SAIGON METROPOLITAN AREA
REPUBLIC OF VIETNAM

REPORT ON WATER SOURCES SURVEY AND GROUNDWATER SUPPLY IMPLEMENTATION PLAN

NOVEMBER 1973

OVERSEAS TECHNICAL COOPERATION AGENCY
GOVERNMENT OF JAPAN

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P R E F A C E

The Government of Japan, in response to the request made by the Government of the Republic of Vietnam decided to make the feasibility study of the Water Supply Project in Saigon Metropolis, succeeding the previous surveys in 1970 and 1971 fiscal year and entrusted the Overseas Technical Cooperation Agency (O.T.C.A.) with the study.

O.T.C.A. organized the 11-member survey team headed by Dr. Hiromu Tanabe in order to make the feasibility study of the groundwater of which the electrical prospecting had been accomplished in 1971, as well as to collect basic data and materials concerning the Saigon River as many as possible and sent the team to Vietnam for 115 days from December 5, 1972.

Under many varying political and social conditions during the field survey period such as the conclusion of the cease-fire agreement at Paris, the survey was carried out quite satisfactorily and successfully by virtue of the cooperation extended to the team by the Government of Vietnam, Saigon Metropolitan Water Office and the staff concerned, and the team was able to collect the necessary data for the objectives. The survey team analysed those data after returning to Japan and reached the conclusion that 200,000 cum groundwater was possibly pumped up daily. As described in details in this report, the recommendation for the development of groundwater is based on the water demand forecast in future, thus showing the realistic development plan on stage by stage basis. We believe that the plan proposed here is quite feasible in view of the present economic and social conditions in Saigon.

On the other hand, the hydrological data for the Saigon River are lacking, as has been pointed out since the first survey in 1970. The discharge measurement and the quality test of the Saigon River water have just been undertaken in the current survey. Therefore, the report could not have gone beyond showing those data collected in the survey.

The future survey is awaited for the further data and analysis.

It will be our pleasure if the report now ready for presentation could be of any help for the expansion plan of water supply and for the social welfare and development of Saigon Metropolis.

In closing, the deep appreciation is rendered to those members engaged in this survey and staffs who gave us the fullest cooperation to execute this survey.

November, 1973

K. Tatsuke

Keiichi Tatsuke
Director General
Overseas Technical Cooperation Agency

NIHON SUIDO CONSULTANTS, CO., LTD.

Professional Engineers in WATERWORKS and SEWERAGE
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1st November, 1973

Overseas Technical Cooperation Agency
42, Ichigaya-Honmuracho,
Shinjuku-ku, Tokyo, Japan

Attention: Mr. Keiichi Tatsuke,
Director General

Dear Sirs,

Since January 1971, three water supply surveys were undertaken as a technical cooperation program for the Saigon Metropolitan Water Office by the Japanese Government by way of the Overseas Technical Cooperation Agency. General situation of the water supply for the Saigon Metropolitan Area was roughly studied by the first survey team. Groundwater was surveyed by the second team in the northern area of the city as one of the future water sources for the Saigon Metropolitan Area. The purposes of the last survey were to ascertain the availability of the groundwater in the survey area and to make implementation plans for a water supply system with the groundwater for the Saigon Metropolitan Area.

The survey reports on the previous two occasions were already completed and submitted, and the present report covers the work performed by the third team on the foregoing subject. In addition, this report includes the final evaluation of the findings of all these three surveys and the recommendation for the water supply by the groundwater for the Saigon Metropolitan Area. Brief report on preliminary survey on the Saigon River is also included.

It has been our privilege to have been retained for the work throughout the series of the surveys, and the support by Overseas Technical Cooperation Agency and the other governmental agencies of Japan is greatly appreciated. Our sincere acknowledgement is also due to the wholehearted cooperation extended to the survey team by officials of the Ministry of Public Works and the Saigon Metropolitan Water Office.

Respectfully yours,

Hiromu Tanabe

Hiromu Tanabe, Dr. Eng.,
Chief, the third survey team,
President,
Nihon Suido Consultants Co., Ltd.

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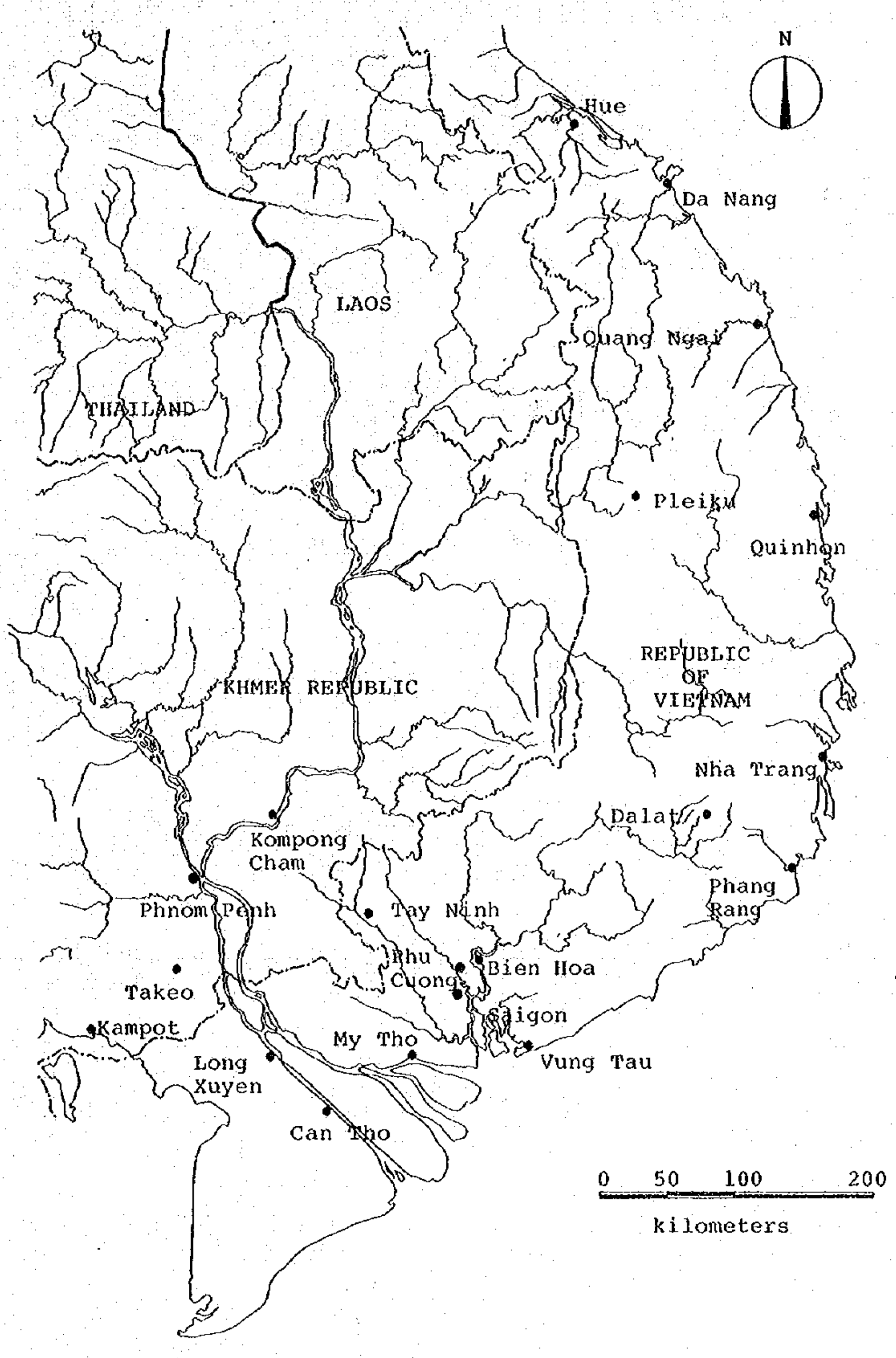


Fig. 1.0.1 REPUBLIC OF VIETNAM

INTRODUCTION

1. General

In January 1971, the preliminary survey mission on water supply system in the Cities of Saigon, Danang & Longxuyen was sent by the Overseas Technical Cooperation Agency (hereinafter called OTCA), the Government of Japan, in response to the request of the Government of the Republic of Vietnam. The recommendation for immediate action and the long-range program to be followed for the improvement and expansion of the existing facilities were worked out for these three cities and were submitted to the Government of the Republic of Vietnam for their consideration. (Ref: Preliminary Report on Water Supply Projects at Saigon, Danang and Longxuyen, issued by OTCA in March 1971.)

For the City of Saigon, it was pointed out in the Report referred above, that 1) development of Dong Nai River water supply system, 2) development of groundwater in the north of the Saigon City, and 3) intake from the upper stream of the Saigon River are the possible sources for additional supply of water for improvement and expansion program to be planned and implemented. The two Government came to the agreement that the development of the above-stated groundwater program should be taken up first of all, and therefore the technical mission on electric prospecting on Hoc Mon area was sent Saigon in March 1972. (Ref: Water Supply Project in Saigon, November 1972)

Another technical mission was sent to Saigon again by OTCA in December, 1972, whose main assignment was to perform test boring, pumping test and others, on the basis of electric prospecting previously undertaken, for the purpose of confirming existence of aquifers dependable for production of sizable quantity of water for a water supply extension project for Saigon Metropolitan Area. It was agreed, however, that the Mission should also undertake preliminary survey on Saigon River and to develop implementation plan using the available groundwater supply.

For the work of the mission, therefore, supplementary electrical prospecting of groundwater was executed, test borings were performed and test wells were drilled, through the aid of a local contractor and, also for Saigon River, topographical survey, flow measurement, installation of water level recorder and water quality analysis were carried out. The procedures of these surveys and the findings of the studies are presented in Part I of the present Report.

Implementation plan using the available groundwater supply is presented in Part II with different alternatives, which, we hope, would be helpful in determining the immediate action to be taken by the Government. The report by Metcalf & Eddy, Inc., "Saigon Water Distribution Project, January 1972", which was provided to us by SMWO, was used as a basis for the planning.

Very efficient assistance and cooperation extended by the Government of the Republic of Vietnam including SMWO are greatly appreciated.

2. Survey Team

<u>Member</u>

Chief:	Hiromu Tanabe	Doctor of Engineering, Consulting Engineer Registered, President, Nihon Suido Consultants Co., Ltd.
Adviser:	Sachiho Naito	Doctor of Engineering, Adviser to Japan Water Works Association
Adviser:	Toshio Murashita	Doctor of Science, Geological Survey Institute, Agency of Industrial Science and Technology
Member:	Hiroshi Shinohe	Consulting Engineer Registered, Deputy Chief, Water Works Department, Nihon Suido Consultants Co., Ltd.
Member:	Katsuyoshi Tomono	Consulting Engineer Registered, Water Works Department, Nihon Suido Consultants Co., Ltd.
Member:	Yuji Fujii	Hydrogeologist, - do -
Member:	Masato Fujinami	Hydrogeologist, - do -
Member:	Takeshi Sakai	Assistant Engineer, - do -
Member:	Yoshiki Ohmura	Assistant Engineer, - do -
Member:	Keiji Iimura	Coordinator, Development Survey Division, OTCA
Member:	Hironao Suzuki	Coordinator, - do -

3. Officials Contacted in Vietnam

People who extended great assistance and support to the team during the survey and to whom our sincere acknowledgement is given are as follows:

(1) Ministry of Public Works

Minister of Public Works	Mr. Duong Kich Nhuong
Director of Cabinet	Mr. Bui Huu Tuan
General Secretary	Mr. Bui Nhu Tiep
Director of National Water Supply Agency	Mr. Vo Dinh Hanh
Assistant Director of National Water Supply Agency	Mr. Tran Phuoc Tho
Chief of Urban Water Supply Department	Mr. Nguyen Van Sang

(2) Saigon Metropolitan Water Office

Director	Mr. Nyugen Huu Tuan
Technical Assistant Director	Mr. Nyugen Kim Chi
Administration Assistant Director	Mr. Tran Minh Su
Chief of Engineering and Planning Division	Mr. Tran Van Thach
Chief of Saigon Sector	Mr. Mai Thanh Toan
Chief of Cholon Sector	Mr. Vo Quang Ly
Chief of Gia Dinh Sector	Mr. Tran Huu Lai
Chief of Thu Duc Plant	Mr. Dong Si Khiem
Assistant Engineer	Mr. Nguyen Xuan Phong
Assistant Engineer	Mr. Tran Van Hoanh

(3) Embassy of Japan

Ambassador	Mr. Yasuhiko Nara
Counselor	Mr. Susumu Matsubara
First Secretary	Mr. Yasutaka Nishimura
First Secretary	Mr. Toru Iwanami
Chief of Saigon Office, OTCA	Mr. Akira Kasai
Resident Officer, OTCA	Mr. Akihiko Hashimoto

4. Conclusions and Recommendations

Groundwater survey in Hoc Mon area

i. Aquifers sufficient to provide additional supply was ascertained by groundwater electrical prospecting, boring and test pumping,

ii. Of the five aquifers confirmed in the survey, the lower 3rd and 4th ones are promising to the present water supply project with respect to the results of the borings and the test pumping and

iii. Some 200,000 cmd (cubic meters per day) of groundwater intake will quite safely be available from the area of approximately 150 sqkm. Minimum of treatment will be required for iron removal, pH control and chlorination.

Saigon River survey

i. Topographical survey, installation of water level recorder, flow measurement and water quality analysis were undertaken. The record thus gathered indicates strong possibility of using the water in the upper stream of the river for a water supply project and

ii. Continued survey on the items which were undertaken by the survey team is required as the period spent was limited so as to further ascertain the possibility of development of the river.

Implementation program for the groundwater resources

i. Drill 70 wells of which respective capacity is 3,000 cmd in the Hoc Mon area and collect the groundwater thus available into the relay pumping stations from which the water is piped to the treatment plant,

ii. Install chemical feeders for lime and chlorine, contact basin, filters and treated water reservoirs in the treatment plant. The output of the plant will be 200,000 cmd as some five percent of raw water (210,000 cmd) is consumed in the processes of treatment at the plant,

iii. Install treated water pumps in the treatment plant and lay treated water main to the south into the Saigon city,

iv. Connect the treated water main with the existing distribution trunk mains at the Cholon sector,

v. Prepare several branches in the new housing areas, along the treated water main, for connection to the distribution mains which will be laid in the coming years,

vi. Two alternative plans are developed on the basis of different financial requirements with hope that it will be found convenient in planning immediate implementation or attaining better economy of the project. They are:

	Foreign	Local	Total
	(millions of US dollars)		
Alternative 1			
1st stage (50,000 cmd)	4.2	2.1	6.3
2nd stage (150,000 cmd)	12.2	6.1	18.3
Total	16.4	8.2	24.6
Alternative 2			
1st stage (100,000 cmd)	9.6	5.2	14.8
2nd stage (100,000 cmd)	5.6	2.4	8.0
Total	15.2	7.6	22.8

The raw water and treated water mains are two-way respectively in the Alternative 1 so that the 1st stage water can be supplied immediately after its completion, whereas those in the Alternative 2 are single requiring the ultimate size of mains from the 1st stage.

The cost for water distribution project is not included in the above estimate since it will be undertaken separately from the present project and

vii. The detail design of the project shall be started immediately after the effectuation of the loan agreement so that the construction works are initiated as early as possible. The design works seem to take some one year for completion. However, the stage 1 construction can be started midway of the design period. The desirable time schedule for the project will be as follows:

Until March 1974	Effectuation of loan agreement.
April 1974	Start of design works.
January 1975	Initiation of Stage 1 construction.
March 1975	Completion of design works.
December 1975	Completion of Stage 1 construction.
January 1976	Initiation of Stage 2 construction.
June 1977	Completion of Stage 2 construction.

ABBREVIATIONS

A	Amperes
cm	centimeters
cm/sec	centimeters per second
cmd	cubic meters per day
cmd/m	cubic meters per day per meter
cum	cubic meters
cum/min	cubic meters per minute
cum/min/sqm	cubic meters per minute per square meter
ha	hectares
kg/hr	kilograms per hour
kg/sqcm	kilograms per square centimeter
km	kilometers
kVA	kilovolt-amperes
kW	kilowatts
l	liters
m	meters
m/d	meters per day
10^{-6} ℧ /cm	micro-mho per centimeter
mg	milligrams
ml	milliliters
mV	millivolts
Ω-m	ohm meters
ppha	persons per hectare
sqkm	square kilometers
sqm	square meters
rpm	revolutions per minute
V	volts

PART I SURVEY

I-1 GROUNDWATER

I-1 GROUNDWATER SURVEY

The purpose of the survey is to study the general hydrogeology of the Hoc Mon area by means of electrical prospecting and to further examine quantitative and qualitative properties of water bearing formations by the methods of a test pumping and test borings.

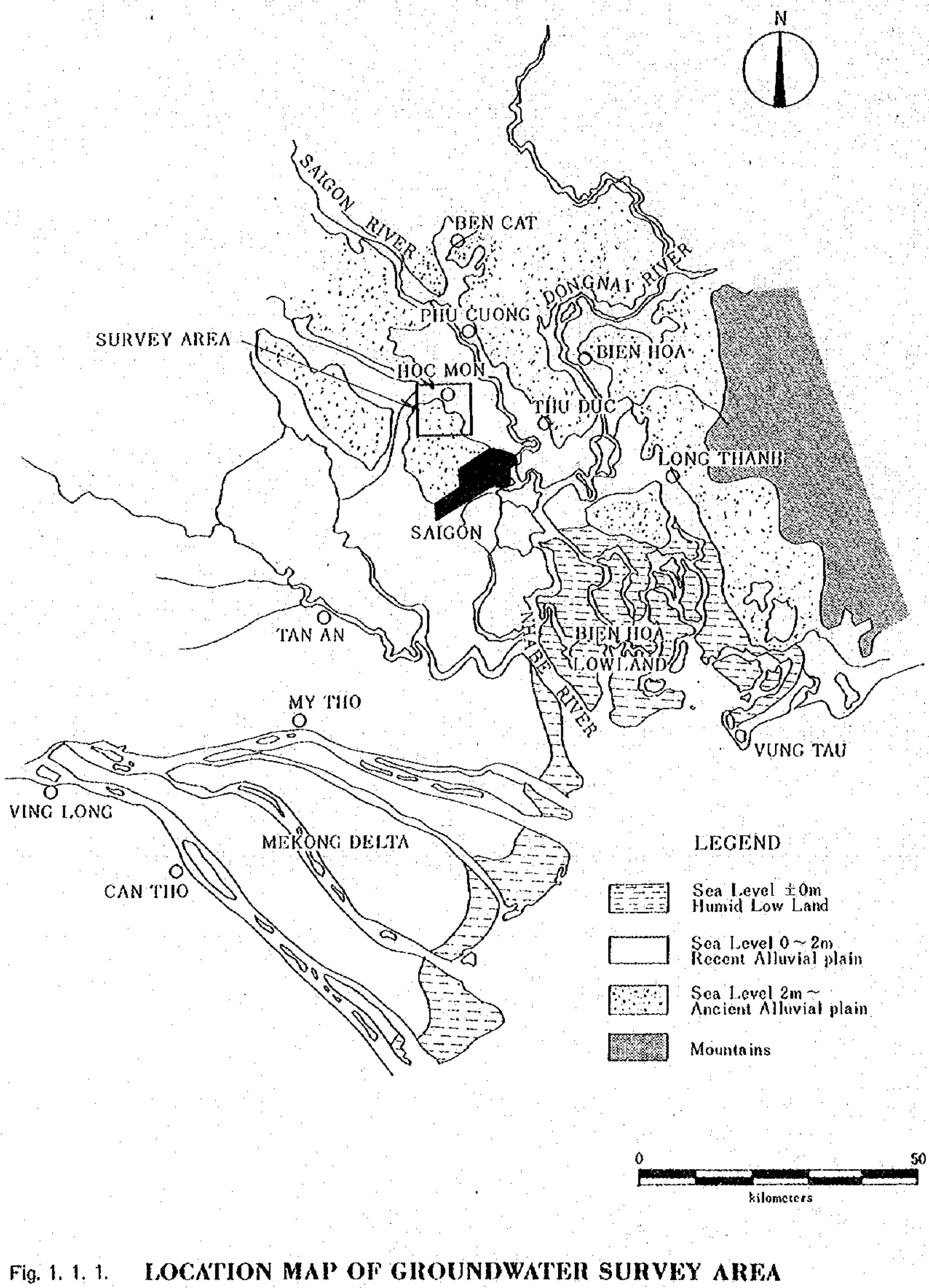


Fig. 1. 1. 1. **LOCATION MAP OF GROUNDWATER SURVEY AREA**

I-1-1 GENERAL

Survey Area

There is a plain of old alluvium extending from the city of Saigon through the town of Hoc Mon. The survey area is mainly within this plain. The area is situated at the northeast end of the Mekong delta and its altitude is 4 to 9 m above the mean sea level. The surrounding area is a recent alluvial plain, of which altitude is mostly not higher than 2 m above the mean sea level. Generally, the ancient alluvium contains laterite and mainly consists of gravel while the recent one lacks laterite and clay and silt are dominant in its composition. The soil in this area indicates strong acidity as its chemical property. Accordingly, water in the swamp surrounding the northwestern part of the plain shows a very low pH value of 4 or so.

Survey Items and Method of Survey

a. Groundwater electrical prospecting

1-Number of measuring points;	50 (See Fig. 1.1.2 and 3)
2-Measuring depth;	150 m
3-Measuring method;	Wenner's method
4-Apparatus;	Model ES-G1 (Alternating current system, maximum load --- 600V - 3A)
5-Electric power source;	dry battery BM-1, 45V x 10 pieces (Cascade connection)

6-The survey area was divided into 6 blocks, in which 50 survey points in total were laid out. (See Fig. 1.1.2) The earth condition was generally good for electrical earthing. Results of measurement are shown by ρ-a curves in Fig. 1.1.4 a to 1.1.4 d.

7-ρ-a curves were analyzed in principle by the method of standard curve analysis, but in some cases, by means of empirical judgement. The results of ρ-a curve analysis are shown in fig. 1.1.5 in the form of resistivity log.

b. Test pumping

1-A pumping test well; depth 95 m, screen diameter 200 mm.

2-An observation well; casing length 107.5 m, diameter 100 mm, drilling depth 201 m.

3-Pumping test, step drawdown test and aquifer test (time drawdown test and time recovery test) were executed for 152 hours in total.

c. Test borings

1-Drilling depth and diameter; depth 120 m, diameter 100 mm.

2-Number of drillings; 3

d. Water quality analysis

26 samples were taken of which 12 samples were analyzed by the Pasteur Institute in Saigon and 14 by the Survey Team.

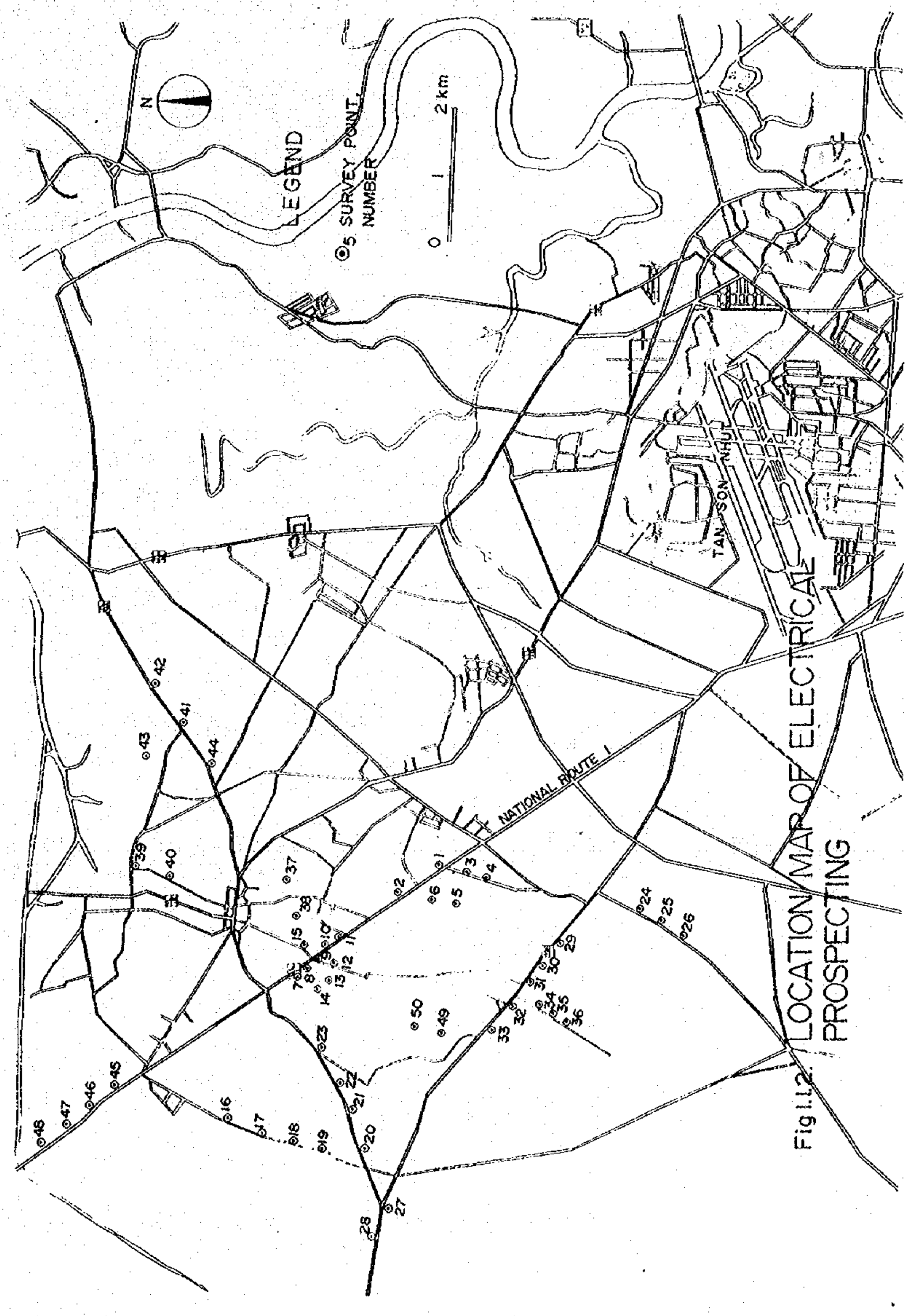


Fig I.1.2 LOCATION MAP OF ELECTRICAL PROSPECTING

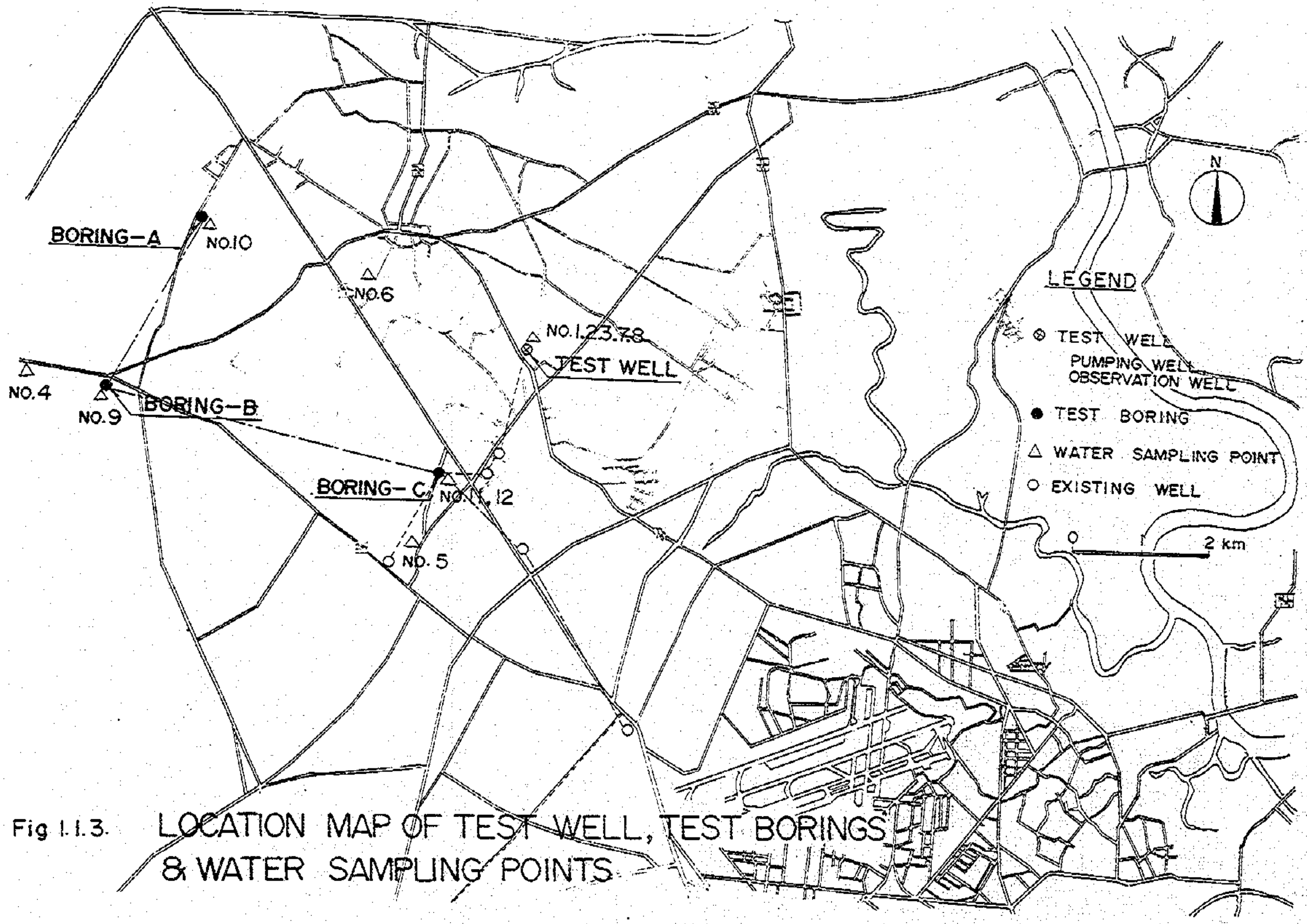
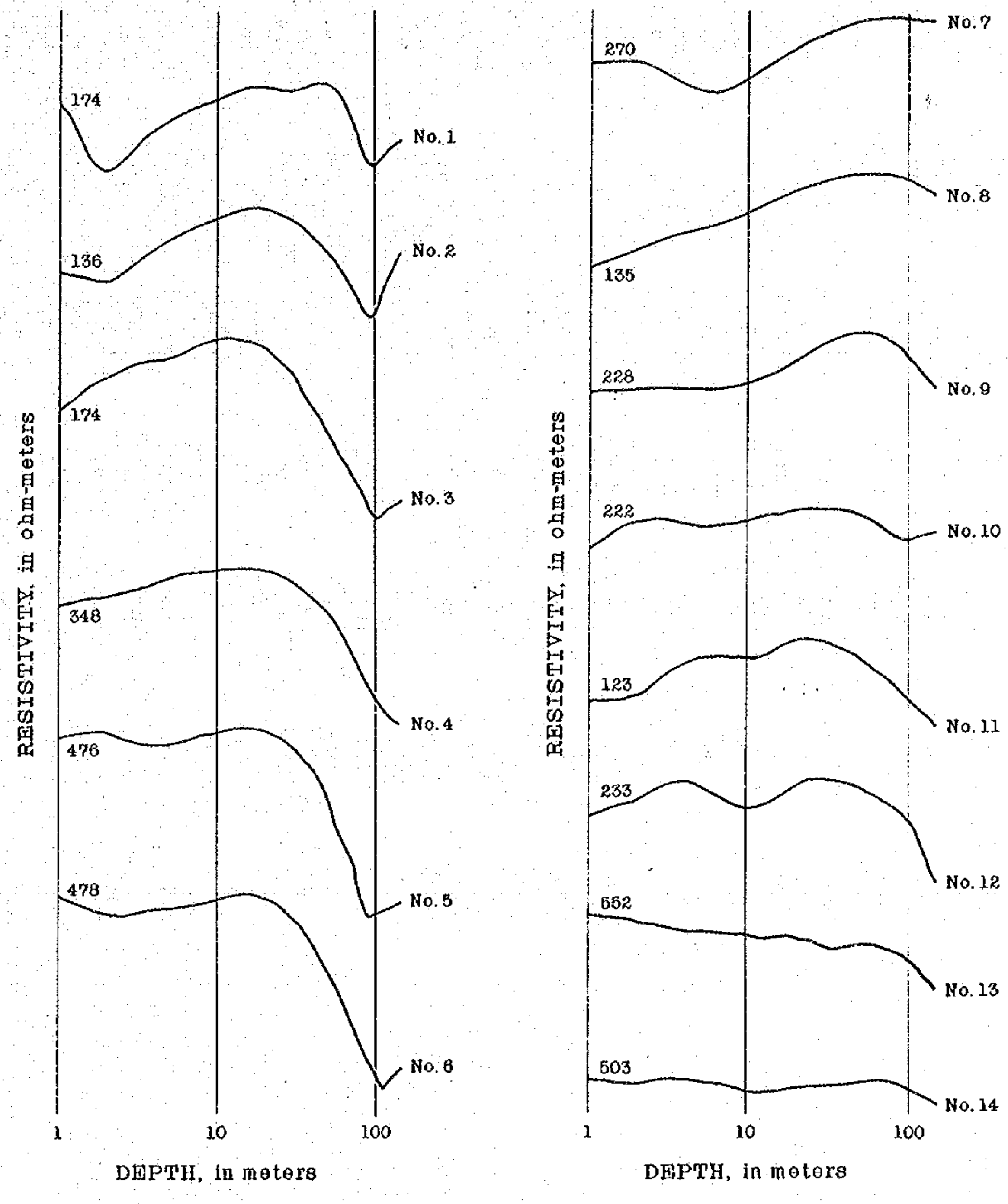
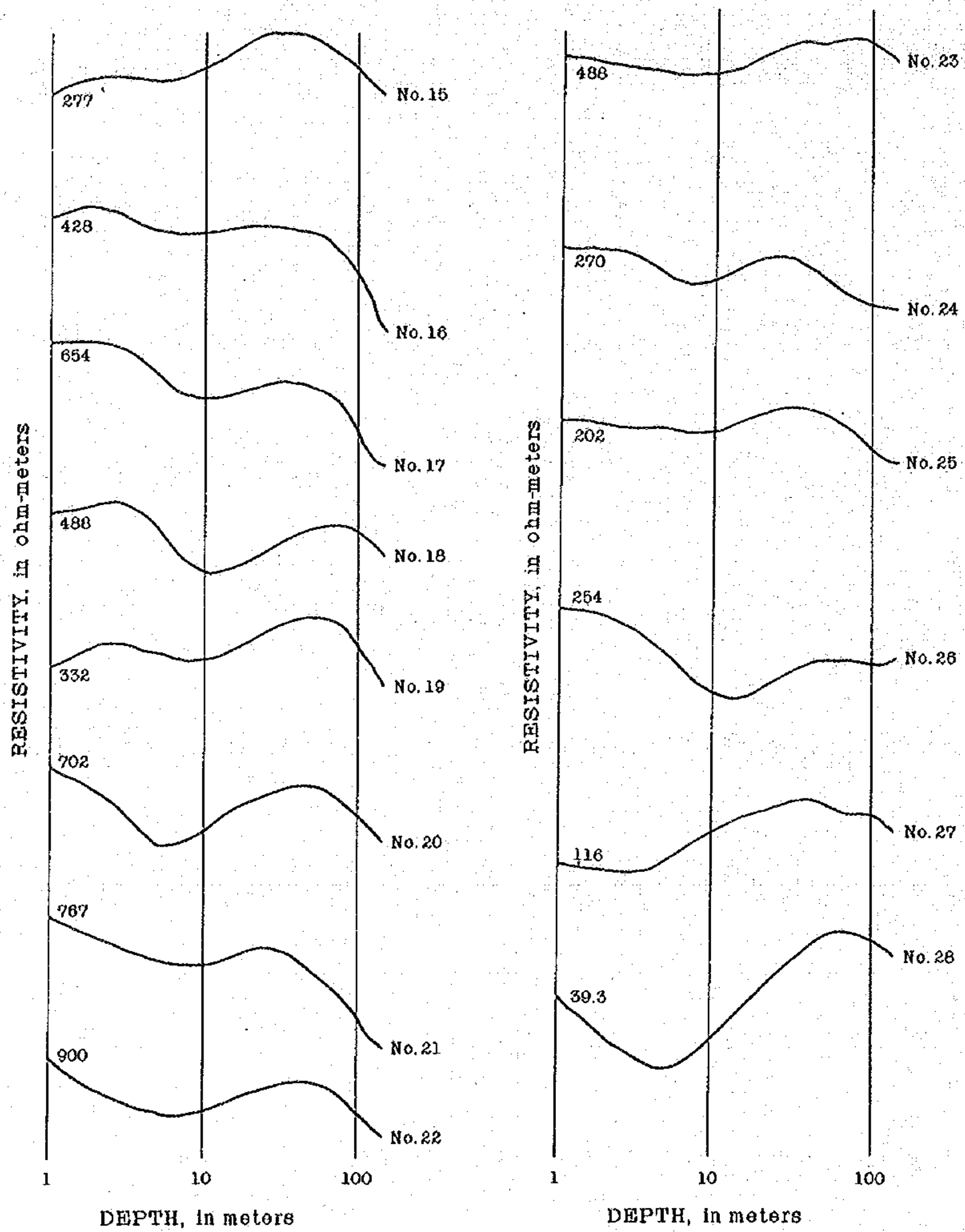


