Point	at the Inlet of Clear Water Reservoir
Dosage Rate	2.0 ppm
Type	Liquid Chlorine (1-ton cylinder)
Amount	9 kg- Cl gas/day
Injector	Vacuum Type Injector
	No. of unit 2 units (excl. 1 units stand-by)
	Rate 0.18 kg/h/unit
	Capacity 10 kg/h/unit
Storage	1 month
Storage Amount	9 kg /day x 30 day = 258 kg
	= 6 cylinders (50 kg)
(9) Clear Water Pump	
No.	N = 2 units + 1 stand-by
Flow per unit	q = 2.1 cu m/min/unit
Diameter	D = 100 mm
Head	H = 30 m
Motor output	P = 20 KW
Total Capacity	Q = 6,020 cu m/day



Plan

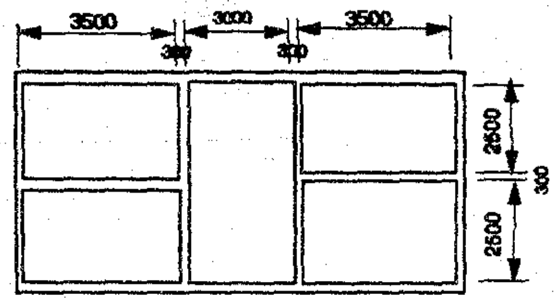
Scale 1:250



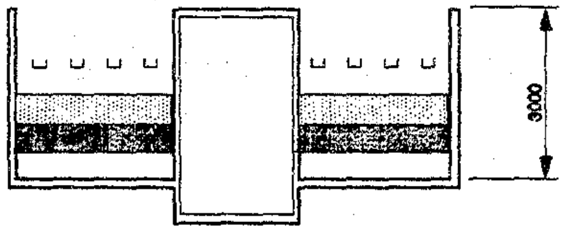
Section

Scale 1:250

FIGURE
Flocculation Channel and
Sedimentation Basin



Plan



Section

FIGURE

Rapid Sanf Filter

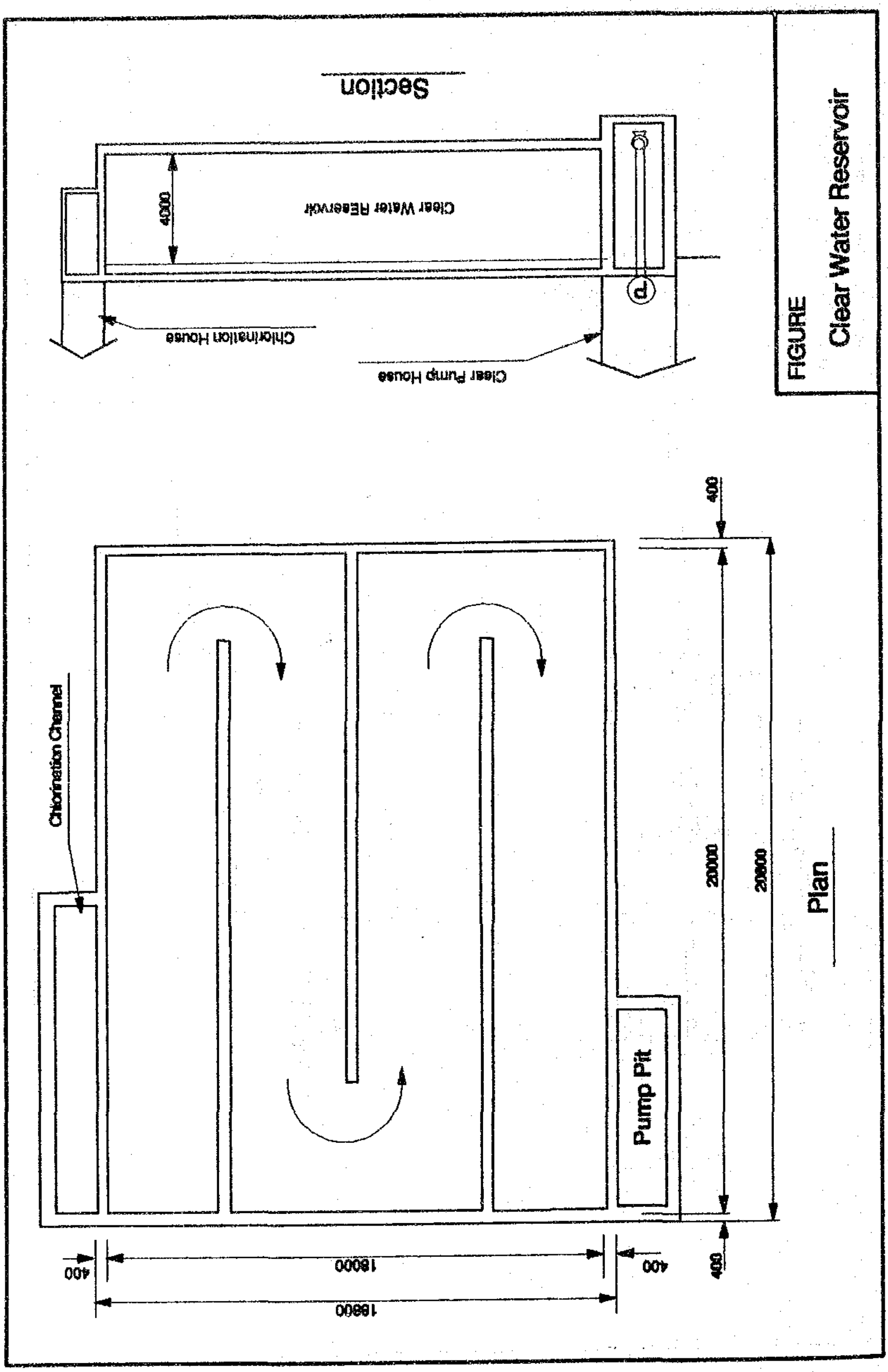


FIGURE
Clear Water Reservoir
Section
Clear Water Reservoir
4000
Chlorination House
Clear Pump House
Plan
Chlorination Channel
Pump Pit
20000
20800
18000
18800
400

APPENDIX A-8-2

Distribution Network Analysis

T I T L E : Takua Pa (Proposed)
NO. OF PIPES : 82
NO. OF NODES : 76
PEAK FACTOR : 1.25
MAX HEADLOSS/Km : 100
MAX UNBAL(LPS) : .005

PIPE NO.	FROM Node	TO Node	LENGTH (M)	DIA (MM)	HWC	FLOW (LPS)	VELOCITY (MPS)	HEADLOSS (M/KM)	HEADLOSS (M)
1	100	1	40.00	300	110	35.91	0.51	1.33	0.05
2	1	64	300.00	300	110	35.87	0.51	1.33	0.40
3	64	2	1080.00	300	110	35.39	0.50	1.30	1.40
4	2	3	1500.00	280	110	35.37	0.57	1.81	2.72
5	3	4	2000.00	300	110	35.27	0.50	1.29	2.57
6	4	5	150.00	300	110	34.26	0.48	1.22	0.18
7	5	6	100.00	300	110	34.25	0.48	1.22	0.12