Fig 1.1.3. LOCATION MAP OF TEST WELL, TEST BORINGS & WATER SAMPLING POINTS



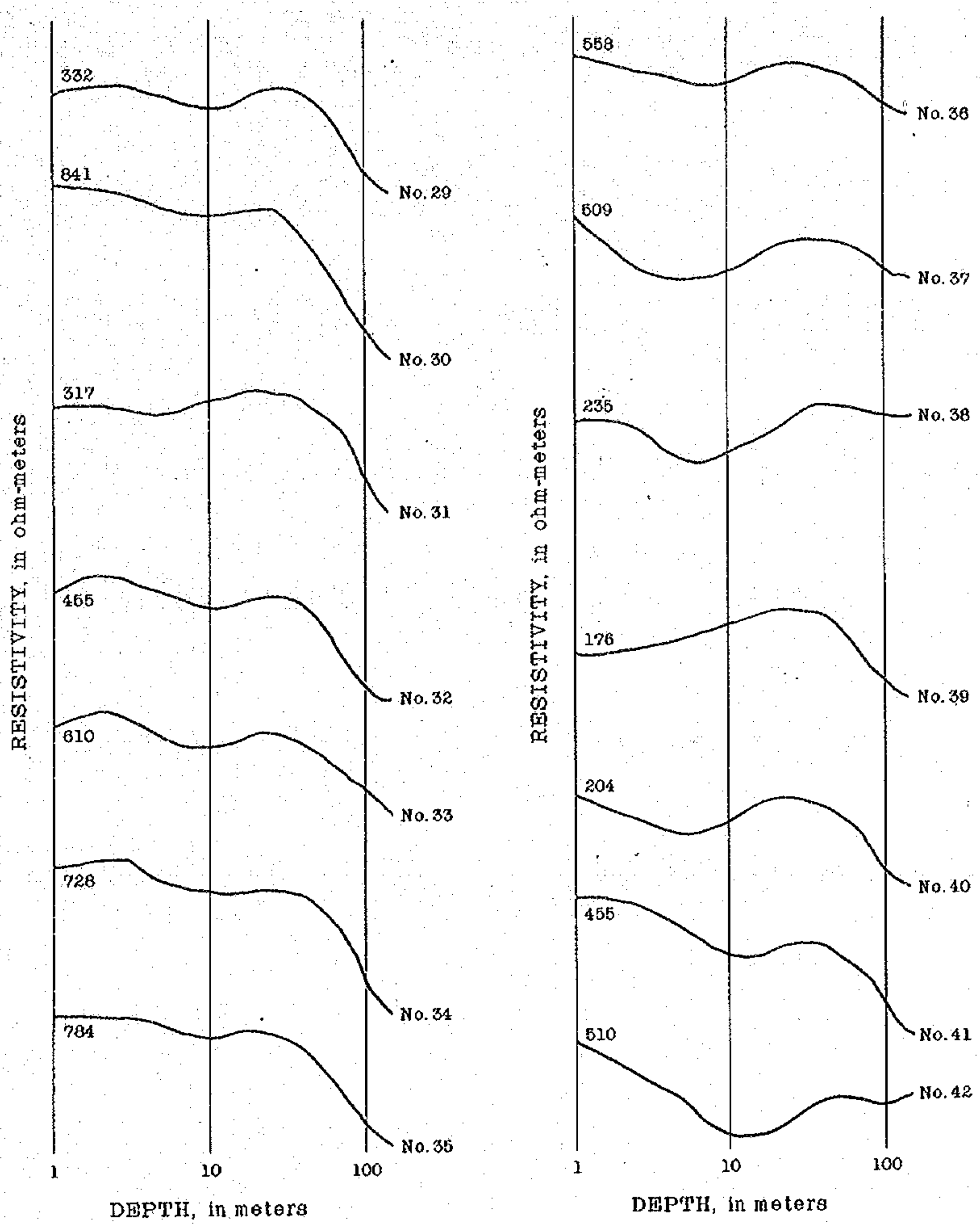
RESISTIVITY, in ohm-meters
174
No.1
136
No.2
174
No.3
348
No.4
476
No.5
478
No.6
1
10
100
DEPTH, in meters
RESISTIVITY, in ohm-meters
270
No.7
135
No.8
228
No.9
222
No.10
123
No.11
233
No.12
552
No.13
503
No.14
1
10
100
DEPTH, in meters

Fig. 1. 1. 4. a



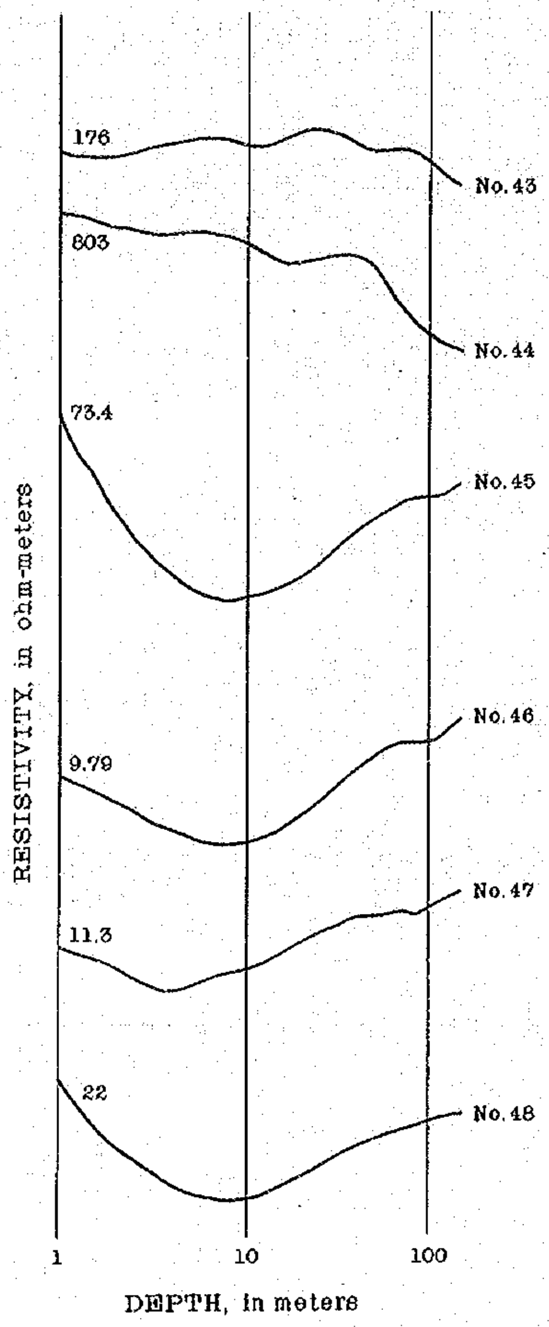
RESISTIVITY, in ohm-meters
277
No.15
428
No.16
654
No.17
488
No.18
332
No.19
702
No.20
767
No.21
900
No.22
1
10
100
DEPTH, in meters
RESISTIVITY, in ohm-meters
488
No.23
270
No.24
202
No.25
254
No.26
116
No.27
39.3
No.28
1
10
100
DEPTH, in meters

Fig. 1. 1. 4. b

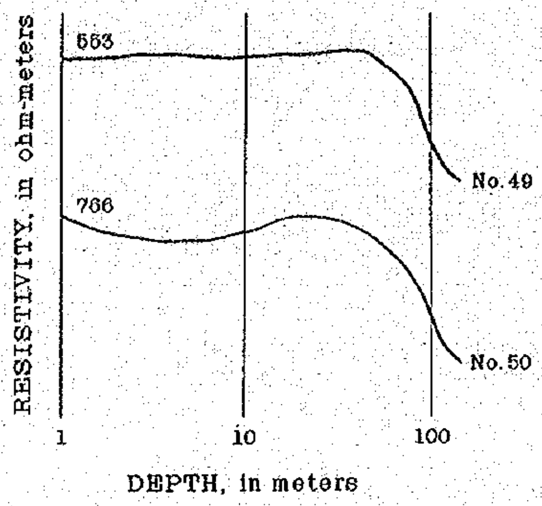


RESISTIVITY, in ohm-meters
332
No. 29
841
No. 30
317
No. 31
465
No. 32
610
No. 33
728
No. 34
784
No. 35
1
10
100
DEPTH, in meters
RESISTIVITY, in ohm-meters
558
No. 36
509
No. 37
235
No. 38
176
No. 39
204
No. 40
455
No. 41
510
No. 42
1
10
100
DEPTH, in meters

Fig. 1. 1. 4. c



176
No.43
803
No.44
73.4
No.45
No.46
9.79
No.47
11.3
22
No.48
RESISTIVITY, in ohm-meters
1
10
100
DEPTH, in meters



553
No.49
766
No.50
RESISTIVITY, in ohm-meters
1
10
100
DEPTH, in meters

Fig. 1. 1. 4. d

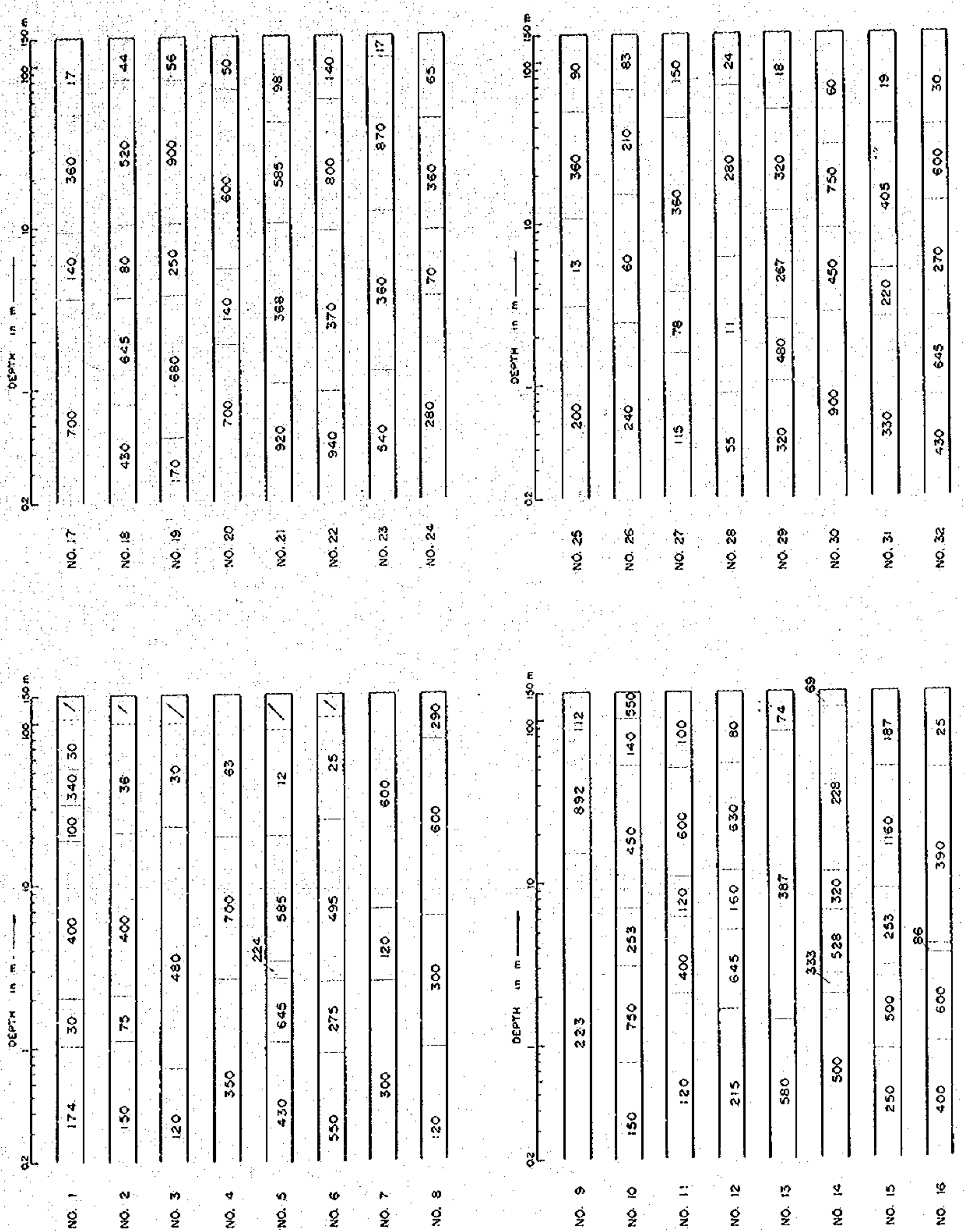


Fig. 1. 1. 6. a RESISTIVITY, in ohm-meters

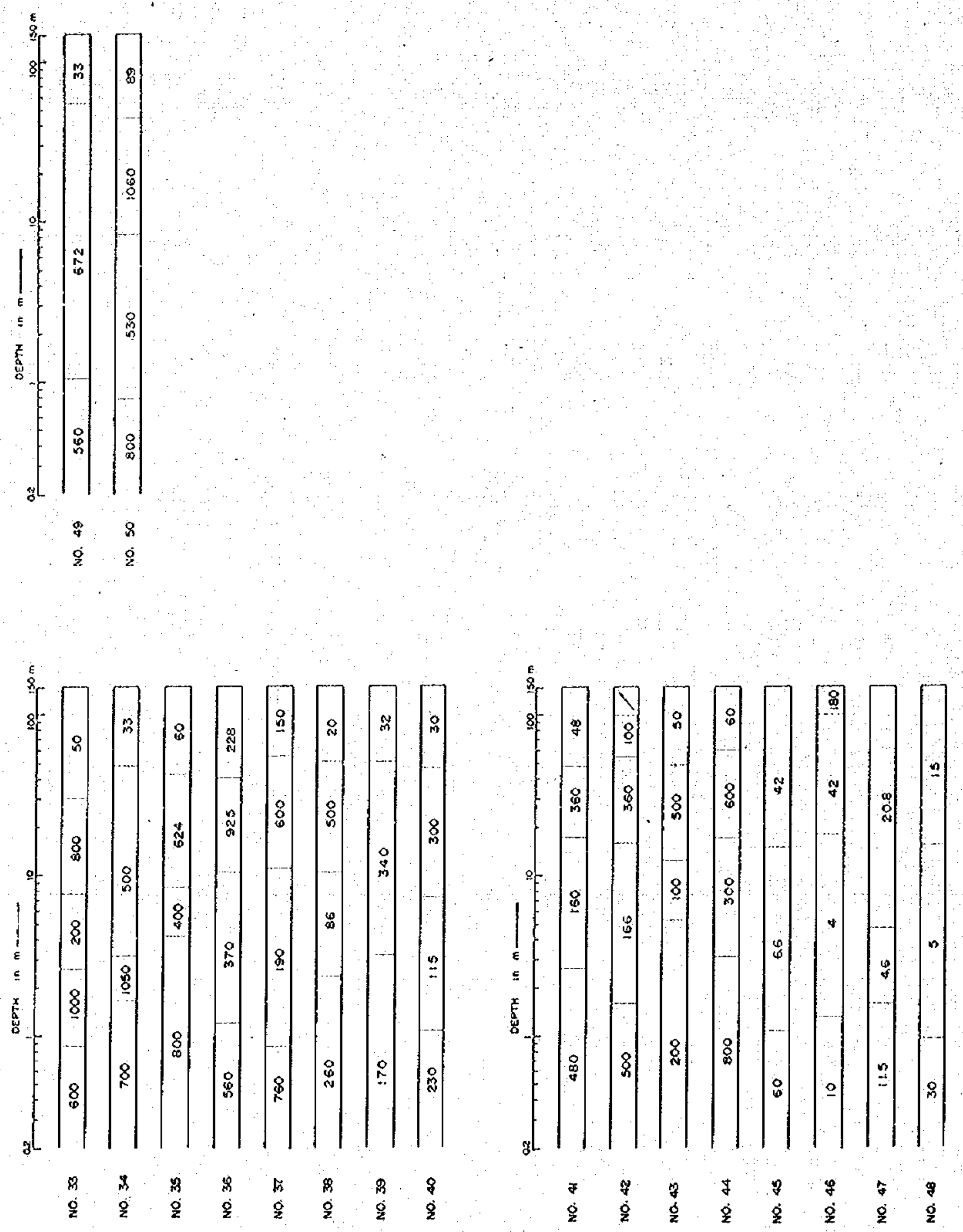


Fig. 1.1.5.b RESISTIVITY, in ohm-meters

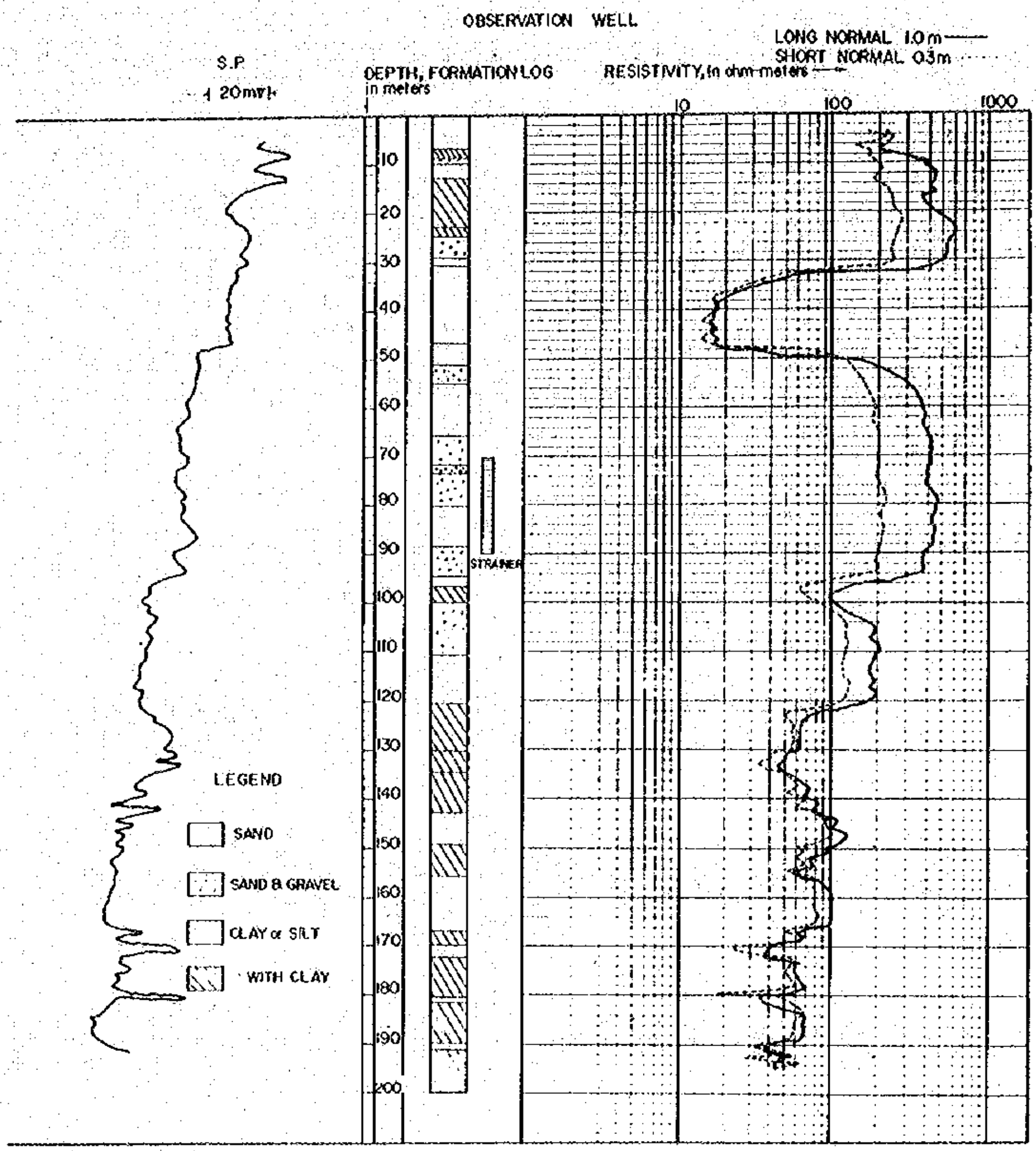


Fig I.1.6 FORMATION LOG, ELECTRIC LOGGING & SELF POTENTIAL CURVE

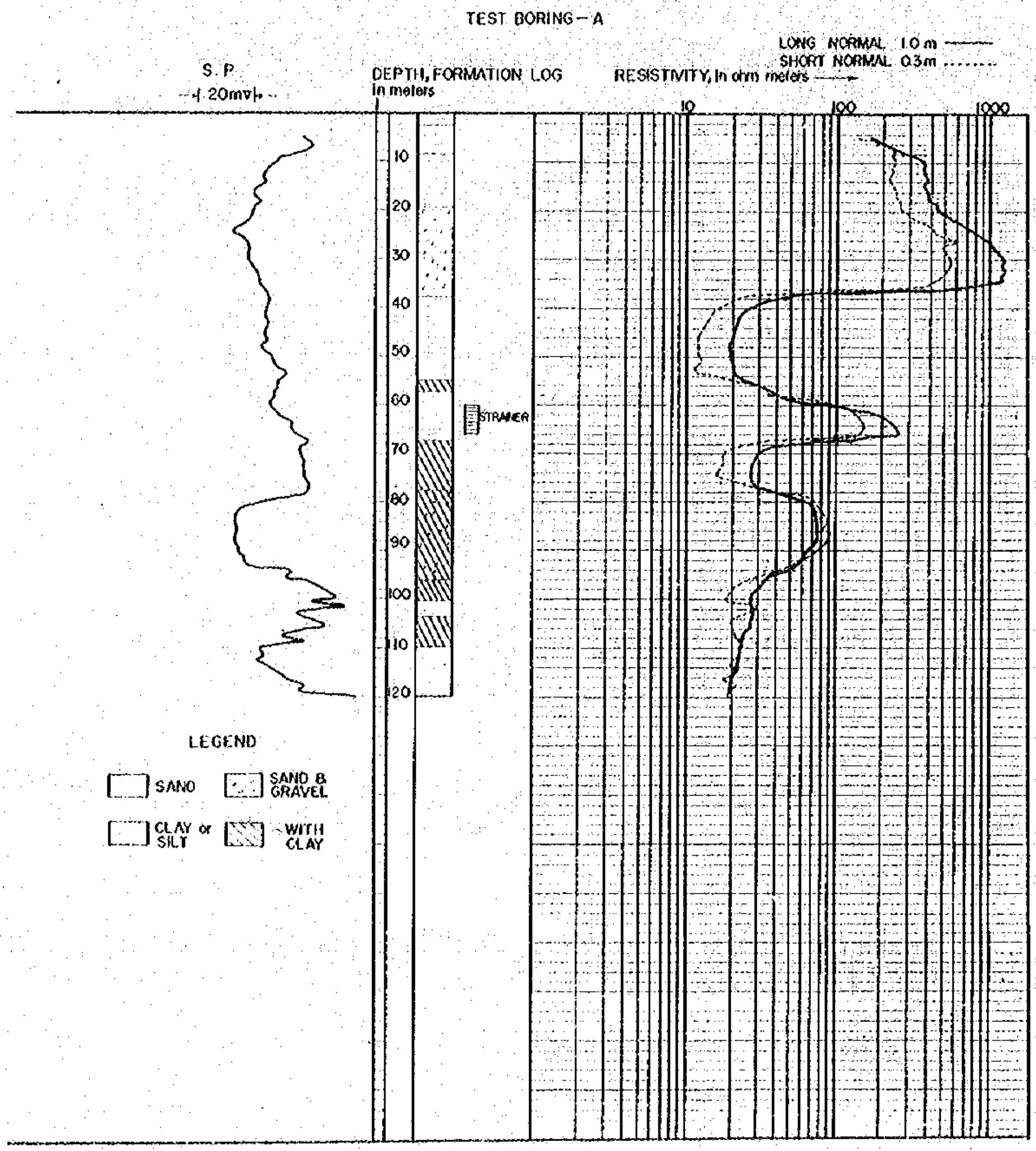


Fig I.1.7 FORMATION LOG, ELECTRIC LOGGING & SELF POTENTIAL CURVE

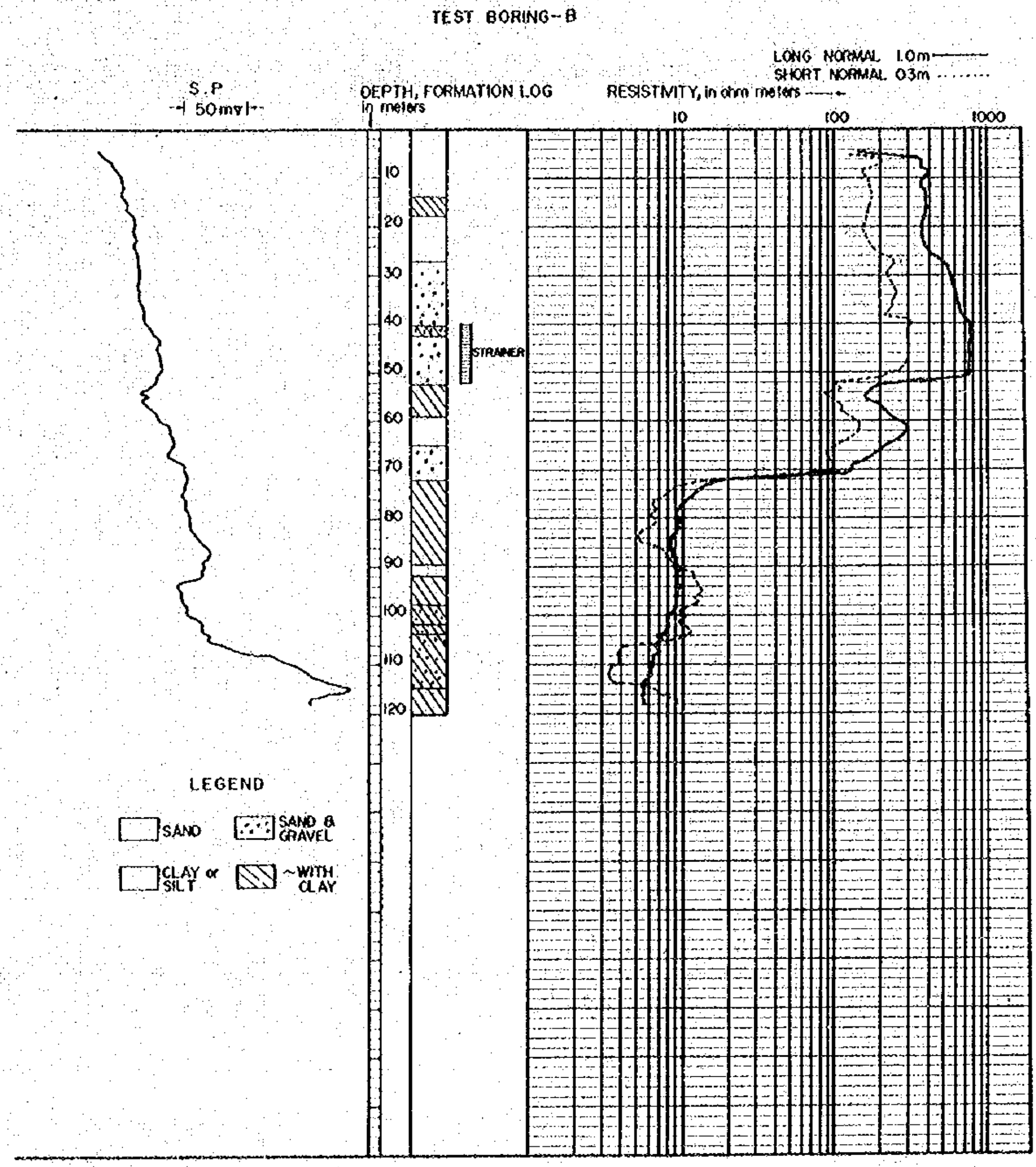


Fig II.8 FORMATION LOG, ELECTRIC LOGGING & SELF POTENTIAL CURVE

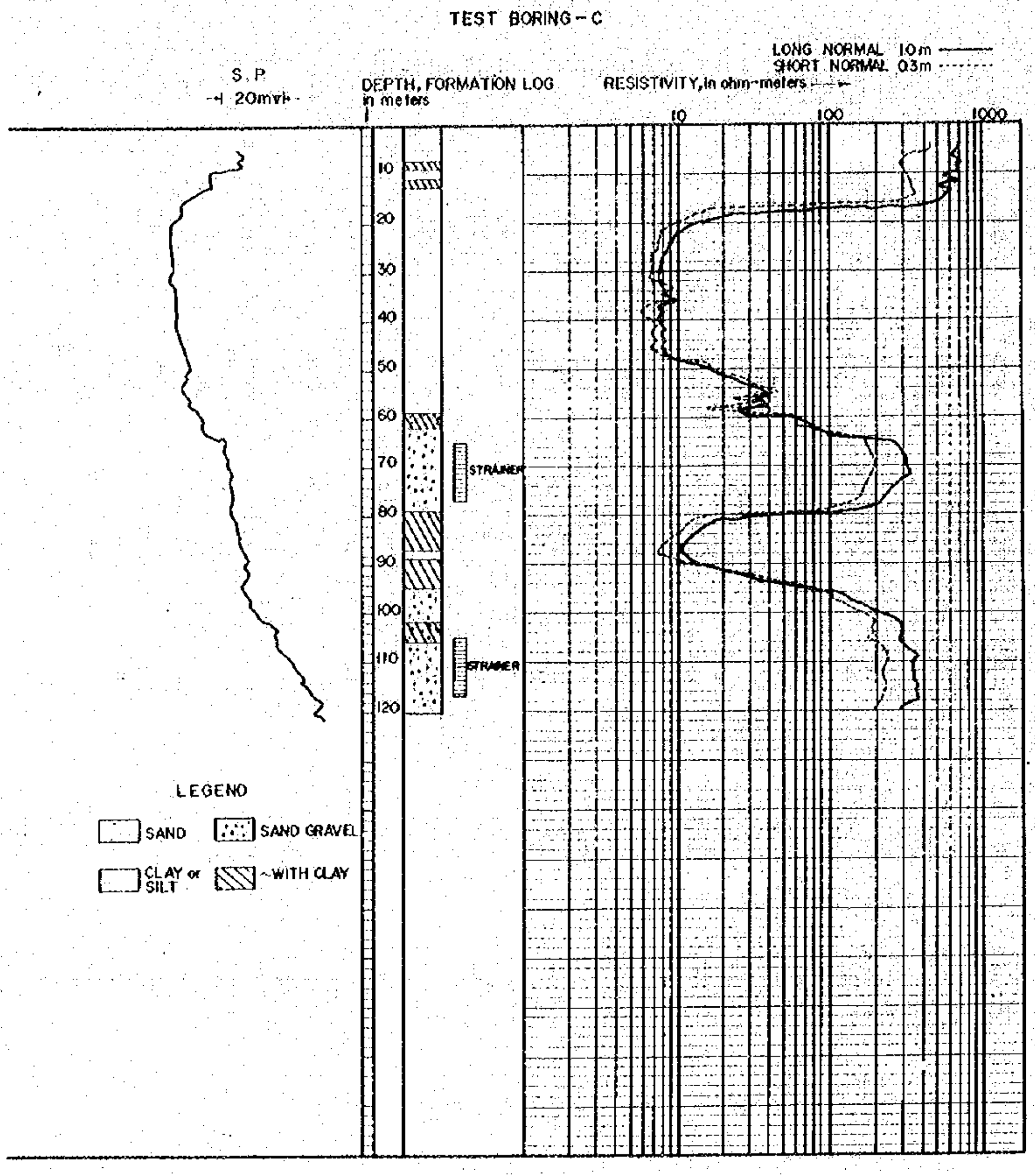


Fig I.I.9 FORMATION LOG, ELECTRIC LOGGING & SELF POTENTIAL CURVE

I-1-2 GEOLOGICAL FORMATIONS

Geological formations are classified as follows:

<u>Formation I</u>: Consists of fine sand and clay, and also laterite in some places. Position (Vertical distribution): Ground surface to 20 m.

<u>Formation II</u>: Composed of sand and coarse gravel; the same strata as the upper sand and/or gravel formation in the City of Saigon. This formation is missing at the boring point C. Position: 20 to 30 m.

<u>Formation III</u>: Clay strata developes well all over the area. The thickness at the boring point C comes to 40 m. Position: 30 to 50 m.

<u>Formation IV</u>: Sand strata with fine gravel, the best developed sand and gravel formation in the area. Especially, its thickness at the test wells is as big as 45 m. Position: 50 to 90 m.

<u>Formation V</u>: Clay strata which divides Formation IV from Formation VI. The thickness is 10 to 20 m. Position: 90 to 100 m.

<u>Formation VI</u>: Sand strata with fine gravel, which is 15 to 20 m thick. It is missing at boring point B. Position: 100 to 120 m.

<u>Formation VII</u>: Sand strata with clay, identified at the pumping test well. This formation is found below the depth of 120 m or so.

Based on the results of ρ-a curve analysis, it can be said that the sand and/or gravel formations with thickness of 30 m to 50 m and resistivity of 300 to 1,000 Ω-m continuously exist at the depth ranging from 10 m to 70 m in most of the survey area. However, at the prospecting points Nos. 45 to 48 where the formation can be classified into three strata, resistivity values are very low (under some 50Ω-m) and their ρ-a curves are different in shape from other group of curves. It is considered that muddy soil near the surface in a swamp area, where these points are situated, predominantly affects ρ-a curves, which means higher resistivity of the lower strata are hindered to reflect on the whole strata resistivity value.

At prospecting points No. 1 to 6 in the southeast of the survey area, there seemed to be a sand and gravel formation with resistivity of 400 to 700Ω-m at the depth of 1 m to 20 m, a clay formation with thickness of 40 m to 80 m and resistivity under 30Ω-m beneath those formations. It was confirmed by the test boring C that the latter was a thick clay formation with thickness of some 40 m. However, sand and gravel formations with high resistivity were found at depth of 60 m to 80 m and 100 m to 120 m under the clay formation. The reason why the property of these sand and gravel formations does not come out on the resistivity curves is that the upper thick clay formation strongly affected the resistivity measured as in case of Nos. 45 to 48. These curves of Nos. 1 to 6 are different in shape from the others.

In general, a sand and/or gravel formation which can be a good aquifer well extends toward the west side of the survey area in the upper depth (the depth of 0 to 60 m or so) and the east side of the area in the lower depth.

Geological profiles of the survey area are illustrated in the Figs. 1.1.10 and 11.

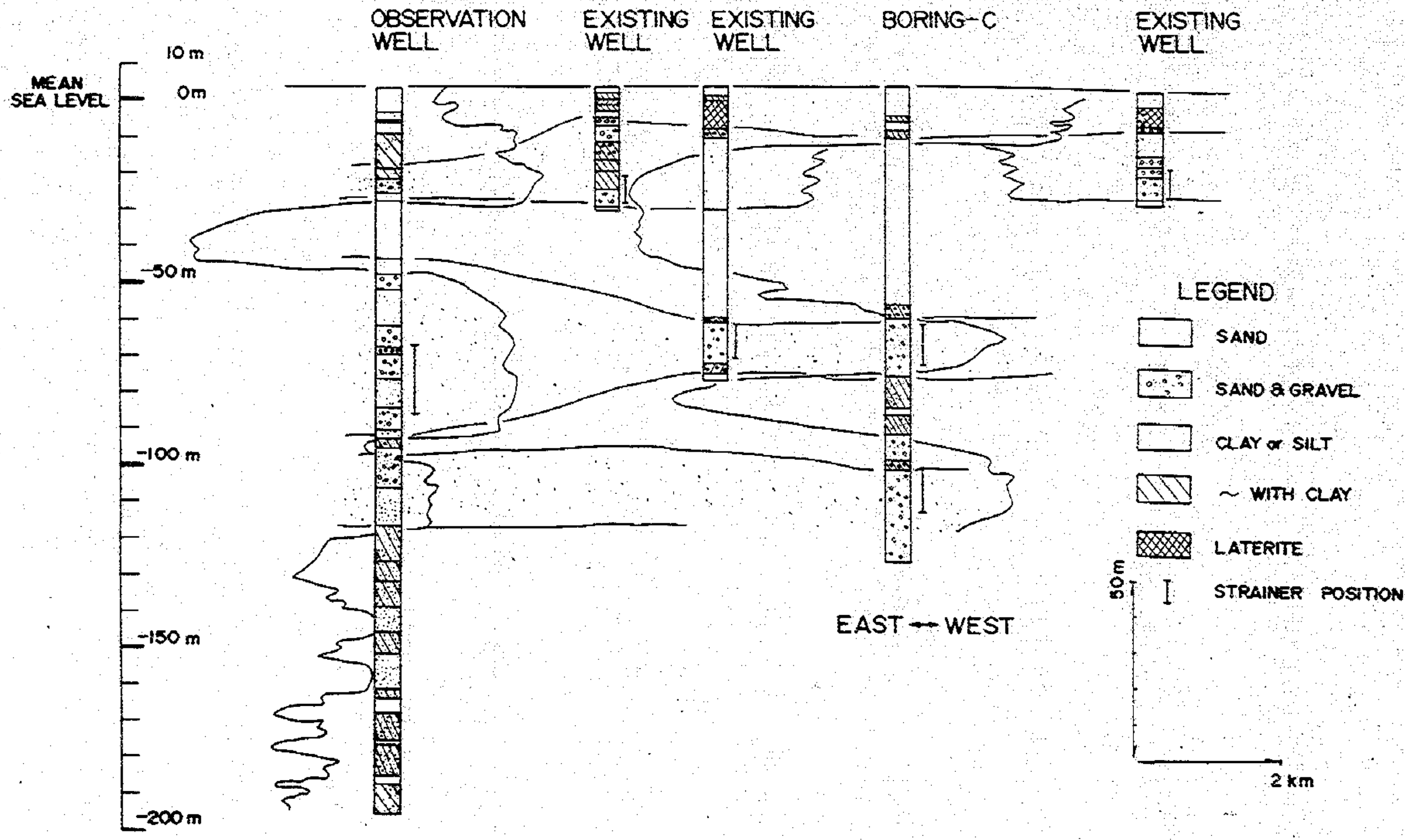


Fig 1.1.10. GEOLOGICAL CROSS SECTION — 1

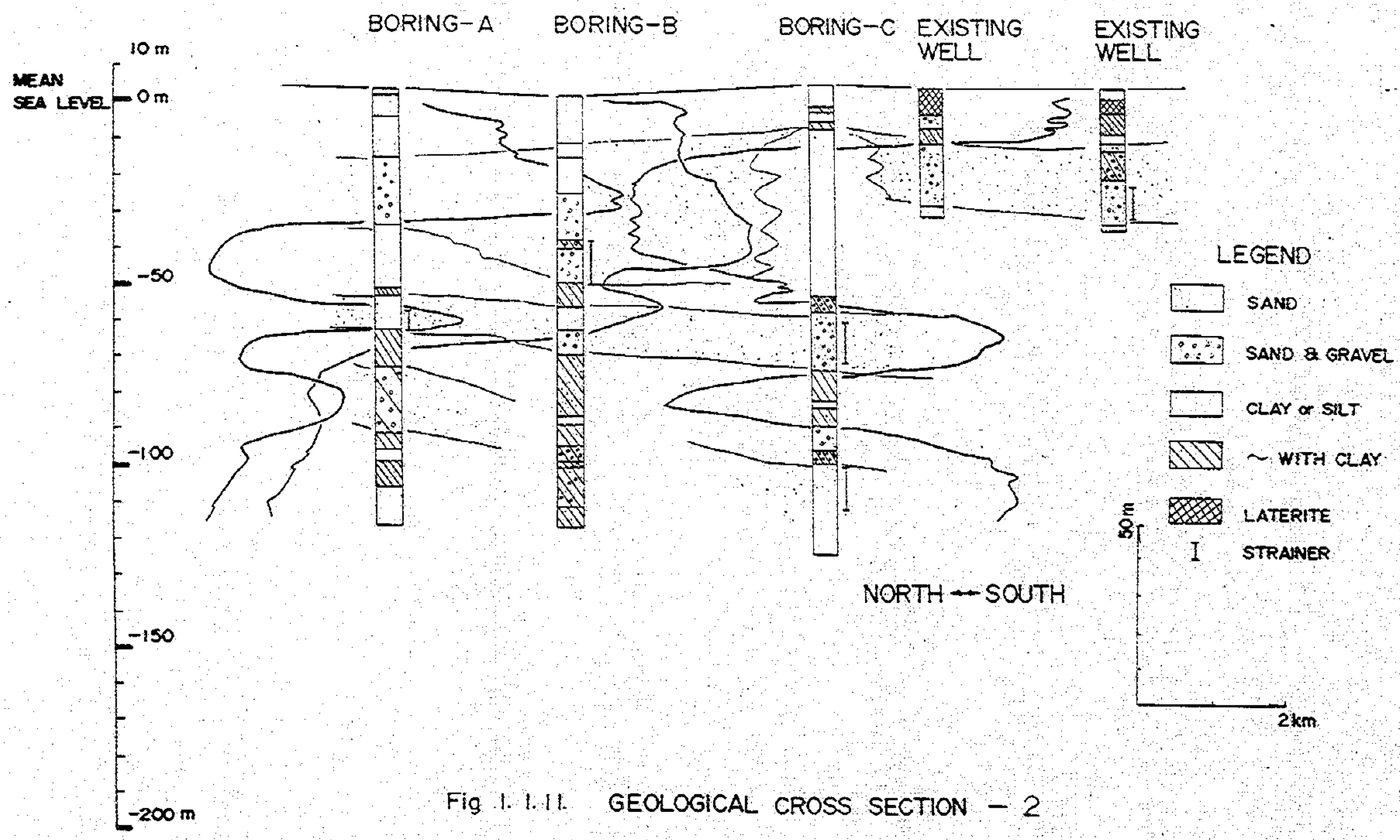


Fig. I. I. 11. GEOLOGICAL CROSS SECTION - 2

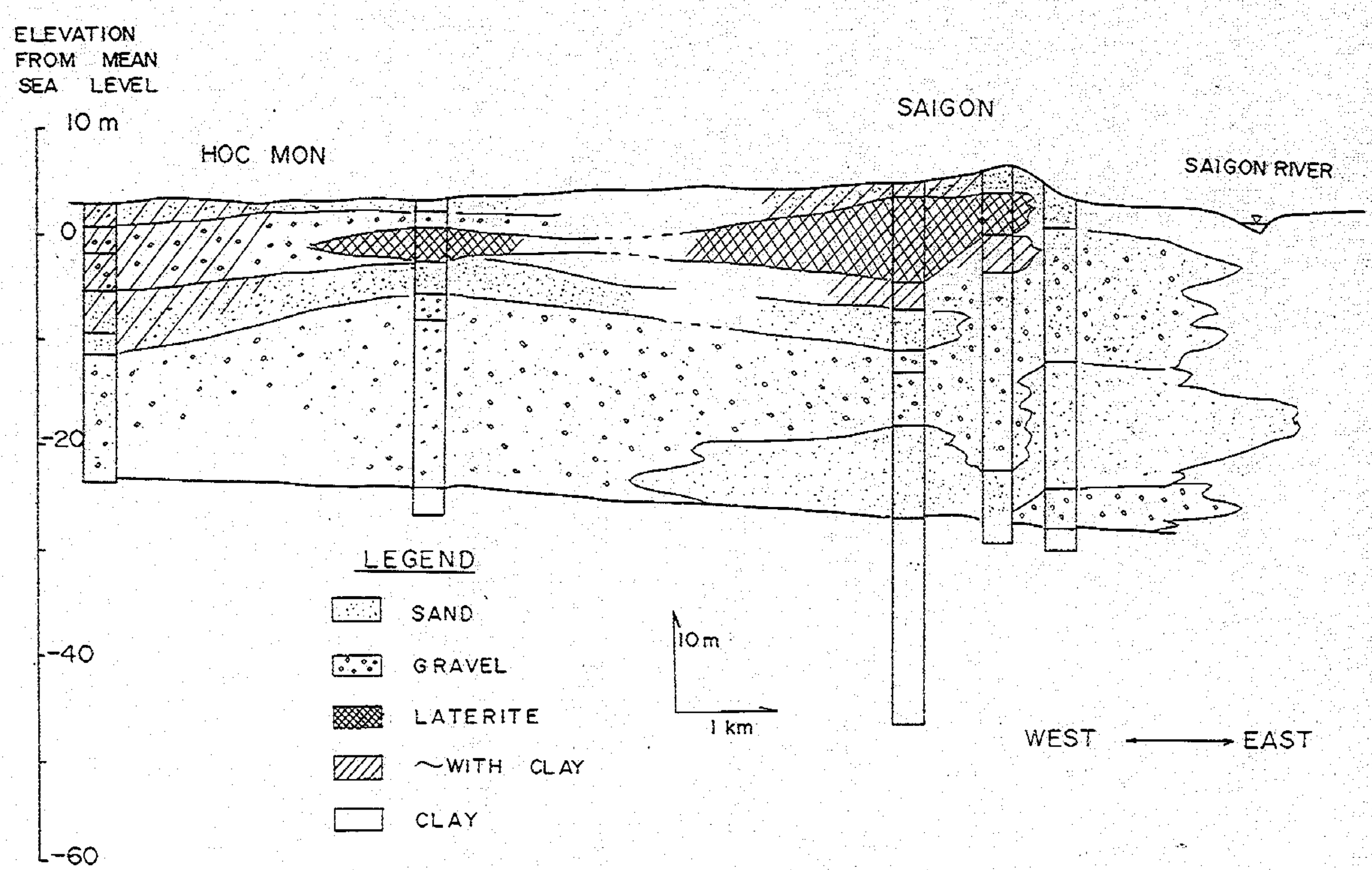


Fig 1.1.12 GEOLOGICAL CROSS SECTION -3

I-1-3 AQUIFERS

Classification and Distribution of Aquifers

Aquifers in the survey area are found and classified as follows: (See Table 1.1.1)

Aquifer I — This is a water-table aquifer which consists of fine sand and clay and is equivalent to the above-mentioned Formation I. There are many shallow wells excavated in the survey area and they are highly utilized for domestic and irrigational water supply. The thickness of this aquifer ranges from 20 m to 25 m.

Aquifer II — This is a confined aquifer mainly consisting of sand and gravel and corresponds to the Formation II. This is identical to the aquifer for the old groundwater supply system in the city of Saigon as shown in Fig. 1.1.12. This has thickness of 10 m to 25 m. The 1st and 2nd aquifers seem to be connected each other hydraulically since separation by impermeable layers between the above two formations is week and characteristics of their water quality is nearly alike as stated in the later section in detail. This formation is missing at the test boring point C.

Aquifer III — Equivalent to the Formation IV and a confined aquifer. This is a sand formation with fine gravel and its thickness is 10 m to 45 m. The thickness is 45 m at the test well point. As shown in Fig. 1.1.10 and 11, this aquifer prevails all over the area and it is distinctly separated from 2nd aquifer by a clay formation.

Aquifer IV — Equivalent to the Formation VI. This aquifer is also hydraulically confined. Its formation materials are the same as those of the 3rd aquifer. Its thickness, 15 m to 20 m, is relatively thin comparing to that of the 3rd. It is not seen at the boring point B. The clay formation

Table 1.1.1 Aquifers, Hoc Mon

	Thickness in meters	Depth in range*			
		Test Well	Boring A	Boring B	Boring C
1st Aquifer	15 - 25	0 - 20	0 - 20	0 - 25	0 - 15
2nd Aquifer	10 - 25	20 - 30	20 - 35	25 - 50 S (40 - 52)	---
3rd Aquifer	10 - 45	50 - 95 S (70 - 90)	55 - 65 S (60 - 66)	55 - 70	60 - 80 S (65 - 77)
4th Aquifer	15 - 20	105 - 120	75 - 95	---	108 - 122 S(105 - 117)
5th Aquifer	30	130 - 160	---	---	---

N.B. S: Elevation of strainer

*: Expression in meters below land-surface

with thickness of 5 m to 10 m separates this aquifer from the 3rd.

Aquifer V — Equivalent to the Formation VII. It is a lower aquifer confirmed only at the point of test well. It is suspected that this aquifer may contain some electrolites, say, salt, in accordance with electric logging data. Therefore, it is likely to have little possibility to be a good source of water supply.

Prospective aquifers

The third aquifer seems to be the best aquifer for development as for its big thickness and good configuration of strata media. There is some possibility for the forth aquifer to be developed but it is subordinate to the third aquifer because of its smaller thickness and transmissibility. Intake from the first and second aquifers is not recommended since it will affect the water intake from the shallow wells, which are used for living and irrigation by the inhabitants in this area.

The fifth aquifer is not prospective because of its poor hydraulic property and possible salinity contamination. Hence, the third aquifer was selected for pumping test and the pumping well strainer was set at the position of the aquifer.

Pumping Test and Hydraulic Constants

Pumping test was carried out after drilling a production well and an observation well with strainers at the 3rd aquifer. The distance between the two wells was 14 m (See Fig. 1.1.13).

Pumping test performed was as follows:

1-Time drawdown test; 48 hours, discharge rates 2,940 and 4,360 cmd for each test.
2-Time recovery test; 8 hours following each time drawdown test.
3-Step drawdown test; discharge rates 415 to 4,360 cmd, 10 steps, 4 hours for each step.

a. Aquifer test (Time drawdown test and time recovery test)

Non-equilibrium equation was adopted in calculation of hydraulic constants. Basic formula of non-equilibrium equation is as follows:

$$T = \frac{0.0796Q \cdot W(u)}{s}$$

$$S = \frac{4T \cdot t}{1440r^2 \cdot (1/u)}$$

$$s = \frac{Q}{4\pi T}\int_u^\infty \frac{e^{-u}}{u}du$$

$$u = \frac{r^2 s}{4T \cdot t}$$

$$T = kd$$

where, s: Drawdown of waterlevel, meters

Q: Discharge rate, cubic meter per day

r: Distance between pumping well and observation well, meters

t: Pumping time, minutes

T: Transmissibility coefficient, cubic meters per day per meter

S: Storage coefficient

k: Permeability coefficient, centimeters per second

d: Thickness of aquifer, meters

W(u): Wenzel's Well Function

Data acquired by the pumping test are substituted into the formula as follows:

$$T = \frac{0.0796 \times 2940 \times 10}{1.44} = 1625 \text{cmd/m}$$

$$S = \frac{4 \times 1625 \times 4.2}{1440 \times 14^2 \times 10^2} = 9.7 \times 10^{-4}$$

$$k = \frac{1625}{20 \times 86400} = 9.4 \times 10^{-2} \text{cm/sec}$$

b. Step drawdown test

Critical discharge rate of the pumping well is found as about 3,000 cmd from discharge-drawdown curve as illustrated in Fig. 1.1.15, where the drawdown was 3 m. It is understood from Fig. 1.1.16 that the value of the safe yield, 3,000 cmd is also reasonable because the well loss (difference of pumping water levels between outside and inside of casing pipes) increases remarkably at higher discharge rate than 3,000 cmd.

The theoletical radius of influence is estimated as about 600 m at the discharge rate of 2,730 cmd, 4 hours after start of pumping. (See Fig. 1.1.16)

Specific capacity of this pumping well is about 1,000 cmd/m.

Note: 1-Critical discharge: Pumping rate at which the turbulent flow occurs in the aquifer around the well strainer.

2-Specific capacity: The value of discharge rate divided by drawdown which is the yielding capacity of wells per unit drawdown.

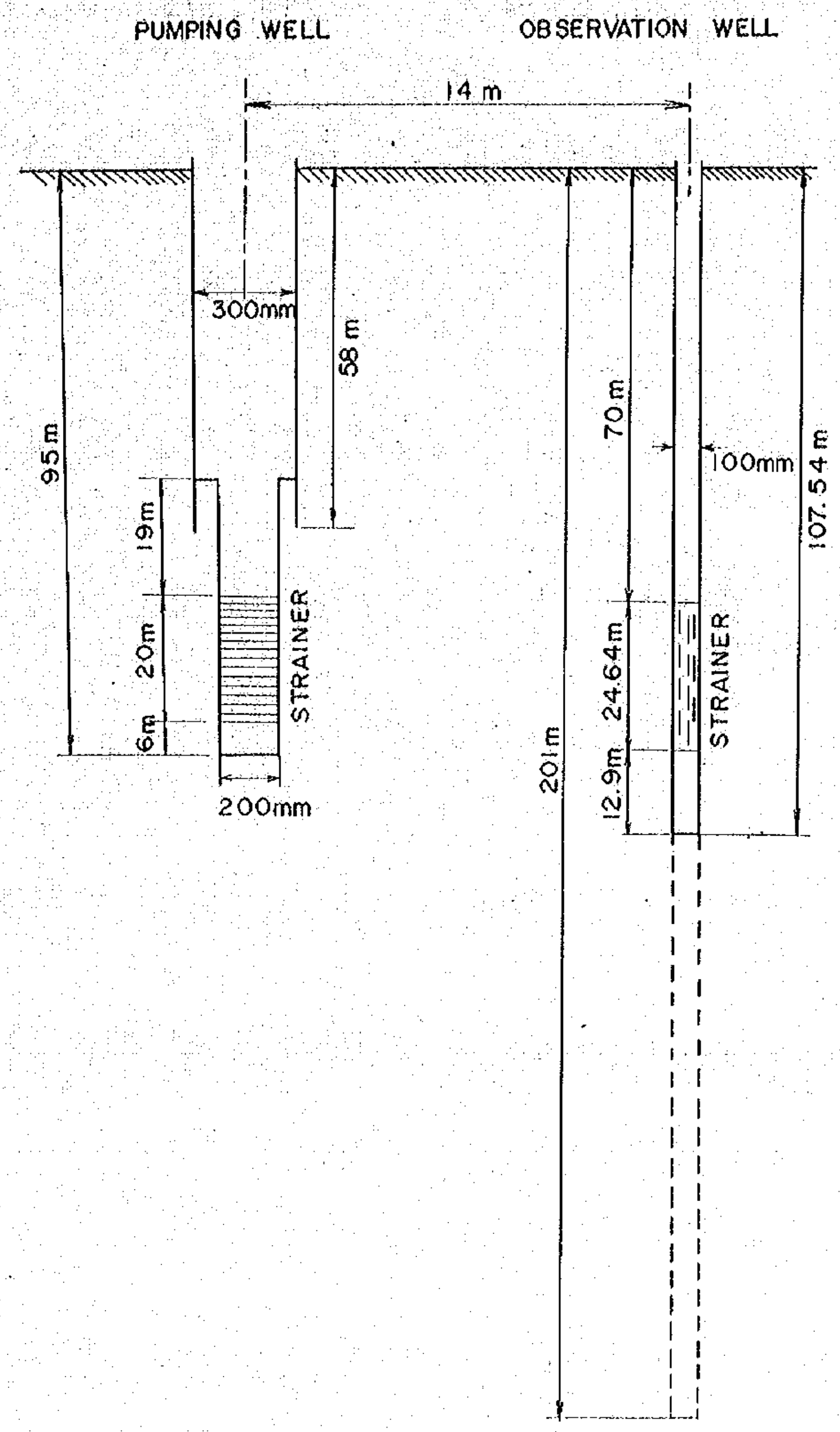


Fig. 1.1.13 TEST WELLS

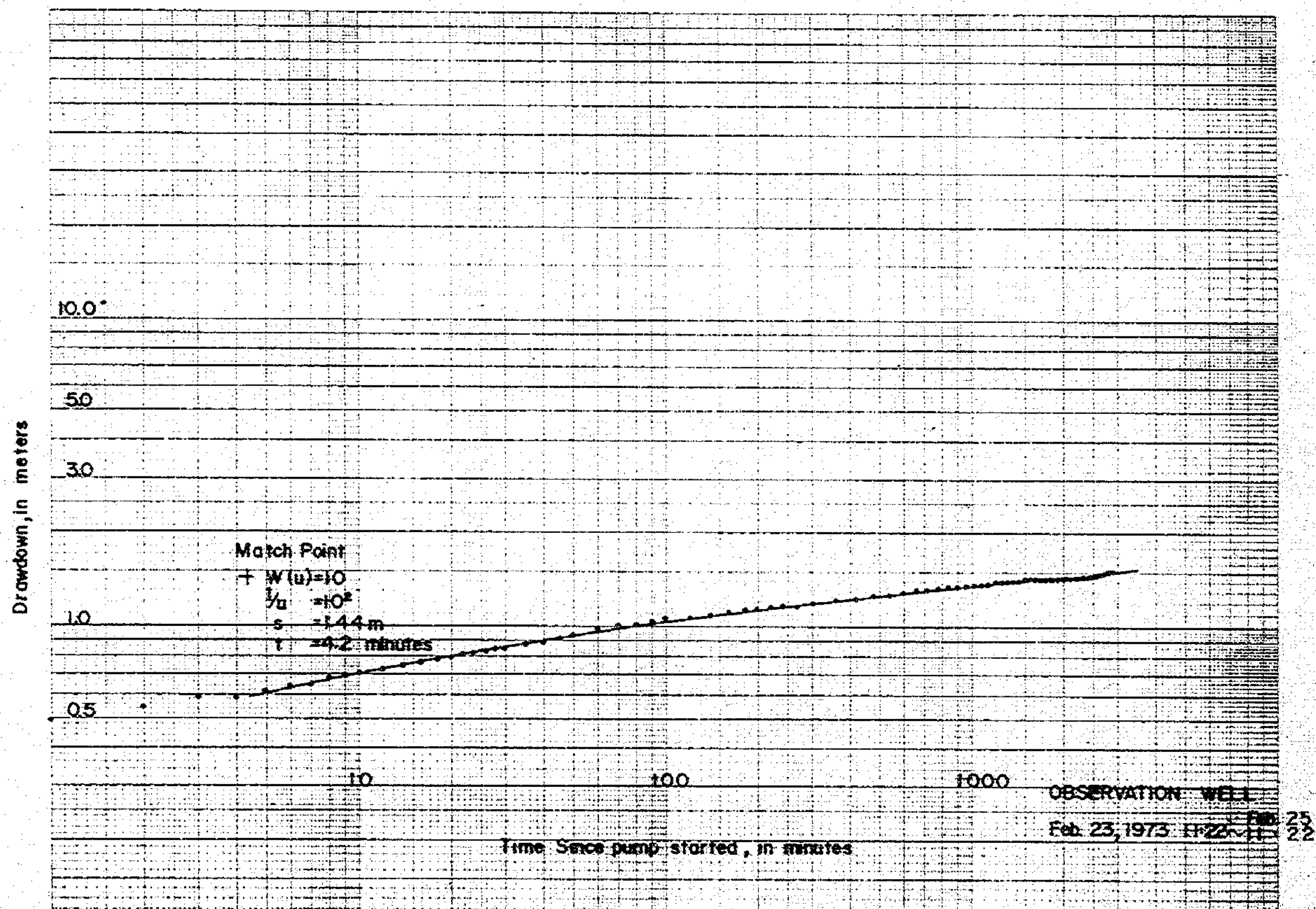


Fig 1.1.14 TIME—DRAWDOWN CURVE

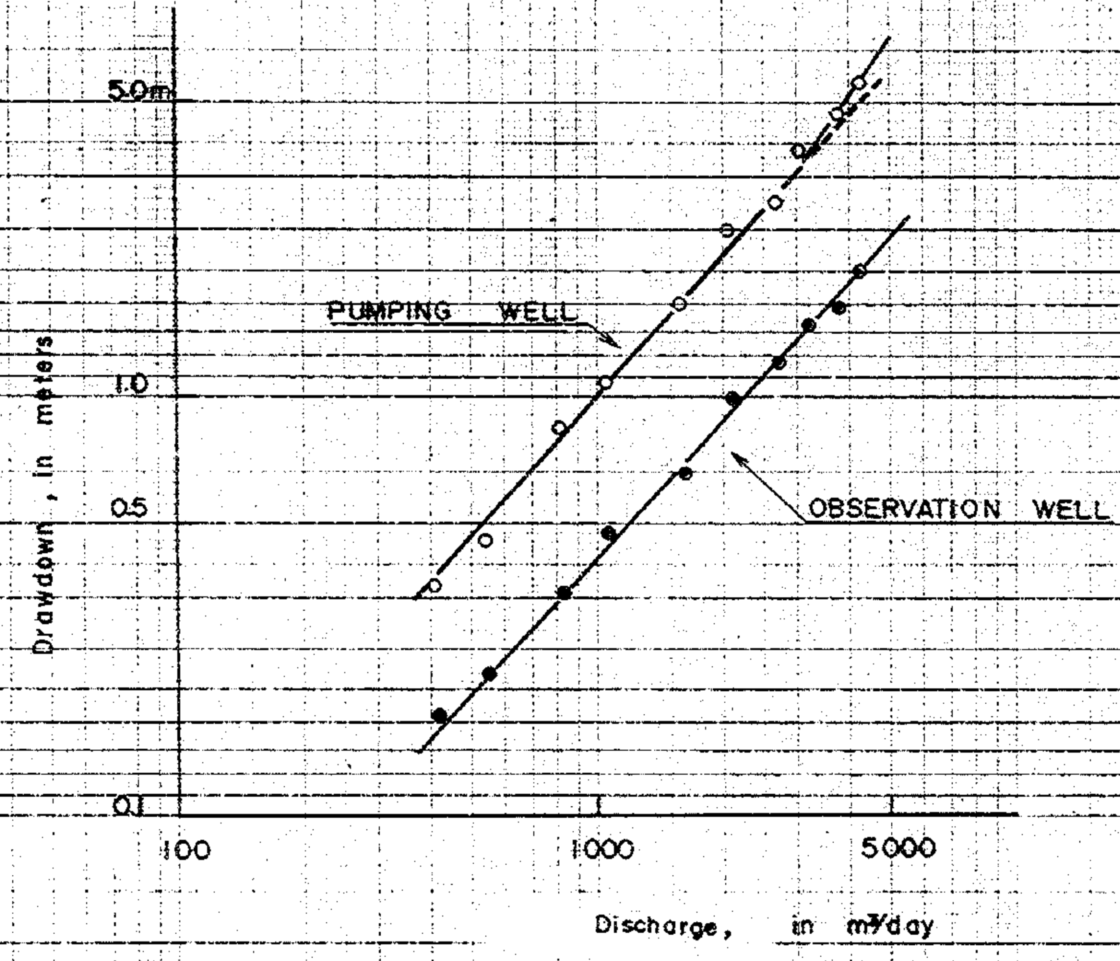
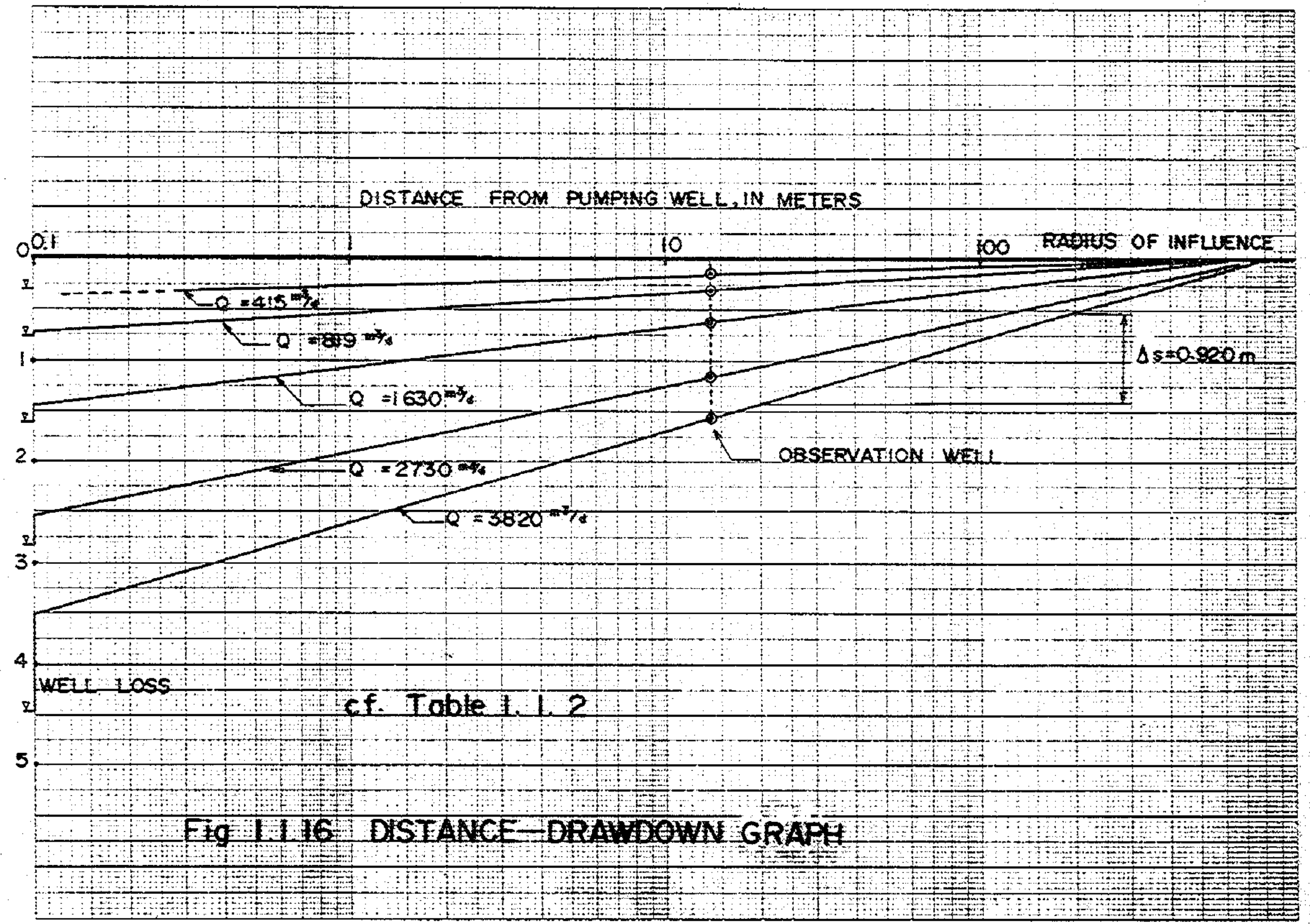


Fig 1.1.15 DISCHARGE — DRAWDOWN CURVE



cf. Table 1.1.2

Fig 1.1.16 DISTANCE—DRAWDOWN GRAPH

Table 1.1.2 Distance-Drawdown Test after Pumping for 240 minutes

Discharge, cmd		Drawdown, meters		Values of Δs, meters
		pumping well	observation well	
1st day	Q1 = 415	0.35	0.18	0.100
	Q2 = 546	0.45	0.22	
2nd day	Q3 = 819	0.82	0.34	0.197
	Q4 = 1090	1.07	0.48	
3rd day	Q5 = 1630	1.64	0.65	0.392
	Q6 = 2180	2.39	0.96	
4th day	Q7 = 2730	2.84	1.19	0.657
	Q8 = 3270	3.68	1.43	
5th day	Q9 = 3820	4.47	1.58	0.920
	Q10= 4360	5.36	1.95	

I-1-4 WATER QUALITY

Twelve samples from test wells (pumping well and observation well), test boring wells, existing wells and the swamp were analyzed at the Pasteur Institute, and fourteen samples by the Survey Team.

The results are shown in Table 1.1.4 to 6.

pH: Both surface water and groundwater indicate low pH values. Groundwater from the 3rd aquifer shows pH 5 to 6. Generally, water taken by air-lift pump has relatively high pH values. On the other hand, sample No. 4, water from the swamp indicates pH 3.4. Attention should be paid to the fact that RpH (pH value after aeration) of this swamp water remains nearly the same as before aeration. Sample water from the 2nd aquifer of test boring B near the sampling point No. 4 also shows comparatively low pH value in spite of air-lift pumping. It is considered that acidity of water from the 3rd aquifer is attributable to free carbon-dioxide and that of water from the surface or near the surface has its origin in sulfate.

Fe^{2+}: All samples contain iron, but the value are far lower than that of water from wells in the City of Saigon. Generally, its concentration is 0.3 to 0.5 ppm.

Cl^-: Relatively big content of Cl^- was found in sample No. 3, but it seems to be attributable to pollution by human activities. Such grade of Cl^- was not detected in the other samples.

SiO_3^{2-}: Generally, this can be found in high concentration of 30 to 60 ppm. It increases with the depth of an aquifer.

Total Hardness:

0.5 to 2.9 ppm as $CaCO_3$.
These values are very low as compared with those of groundwaters in Japan, U.S.A., Europe etc.

Conductivity:

Low conductivity as found by the test means that groundwater in this area has very little soluble matters.

Key-Diagram

Key-diagram (Fig. 1.1.17) shows that the 3rd aquifer belongs to Sodium Carbonate type. Such kind of water is generally found in relatively deep, confined aquifers. Although water of No. 4, swamp water, is classified as Non Sodium Carbonate type like as sea water, it should rather be called Sodium Sulfate type as it contains much more SO_4^{2-} than Cl^-. Another interesting finding in the key-diagram is that sample No. 9 (boring B) and sample No. 6 (water-table well, 8.4 m depth) belong to the same group. This means that the 1st aquifer and the 2nd aquifer are in the same group in terms of water quality. For this reason, the result of the water treatment test with samples from shallow wells shall also be valid to the case of the water from the 2nd aquifer.

Laboratory Test

Water was sampled on 29th March 1973 at the existing water-table well (shallow well) which is being used for municipal water supply system in the town of Hoc Mon (point No. 6 in Fig. 1.1.3). Means of tests mainly for pH adjustment and their results are as follows:

a. Aeration

100 ml of sample water was poured in to a 100 ml beaker and air was continuously sent in it through a rubber tube. pH values were directly read by a pH meter.

b. Chemical Dosage

Emulsified Calcium Hydroxide, $Ca(OH)_2$, was used. (Distilled water was added to 100 mg of $Ca(OH)_2$ to become 100 ml in total volume.) 1 ml of emulsion is equivalent to 1 mg of $Ca(OH)_2$. 100 ml of sample water was poured into a beaker and forestated liquid was dropped on to the sample while mixing by a stirrer. pH values were measured directly by a pH meter.