10	8	9	200.00	250	110	19.20	0.39	1.02	0.20
11	9	10	150.00	250	100	18.14	0.37	1.09	0.16
12	10	11	450.00	250	110	17.17	0.35	0.83	0.37
13	11	12	215.00	200	100	10.90	0.35	1.26	0.27
14	12	13	210.00	150	100	3.31	0.19LO	0.56	0.12
15	13	14	100.00	100	110	1.13	0.14LO	0.46	0.05
16	14	15	180.00	100	100	0.16	0.02LO	0.01	0.00
18	15	17	23.00	100	100	0.03	0.00LO	0.00	0.00
19	17	18	267.00	100	110	0.03	0.00LO	0.00	0.00
20	14	19	10.00	100	110	0.87	0.11LO	0.29	0.00
21	19	20	410.00	100	110	0.56	0.07LO	0.13	0.05
22	19	21	295.00	100	110	0.31	0.04LO	0.04	0.01
23	11	22	140.00	150	100	5.47	0.31	1.43	0.20
24	22	23	492.00	100	100	0.80	0.10LO	0.29	0.14
25	23	24	100.00	100	110	0.15	0.02LO	0.01	0.00
26	26	23	312.00	100	100	0.48	0.06LO	0.12	0.04
27	25	26	15.00	150	100	1.81	0.10LO	0.19	0.00
28	22	25	120.00	150	100	4.20	0.24LO	0.88	0.11
29	26	27	15.00	100	100	1.33	0.17LO	0.75	0.01
30	27	28	327.00	100	100	0.42	0.05LO	0.09	0.03
31	28	29	100.00	100	110	0.42	0.05LO	0.08	0.01
32	27	36	476.00	100	100	0.64	0.08LO	0.20	0.09
33	12	30	290.00	200	100	6.66	0.21LO	0.51	0.15
34	30	31	100.00	150	100	5.82	0.33	1.60	0.16
35	31	32	600.00	150	110	4.68	0.26LO	0.90	0.54
36	32	33	250.00	150	100	2.02	0.11LO	0.23	0.06
37	33	34	150.00	50	100	0.04	0.02LO	0.04	0.01
38	35	30	150.00	200	100	1.68	0.05LO	0.04	0.01
39	25	35	476.00	150	100	2.02	0.11LO	0.23	0.11
40	36	35	20.00	150	100	0.26	0.01LO	0.00	0.00
41	36	37	150.00	200	100	0.14	0.00LO	0.00	0.00
42	37	38	200.00	150	100	0.27	0.02LO	0.01	0.00
43	38	39	70.00	50	100	0.21	0.11LO	0.71	0.05
44	40	37	50.00	200	100	0.50	0.02LO	0.00	0.00

PIPE NO.	FROM Node	TO Node	LENGTH (M)	DIA (MM)	HWC	FLOW (LPS)	VELOCITY (MPS)	HEADLOSS (M/KM)	HEADLOSS (M)
45	40	41	100.00	38	100	0.21	0.19LO	2.79	0.28
47	42	43	575.00	250	100	10.09	0.21LO	0.37	0.21
48	43	44	110.00	250	110	0.21	0.00LO	0.00	0.00
50	43	46	367.00	200	110	8.51	0.27LO	0.67	0.25
51	46	47	15.00	150	100	3.50	0.20LO	0.62	0.01
52	47	48	350.00	100	110	1.02	0.13LO	0.38	0.13
53	48	49	223.00	200	110	0.64	0.02LO	0.01	0.00
54	47	50	255.00	150	100	0.66	0.04LO	0.03	0.01
55	50	51	200.00	100	110	0.00	0.00LO	0.00	0.00
56	50	52	250.00	100	110	0.48	0.06LO	0.10	0.02
57	47	52	190.00	150	100	1.71	0.10LO	0.17	0.03
58	52	53	30.00	150	100	1.50	0.08LO	0.13	0.00
59	53	54	150.00	100	110	0.29	0.04LO	0.04	0.01
60	46	55	15.00	150	100	2.45	0.14LO	0.32	0.00
61	55	56	150.00	100	100	0.53	0.07LO	0.14	0.02
62	55	57	150.00	150	100	1.66	0.09LO	0.16	0.02
63	56	57	152.00	100	100	0.18	0.02LO	0.02	0.00
64	57	58	30.00	100	100	1.18	0.15LO	0.60	0.02
65	53	58	160.00	150	100	0.38	0.02LO	0.01	0.00
66	58	59	250.00	100	100	0.37	0.05LO	0.07	0.02
67	46	60	170.00	100	110	2.06	0.26LO	1.42	0.24
68	60	61	410.00	100	110	1.17	0.15LO	0.49	0.20
69	60	62	436.00	100	110	0.22	0.03LO	0.02	0.01
70	1	63	1200.00	250	100	0.04	0.00LO	0.00	0.00
71	64	65	700.00	75	100	0.35	0.08LO	0.25	0.18
72	200	8	300.00	250	100	19.62	0.40	1.26	0.38
73	6	200	380.00	300	110	34.00	0.48	1.20	0.46
74	200	201	810.00	250	110	14.21	0.29LO	0.58	0.47
75	201	202	780.00	250	110	13.85	0.28LO	0.56	0.43
76	202	203	660.00	250	110	13.42	0.27LO	0.52	0.35
77	203	204	720.00	100	110	0.28	0.04LO	0.03	0.03
78	203	205	440.00	250	110	12.80	0.26LO	0.48	0.21
79	205	40	2850.00	200	100	1.26	0.04LO	0.02	0.07
80	205	42	2021.00	250	110	10.82	0.22LO	0.35	0.71
81	61	206	680.00	100	110	0.10	0.01LO	0.01	0.00
82	206	207	720.00	100	110	0.04	0.01LO	0.00	0.00
83	32	208	1260.00	100	110	0.44	0.06LO	0.08	0.10
84	208	209	880.00	100	110	0.18	0.02LO	0.02	0.01
85	33	210	600.00	100	110	0.68	0.09LO	0.18	0.11
86	210	211	660.00	100	110	0.42	0.05LO	0.07	0.05
87	211	212	880.00	100	110	0.14	0.02LO	0.01	0.01