Table 1.1.3 Water Quality Standards for Drinking Water

Substance	WHO	JAPAN	USA	WHO for Europe
Coliform groups	less than MPN 10	never detected in 50 ml	positive samples: less than 10% in a month	less than 15 samples in 100 samples(100ml)
Number of bacteria	-	less than 100	-	-
Odour	-	unobjectionable	3°	-
Taste	-	"	unobjectionable	-
Colour	-	5°	120°	-
Turbidity	-	2°	5°	-
Total solids	-	500	500(1,000)	-
pH range	7.0-8.5 unit	5.8-8.6 unit	-	-
Total hardness	100-500 *	300 *	-	100-500
$KMnO_4$ consumed	10	10	-	-
Chloride	200	200	250	350
Sulphate	200(400)	-	250	250
Ammonia nitrogen	0.5	never detected at the sample	-	0.5
Nitrite nitrogen	-	"	-	-
Nitrate nitrogen	40(80) **	10	45 *	5.0
Iron	0.3(1.0)	0.3	0.3	0.1
Manganese	0.1(0.5)	0.3	0.05	0.1
Fluorine	1.0(1.5)	0.8	0.6-1.7	1.5
Lead	0.1	0.1	0.05	0.1
Arsenic	0.2	0.05	0.01(0.05)	0.2
Selenium	0.05	-	0.01	0.05
Chromium	0.05	0.05 **	0.05 **	0.05
Copper	1.0	1.0	1.0	0.05
Zinc	5.0(15.0)	1.0	5.0	5.0
Phenol	0.001(0.002)	0.005	0.001	0.001
Mercury	-	-	0.05	-
Barium	-	-	1.0	-
Cadmium	-	-	0.01	0.005
ABS	-	-	0.5	-
Organic Phosphate	-	never detected	-	-
Free residual chlorine	-	less than 0.1	0.05-0.1	-
Magnesium	50(150)	-	-	-
Calcium	75(200)	-	-	-
Radioactivity	α-ray 1 μμc/l β-ray 10 μμc/l	-	Ra^{226} 3 μμc/l a year Sr90, 10 μμc/l a year	α-ray 1 μμc/l β-ray 10 μμc/l
	( ): Max. allowable *: as $CaCO_3$ **: as NO_3 no indication number unit: ppm	*: as $CaCO_3$ **: Sexivalent Cr	*: as NO_3 *: Sexivalent Cr ( ): Max. allowable	

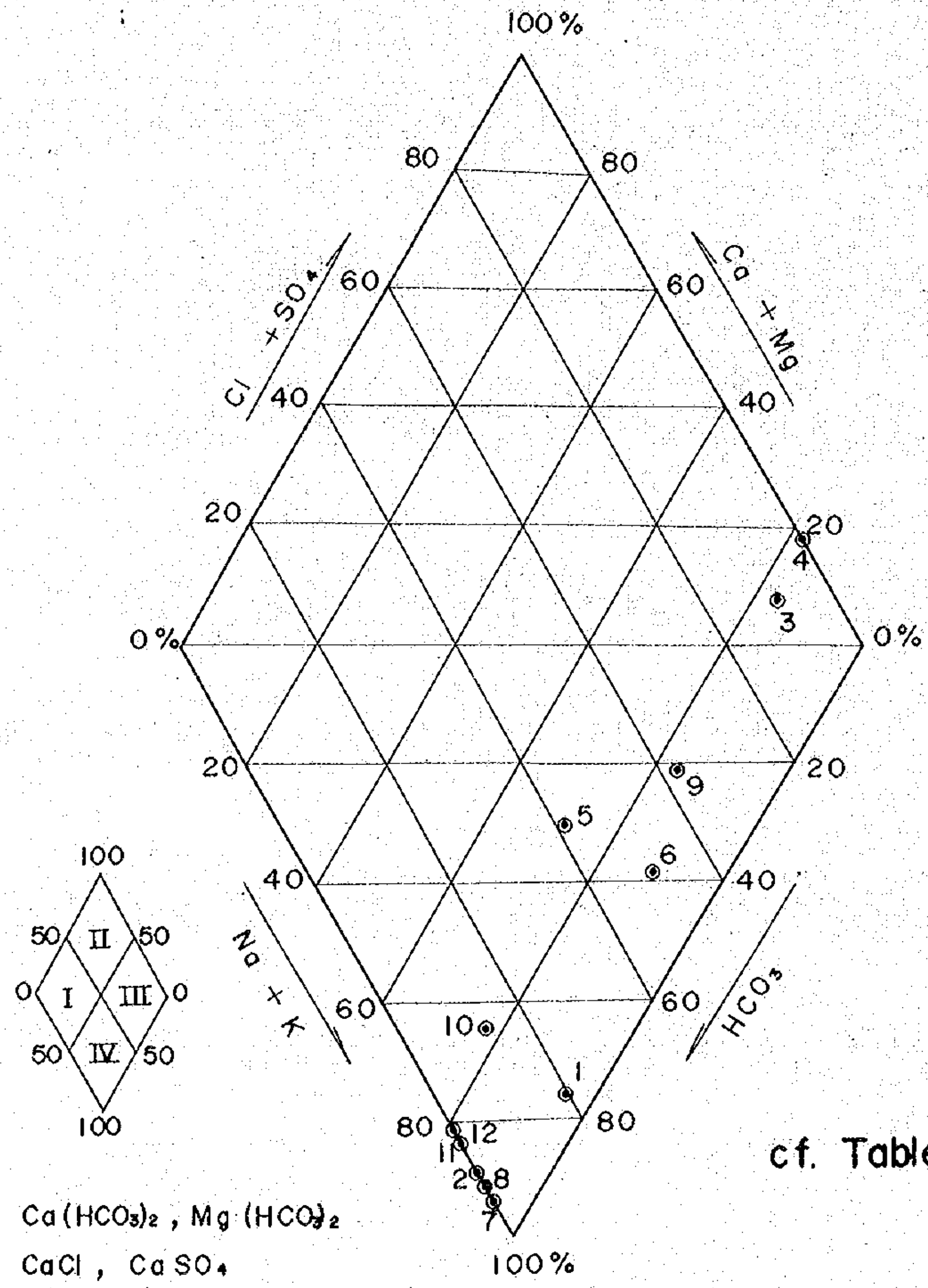
Table 1.1.4 **WATER QUALITY DATA NO. 1**

Sampling Point * (Depth x Diameter)		pH	HCO_3^- ppm	CO_3^{2-} ppm	Cl^- ppm	SO_4^{2-} ppm	SiO_3^{2-} ppm	NO_3^- ppm	Ca^{2+} ppm	Mg^{2+} ppm	Na^+ ppm	Fe^{2+} ppm	Al^{3+} ppm	Mn^{2+} ppm	NH_4^+ ppm	Total Hardness ppm ***	Turbidity ppm	Conductivity 10^{-6}℧/cm	Total Residue ppm	Alkalinity P.P. ppm	Alkalinity M.O. ppm	Acidity ppm	Sampling Date
NO. 1**	OBSERVATION WELL (110m x 100mm)	6.7	18.3	0	1.5	1.65	63.5	0.1	1.6	0	40.92	0.36	1.32	0	0	0.5	9.7	43.6	68	0	1.5	0	1 Feb. 1973
NO. 2	PUMPING WELL (95m x 200mm)	5.8	15.25	0	t	t	63.5	0.1	2.4	0.72	35.20	0.56	1.70	0	0	0.9	0	43.5	60	0	1.25	0	15 Feb. 1973
NO. 3	EXISTING WELL (2.5m x 600mm)	5.6	9.15	0	64	1.65	22.8	4.6	8.0	0.24	50.40	0.18	0.30	0	0	2.1	0.4	206	172	0	0.75	0	13 Feb. 1973
NO. 4	SWAMP WATER	3.35	0	0	27.4	191.5	5.08	t	9.2	1.45	61.45	1.51	5.21	0.25	1.0	2.9	22.5	508	316	0	0	4.05	28 Feb. 1973
NO. 5	EXISTING WELL (37m x 200mm)	5.4	15.25	0	6.1	t	30.48	0.4	5.6	0.24	17.50	0.42	1.27	0	0	1.5	0.75	40.3	42	0	1.25	0	"
NO. 6	EXISTING WELL (8.4m x 1500mm)	4.6	6.1	0	3.05	0	25.40	t	1.2	0.24	12.90	0.31	1.89	0	0	0.4	0.04	16.3	24	0	0.5	0	"
NO. 7	PUMPING WELL (95m x 200mm)	5.15	18.3	0	t	t	69.85	0.1	0.8	0.97	40.30	0.42	2.34	0	0	0.6	2.5	36.5	59	0	1.5	0	19 Feb. 1973
NO. 8	PUMPING WELL (95m x 200mm)	5.2	18.3	0	t	t	63.5	t	3.2	0.24	38.36	0.38	0.77	0	0	0.9	2	31	53	0	1.5	0	26 Feb. 1973
NO. 9**	BORING - B (52m x 100mm)	5.0	6.1	0	6.1	t	25.4	0.1	1.2	0.97	15.90	0.11	0.97	0	0	0.7	8.8	22.6	39	0	0.5	0	8 Mar. 1973
NO. 10**	BORING - A (66m x 100mm)	7.0	82.35	0	4.58	4.94	50.8	0.1	8.0	2.18	46.0	0.31	2.94	0	0	2.9	96	111	113	0	0.75	0	1 Mar. 1973
NO. 11**	BORING - C (117m x 100mm)	6.2	42.7	0	t	0	63.5	0.1	2.0	2.67	36.1	1.61	3.82	0	t	1.6	6.9	59.3	74	0	3.5	0	15 Mar. 1973
NO. 12**	BORING - C (77m x 100mm)	6.5	57.95	0	t	0	63.5	t	4.81	2.67	48.5	0.21	0.37	0	0	2.3	1.8	75	78	0	4.75	0	"

* See Fig. 1.1.3

** Pumped up by air-lifting

*** as $CaCO_3$



cf. Table 1.1.4

I : $Ca(HCO_3)_2$, $Mg(HCO_3)_2$

II : CaCl , $CaSO_4$

III : Nacl , Na_2SO_4

IV : $NaHCO_3$

Fig 1.1.17 KEY—DIAGRAM

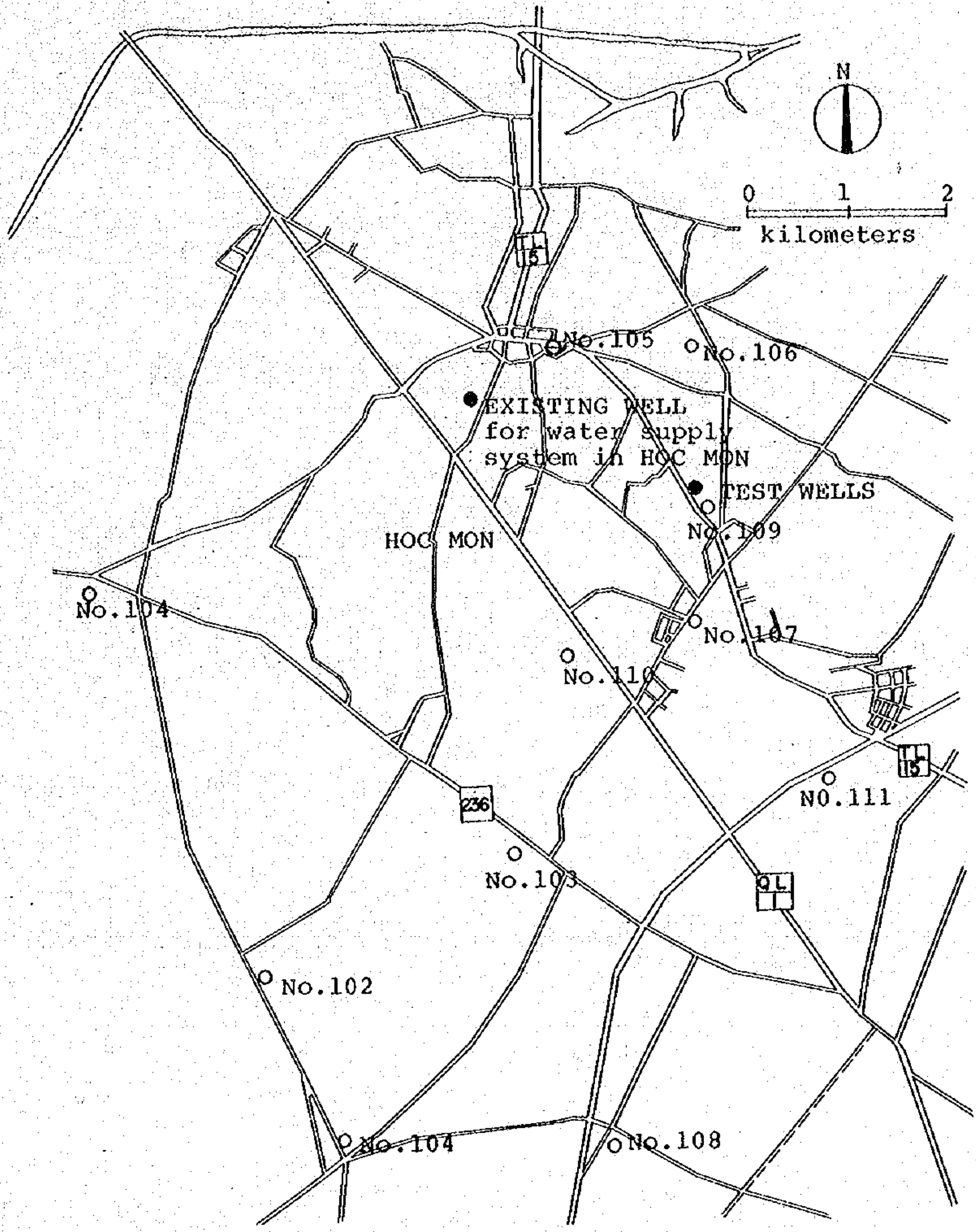


Fig. 1.1.18 SAMPLING POINTS

Table 1.1.5 WATER QUALITY DATA NO.2

NO.	Location	pH	RpH	*Cl^-	*Fe^{2+}	*So_4^{2-}	*Hardness	*Alkalinity	*Acidity	depth of bottom	date
	SHALLOW WELLS										
101.	Vinh Thanh	6.1	6.7	106	0.06	1.0	34	domestic	—	-5.0m	19/3/73
102.	"	5.0	6.3	32	0.04	trace	—	irrigation	—	-5.7	"
103.	"	6.2	6.7	36.2	0.13	3	—	irrigation	—	-4.3	"
104.	"	4.2	4.8	78	0.05	5	—	irrigation	—	-2.5	"
105.	Hoc Mon	6.0	7.3	121	0.06	37	—	domestic	—	-5.0	"
106.	"	4.2	5.0	56.8	0.08	5	11	"	—	-7.4	"
107.	"	5.0	6.6	163	0.05	15	—	"	—	-7.5	"
108.	"	5.7	6.9	121	0.18	15	—		—	-5.3	"
109.	Near Test well	4.5	5.9	121	0.08	2	12.5	4	31		17/3/73
110.	Near boring C point	4.0	4.4	85	0.05	1	20	0	—		"
111.	Hoc mon	5.2	7.6	16	0.7	—	9	7	—		"
	DEEP WELLS (for pumpint test)									**Specific conductivity	
Pumpint Test Well		5.3	7.6	—	0.4	—	3	21	—	54	24/2/73
"		5.5	7.2	8	1.5	—	5	26	60	70	14/2/73
Observation Well (air lift)		6.2	6.7	9.2	0.5	—	4	21	13	—	6/2/73

cf. Fig. 1.1.18 SAMPLING POINTS

unit: * ppm
** 10^{-6} ℧/cm

Table 1.1.6 WATER QUALITY OF SHALLOW WELL IN HOC MON

ITEM	VALUE
Temperature of Water at the time of analysis	23.7°C
pH	4.9
Colour	clear, no colour
Turbidity	0.0 ppm as $CaCO_3$
Conductivity	21×10^{-6} ℧/cm
M-Alkalinity	1.1 ppm
Acidity	51.6 ppm
Total Hardness	nil
Chloride ion	6.00 ppm by the method of Mohr(Silver Nitrate)
$KMnO_4$ consumed	0.95 ppm
Nitrogen Nitrate	0.012 ppm
Nitrogen Ammonium	nil
Total Iron	0.21 ppm
Manganese	0.04 ppm
Sulfate	nil

cf. Fig. 1.1.18 SAMPLING POINTS

sampled at the existing well for water supply system in Hoc Mon

on 29th March, 1973.

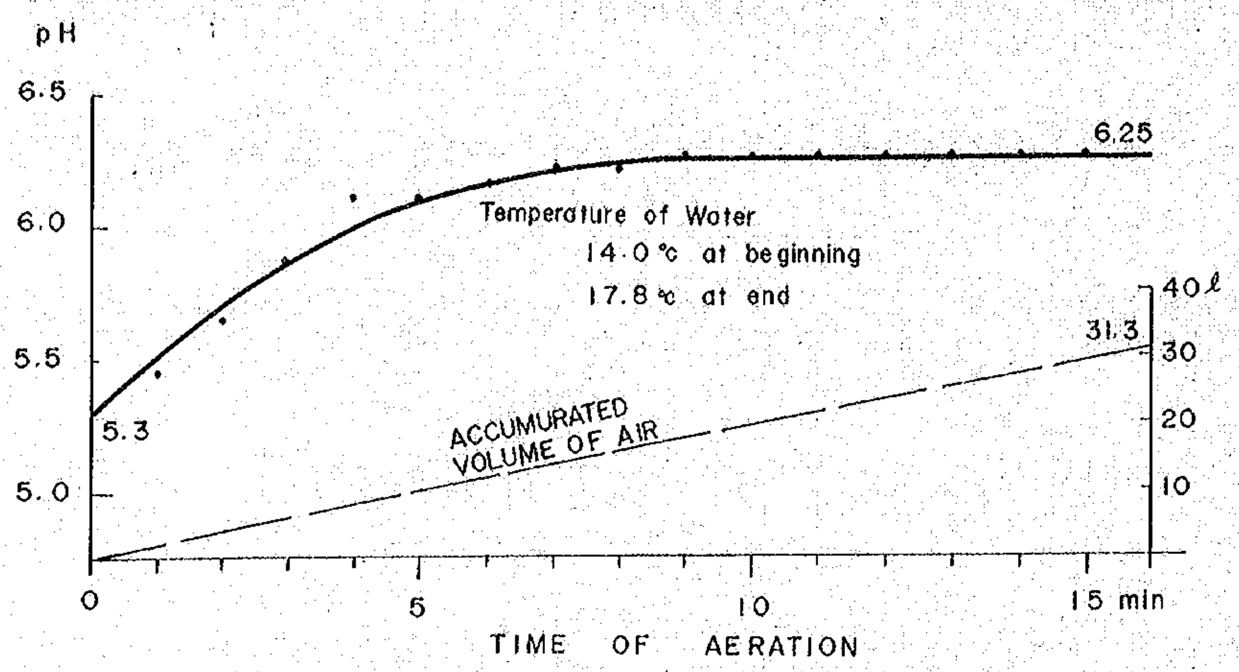


Fig 1.1.19 pH ADJUSTMENT BY AERATION

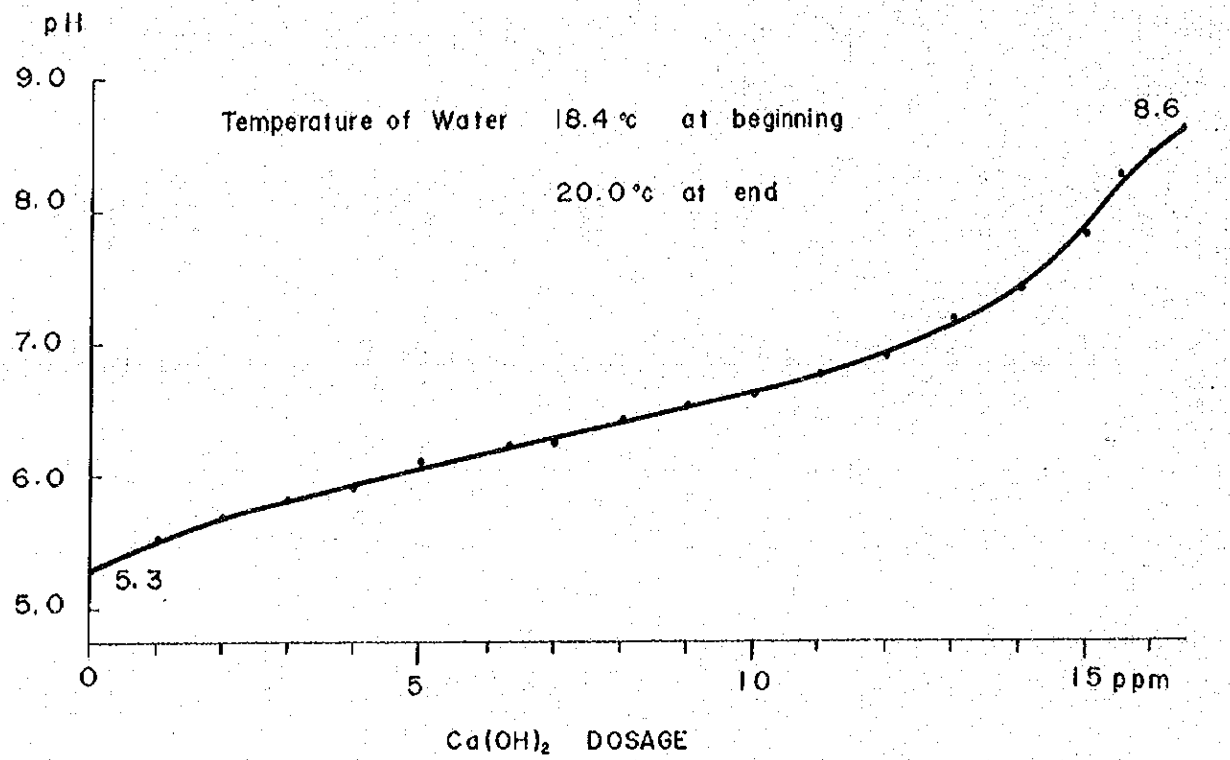


Fig 1.1.20 pH ADJUSTMENT BY CHEMICAL

I-1-5 AVAILABILITY OF GROUNDWATER

Potential of groundwater development for the city water supply is stated herein based on the results of electric prospecting, pumping test, test borings and chemical and physical analysis of sample waters.

There are two basic factors for the safe yield from a well field. One is the hydraulically critical discharge from wells in the field and the other is the area of the field.

Prospective water-bearing formation to be used for the proposed project will be the 3rd and 4th aquifers as mentioned in I-1-3 AQUIFERS. Hydraulic constants of the 3rd aquifer obtained by the pumping test are as follows:

Permeability Coefficient:	9.4×10^{-2} cm/sec
Storage Coefficient:	9.7×10^{-4}
Critical Discharge of a well:	Approx. 3,000 cmd

As for lay-out of wells, there is some portion of land where no wells can be drilled such as towns, hamlets and military settlements and wells should be located near the existing roads to save the contruction cost. Moreover, wells should be spaced in interval of more than 500 m so as to avoid excessive mutual interference. Considering these restrictions, some 70 wells can be drilled in this area. Hence, the total discharge will be approximately 210,000 cmd.

On the other hand, it is generally understood that the long-term safe yield in a flat land is eventually the function of land area since the area has no distinct lateral feeding of water from adjacent areas other than precipitation. More yield than allowable results in excessive drawdown of the water table. Long-term safe yield of groundwater is determined in terms of maximum allowable drawdown.

In this connection, it should be noted that, in the past, no remarkable and continuous drawdown of groundwater level nor such deterioration of water quality as salinity intrusion and iron contamination were experienced until the withdrawal of groundwater exceeded 60,000 to 80,000 cmd within the area of 25 sqkm or so in the city of Saigon. From this experience, the safe yield may be inferred less than 2,400 to 3,200 cmd per sqkm. In contrast, the average unit withdrawal is calculated as 1,400 cmd per sqkm in the present project since the land area of the well field is approximately 150 sqkm. This figure may seem to be significantly conservative, but as the "safe yield" implies the safe rate of continued withdrawal for generation to come without depleting the resources, it is considered advisable to be conservative for the long range planning purpose, involving sizable investment, in order to ensure the longer life of groundwater resources to depend on. In this connection, another consideration should be given such that the hydrogeological condition of the Hoc Mon may not be the same as that of the Saigon city area and, empirically, safe yield does not seem to much exceed one third of the precipitation. In conclusion, the total discharge of 210,000 cmd (The treated water production will be 200,000 cmd since some 5 percent of raw water is consumed in treatment processes.) will certainly be a safe and long-lasting figure.

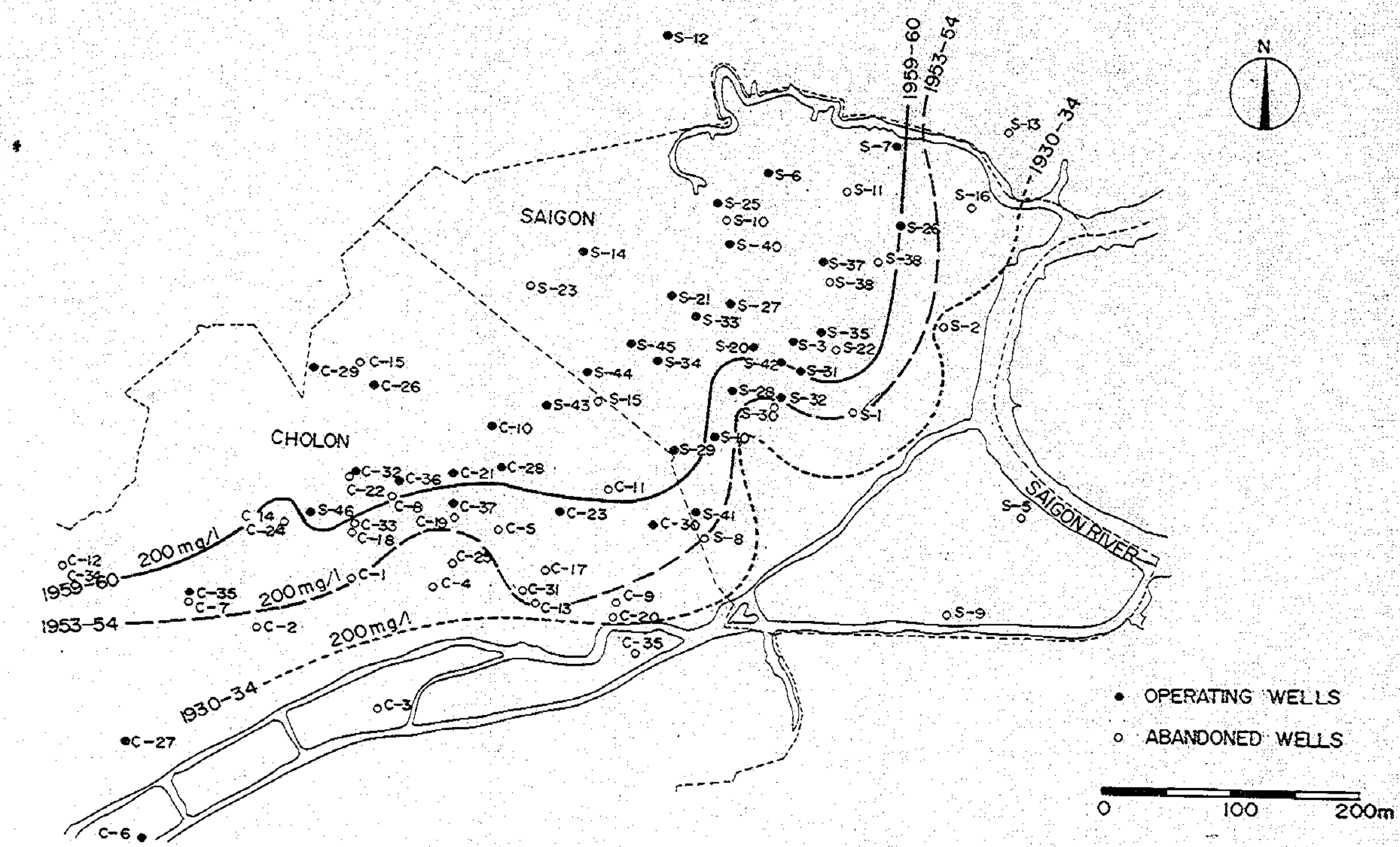
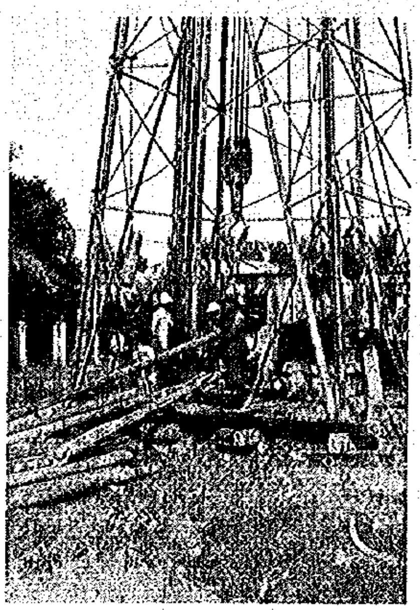
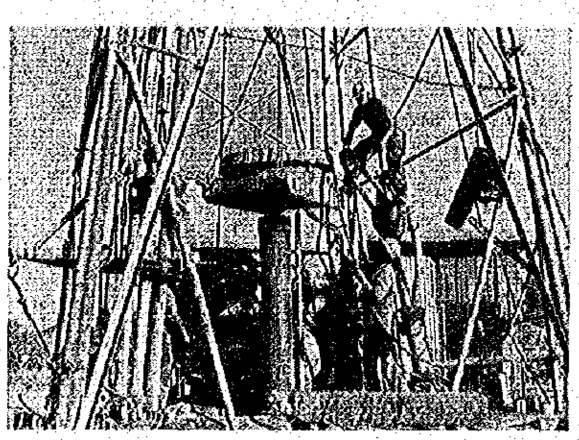
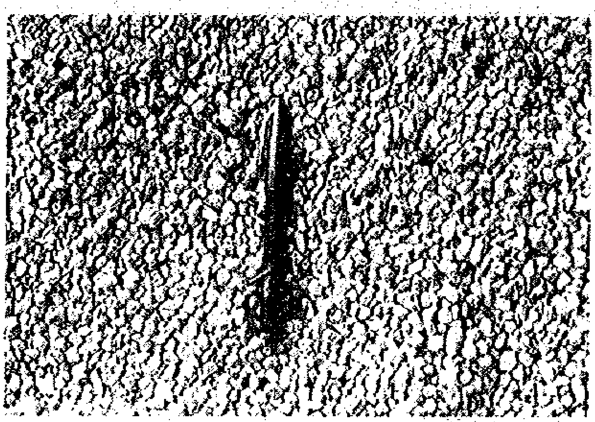


Fig I. I. 21 SALT CONTENT OF SAIGON-CHOLON GROUND WATER

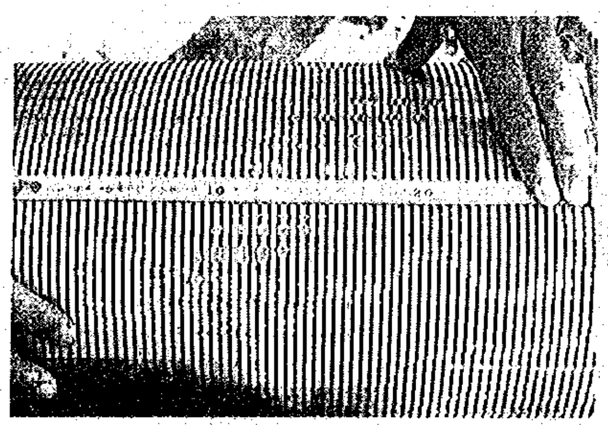




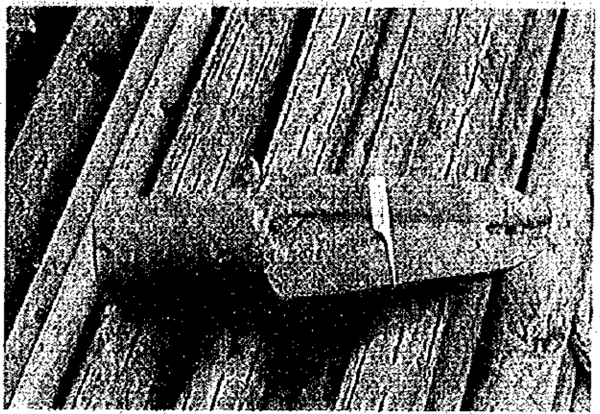
Drilling of Pumping Well



Gravels for Packing

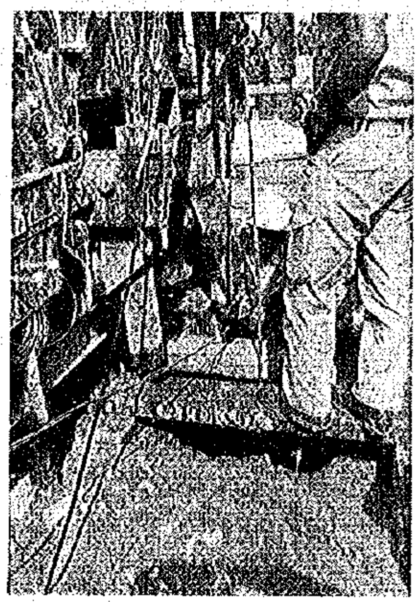


Screen of Pumping Well



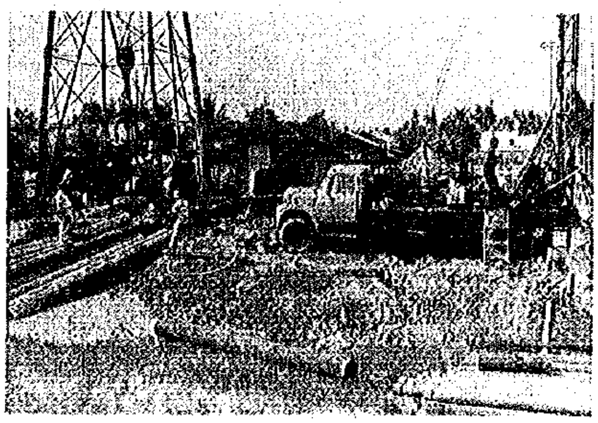
Jetting Drill Bit and
Screen of Observation Well

Drilling of Observation Well

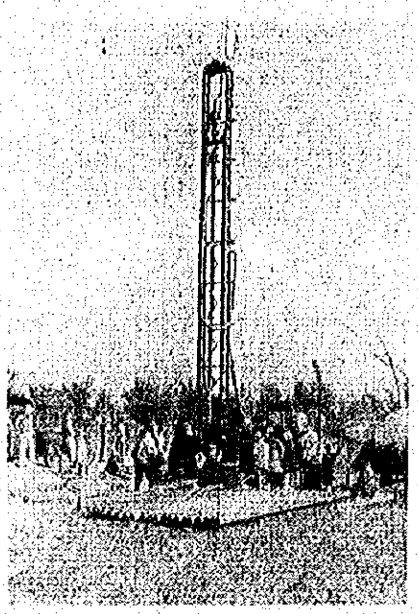


Electrical Logging

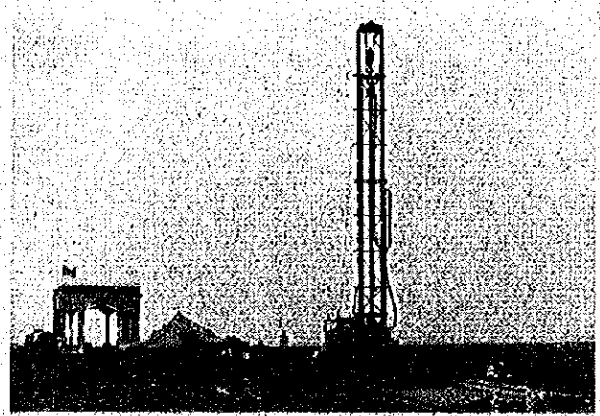
Pumping Test



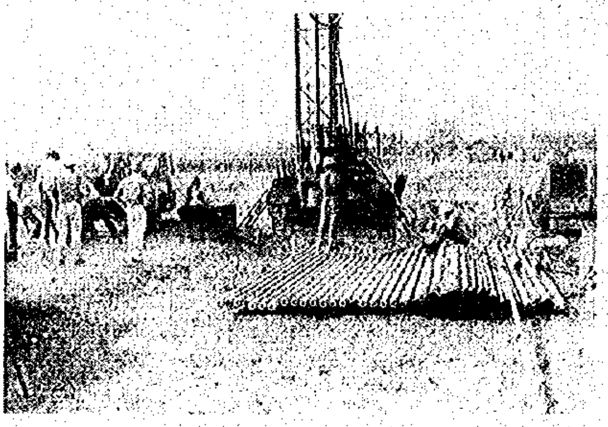
Test Wells



Boring A Point



Boring B Point



Boring C Point

Electrical Groundwater Prospecting

Swamp near C Point

I-2 SAIGON RIVER

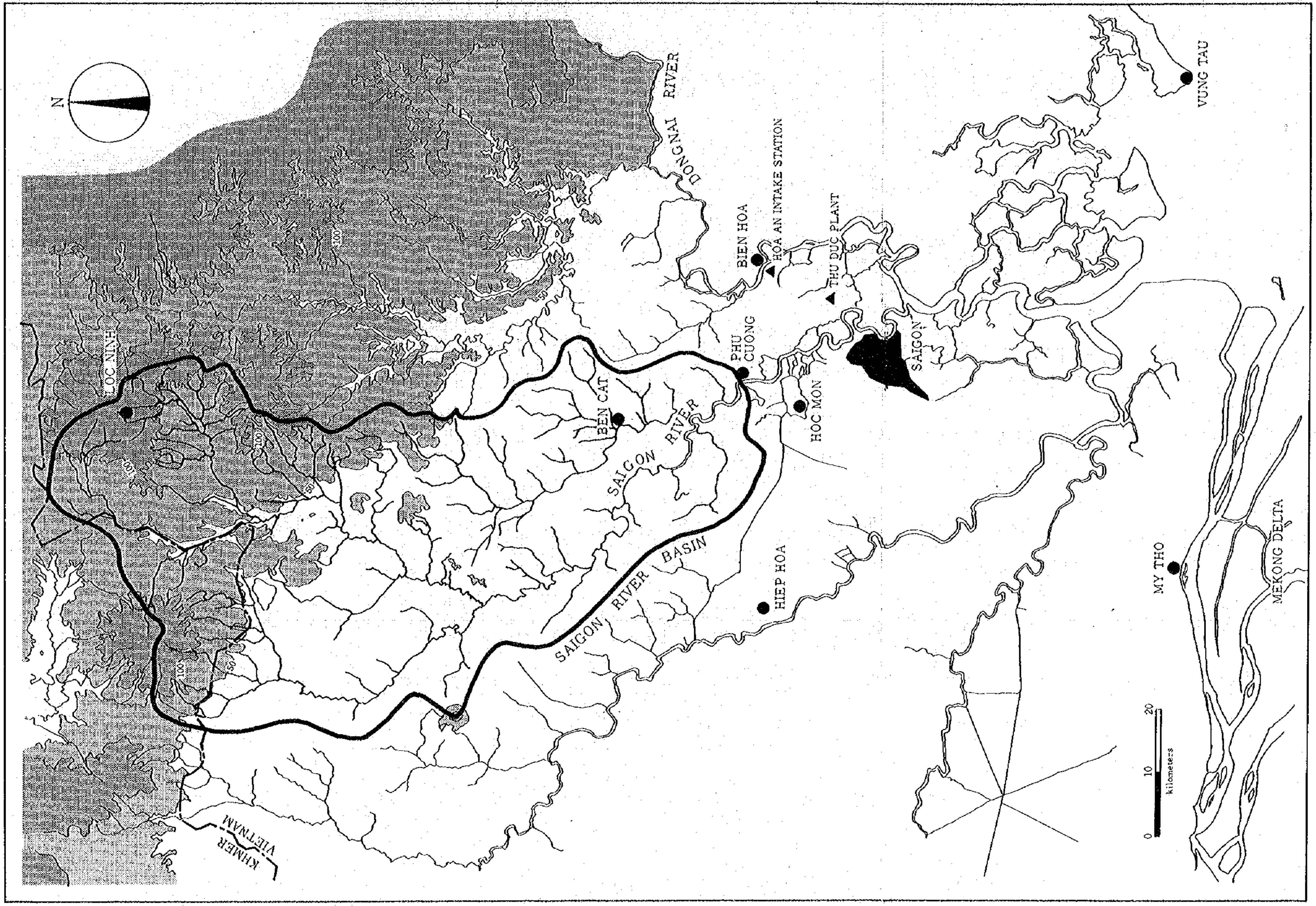


Fig. 1. 2. 1. **SAIGON RIVER SYSTEM**

I-2-1 RIVER SYSTEM AND SURVEY SITE

Saigon River System

The Saigon River has its origin in the long range of hills on the border of Vietnam and Khmer, where the elevation is about 200 m or less. Its numerous small tributaries run down valleys and join together to become a meandering wide river in the plain. Hence the River passes by the eastern end of the Saigon City to meet the Dong Nai River about 5 km southeast of Saigon. The river is called the Nha Be River after the confluence.

Length of the main stream of the river is about 250 km and drainage area is 4,300 sqkm at Phu Cuong and 5,200 sqkm at Saigon. The river basin is shaped slender with its length of 180 km and average width of some 24 km. The shape factor by Horton is 0.13. As for the Dong Nai River, the drainage area is 22,800 sqkm at Bien Hoa with its origin in the central highland, of which altitude is nearly 2,000 m above the mean sea level at the highest places.

Meandering of the Saigon River develops as it flows down through the flat plain that was presumably formed by floods of the Mekong River in the ancient days. The river bottom of the Saigon River reaches 50 m above the mean sea level well at 200 km upstream from the estuary.

The climate is closely tropical in this area having two seasons, i.e., the wet and dry seasons. Naturally, the river flow is very affluent during the wet season usually from May through November. River flow near the end of the dry season is most important for planning of water supply since the flow is generally minimum in this period and the planning should be based on the minimum flow. Therefore, the dry season, especially its later part must absolutely be included in the term of the river flow survey. Thus the present survey was executed in the relatively later part of the dry season.