NODE NO.	FLOW (LPS)	ELEVATION (M)	H G L (M)	PRESSURE (M)
1	0.000	13.80	39.95	26.15
2	-0.017	11.65	38.15	26.50
3	-0.104	11.76	35.43	23.67
4	-1.014	11.60	32.86	21.26
5	-0.003	11.20	32.68	21.48
6	-0.249	11.20	32.55	21.35
8	-0.422	11.48	31.72	20.24
9	-1.056	12.00	31.52	19.52
10	-0.966	12.00	31.35	19.35
11	-0.811	10.20	30.98	20.78
12	-0.924	10.00	30.71	20.71
13	-2.186	10.00	30.59	20.59
14	-0.101	10.00	30.54	20.54
15	-0.127	10.00	30.54	20.54
17	0.000	10.00	30.54	20.54
18	-0.032	10.00	30.54	20.54
19	0.000	10.00	30.54	20.54
20	-0.559	10.00	30.49	20.49
21	-0.307	10.00	30.53	20.53
22	-0.470	11.00	30.78	19.78
23	-1.132	11.00	30.64	19.64
24	-0.149	11.00	30.64	19.64
25	-0.368	11.00	30.68	19.68
26	0.000	11.00	30.67	19.67
27	-0.265	11.00	30.66	19.66
28	0.000	11.00	30.63	19.63
29	-0.423	11.00	30.62	19.62
30	-2.522	10.47	30.56	20.09
31	-1.143	11.08	30.40	19.32
32	-2.221	17.10	29.86	12.76
33	-1.296	21.40	29.81	8.41
34	-0.043	21.40	29.80	8.40
35	-0.593	11.00	30.57	19.57
36	-0.243	11.20	30.57	19.37
37	-0.372	11.30	30.57	19.27
38	-0.061	11.48	30.57	19.09
39	-0.209	11.50	30.52	19.02
40	-0.550	12.00	30.57	18.57
41	-0.212	12.00	30.29	18.29
42	-0.732	22.49	29.92	7.43
43	-1.365	13.84	29.71	15.87
44	-0.212	12.00	29.71	17.71
46	-0.503	12.00	29.47	17.47
47	-0.105	12.00	29.46	17.46
48	-0.380	15.06	29.32	14.26
49	-0.638	22.50	29.32	6.82
50	-0.180	12.00	29.45	17.45
51	0.000	12.00	29.45	17.45

NODE NO.	FLOW (LPS)	ELEVATION (M)	H G L (M)	PRESSURE (M)
52	-0.691	12.00	29.43	17.43
53	-0.831	12.00	29.42	17.42
54	-0.294	12.00	29.42	17.42
55	-0.261	12.00	29.46	17.46
56	-0.353	12.00	29.44	17.44
57	-0.661	12.00	29.44	17.44
58	-1.185	12.00	29.42	17.42
59	-0.369	12.00	29.40	17.40
60	-0.673	12.00	29.23	17.23
61	-1.069	12.00	29.02	17.02
62	-0.223	12.00	29.22	17.22
63	-0.038	14.60	39.95	25.35
64	-0.135	13.80	39.55	25.75
65	-0.345	15.00	39.37	24.37
100 R	35.908	15.00	40.00	25.00
200	-0.173	11.20	32.10	20.90
201	-0.359	11.20	31.62	20.42
202	-0.433	11.50	31.19	19.69
203	-0.343	11.40	30.85	19.45
204	-0.278	11.40	30.82	19.42
205	-0.718	14.70	30.64	15.94
206	-0.057	12.00	29.02	17.02
207	-0.041	12.00	29.02	17.02
208	-0.258	17.10	29.76	12.66
209	-0.182	17.00	29.75	12.75
210	-0.259	21.00	29.70	8.70
211	-0.282	21.00	29.65	8.65
212	-0.135	21.00	29.64	8.64

APPENDIX A-11-1

Details of Operation Cost

WATER TRANSMISSION AND DISTRIBUTION COST STUDY (Takua Pa)

Item	1990	1991	1992	1993	1994	Y 1995	1996	1997	E 1998	1999	2000	A 2001	2002	2003	R 2004	2005	2006	2007	2008	2009	2010	2011
1. Planned Daily Average Water Demand (cu m/d)																						
	2,796	2,769	2,745	2,723	2,702	2,684	2,760	2,755	2,754	2,755	2,760	2,766	2,780	2,796	2,813	2,832	2,852	2,866	2,881	2,899	2,917	2,938
2. Planned Daily Maximum Water Demand: QDM (cu m/d)																						
Peak Factor = 1.35																						
Planned Total	3,775	3,738	3,706	3,676	3,648	3,623	3,726	3,719	3,718	3,719	3,726	3,734	3,753	3,775	3,798	3,823	3,850	3,869	3,889	3,914	3,938	3,966
3. Treatment Plant																						
Existing Plant	¦**********					>> (abondoned in 1994)			Max. Capacity		960 cu m/d	Net Capacity			889 cu m/day							
New Treatment Unit					¦**********				>>	Max. Capacity		4,300 cu m/d	Net Capacity		3,981 cu m/day			**********				>>
Treatment Capacity	960	960	960	960	4,300	4,300	4,300	4,300	4,300	4,300	4,300	4,300	4,300	4,300	4,300	4,300	4,300	4,300	4,300	4,300	4,300	4,300
Net Treatment Capa	889	889	889	889	3,981	3,981	3,981	3,981	3,981	3,981	3,981	3,981	3,981	3,981	3,981	3,981	3,981	3,981	3,981	3,981	3,981	3,981
4. Water Amount for Intake Design : (cu m/d)																						
Raw water for Treatment Plant	4,484	4,441	4,402	4,367	4,333	4,305	4,426	4,418	4,417	4,418	4,426	4,436	4,459	4,484	4,511	4,542	4,574	4,596	4,621	4,649	4,678	4,712
(Daily Max)*1.08*1.1																						
5 Daily Average Transmission Amount																						
Raw water for Treatment Plant	2,796	2,769	2,745	2,723	2,702	2,684	2,760	2,755	2,754	2,755	2,760	2,766	2,780	2,796	2,813	2,832	2,852	2,866	2,881	2,899	2,917	2,938

6. Pump Characteristics

Raw Water Pump		Dia= 200 mm,	P = 20 KW,	H = 20.0 m,	Q = 3.2 cu m/min,	No.of Pumps =	1 units (excluding 1 unit stand-by)	
		Dia= 100 mm,	P = 20 KW,	H = 30.0 m,	Q = 2.1 cu m/min,	No.of Pumps =	1 units (excluding 1 unit stand-by)	
Clear Water Pump								
at New WTP		Dia= 100 mm,	P = 20 KW,	H = 30.0 m,	Q = 2.1 cu m/min,	No.of Pumps =	2 units (excluding 1 unit stand-by)	
at Exis.WTP	Exis.Pump	Dia= 100 mm,	P = 10 KW,	H = 40.0 m,	Q = 0.5 cu m/min,	No.of Pumps =	2 units	

WATER TRANSMISSION AND DISTRIBUTION COST STUDY (Takua Pa)