Survey Site

The survey was undertaken by the survey team at Phu Coung, which once called Thu Dau Mot, is located about 30 km north of Saigon, and is the capital of Binh Duong province (See Fig. 1.2.2) with its population of approx. 40,000.

A 600m-long straight channel of the river along the town was selected for the survey although the stream is in the tidal area and is slightly affected by meandering of the river. At Phu Cuong, that is situated 105 km upstream from the estuary, the elevation of the bank is 1 to 2 m above the mean sea level and the average water level was later found as 0.4 m above the mean sea level during the survey. Normally it is desirable that the flow measurement and water level observation are carried out at a sufficiently long straight channel where no biased flow is caused by meandering and the flow itself is not affected by the tide. However, no such place was found available near the proposed intake site and with in the range where security was guaranteed. Hence the stream in the town was selected as the best among those available.

The downtown of the city is developed on the left side of the Saigon River, and the opposite side of the river is the rice field. The left bank has a masonry reventment, whereas no reventment but natural shore on the right bank, and this was considered suitable for the survey base. The proposed intake site by SMWO is located about 2 km upstream from the survey site.

The original idea of flow measurement to be carried out at Phu Cuong bridge for easier operation was abandoned later as the bridge was built on iron piers protected from explosives by floating enclosures and fences, which must innevitably cause excessively contracted flow of the river. Therefore the survey was conducted at the place where 1972 survey was performed by the Navigation Office, Ministry of Telecommunication and Transportation. (See Fig. 1.2.3.)

There were three beacon staffs left at the survey site which were prepared for the previous flow survey and was used for locating the survey boats on the survey line. They were used again for the same purpose by the present team.

A water level recorder was newly installed on the left side near the survey line.

At the survey section, the width of the river was about 200 m, the maximum depth of water was about 14 m at high tide and the straight section of the river was 600 m in length. (See Fig. 1.2.4.)

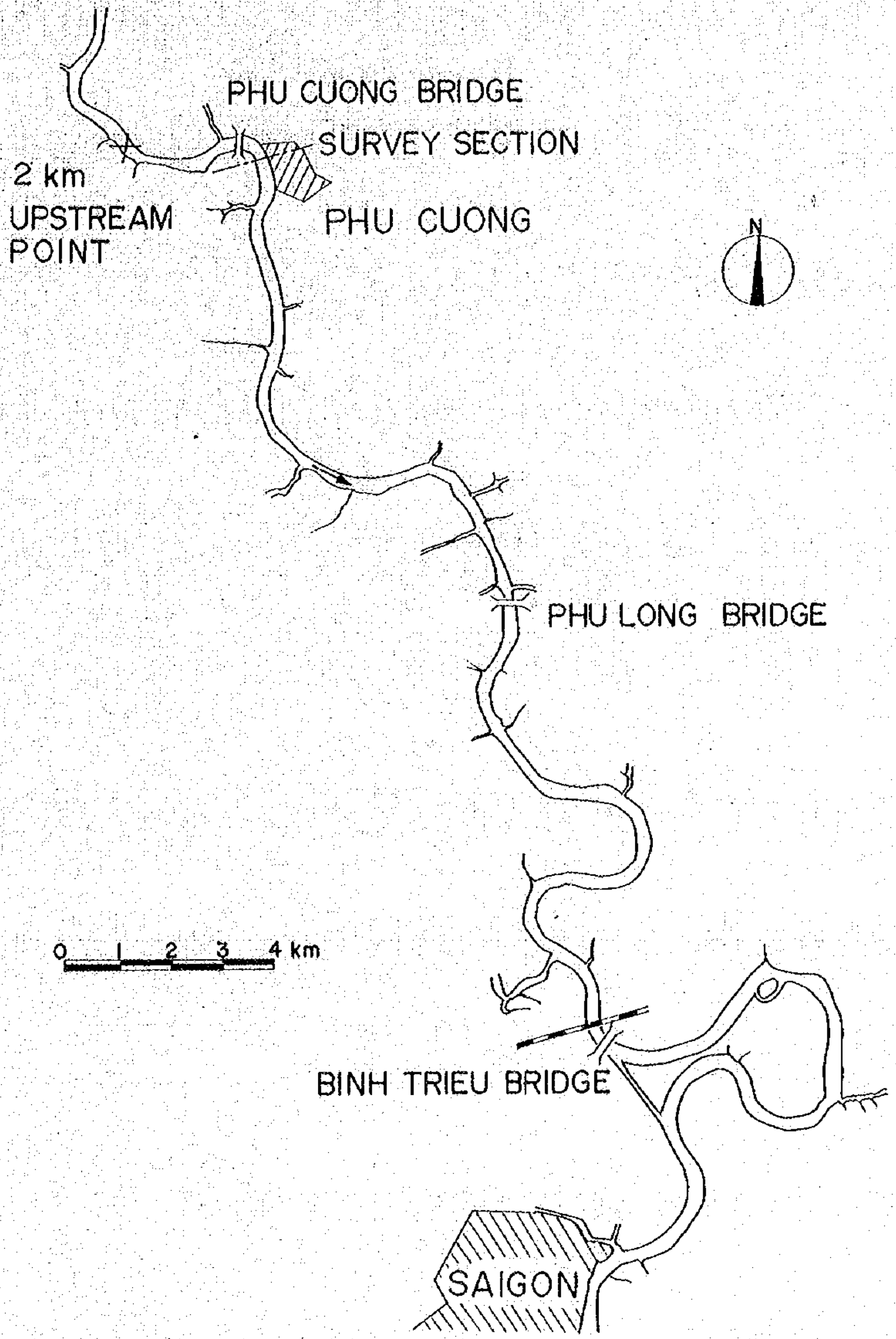


Fig. I. 2. 2 SAIGON RIVER

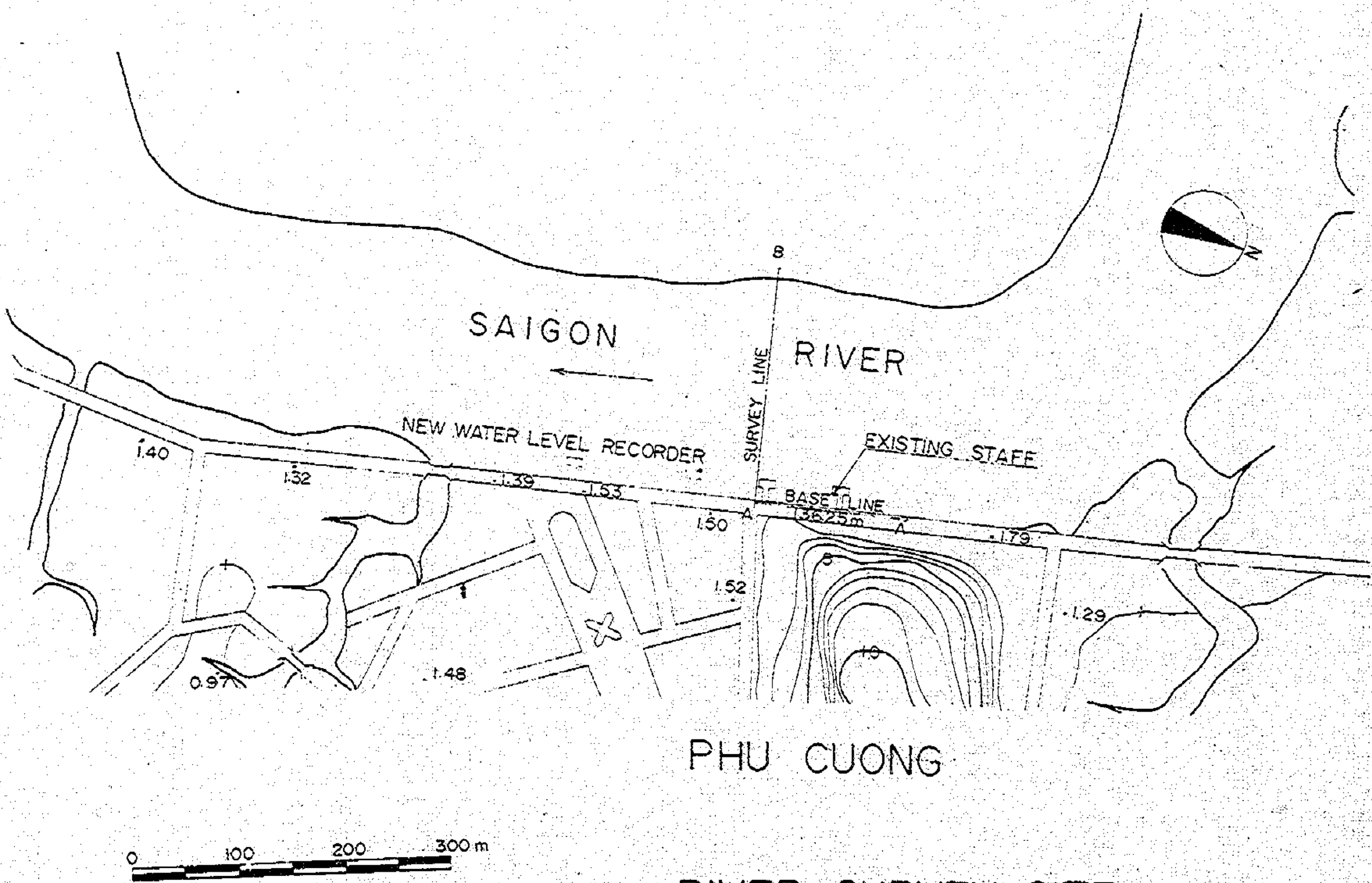


Fig 1.2.3 RIVER SURVEY SITE

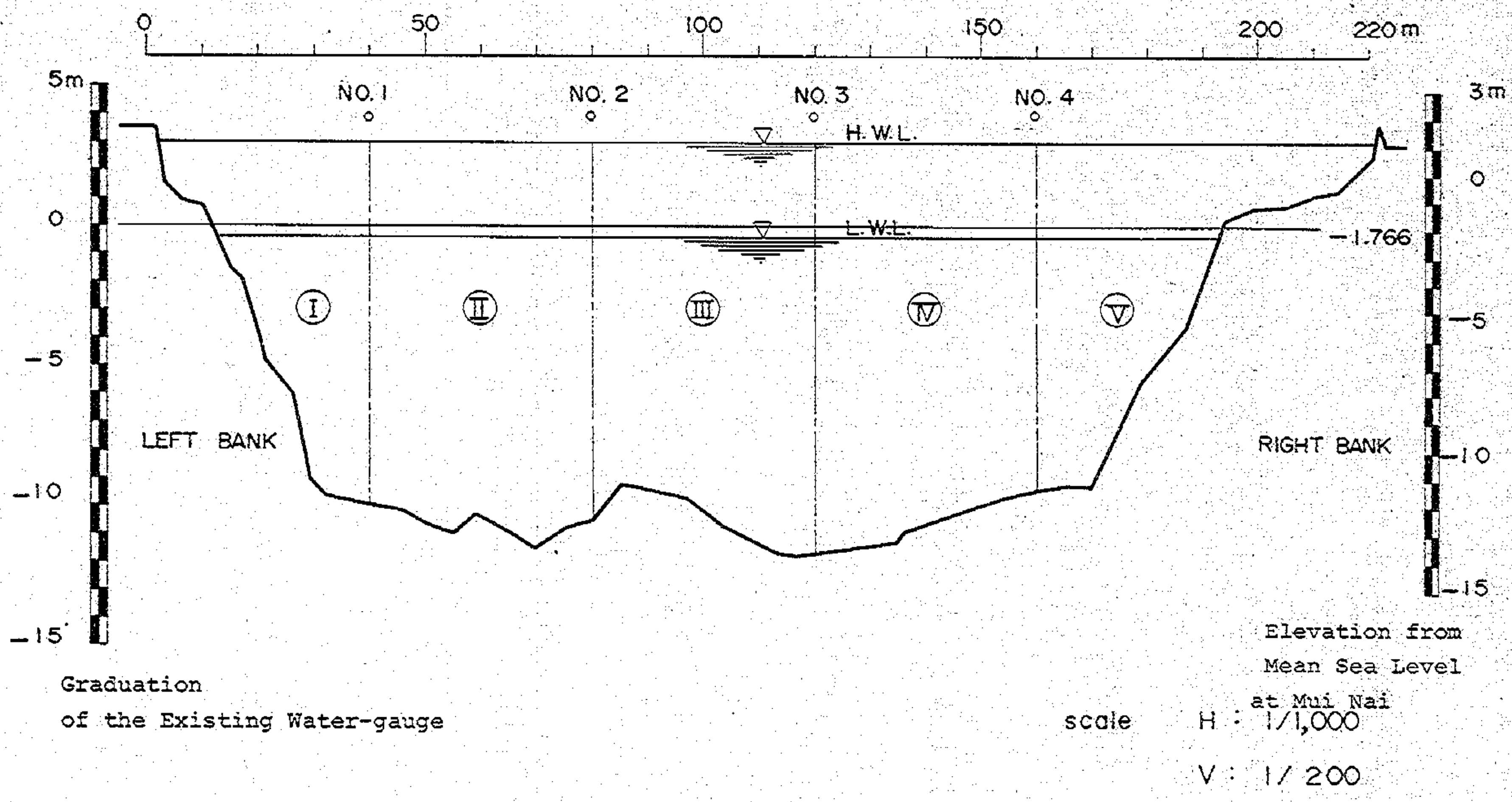


Fig I.2.4. CROSS SECTION

I-2-2 SURVEY ITEMS

The following items were taken up by the survey team.

- Cross section of the stream.
- Water level (by the newly installed water level recorder).
- Current velocity.
- Water quality.

The first three items are for calculating of the discharge of the river which are described below, whereas the last item is discussed in the later section. Topography at and around the survey site was studied by means of reconnaissance and a map supplied by SMWO.

Cross Section

The survey team was supplied with a drawing of a cross section at the survey line, that was made during the previous survey but the measurement of the section was carried out again for a reconfirmation purpose, which was executed in the following manner from 10th to 20th January 1973.

The base line perpendicular to the survey line was settled on the left bank before the depth sounding. Its length was 136.25 m.

The members of the survey team were then separated into two parties, one was on a boat to measure the depth at 12 or 18 points on the survey line in one round, the other at the end of the base line on the left bank to shoot the location of the survey boat by a transit.

As a result of 6 times of trials, the cross section at the survey line was aquired as in Fig. 1.2.4.

Water Level

The sectional area of the river varies in response to the changing water level by tide. Hence, it is necessary for flow measurement to observe the water level continuously.

SMWO has measured water level for years by a water gauge with no automatic recorder which is located some 80 m upstream from the survey line. The team brought two sets of automatic water level recorders into Vietnam to measure the water level continuously. One of them was installed just near the survey line. The other was initially planned to be installed 10 or 20 km upstream of the survey line where the river flow would not be influenced by tide, so that the basic flow could be calculated by water level data. Up to the present, however, this was not done due to the security problem.

There were frequent navigation of boats across the survey line and the water level in the float well of the recorder went up and down within a range of 10 cm whenever a boat passed by but it did not disturb the recording of the water level. The curves of level on recording charts were identified without difficulty. A water gauge was newly installed close by the level recorder for calibration purpose. The zero level of the new water gauge is exactly 50 cm lower than that of existing one, which means the new zero level is 2.266 m below the mean sea level at Mui Nai.

Current Velocity

Among the several methods of current measurement of a stream, current meter method was considered the best to be employed under the circumstance with the condition of tide and the size of the River. Price's current meter was used in this survey.

It was observed during the preparatory surveys that maximum velocity was nearly 1.0 m/sec and it was difficult to stabilize the survey boat on the survey line only by controlling power of the engine. The idea of setting poles in the river or stretching a cable across it was not adopted because of the fairly busy traffic in the river. The use of relatively heavy anchors was found to be the best way to fix the survey boat.

While many measurement points along the survey line as possible are disirable for high accuracy in a big river such as the Saigon River, it was limited to four for the survey, due to small man power and the frequent boat traffic. The cross section of the river at the survey line was separated into five. Fig. 1.2.5 shows the cross-sectional area of the river and the area of each section in relation to water level.

Regarding vertical velocity distribution of the river stream, the two-point method was adopted in the survey, because, 1) for a deep river, there would be no big difference between velocities at surface and at the level near the bottom and velocity distribution was assumed to be analogously a parabola -- this assumption was almost correct in the present case -- and 2) it was not practical to take time for many measurements when the velocity was changing rapidly by tide. Thus, 20 percent and 80 percent velocities were measured and averaged for the individual mean velocity.

Profile

Profile, namely, longitudinal section of the river, would be useful to have if it covers sufficient distance for calculation of river channel grades and others. No profile survey was made, however, because of the lack of time, equipment and security condition.

Water Quality

The survey on water quality is one of the most important survey items for water resources. The details of the survey are described separately in the section, I-2-4.

I-2-3 FLOW MEASUREMENT

Flow rate of the river changes in response to changes of flow velocity and water level, which necessitates the flow measurement to be carried out at least 24 hours. For the assessment of tidal action of a river as a whole, it is necessary to have the information regarding astronomical components on lunar and solar semidiurnals and lunar and lunisolar diurnals of the tide, which makes it desirable to continuously measure the current for more than 2 weeks. However, for the practical reason, our survey was limited to 24 hours of continuous measurement.

Flow measurement

The 24-hour survey started at 14 hours, 5th March 1973 and completed at the same time the next day.

Four measuring points were established as stated in the previous section. Two parties were organized by the members of the team together with those from SMWO. Each party in charge of two sections with respective two measuring points was to measure currents at these points as quickly as possible at the interval of 30 minutes.

Data thus obtained are analyzed in the following section.

Analysis and Result

Flow of the river is given as sum of flows at the four sections, where the flow of each section is the product of the area and the average velocity of the section.

The areas of sections No. 1, 2, 3, 4 and 5 are denoted by A1, A2, A3, A4 and A5 respectively. These values are illustrated in Fig. 1.2.5 in relation to water level (cf. Fig. 1.2.6 to 9). The section No. 1 is situated on the far left.

Flow velocity was calculated as follows:

The average velocity values at survey points are denoted as v1, v2, v3, and v4, respectively. Each point has 2 kinds of velocities, namely ones at 20 percent and 80 percent depths. The average value at each point is obtained by the arithmetic mean value of these two velocities. These are illustrated in Fig. 1.2.10 and 11.

The average velocities of areas No. 1, 2, 3, 4 and 5 are represented by V1, V2, V3, V4 and V5 respectively which are calculated by means of the figures mentioned above.

V1 is given by v1.

V2 is obtained by way of arithmetic mean value of v1 and v2.

V2 is the mean value of v2 and v3 and, in the same way, V4 is that of v3 and v4.

V5 is given by v4.

Velocity at each survey point is seen in Fig. 1.2.10 and in which some dispersion is seen, especially at points No. 1 and 2.

The result of calculation is shown in the Fig. 1.2.12. The average rate of flow for the survey period was about -1.0 cum/sec which means upstream flow exceeded downstream flow during the survey period.

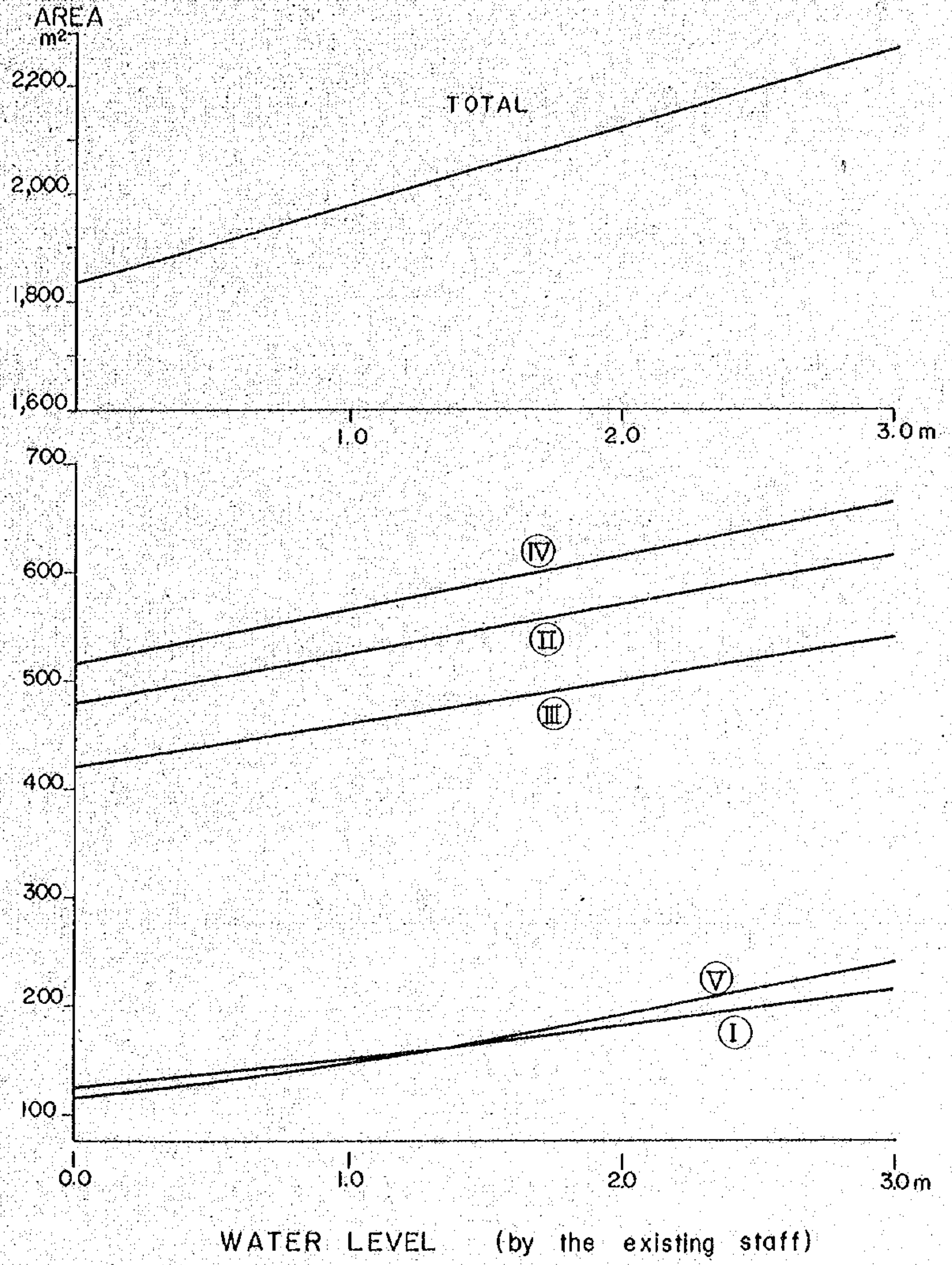


Fig I.2.5 AREA of CROSS SECTION

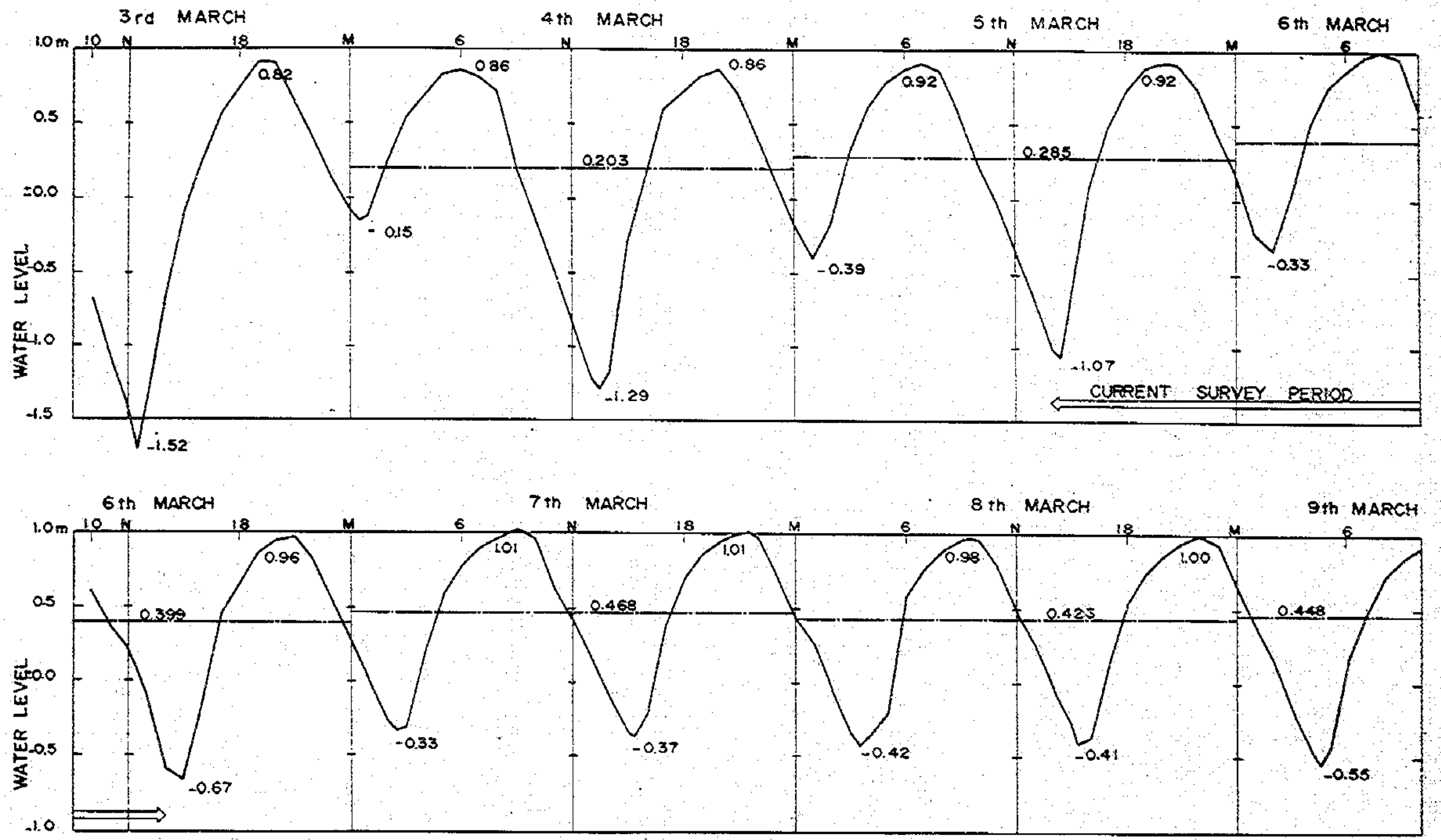


Fig 1. 2. 6 WATER LEVEL at PHU CUONG (I)

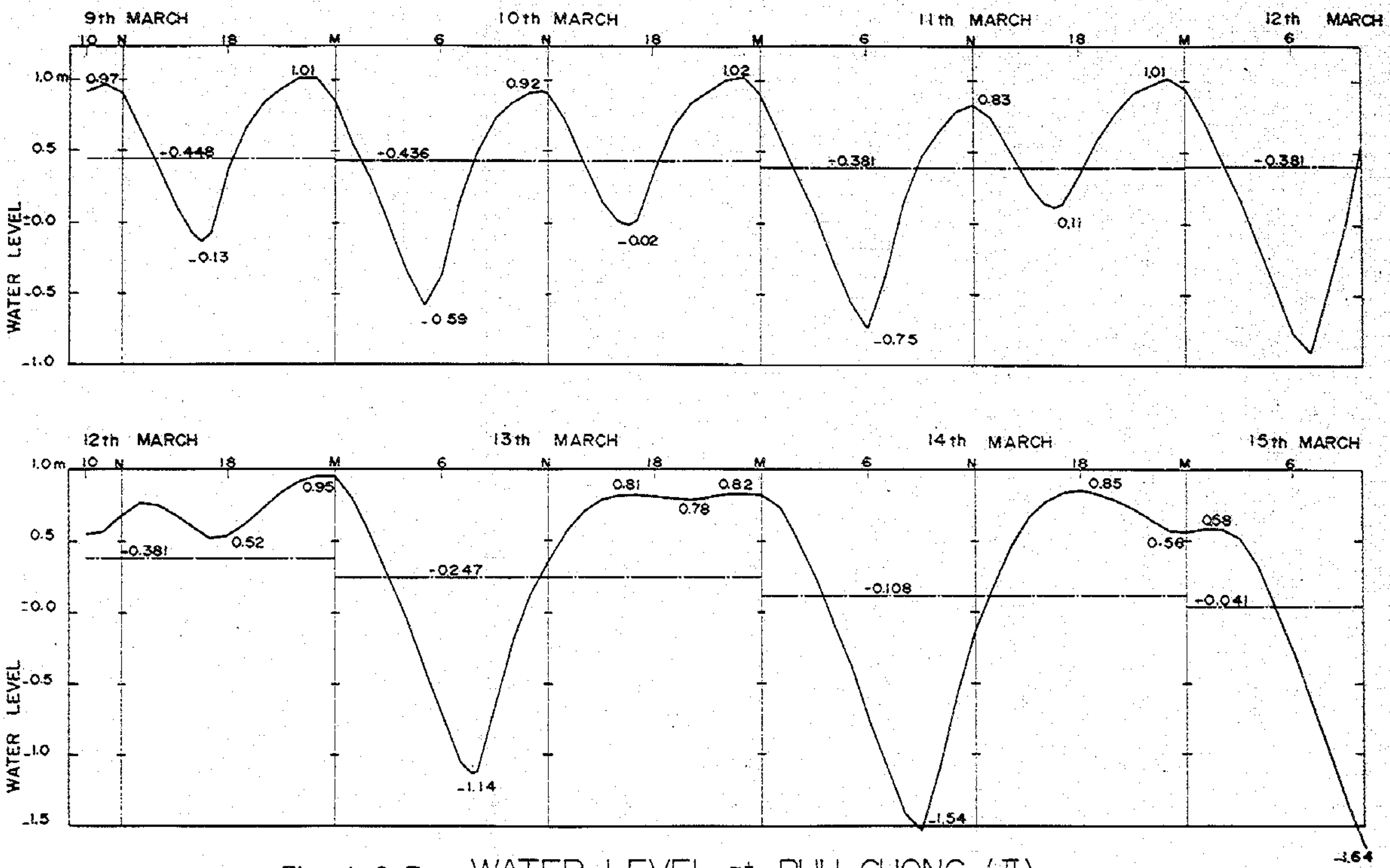


Fig 1.2.7 WATER LEVEL at PHU CUONG (II)

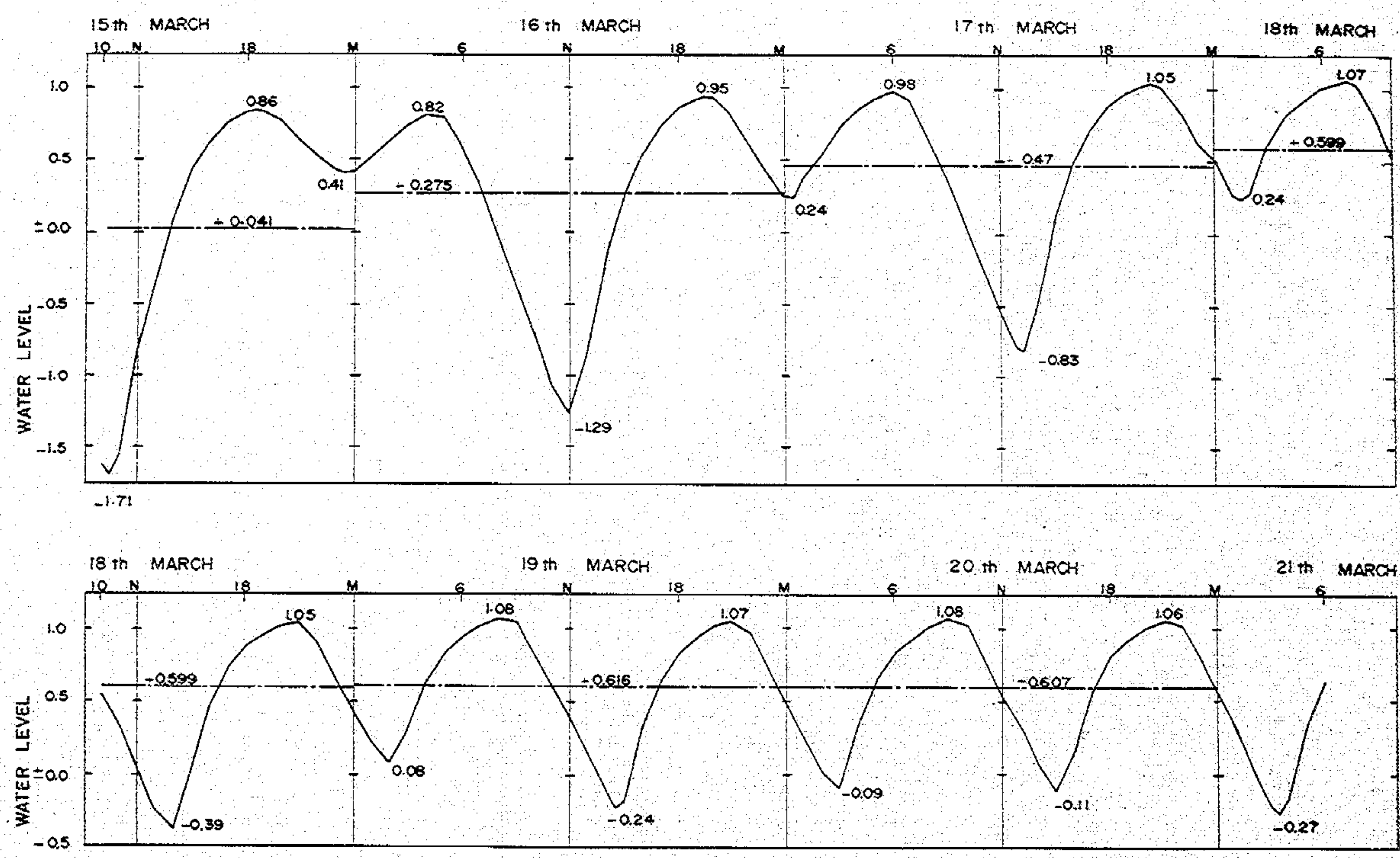


Fig 1. 2. 8 WATER LEVEL at PHU CUONG (III)

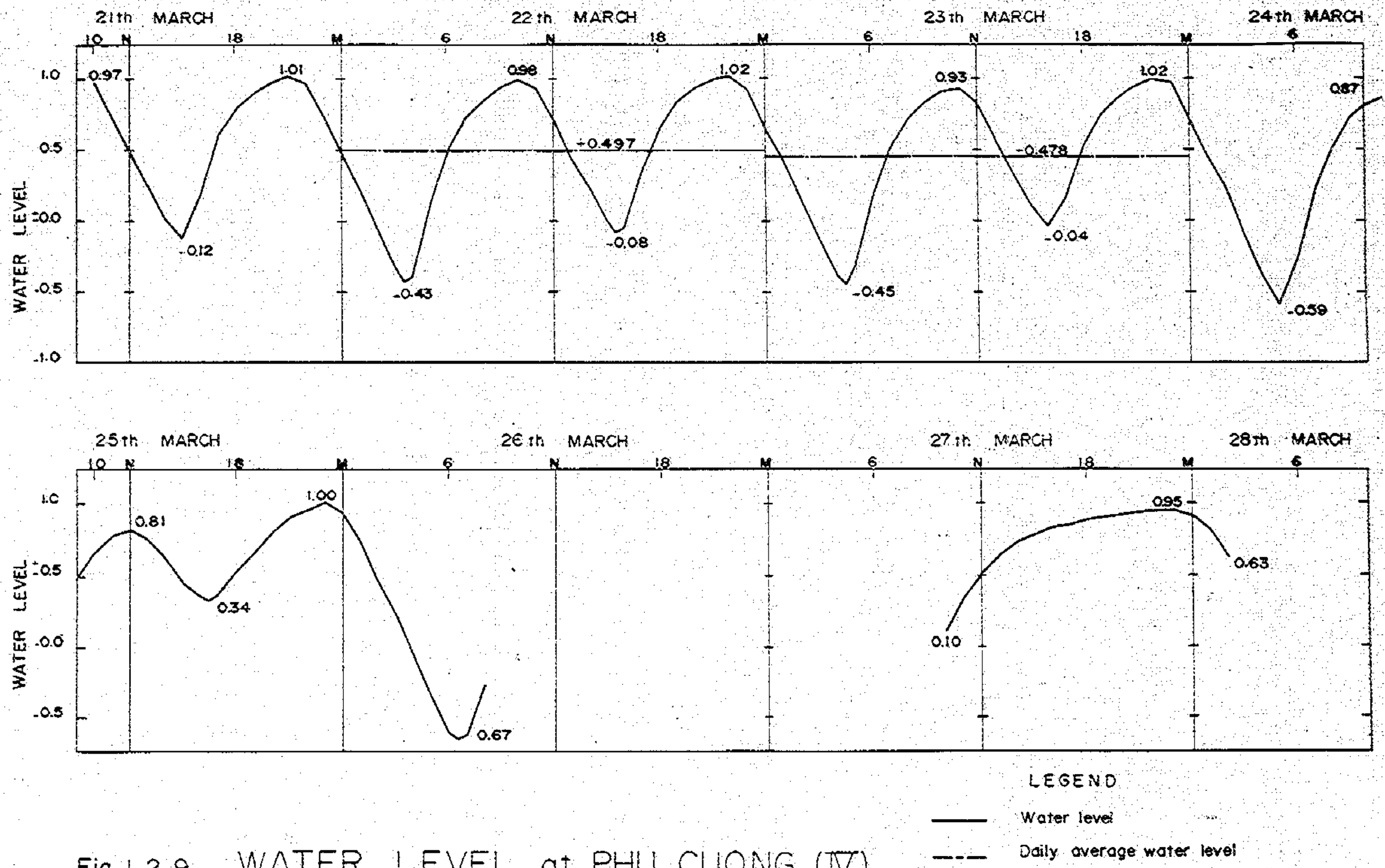


Fig I. 2. 9 WATER LEVEL at PHU CUONG (IV)