Item	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
7. No.of Operating Pumps																						
Raw Water Pump	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Max.Capa.of Pump	4,608	4,608	4,608	4,608	4,608	4,608	4,608	4,608	4,608	4,608	4,608	4,608	4,608	4,608	4,608	4,608	4,608	4,608	4,608	4,608	4,608	4,608
Clear Water Pump																						
at New WTP					2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Max.Capa.of Pump					6,020	6,020	6,020	6,020	6,020	6,020	6,020	6,020	6,020	6,020	6,020	6,020	6,020	6,020	6,020	6,020	6,020	6,020
at Exis.WTP	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Max.Capa.of Pump	1,344	1,344	1,344	1,344	1,344	1,344	1,344	1,344	1,344	1,344	1,344	1,344	1,344	1,344	1,344	1,344	1,344	1,344	1,344	1,344	1,344	1,344
Total Capacity (cu m)	1,344	1,344	1,344	1,344	7,364	7,364	7,364	7,364	7,364	7,364	7,364	7,364	7,364	7,364	7,364	7,364	7,364	7,364	7,364	7,364	7,364	7,364
8. Motor Output (Kw)																						
Raw Water Pump	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20
Clear Water Pump	20	20	20	20	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60
9. Energy Consumption (Kwh/day)																						
Raw Water Pump	467	463	459	455	451	448	461	460	460	460	461	462	464	467	470	473	476	479	481	484	487	491
Clear Water Pump	317	317	317	317	528	525	540	539	539	539	540	541	544	547	550	554	558	560	563	567	570	575
10. Pump Operation Cost (Baht x1,000/year)																						
Demand Charge	110	110	110	110	226	220	220	220	220	220	220	226	226	220	220	220	220	220	220	220	220	220
Energy Charge	352	350	348	347	440	437	449	448	448	448	449	450	453	455	458	461	464	467	469	472	475	478
Total Cost	462	460	458	457	666	657	669	668	668	668	669	670	672	675	678	681	684	686	689	692	695	698
																				Total (1990-2011) =		14,017
Chemical Cost																						
Alum (ave 5.0 mg/l)																						
Chemical (kg/y)	5,103	5,053	5,010	4,969	4,931	4,898	5,037	5,028	5,026	5,028	5,037	5,048	5,074	5,103	5,134	5,168	5,205	5,230	5,258	5,291	5,324	5,362
Cost (Baht 1000)	20.7	20.5	20.3	20.1	20.0	19.8	20.4	20.4	20.4	20.4	20.4	20.4	20.5	20.7	20.8	20.9	21.1	21.2	21.3	21.4	21.6	21.7
Lime (ave 13.0 mg/l)																						
Chemical (kg/y)	13,267	13,139	13,025	12,921	12,821	12,736	13,096	13,072	13,068	13,072	13,096	13,125	13,191	13,267	13,348	13,438	13,533	13,599	13,670	13,756	13,841	13,941
Cost (Baht 1000)	16.6	16.4	16.3	16.2	16.0	15.9	16.4	16.3	16.3	16.3	16.4	16.4	16.5	16.6	16.7	16.8	16.9	17.0	17.1	17.2	17.3	17.4
Chlorine (ave 2.0 mg/l)																						
Chemical (kg/y)	2,041	2,021	2,004	1,988	1,972	1,959	2,015	2,011	2,010	2,011	2,015	2,019	2,029	2,041	2,053	2,067	2,082	2,092	2,103	2,116	2,129	2,145
Cost (Baht 1000)	31.8	31.5	31.3	31.0	30.8	30.6	31.4	31.4	31.4	31.4	31.4	31.5	31.7	31.8	32.0	32.3	32.5	32.6	32.8	33.0	33.2	33.5
Total cost(Baht 1000	69.1	68.4	67.8	67.3	66.8	66.3	68.2	68.1	68.1	68.1	68.2	68.3	68.7	69.1	69.5	70.0	70.5	70.8	71.2	71.6	72.1	72.6
																					Total	1,521

WATER TRANSMISSION AND DISTRIBUTION COST STUDY (Takua Pa)

Item	1990	1991	1992	1993	1994	Y 1995	1996	1997	E 1998	1999	2000	A 2001	2002	2003	R 2004	2005	2006	2007	2008	2009	2010	2011

Note: Pumps is designed for Qda (Daily Average Demand)

8. Energy Consumption (KWh) = No.of Pumps x Motor Output(KW) x 24 h/day x {actual daily demand(qla)/max.capacity of pump(8)}

9 . Demand Charge = Baht 229 /KW/mon x 12 mon/year x Motor Demand(7) KW

Energy Charge = Baht 1.23 /KWh x Energy Consumption (8) KWh/day x 365 days/year

Design Pump Head=(Head Loss of Pipeline)+(Actual Head for M.W.L)+(Pump Head 1.5 m)

DA : Daily Average

DM : Daily Maximum

Electricity Fee = Rate of Provincial Electricity Authority(PEA) for Narathiwat as of January, 1989.

Chemical Cost

Alum	:Baht	4.05 /kg
Lime	:Baht	1.25 /kg
Cl gas	:Baht	15.60 /kg

Year	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Operation Chemical Cost	0	0	529	526	524	726	723	737	736	736	736	737	738	741	744	747	751	755	757	760	763	767	771
Discount Rate	10.00 %																						
NPV	4,850 x 1000 Baht