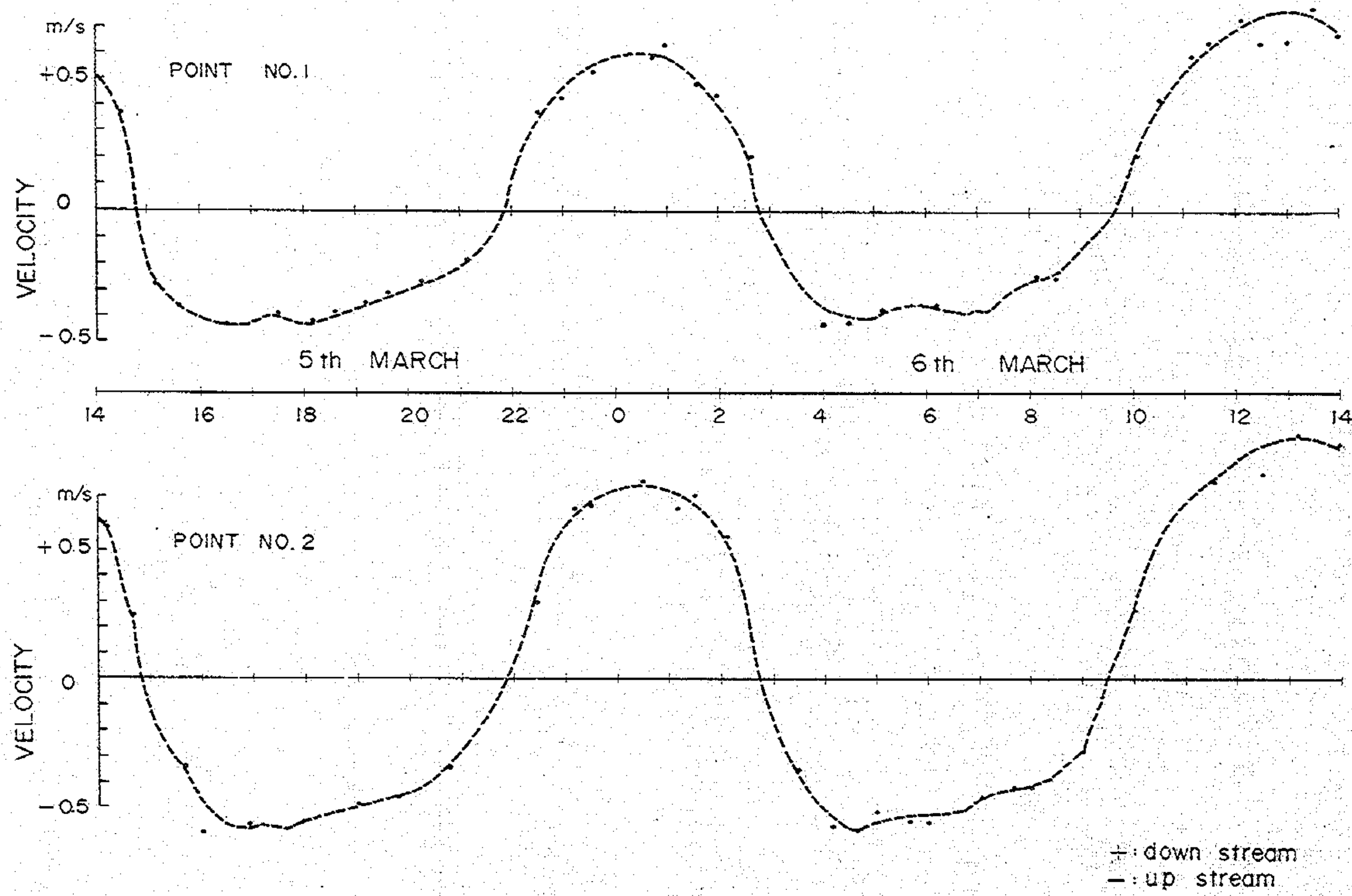


Fig I. 2.10 FLOW VELOCITY (I)

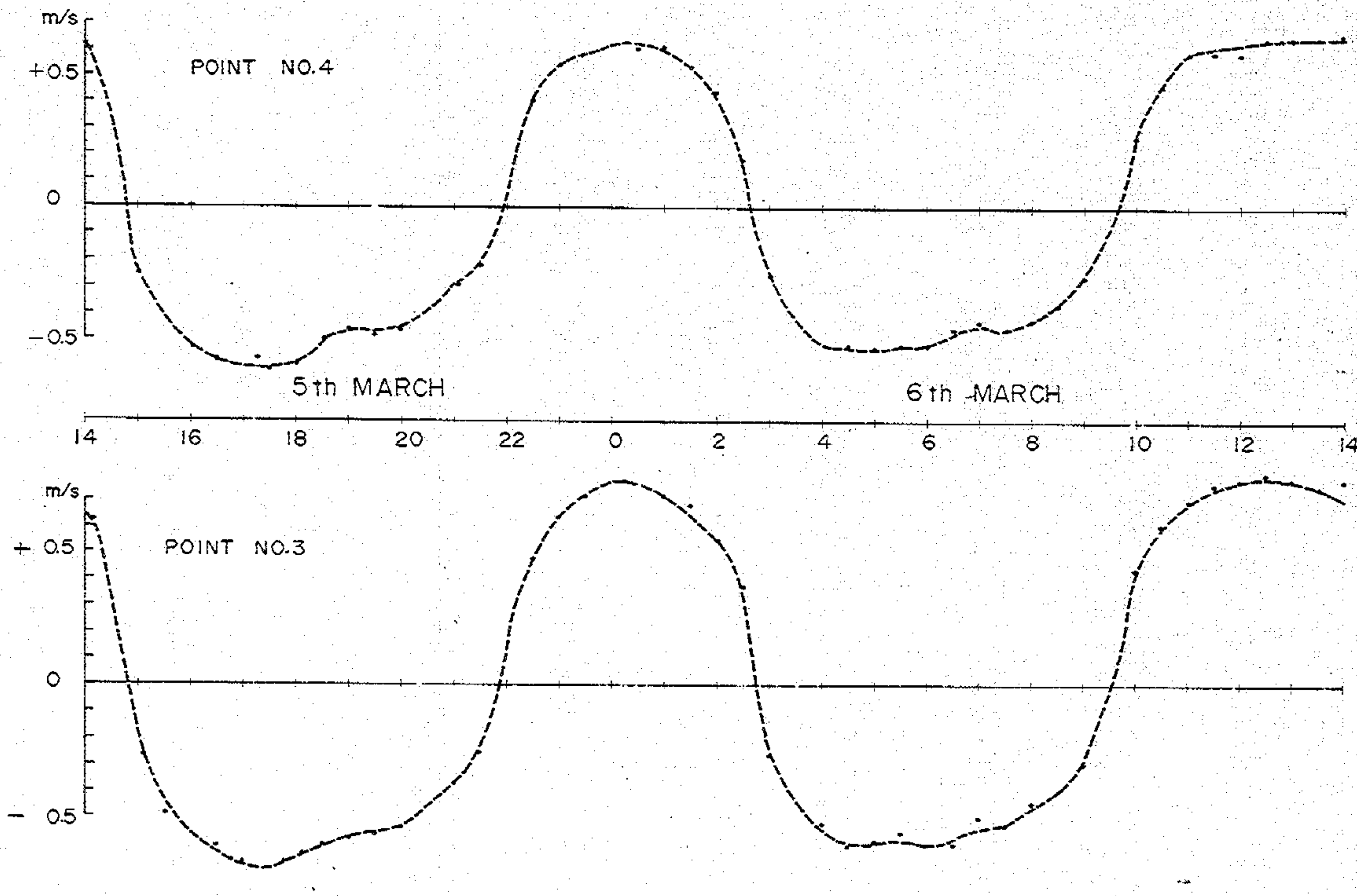


Fig 1.2.11 FLOW VELOCITY (2)

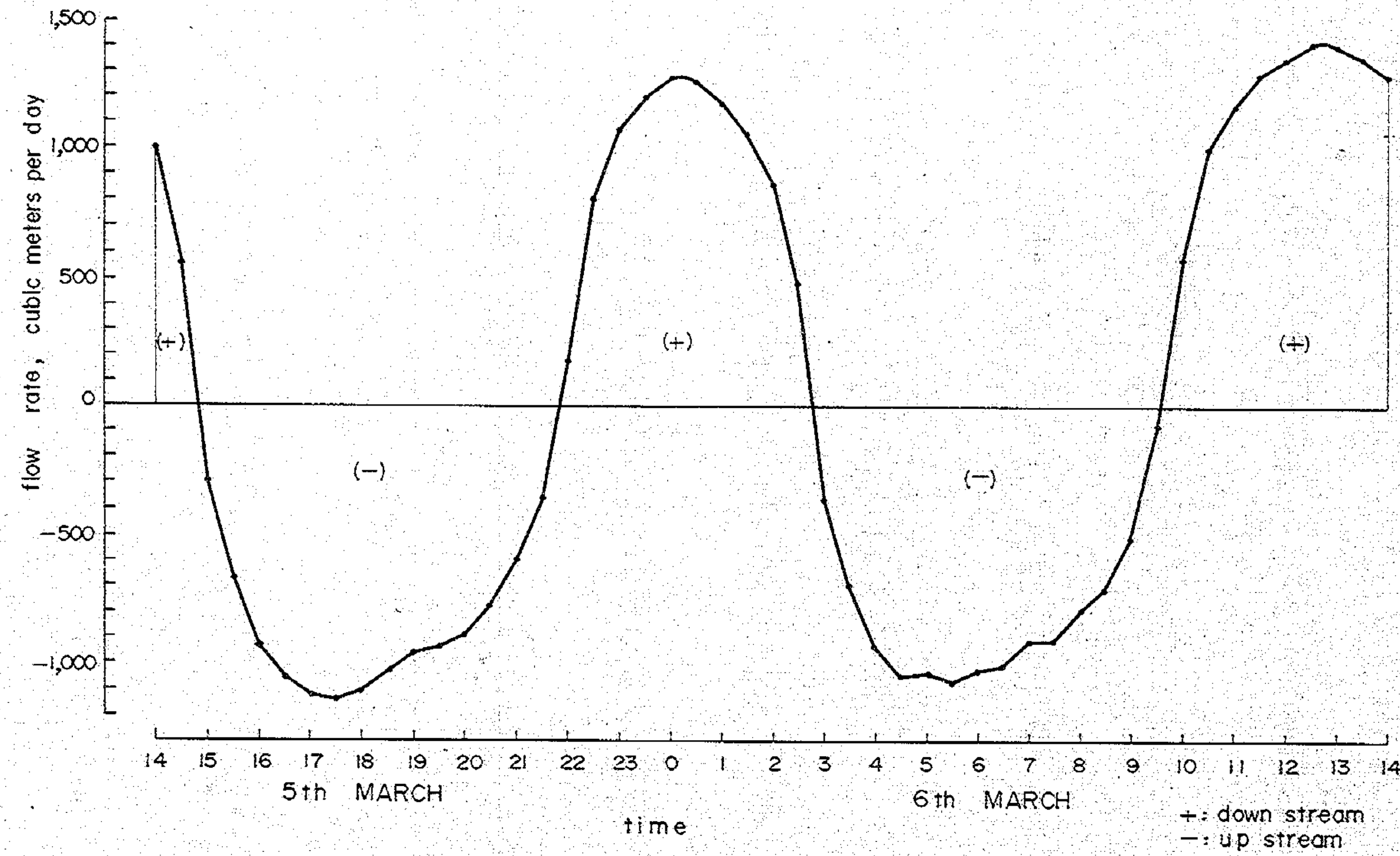


Fig 1.2.12 FLOW RATE

I-2-4 WATER QUALITY

Sampling and water quality analysis executed during the survey are as follows and are reviewed together with the past data obtained by SMWO.

Period of Sampling

As long survey period for sampling and many samplings as possible were desirable since salt intrusions due to the small flow rate had occurred during the dry season (usually, from December through April) and the probability of accurrence seemed to be higher near the end of the season according to the past data. Thus, water was sampled some 20 times from 16th December 1972 through 29th March 1973.

Sampling Points

Water was sampled mainly at the center of the survey line, i.e., at the center of the stream, along which current was measured. However, sampling was also performed two times at one point upstream and two points downstream the survey line to detect salinity intrusion if any. One of the sampling points is 2 km upstream from Phu Cuong bridge and the others are at Binh Trieu bridge near the city of Saigon and at Phu Long bridge which is situated almost in the middle of the other two points. (See Fig. 1.2.2.)

Sampling Method

Water was sampled by a serviceable sampling cylinder having a built-in thermometer. Two kinds of sampling depths were selected, i.e., one at 2 m and the other at 9/10 m below the surface according to the depth of the water. In case of depth of 9/10 m, however, it was difficult to be certain whether the sampling cylinder reached to the right depths when the current was fast. Sample waters would have been taken simultaneously at such several points as stated above along the stream if manpower and equipment were sufficient to do so, but such was not possible.

Items and Methods of Water Quality Analysis

Sample waters were analized for the items as follows by the testing apparatus by Hach Chemical Co. by their own method.

Turbidity
pH
Iron
Manganese
Hardness
Alkalinity
Nitrogen nitrate
Nitrogen nitrite
Nitrogen ammonia
Sulfate

The following items were tested according to "Analysis Methods for Potable Water" by Japan Water Works Association, 1970.

Chloride
Acidity
$KMnO_4$ consumed

Review

The data (Table 1.2.1 a. to c.) thus collected indicates that the water quality of the river is characteristic of low pH, comparatively high turbidity and relatively high iron content, but no difficulty is expected for treatment. No specific difference of temperatures and qualities is observed between surface and bottom. Mixing by meanders of the river may be the cause of the similarity.

Concentration of chloride ion in the dry season has been of the greatest concern. The maximum value recorded during the period of field survey is 153 ppm, which does not exceed the WHO and the Japanese water quality standard of 200 ppm, and the USA standard of 250 ppm. Fig. 1.1.13 shows correlation between chloride ion concentration and distance from the estuary. (cf. Fig. 1.2.2.)

Both alkalinity and hardness are low. It may indicate that soils in the river basin contains almost no lime which supplies alkalinity and hardness.

There is no problem as to nitrogen compounds. The value of $KMnO_4$ (potassium permanganate) consumed is slightly high though it is not above the WHO standard. Suspended organic matters are supposedly attributable to this value of $KMnO_4$ consumed.

One water sample was brought to Tokyo. It was analyzed and a few treatments were tried at the laboratory of Nihon Suido Consultants Co. The result of the study is shown in Table 1.2.2 and Fig. 1.2.14 and 15, which would be helpful for the follow-up study. The sample water was taken on 29th March 1973 from the river when the flow was downward.

The Saigon River will possibly be a good source of water supply, from the qualitative standpoint, if pH adjustment and iron removal are provided, although the continued survey has to be undertaken for the purpose of confirmation.

Table 1.2.1' a. WATER QUALITY DATA OF SAIGON RIVER in 1973 at the Survey Site

Date		Site	Temperature ppm	pH	R-pH	Turbidity ppm	Cl^- ppm	SO_4^{2-} ppm	Fe^{2+} ppm	Mn^{2+} ppm	Total Hardness ppm	Total Alkalinity ppm	Acidity ppm	KMnO4 consumed ppm	Ammonia Nitrogen ppm	Nitrite Nitrogen ppm	Nitrate Nitrogen ppm
25	Jan.	U S	28.6	5.5	–	36	6	–	0.90	–	7	10	–	–	–	–	–
		B	28.3	5.6	–	30	6	–	0.90	–	6	8	–	–	–	–	–
		D S	28.6	5.5	–	28	6	–	0.84	–	7	11	–	–	–	–	–
		B	28.6	5.6	–	30	6	–	0.80	0	5	9	–	–	–	–	–
26	Jan.	U S	28.6	5.5	7.1	32	6	–	0.90	0	10	10	–	–	–	–	–
		B	28.4	5.5	7.1	32	6	–	0.90	0	6	10	–	–	–	–	–
30	Jan.	D S	27.3	6.2	7.6	45	5	–	0.90	0	6	8	–	–	–	–	–
		B	27.3	6.2	7.2	48	5	–	0.90	0	7	9	–	–	–	–	–
1	Feb.	D S	27.0	6.2	7.0	50	–	–	1.17	0	6	7	–	–	0	trace	0.05
		B	27.0	6.2	6.7	55	5	–	1.25	0	6	8	–	–	–	–	–
		U S	27.0	6.3	6.9	30	4	–	0.97	(0.78)	8	9	–	–	–	–	–
		B	27.2	–	–	–	5	–	0.95	–	–	–	–	5.6	0	trace	0.06
8	Feb.	D S	28.1	6.2	7.0	28	5	–	0.95	–	7	13	–	–	–	–	–
		B	28.1	6.2	7.0	32	–	–	1.15	–	–	–	5	6.3	0	0	0.08
12	Feb.	UbS	27.9	6.2	–	25	5	–	0.95	–	7	6	–	7.8	trace	0	0.05
		B	28.0	6.2	7.3	30	5	–	0.95	–	8	8	–	7.7	trace	0	0.04
16	Feb.	D S	27.5	–	–	30	6	–	1.30	–	9	8	–	6.5	–	–	–
		U S	27.8	–	–	32	5	–	–	–	–	–	–	–	–	–	–
		B	27.8	–	–	38	5	–	0.97	–	9	8	–	5.7	–	–	–
4	Mar.	S	28.6	6.2	6.6	42	5	trace	–	–	6	8	4	5.1	0	trace	0.06
		B	28.6	6.2	6.6	45	5	–	–	–	8	7	5	5.1	–	–	–
21	Mar.	D S	–	5.9	6.5	–	149	23	0.45	–	–	–	–	–	–	–	–
		B	–	6.0	6.4	–	153	25	0.55	–	–	–	–	–	–	–	–

Table 1.2.1. b. WATER QUALITY DATA OF SAIGON RIVER in 1973

Sampling Point	Date		Temperature ppm	pH	R-pH	Turbidity ppm	Cl^- ppm	SO^{2-} ppm	Fe^{2+} ppm	Mn^{2+} ppm	Total Hardness ppm	Total Alkalinity ppm	Acidity ppm	KMnO Consumed ppm	Ammonia Nitrogen ppm	Nitrite Nitrogen ppm	Nitrate Nitrogen ppm
Phu Cuong	8 Mar.	D S	28.2	6.1	–	60	23	–	1.3(1.0)*	–	13	5	4	8.8	0	0	0.18
Bridge		B	28.2	6.2	–	61	26	–	1.28	–	–	–	–	–	–	–	–
2 km up-	12 Feb.	U S	27.8	–	–	38	5	–	1.08	–	8	8	4	6.3	–	–	–
stream		B	27.7	–	–	35	5	–	–	–	–	–	–	–	–	–	–
from																	
Phu Cuong	21 Feb.	Db S	–	6.0	6.4	–	85	9	0.75	–	–	–	–	–	–	–	–
Bridge		B	–	6.0	6.6	–	68	1	0.72	–	–	–	–	–	–	–	–
Phu Long	1 Feb.	U S	27.4	6.2	6.8	5	16	–	–	–	–	–	–	–	0.27	0	–
Bridge		B	–	6.2	–	–	18	–	–	–	10	7	–	–	–	–	0.17
	8 Feb.	D S	27.6	6.3	6.7	35	11	–	1.25(1.15)*	–	11	8	6	7.2	trace	0	0.17
Binh Trieu	1 Feb.	U S	28.0	6.3	7.2	40	250	–	0.4(0.26)*	–	87	10	–	3.8	0.13	–	–
Bridge	8 Feb.	D S	28.0	6.0	6.9	20	315	–	1.22(0.85)*	–	88	16	5	6.7	0.08	0	0.44

U: upstream
D: downstream
S: sample taken at surface
B: sample taken at bottom
Ub: at the beginning of upstream
Db: at the beginning of downstream
*: after filtration

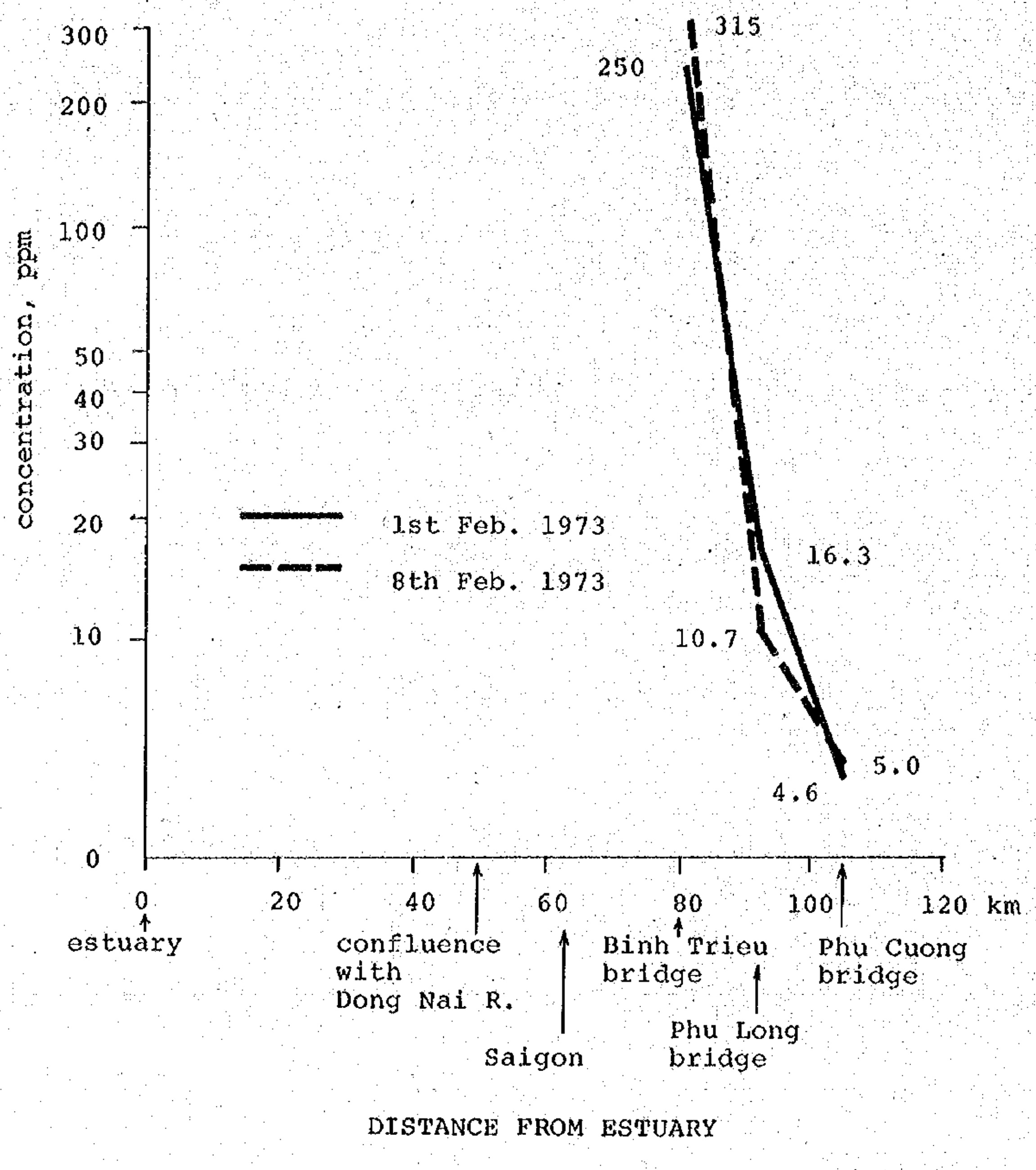


Fig. 1.2.13 CHLORIDE CONCENTRATION AND DISTANCE FROM ESTUARY

Table 1.2.2 WATER QUALITY OF SAIGON RIVER

ITEM	VALUE
Temperature of Water at the time of analysis	23.5°C
pH	5.9
Colour	yellowish, turbid contains a little brown sedimentation
Turdidity	50.5 ppm as SiO_2
Conductivity	34×10^{-6} ℧/cm
M-Alkalinity	1.1 ppm
Acidity	51.6 ppm
Total Hardness	nil
Chloride ion	6.65 ppm by the method of Mohr
$KMnO_4$ consumed	14.66 ppm
Nitrogen Nitrate	0.016 ppm
Nitrogen Ammonium	0.16 ppm
Total Iron	1.55 ppm
Manganese	0.11 ppm
Sulfate	2.50 ppm

sampled at Phu Cuong bridge on 29th March, 1973

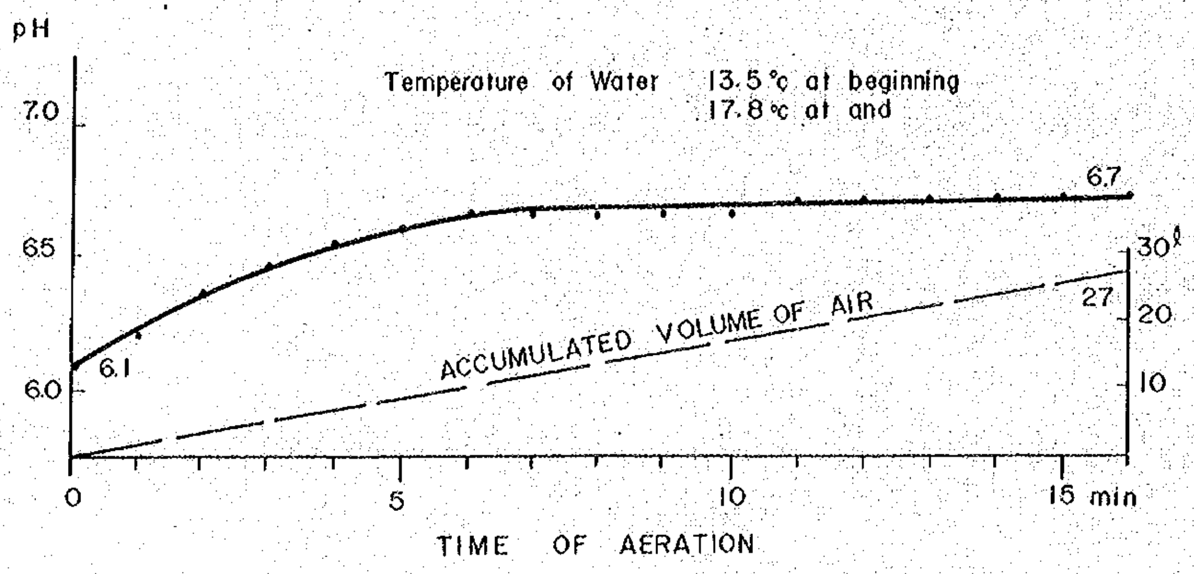


Fig I. 2.14 pH ADJUSTMENT BY AERATION

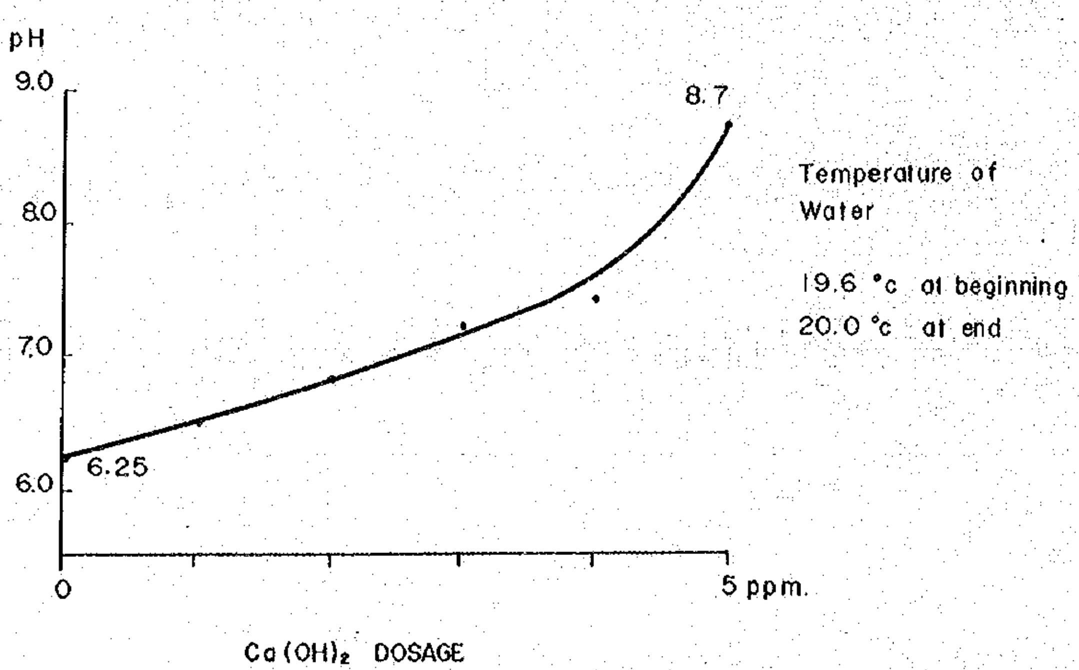


Fig I. 2.15 pH ADJUSTMENT BY CHEMICAL

I-2-5 POTENTIAL OF THE RIVER

The dry season flow of the Saigon River is considered to be a substantial amount as discussed below although sufficient data are not yet available.

An existing information states that the dry season flow was some 80 cubic meters per second. The other says that it was 25 cum per second upward, which means that the balance of alternate flows was negative. The present observation indicates that it was almost zero on an average per day.

The water surface of the river swells and lowers alternately in a long cycle of half a month relating to the tide by the orbit of the moon embracing day-to-day water surface oscillations by rotation of the earth. By the former action, water surface slowly heaves simultaneously carrying a larger frequency of oscillation during certain two weeks and then lowers during the next fortnight. Thus a considerable one day average upward flow will be observed during the swelling period even if the basic river discharge is zero and vice versa.

Since the largest average rate of swelling of water level is observed around 10 cm per day and the distance from Phu Cuong to the end point of tidal wave is roughly 22 km with average river width of about 200 m, rough balance of water brought upstream seems to be some 10 cubic meters per second on an average and vice versa as to a lowering period. As our observation mentioned above showed the discharge balance as zero per day on an average in a swelling period, this should mean that considerable basic downstream flow must exist whereas the above mentioned 25 cubic meters per second of average upward flow seems to be too big. Hence, the existence of substantial basic flow may be assumed, say, 10 cubic meters per second, during the present 24-hour survey period.

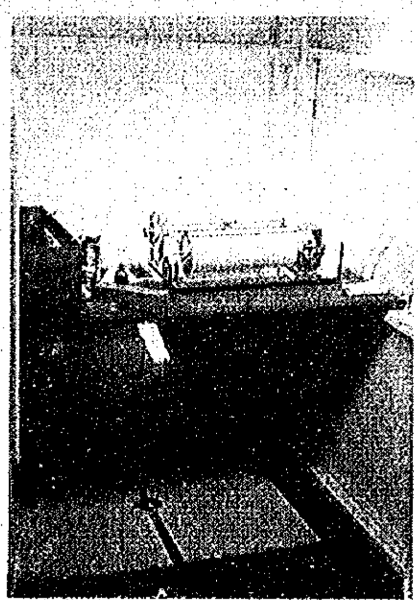
This deductive inference shall also be supported by the low salinity of the river. River water should naturally show high saliniation where the tide is predominant, near the end of the dry season if the basic flow, namely, the fresh water flow, is poor. The water analysis shows, however, that actual salt contents are unexpectedly small, which can only be explained by the existance of sizable fresh water flow.

The source of such fresh water can only be traced to the ground water at the time when there is no rainfall. Water should be stored in the ground during the wet season and discharges when river water level is lower than that of groundwater -- primarily in the dry season. In fact, small streams from the tiny springs were observed pouring into the river during the field survey.

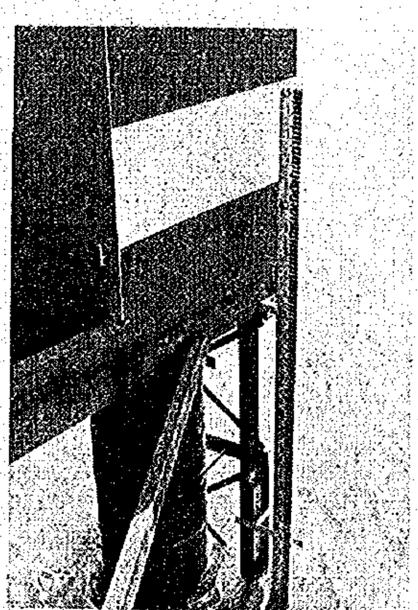
Water analysis shows that there is close similarity between qualitative property of the groundwater and that of the river water. This would also imply the origin of the river water. Groundwater will be exhausted quickly if the grade of river basin is steep like mountain side, but, in case of the Saigon River, water come out gradually to the river because of its flat river basin. Although there are only limited data to depend on as to the minimum water flow of the Saigon River, 200,000 cmd to 300,000 cmd of safe intake is anticipated on the bases of the above discussion and the information shown in Appendix A. It is worthwhile and necessary, therefore, to continue survey of the river to determine the quantity available for water supply.

View of Survey Section,
Phu Cuong,
Saigon River

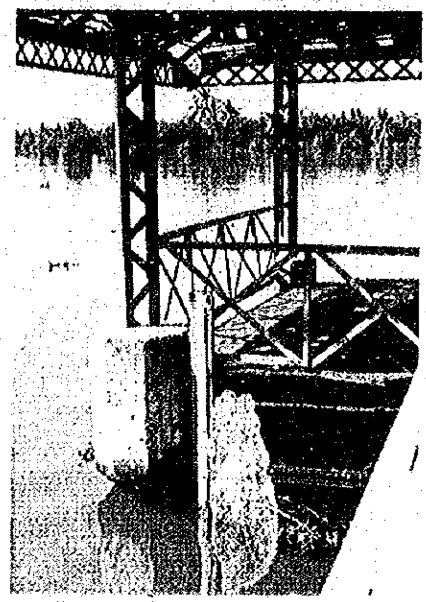
Whole View of Level Recorder House



Automatic Level Recorder



Float Well and Water Gauge



Existing Water Gauge
(80m Upstream from the Survey Line)

Current Survey

PART II IMPLEMENTATION PLAN FOR GROUNDWATER

PART II IMPLEMENTATION PLAN FOR GROUNDWATER

As the availability of the groundwater from the Hoc Mon area is confirmed as stated in PART I of the present report, the implementation plan to use the available quantity with proper facilities required is developed herein. For such purpose, future requirement of the water supply in terms of population served, per capita use and others is reviewed, on the basis of which the value of the groundwater supply as planned is assessed. The review is based on the data included in the report on Saigon water distribution project, 1972, by Metcalf & Eddy, Inc.

II-1 WATER REQUIREMENTS

According to the study referred above, there are two alternatives for the estimates on population growth, low and high, as shown in Table 2.1.2 and Fig. 2.1.1, attached herewith, on the basis of which future demands are estimated by multiplying the population served with per capita consumption. It is considered appropriate to depend on the upper trend curve for planning purpose since these two estimates are on the basis of the flat population increase rate but the population tends to trace a geometrical progression pattern rather than the arithmetical progression pattern in the urban areas of the world during the present generation. This can also be applied in case of per capita consumption rate and the high rate of estimate shown in Fig. 2.1.3 and 2.1.4 is used for the planning, which is 750,000 cmd for the population of 3,500,000 in 1980 and 1,620,000 cmd for the population of 6,500,000 in 2000. The present population in the metropolitan area is roughly estimated to be 3,300,000 to 3,500,000. The existing water supply system is the Dong Nai River system with the design capacity of 480,000 cmd but producing only 400,000 cmd due to the defect of the pumps at Hoa An intake station, which is supplying water to some 60 per cent of the population. Obsolete small scale groundwater system exists in the city but not in use except in case of emergency due to the deterioration of the water quality such as salt intrusion and high iron contents. Obviously, some 1,400,000 population is not provided with adequate treated water supply under the present condition. The additional effort therefore has to be directed to 1) improvement of the existing Dong Nai system, 2) expansion of facilities to cover unserved population and 3) preparation for meeting the future demand.

Table 2.1.1 Estimated 1970 Population in Study Area

Location	Estimated population	Area, ha	Density, ppha
Prefecture of Saigon	2,075,000	6,920	300
Gia Dinh Province(portion within study area)	823,000	12,960	63
Total in study area	2,898,000	19,880	146

Table 2.1.2 Estimated Population and Population Served

		1980		2000	
	1970	Low	High	Low	High
Population, amount					
Saigon	2,075,000	2,768,000	2,768,000	2,600,000	3,460,000
Gia Dinh[1]	823,000	1,832,000	1,832,000	3,000,000	4,490,000
Total	2,898,000	4,600,000	4,600,000	5,600,000	7,950,000
Population Served, percent					
Saigon	77	83	83	96	90
Gia Dinh[1]	44	55	66	75	76
Study Area	68	72	76	85	82
Population Served, amount					
Saigon	1,600,000	2,300,000	2,300,000	2,500,000	3,100,000
Gia Dinh[1]	360,000	1,000,000	1,200,000	2,250,000	3,400,000
Total	1,960,000	3,300,000	3,500,000	4,750,000	6,500,000

1 That portion of Gia Dinh Province within the study area.

Table 2.1.3 Total Per Capita Water Requirements

		Per capita requirements, lpd		
		1970	1980	2000
Saigon	Low	175	200	220
	High	175	220	250
Gia Dinh	Low	133	180	200
	High	133	200	250

Table 2.1.4 Estimated Annual Average

Daily Water Requirements

Within Study Area

Year	Area	Estimated population served	Per capita water demand,[1] lpd	Estimated water demand, thousands cu m/day
1970	Saigon-Cholon	1,600,000	175	281
	Gia Dinh	360,000	133	48
	Total	1,960,000		329
Low Estimate				
1980	Saigon-Cholon	2,300,000	200	460
	Gia Dinh	1,000,000	180	180
	Total	3,300,000		640
2000	Saigon-Cholon	2,500,000	220	550
	Gia Dinh	2,250,000	200	450
	Total	4,750,000		1,000
High Estimate				
1980	Saigon-Cholon	2,300,000	220	510
	Gia Dinh	1,200,000	200	240
	Total	3,500,000		750
2000	Saigon-Cholon	3,100,000	250	770
	Gia Dinh	3,400,000	250	850
	Total	6,500,000		1,620

[1] Includes allowances for government, millitarry, industrial, society, and unaccounted-for water.

Table 2.1.1 to 4 were extracted from "Saigon Water Distribution Project", January 1972, Metcalf & Eddy Inc.

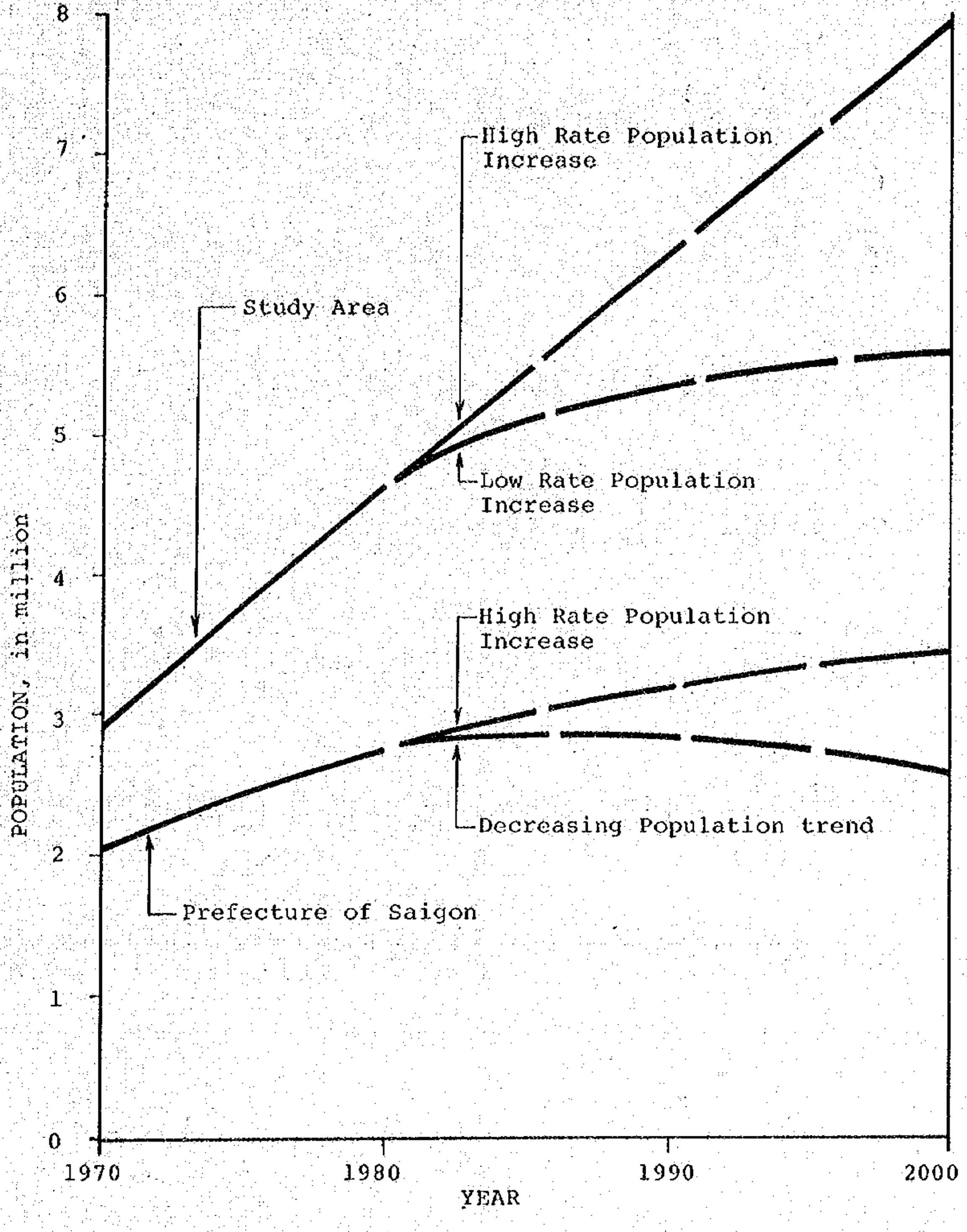


Fig. 2.1.1 POPULATION OF SAIGON

Extracted from "SAIGON WATER DISTRIBUTION PROJECT" January 1972, Metcalf & Eddy Inc.

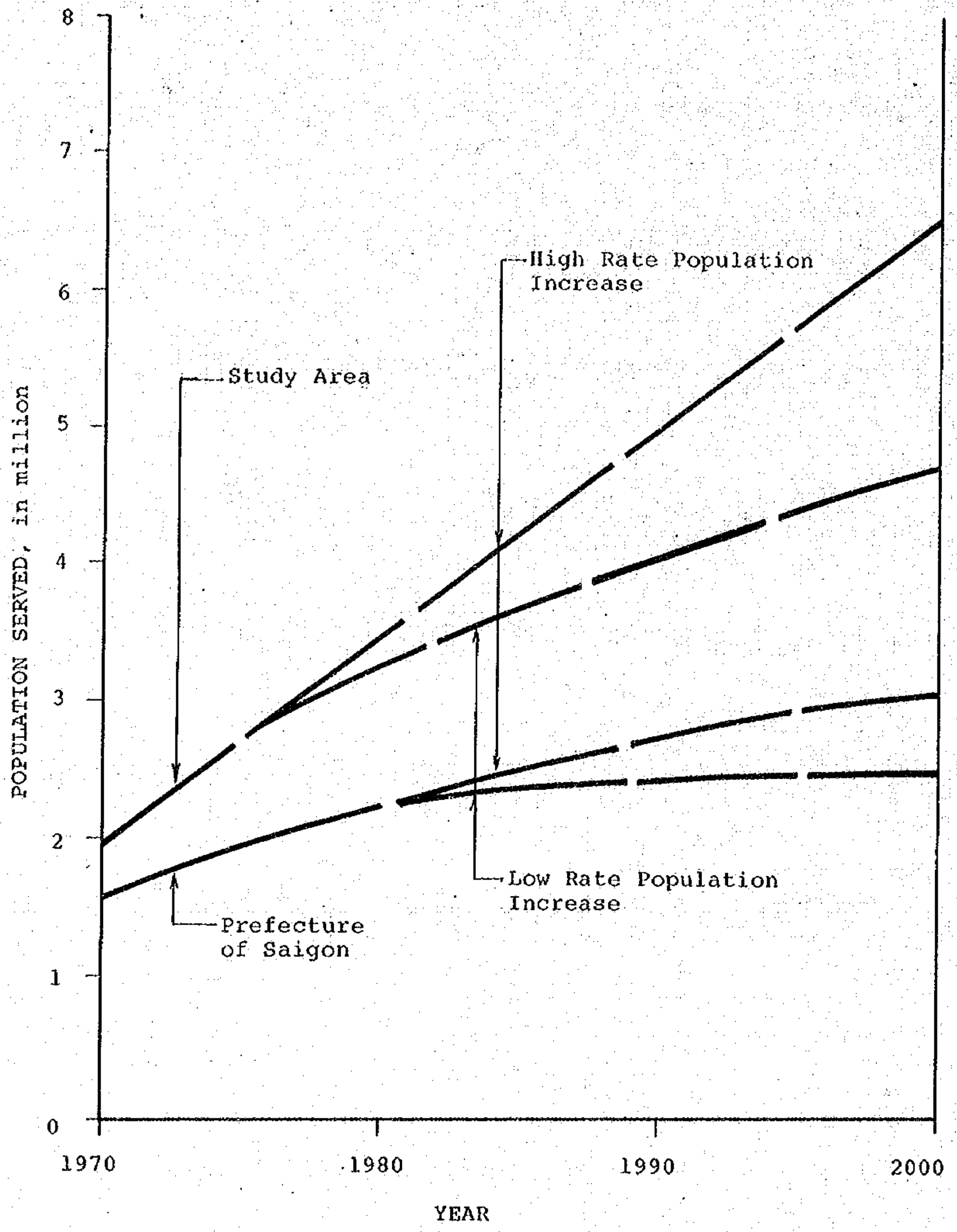


Fig. 2.1.2 POPULATION SERVED BY WATER SYSTEM

Extracted from "SAIGON WATER DISTRIBUTION PROJECT"
January 1972, Metcalf & Eddy Inc.

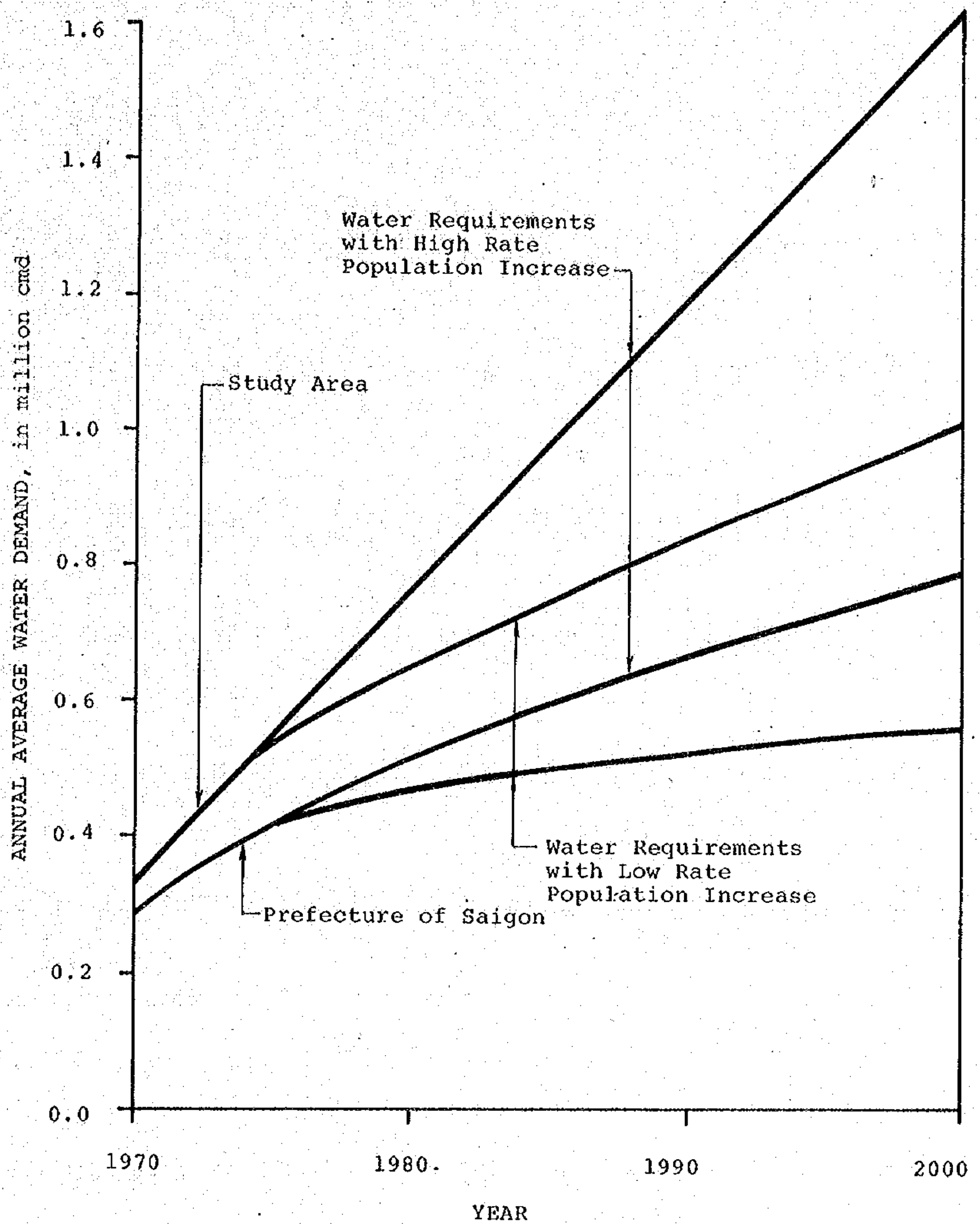


Fig. 2.1.3 DEMAND FOR WATER

Extracted from "SAIGON WATER DISTRIBUTION PROJECT"
January 1972, Metcalf & Eddy Inc.

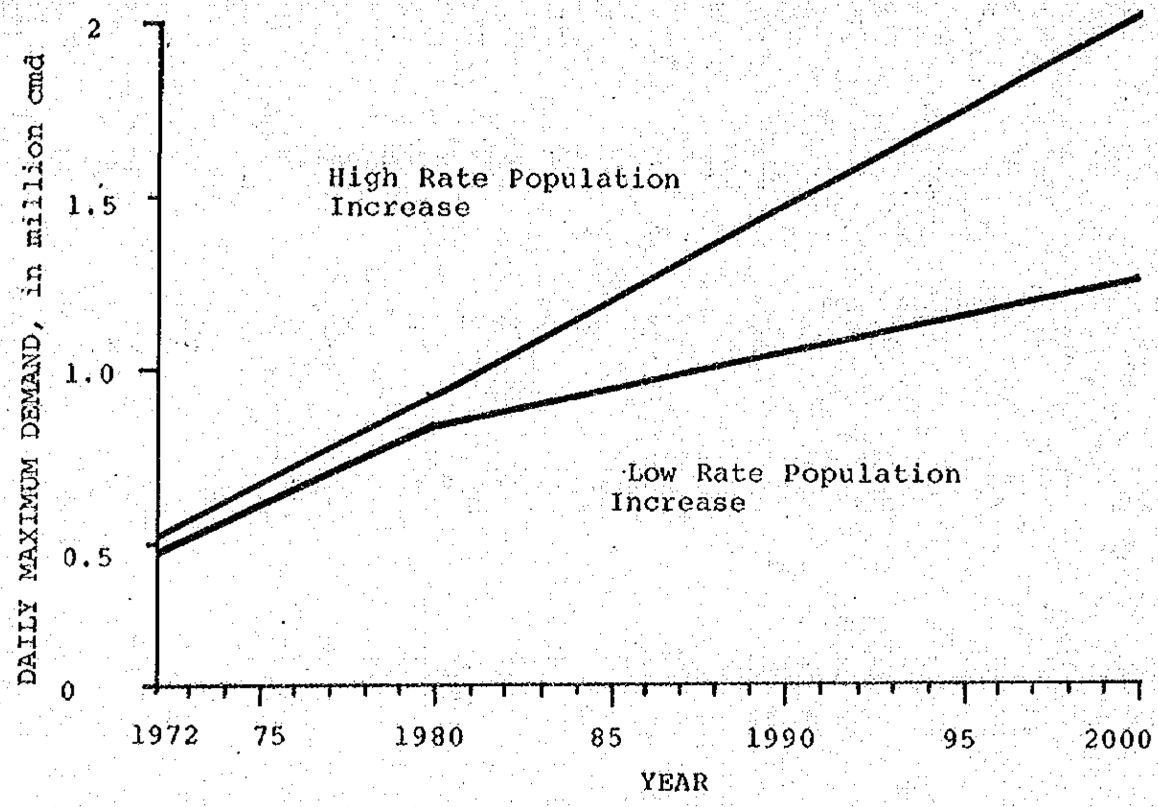


Fig. 2.1.4 DAILY MAXIMUM DEMAND

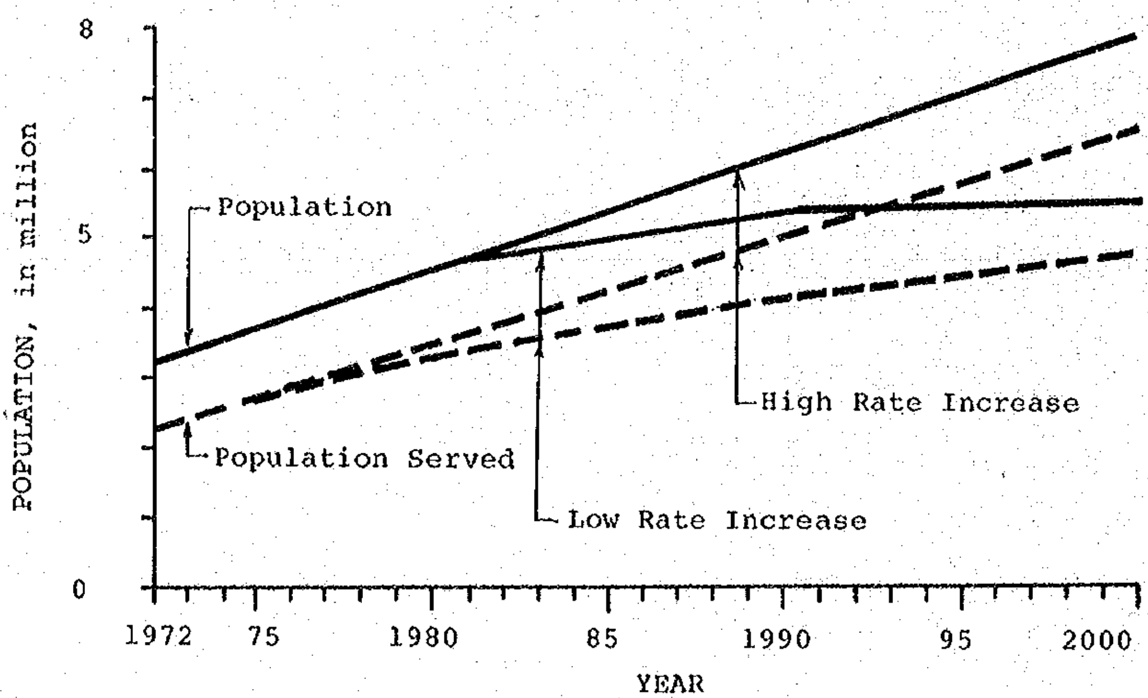


Fig. 2.1.5 POPULATION ESTIMATED

Based on "SAIGON WATER DISTRIBUTION PROJECT"
January 1972, Metcalf & Eddy Inc.

II-2 EXPANSION PROGRAM

As discussed previously, need of an additional water supply in Saigon Metropolitan Area is imminent. In this situation a couple of measures have been envisaged by SMWO as follows:

a) Improvement of the existing intake and treatment facilities in the Dong Nai system,

b) Development of groundwater in the northern suburbs of the Saigon City and

c) Development of the Saigon River.

Improvement of intake pumps at the Dong Nai River has already been undertaken in the way of engineering studies since a certain amount of supply increase, hopefully 300,000 cmd, is likely to be attained economically by this measure. When implemented, this will no doubt be helpful in adding water supply but this alone does in no way solve the supply shortage of the city.

Development of groundwater in the northern suburbs of the city is long-discussed problem. The possibility of groundwater development was also suggested in the report of the first water supply survey mission from Japan to Saigon in 1971 and the availability of groundwater is now confirmed by two technical teams in 1972 and 1973, and the details of the findings are stated in PART I of the present report. In this connection, it is important to take note of the several distinctive merits in undertaking the groundwater supply project, which can be summarized as follows:

1) Some 200,000 cmd of groundwater is available relatively near the City of Saigon,

2) Continuity of supply will be assumed even in case of breakdown of either one of the supply sources since the Dong Nai and the groundwater sources are independent each other.

3) Construction period will be shorter than the case of a supply system by the surface water source,

4) Water distribution will be improved since the groundwater supply main is planned to be connected to the distribution mains at the Cholon sector where low service pressure areas are dominant and number of housing areas are expected to be developed,

5) Expansion program in several stages can easily be developed by adding production wells one after another in accordance with the growth of demand and the availability of financial resources,

6) Project cost will relatively be small since no expensive treatment is required and

7) Groundwater is a safer water source in terms of water quality while surface water is subject to salinity intrusion and other pollution sources.

The plan and the facilities required are enumerated in the succeeding section of this report.

The Saigon River will be a useful water source for the distribution system of the Metropolitan Area as it requires less length of transmission main than that from the Dong Nai River with no necessity of river crossing at the Saigon River and also the supply from such direction contributes to the improvement of water distribution more than from the Dong Nai River. Unfortunately, however, data on the flow of the river have not yet been sufficiently collected in determining the action to be taken, and the continued effort in securing necessary data is needed.

In addition to the above-mentioned three measures, further development of the Dong Nai River should be considered for long-range planning. A master plan for Saigon Metropolitan Water Supply System up to the year 2000 with possible water sources is currently being prepared by an engineering consultants, and it is expected that the use of the Dong Nai River will fully be explored in this report.

For the sake of easy reference, correlation between estimated demands and the expected implementation schedule of water supply projects as described in the preceeding paragraphs is shown in Fig. 2.2.1. Demand curves in the figure are based on the estimates in the report by Metcalf and Eddy, Inc., as previously referred.

The sources of supply are, for the immediate projects, 200,000 cmd from Dong Nai improvement program in two stages and another 200,000 cmd from groundwater also to be implemented in two stages. For further implementation of the projects, supplies from the Saigon and the Dong Nai Rivers are indicated, assuming that the further surveys will verify the availability of sufficient water to meet the estimated demand.

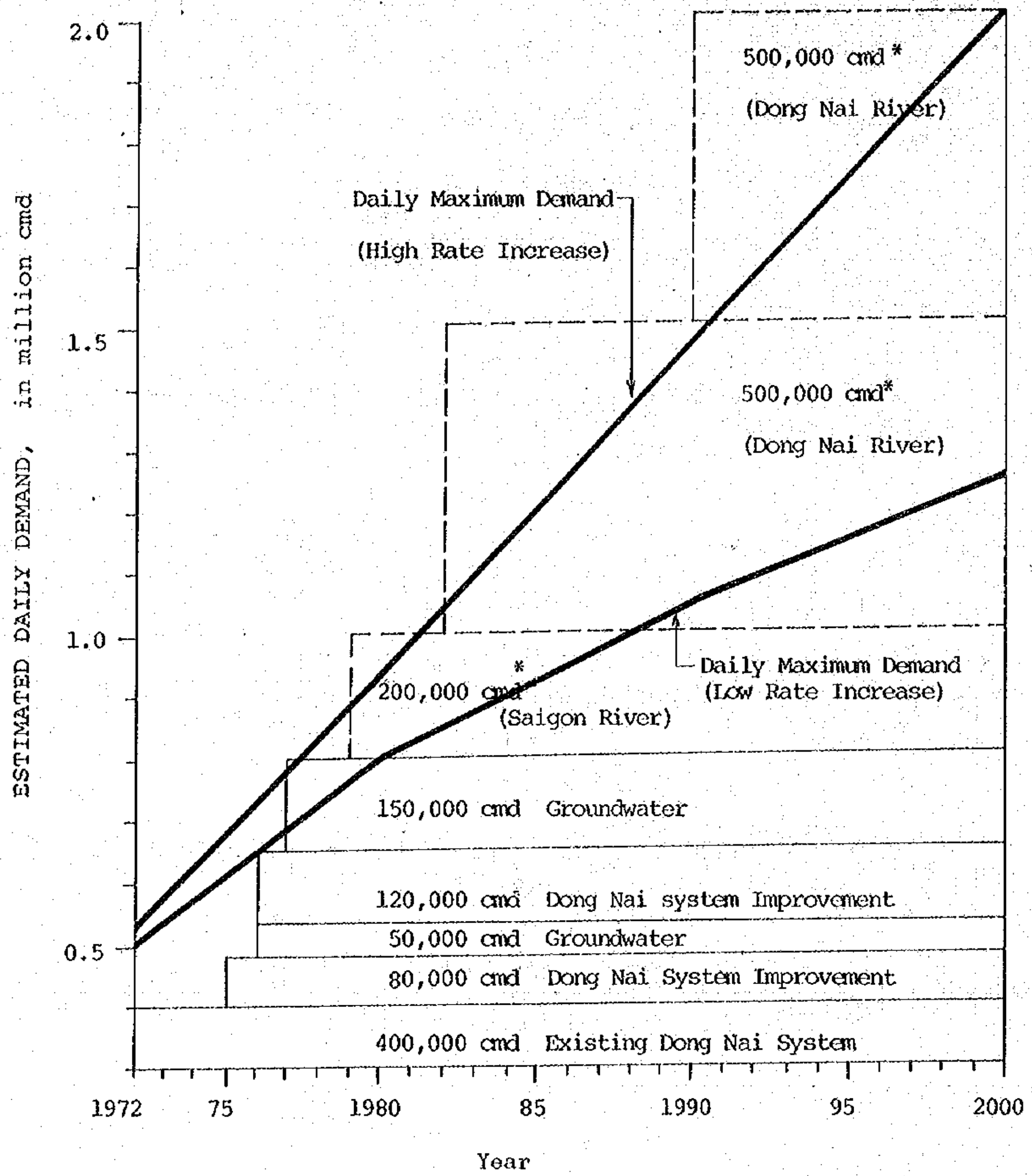


Fig. 2.2.1 ESTIMATED DAILY DEMAND AND CONSTRUCTION SCHEDULE

Based on "SAIGON WATER DISTRIBUTION PROJECT" January 1972, Metcalf & Eddy Inc.

* Not yet projected

II-3 IMPLEMENTATION OF THE GROUNDWATER PROJECT

II-3-1 GENERAL

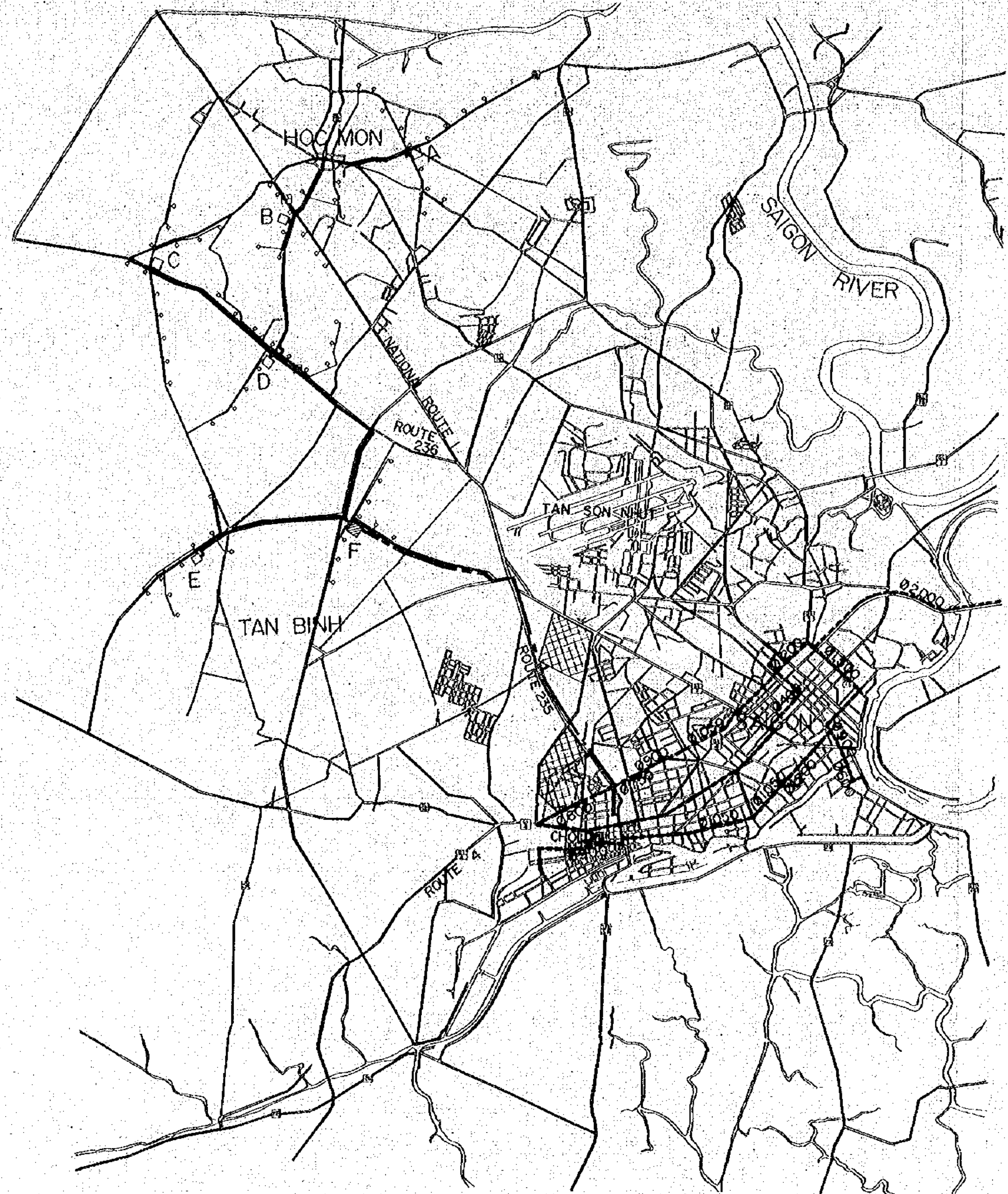
Development of groundwater is proposed in the area of 150 sqkm of which center is the town of Hoc Mon. For the reason already stated in PART I of the present report, the lower aquifers of the 3rd and 4th will be used for the project, which is feasible avoiding adverse effect to the shallow wells for inhabitants in this proposed well field.

Proper pumpage per well will be 3,000 cmd on an average, requiring 70 (deep) wells for the project. These wells are to be divided into six groups for the purpose of sound hydraulic designs and reliable control of the well system. Wells will be arranged at an interval of at least 500 m and discharge from one well group will be 27,000 to 39,000 cmd. A tentative layout of the project is shown in Fig. 2.3.1. Locations of wells will be carefully selected to avoid possible pollution from the ground surface and also any damage to the shallow wells.

As shown in Fig. 2.3.1, the groundwater amounting some 210,000 cmd at the Hoc Mon area and through the treatment plant, transmitted southward into the existing distribution trunk mains, which will improve chronical low pressure in the Cholon area and boost up the supply. Besides, a few branches for the new distribution network are planned to be implemented shortly.

The estimated total cost for construction will be between US$7,580,000 and US$8,190,000 in local currency and between US$15,220,000 and US$16,410,000 in foreign currency, according to the schedule of implementation, which makes the total of US$22,800,000 to US$24,600,000.

It is considered advisable that the size of construction schedule shall initially be small which will be followed by the succeeding program in accordance with the increase of demand. This will have the merit of limitting the size of the investment according to the actual need of water supply avoiding over-investment by embarking on the large scale construction program from the very beginning, and also the construction period is short for getting additional water supplies. Another merit which should not be overlooked is the fact that the personnel engaged in the management of the groundwater system which will be the new type of work for them shall have the opportunity to gain experience and train themselves for their responsibilities before they enter into the new type of operation since not many educated personnels seems to be available from the beginning. The plan is developed, therefore, to undertake some 50,000 cmd project initially and 150,000 cmd project at the next stage separately. Another alternative of initially 100,000 cmd to be followed by another 100,000 cmd later is also considered and cost estimates developed. These are described in detail in the succeeding section of the report.



LEGEND

- WELL
- RELAY PUMPING STATION
- WATER TREATMENT PLANT
- COLLECTION MAIN
- RAW WATER MAIN
- TREATED WATER MAIN
- EXISTING SERVICE MAIN
- NEW HOUSING AREA

1 0 1 2 3 4
kilometers

Fig. 2.3.1 LAYOUT OF GROUNDWATER SUPPLY SYSTEM

II-3-2 PROPOSED FACILITIES

ALTERNATIVE 1

The project will be in two different stages. The production will actually be 54,000 cmd from 18 wells for the first construction program and 156,000 cmd from 52 wells for following construction stage totaling 210,000 cmd from 70 wells.

At Stage 1, treatment will be only aeration, lime dosing and disinfection. No filtration shall be provided because of its relatively small quantity to be fed into the existing trunk mains from Dong Nai source.

At Stage 2, filtration will be added to the above for treatment with design capacity of 210,000 cmd also accommodating the raw water from Stage 1 program. The raw and treated water mains for the Stage 2 are laid in parallel with the previously installed mains during Stage 1.

1) Intake Stations

An intake station consists of a production well, a pump and a pump house. The site area will be some 120 sqm. Generally speaking, a well will be sized as 300 mm in diameter and 150 m in depth. Because of the particular raw water quality, thick wall steel pipe is recommended for well casing and stainless steel well screen should be incorporated. Well pumps will be a type of submersible motor pumps whose material facing the water will be also stainless steel. One spare set of well pump will be provided at each block.

In addition to the above, a level meter for the water level inside the casing pipe and a flow meter for the individual well will be installed so as to inspect the discharge and the productivity of the well. Local switch gears will also be installed in the pump house for the purpose of manual operation of an individual pump.

The layout is shown in Fig. 2.3.2.

2) Raw Water Transmission

a. Collection Main

Raw water is collected from the wells by pipes of 250 to 450 mm in diameter to each pumping station except the one from the well group next the treatment plant from which the water will be directly piped to the treatment plant. Reinforced concrete pipe (hereafter RCP) is preferable than the other materials, such as ductile cast iron or steel pipe, as the cost is less and yet more resistible against the aggressive property of the raw water. The relatively small diameters of pipes and fairly low hydrostatic pressure according to the plan also support the use of RCP for the raw water collection mains.

b. Relay Pumping Station

Each pumping station consists of an aerator for decarbonation of the raw water, three pumps and a pump house. The site area will be some 2,400 sqm on an average.

The pump house includes a pump suction well, a pump room, a control room, an electric room, an office and others. One relay pumping station will be constructed in Stage 1 and four stations in Stage 2. The relay pumps are manually operated by a command from the control center in the treatment plant. Electric power for well pumps and relay pumps is supplied by a commercial power plant through the transformers in the treatment plant.

c. Raw Water Main

The raw water mains are laid from the relay pumping stations to the treatment plant. The national route 1 is topographically a good road to follow for a piping route, but is now completely paved and the traffic is heavy. The communal route 236 runs in parallel with the route 1 on the west side with less traffic and sufficient width for pipe laying. Hence, raw water main is to be laid in this road. Some part of it will touch the town of Hoc Mon but it is unavoidable in order to be economical.

The relay pumping stations shall be placed in accordance with the route of the pipe lines.

The material of the pipe to be used both for raw and treated water should be against corrosion by the groundwater and soils. Buoyancy occasionally caused by the groundwater while pipes are empty during construction may occur and the heavy materials may be preferable. In addition, it should of course be inexpensive. Taking these factors into consideration, Pre-Stressed Concrete Pipe (hereafter PSCP) is recommended in comparison with steel and ductile cast iron pipes.

Diameters of raw water main ranges from 600 mm to 1,100 mm. At Stage 1, the raw water main will be 600 mm in diameter and its hydrostatic pressure will be less than 2.0 kg/sqcm. At Stage 2, they ranges from 700 mm to 1,100 mm and the hydrostatic pressure will be 4.5 kg/sqcm for smaller diameter pipes (700 mm to 900 mm) and 2.0 kg/sqcm for the bigger diameter pipe (1,100 mm) at maximum. However, 14 kg/sqcm and 10 kg/sqcm of test pressures will be required for specification of pipe manufacturing with anticipation of additional loads by handling during construction and vehicle traffic after completion. Industrial standards for these types of materials are available in Japanese standard, JIS (A5333-1971), US standard, ASTM, etc. Special protection may be considered for outside of the pipe body in the area of the most corrosive soils. Pipe installation must be executed during the dry season, especially in lowlands. Sand or pebble foundation should be provided for pipe laying in order to disperse exterior load uniformly and to prevent pipes from unequal sinking.

3) Treatment Facilities

The water treatment plant will be located some 3 km west of Tan Son Nhut airport.

Simple method of treatment will be sufficient since the quality of the raw water is fairly good. The water is distinguished by low pH, alkalinity and hardness values, high content of free carbon dioxide and accordingly high acidity. It looks colorless and transparent but tastes slightly bitter supposedly because of dissolved iron, whose concentration, however, is rather low. The result of water quality analysis in the groundwater survey is shown in Tables 1.1.4 to 6. Iron and manganese removal must be provided since potential increase of their contents is predictable in the future although they are rather small at present. Control of alkalinity and pH value by adding lime is also needed to prevent supply system from corrosion and to make water palatable. Pre-chlorination and sand filtration will be effective to remove iron and manganese.

Raw water aerated at relay pumping stations will come to the flash mixer of the plant where it is rapidly mixed with (hydrated) lime and chlorine. Lime will be dosed so as to raise pH and alkalinity. Higher pH is effective to acceralate oxidation of iron and manganese. Then the water flows down in sequence of flash mixer, contact basin, filter and treated water reservoir. Treated water is desirable to maintain some 20 ppm of alkalinity and 8 to 9 of pH value. This will be attained by dosing 15 ppm of lime. Chlorine residual shall be adjusted by postchlorination. The dosing rate of chemicals will be as follows:

	Normal	Maximum
Pre-chlorination	1 to 2 ppm	4 ppm
Post-chlorination	1	2
Lime	15	20

Quantity of treatment is controlled by arbitrarily setting number and output of the individual unit process. Filters are washed through programmed sequence triggered manually or automatically and the wash water is pumped from the treated water reservoir to the filter directly. Individual and total production from filters are recorded at the control room. Structures of the contact basin and the filter are shown in Fig. 2.3.6.

4) Treated Water Pumps and Pumping Station

The hourly maximum pumping rate will be 80,000 cmd at Stage 1 and 320,000 cmd at Stage 2 which are 1.6 times the daily maximum pumping rates.

a. Treated Water Pumps

Three sets and five sets of treated water pumps will be installed for Stage 1 and Stage 2 respectively. They will be specified so that water head at the end of the treated water main is maintained at 40 m above the mean sea level (effective pressure, some 35 m) at peak hours. Pumps are controlled manually in order to maintain outlet pressure optimum. An alarm will come up for drop of outlet pressure and pumps will be put into operation one after another and vice versa in case of pressure increase. In some occasions, however, e.g., in case demand is too small or too large as to the plant capacity, pumping shall be rated irrespective of the above optimum pressure. Pumps will be operated from the control room.

b. Pumping Station

The pumping station will be situated on the basement of each administration building for both of the stages, where three treated water pumps for Stage 1 and five treated water pumps, two backwash pumps and two surface wash pumps for Stage 2 will be installed respectively. Flow-meters and control valves of treated water main are placed in each flow-meter chamber outside the pumping stations.

5) Administration Building

A small scale administration building will be constructed in Stage 1 containing control center, electric room, chemical feeding room and pumping station. Some of facilities in these rooms may be transferred to the administration building which will be constructed in stage 2 for functional administration. Chemicals can be stored in a temporary storehouse of inexpensive structure.

The administration building for Stage 2 will contain control center, laboratory, chemical feeding room, chemical storage room, electric room, attendants room, pumping station and others. The chemical storage room shall be equipped with truck deck for chemical handling. Principal rooms will be air-conditioned. The administration building is outlined in

Fig. 2.3.7.

6) Power Supply

A power plant will not be needed since the power as required in this project will be supplied from a commercial plant near the proposed treatment plant. Well pumps and relay pumping stations will also be supplied with power from this power plant through transformers in the treatment plant. High tension receiving equipment will be installed with total capacity of 10,000 kVA.

7) Treated Water Main

a. Size and Material

The size of the treated water mains will be 900 mm in diameter at Stage 1 and 1,350 mm at Stage 2 on the hourly maximum flow of 80,000 cmd and 240,000 cmd respectively. PSCP is again recommended for both mains. PSCP by 14 kg/sqcm of test pressure will be sufficient for maximum hydrostatic pressure of 6.5 kg/sqcm plus additional pressure and impacts for both of the mains.

b. Piping Route

Considered should be the conditions as follows:

1. Improvement of distribution is desired especially for an increase of service pressure in the Cholon sector,
2. The new water treatment plant is situated in the northwest of Saigon and
3. The new treated water mains shall be connected to the existing trunk mains which are big enough to receive newly supplied groundwater.

The route of the treated water mains (900 mm and 1,350 mm in diameter) shall be the national route 1 from the plant, run several hundred meters along it, turn into the communal route 235 and go southward until they reach the center of the Cholon area passing through the west side of the horse-racing track.

The treated mains are connected to the existing distribution trunk mains, ϕ 750 mm, ϕ 400 mm and ϕ 1,050 mm at Tran Quoc street, Hong Bang street and Dong Khan street respectively. Two branches may be provided so that water can be supplied into the new distribution network when completed in the north of the Cholon sector, where population is growing rapidly. (See Fig. 2.3.1.)

ALTERNATIVE 2

The project will be in two different stages. The production will be 105,000 cmd from 35 wells for the first construction program and the same quantity for the following construction stage.

The raw and treated water transmission mains for ultimate treatment quantity, 200,000 cmd, will be one line and installed at Stage 1.

The layout of wells, relay pumping stations and treatment plant is not different from that of Alternative 1 shown in Fig. 2.3.1.

Diameter of collection main will be ϕ250 to ϕ450 mm, that of raw water main will be ϕ800 to ϕ1,100 mm at first stage. They will be respectively ϕ250 to ϕ450 mm and ϕ600 to ϕ700 mm at second stage construction.

The method of water treatment will be aeration, lime dosing, filtration and disinfection, which will be provided from Stage 1.

The layout of treatment facilities is shown in Fig. 2.3.4.b.

The treatment water transmission main will be 1,500 mm in diameter and laid as shown in Fig. 2.3.1.

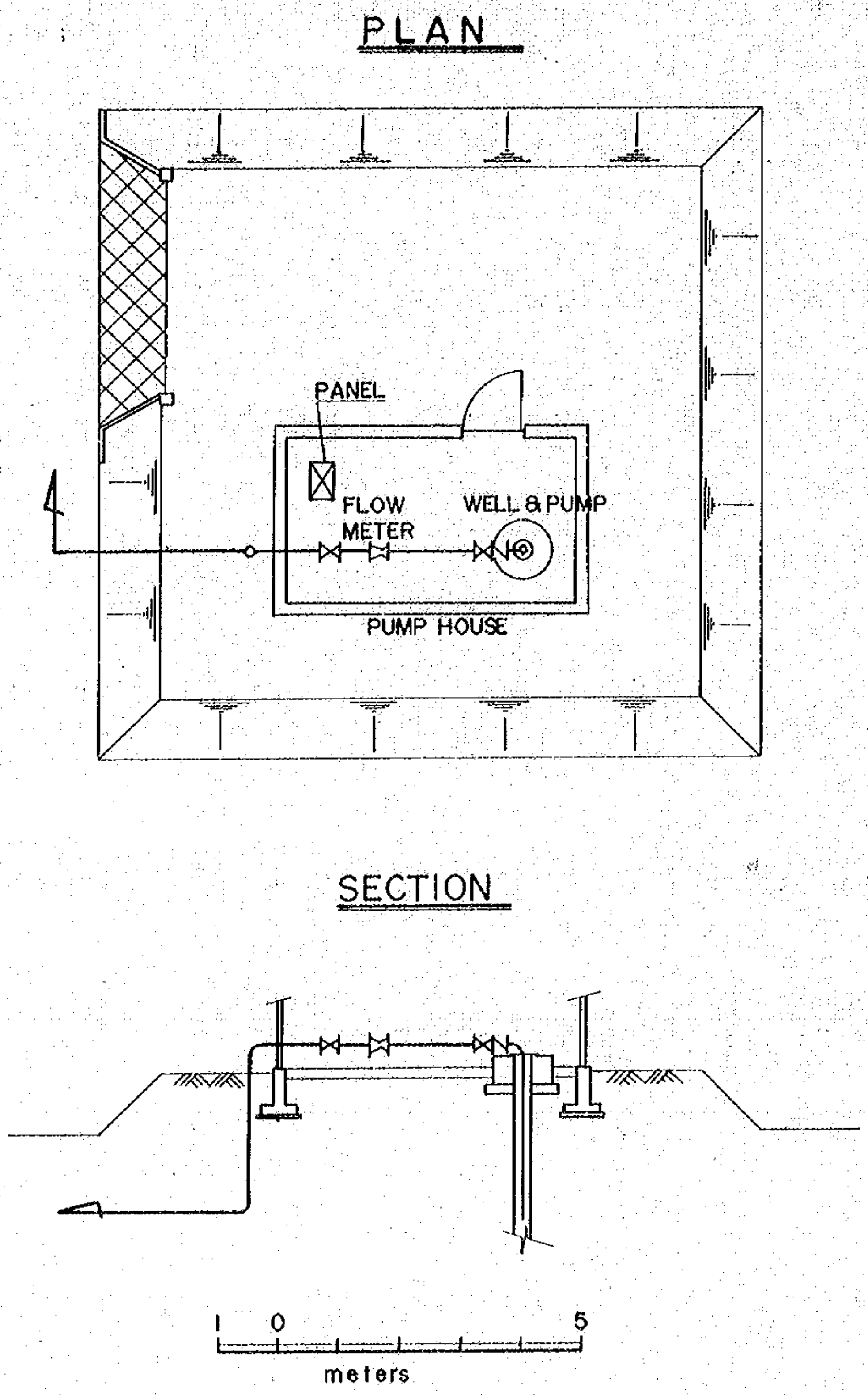


Fig. 2.3.2 INTAKE STATION

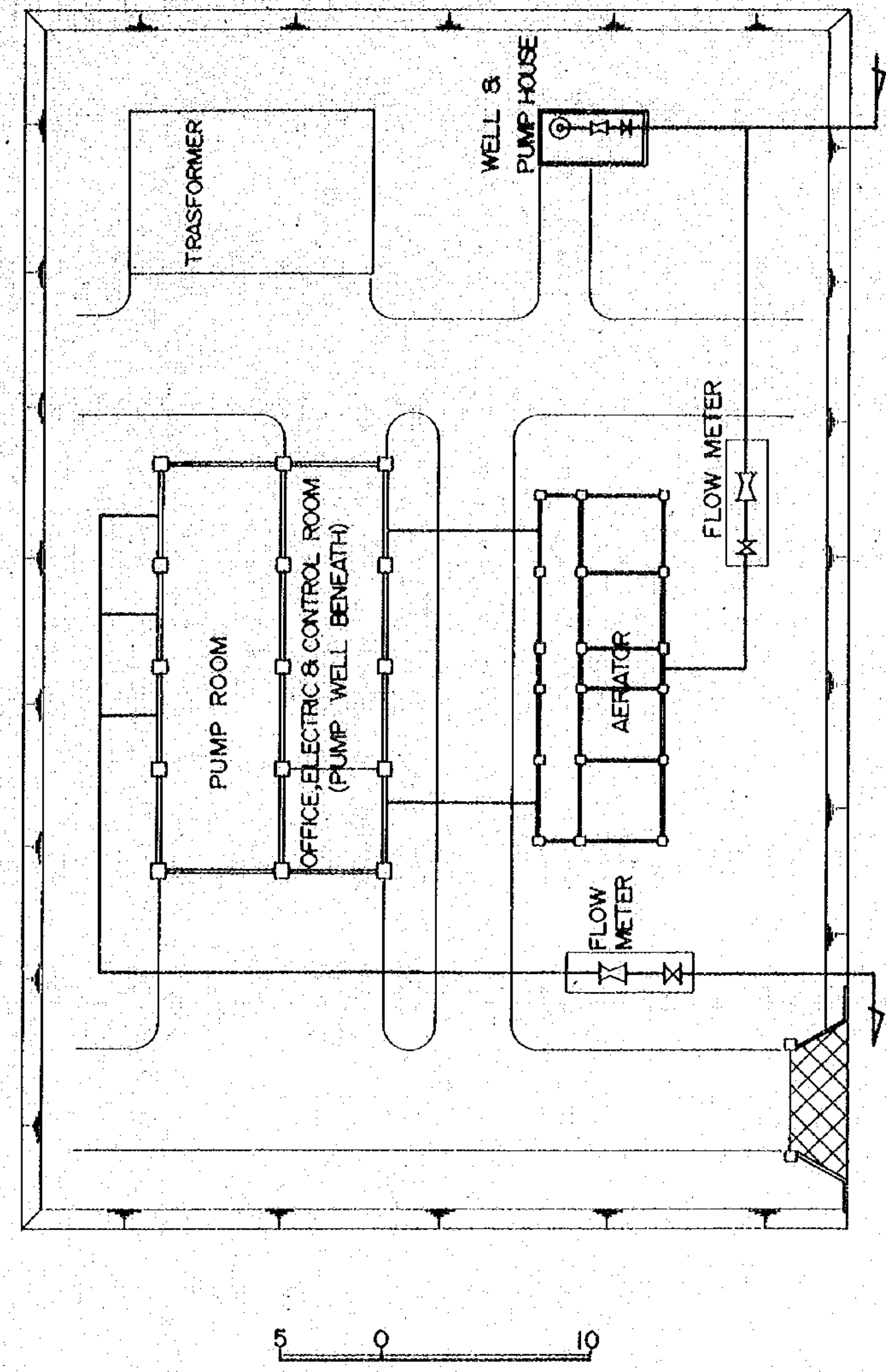
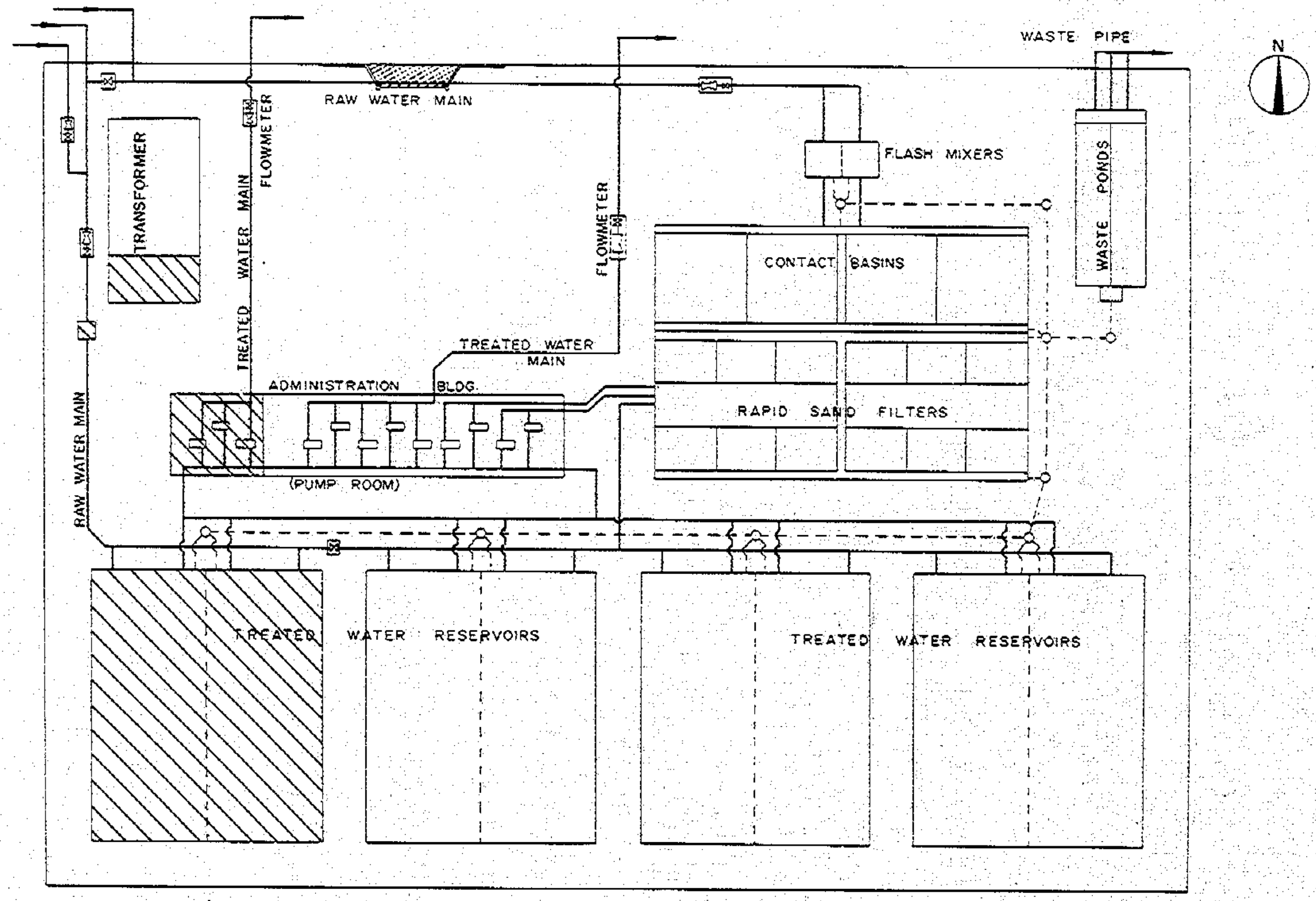


Fig.2.33 RELAY PUMPING STATION



LEGEND
1 st Stage 2 nd Stage

0 10 20 30 40 50
meters

Fig. 2.3.4.a TREATMENT PLANT
GENERAL PLAN ALTERNATIVE I

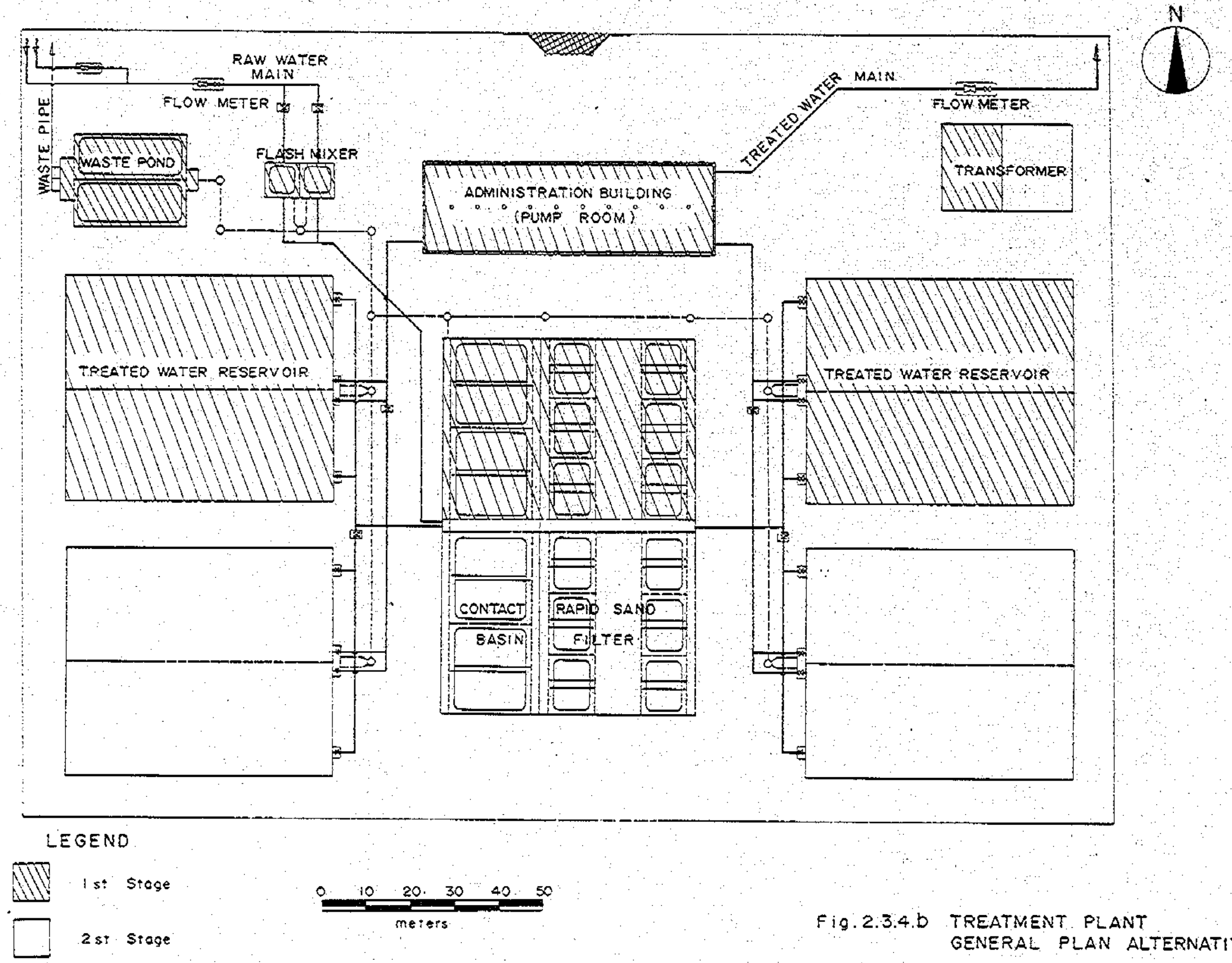


Fig. 2.3.4.b TREATMENT PLANT
GENERAL PLAN ALTERNATIVE 2

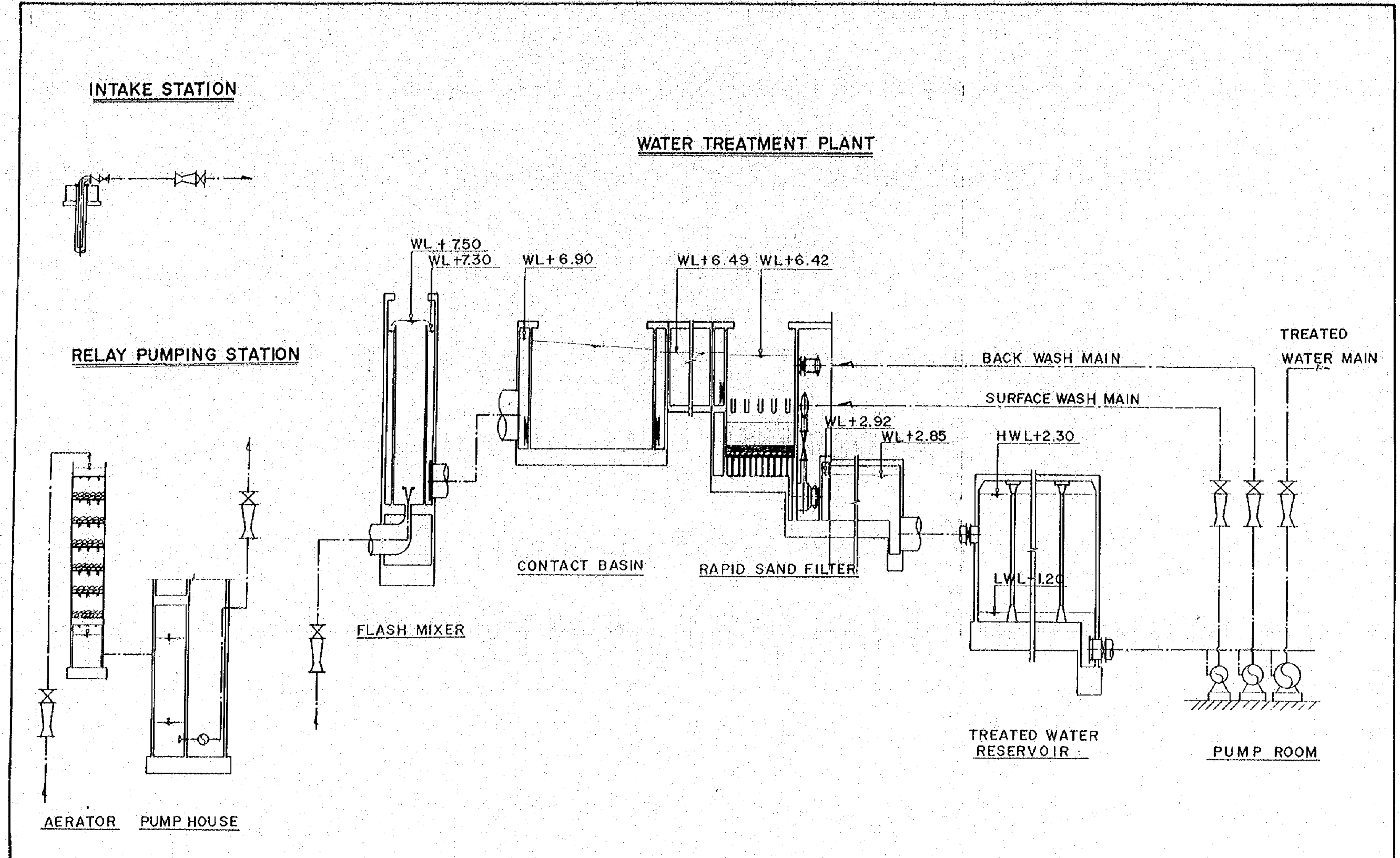


Fig. 2.3.5 FLOW DIAGRAM

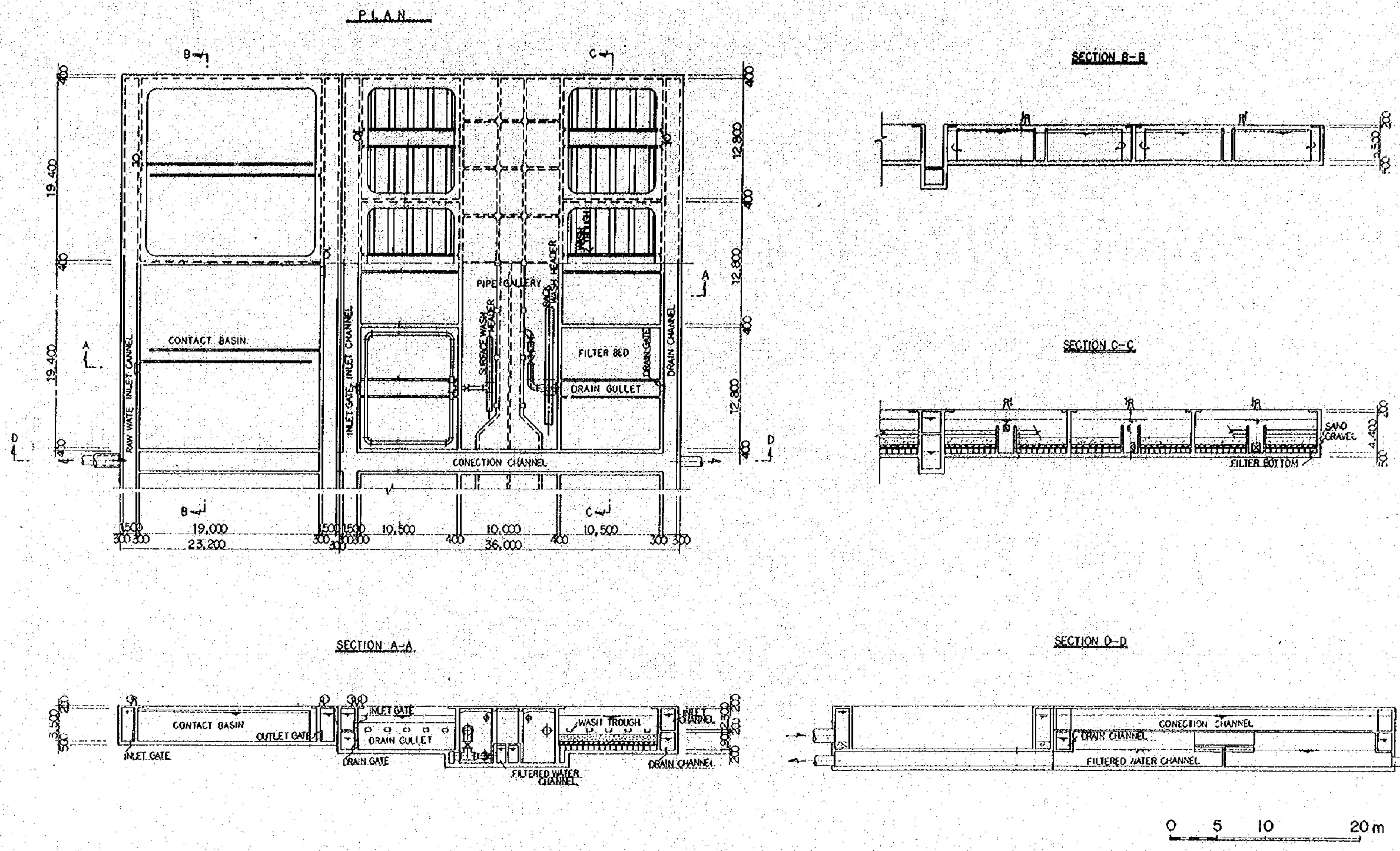


Fig. 2.3.6 CONTACT BASIN & RAPID SAND FILTER

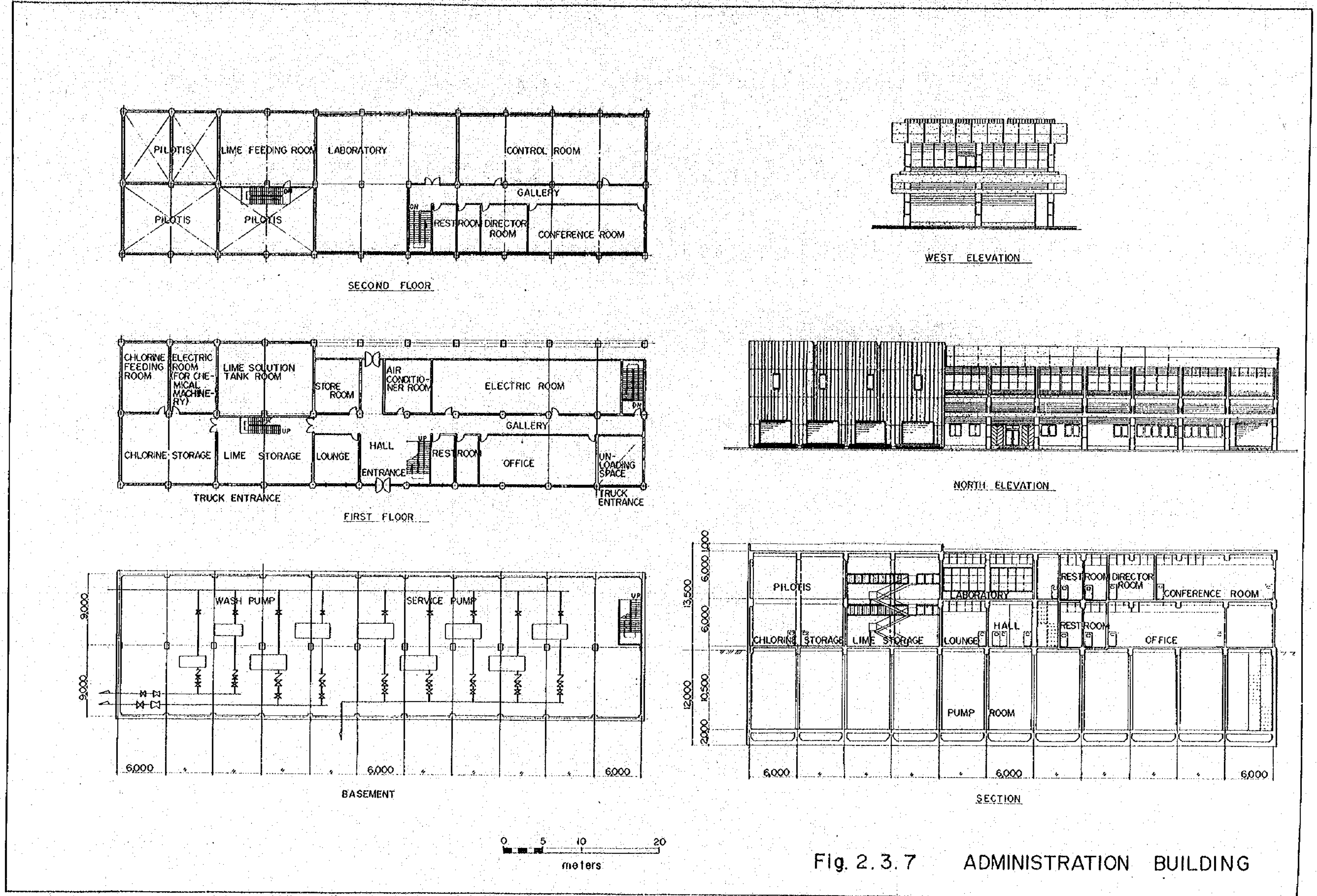


Fig. 2.3.7 ADMINISTRATION BUILDING

8) Summary of Facilities

Alternative 1

Stage 1 (Q = 50,000 cmd)

(1) Intake Stations

Total discharge: 54,000 cmd (18 wells x 3,000 cmd/well)

Well: diameter ϕ 300 mm, depth 150 m

Screen: diameter ϕ 300 mm, length 25 m

Pump: submersible motor pump

Delivery dia. (mm)	Discharge (cum/min)	Delivery head (m)	Speed power (rpm)	Input power (kw)	No. of set
150	2.1	35	3,000	22	1

Pump house: 3 m x 5 m = 15 sqm

Electrical equipment:

3 kV power receiving and transformation equipment from relay pumping station and 400 V low tension power distribution equipment.
Indicators of well water level and discharge.
Switch gear.

Miscellaneous: piping, fence, road, etc.

Site area: 120 sqm

(2) Raw Water Transmission

a) Relay pumping station: 1

Aerator: 45 sqm x 6 stages

Relay pumps: horizontal-shaft, double-suction and volute type.

Suction dia. (mm)	Delivery dia. (mm)	Discharge (cum/min)	Delivery head (m)	Speed (rpm)	Input power (kw)	No. of set
300	250	9.4	25	1,500	75	3*

* including 1 standby

Pump house: Total floor area: 320 sqm including pump suction well, pump room, control room, electric room and office.

Power equipment: 3 kV power distribution equipment
Low tension power distribution equipment to the relay pumps and the intake pumps, etc.

Control equipment: Telemetering, remote-control and local control equipment.
Indicators of water level of pump well and flow rate.
Alarm for water level of pump well.

b) Raw water main

Collection main
- Material: RCP
- Diameter: ϕ 250 to ϕ 450 mm
- Total length: 9 km

Transmission main
- Material: PSCP
- Diameter: ϕ 600 mm
- Total length: 3.8 km

(3) Water treatment plant

Treating capacity: 54,000 cmd

Aerator: 45 sqm x 6 stages x 1 set

Chemical feeders

Chlorinators: 5 kg/hr x 2 sets (including 1 standby)
1-ton chlorine containers x 2 sets Pumps, hoist, etc.

Lime feeding equipment:

Solution tanks: 10 cum x 2 sets

Transfer pumps: Q0.1 cum/min x 2.2 kw x 2 sets

Head tank: 1.5 cum x 1 set

Agitator, hoist, etc.

Treated water reservoir

Number: 1 (separated into two sections by a partition)

Capacity: 10,500 cum (effective depth: 3.5 m)

Administration building

Stories: 3

Total floor area: 1,000 sqm (including pump room)

Power equipment: High tension receiving and transformation, 2.5 MVA in capacity

Power distribution equipment for treated water pumps and intake pumps, etc.

Control equipment

Telemetering, remote-control and local control equipment. Water level indicators of the reservoir and flow indicators of raw water and treated water. Alarms for water level of the reservoir and delivery pressure of treated water pumps, etc.

Miscellaneous: Piping, fence, road, etc.

Site area: 12,000 sqm

(4) Treated water transmission

Treated water pumps:

Horizontal-shaft, double-suction and volute type.

Suction dia. (mm)	Delivery dia. (mm)	Discharge (cum/min)	Delivery head (m)	Speed (rpm)	Input power (kw)	No. of set
500	350	27.8	65	1,500	450	3*

* including 1 standby

Treated water main

Material: PSCP

Diameter: Ø900 mm

Total length: 10 km

Stage 2 (Q = 150,000 cmd)

(1) Intake Stations

Total discharge: 156,000 cmd (52 wells x 3,000 cmd/well)

Facilities of each station are same as Stage 1.

(2) Raw water transmission

a. Relay pumping station

Number: 4

Aerator: 65 sqm x 6 stages

Relay pumps: The type of pumps are same as Stage 1.

	Suction dia. (mm)	Delivery dia. (mm)	Discharge (cum/min)	Delivery head (m)	Speed (rpm)	Input power (kw)	No. of set
i	300	200	13.5	40	1,500	130	3*
ii	300	200	13.5	39	1,500	130	3*
iii	300	200	13.5	36	1,500	110	2*
iv	300	200	13.5	28	1,500	90	3*

* including 1 standby set

Pump house: Same as Stage 1

Electric equipment: - ditto -

Miscellaneous equipment: - ditto -

Site area: - ditto -

b. Raw water main

Collection main

Material: RCP

Diameter: ϕ250 to ϕ450 mm

Total length: 26 km

Transmission main

Material: PSCP

Diameter: ϕ700 to ϕ1,100 mm

Total length: 15.5 km

(3) Water treatment plant

Treating capacity: 210,000 cum including Stage 1
(plant output: 200,000 cmd)

Flash mixers

Number: 2

Retention time: 1 minute

Contact basins

Number: 4

Retention time: 30 minutes

Rapid sand filters

Number: 12 beds

Filtration rate: 180 m/day (180 cum/day/sqm)

Filter media: gravel 30 cm thick
sand 70 "

Backwash rate: 0.7 cum/min/sqm

Surfacewash fate: 0.2 cum/min/sqm

Wash pumps:

	Suction dia. (mm)	Delivery dia. (mm)	Discharge (cum/min)	Delivery head (m)	Speed (rpm)	Input power (kw)	No. of set
bach-wash	700	600	80	16	750	280	2*
surface-wash	450	300	23	35	1,000	180	2*

* including 1 standby

Treated water reservoirs

Number: 3 (4 in total)

Capcity: 31,500 cum (effective depth: 3.5m)

Waste pond

Number: 1 (separated into two sections by a partition)

Capacity: 1,260 cum

Sewage pumps: 3 sets including 1 standby set.

Chlorination equipment

Chlorinator: Pre-chlorination 40 kg/hr x 2 sets (including 1 standby set)
Post-chlorination 15 kg/hr x 2 sets (- ditto -)

1-ton chlorine containers:: 10
Pumps, hoist, etc.

Chlorine neutralization equipment

Capcity: 1 ton

Lime feeding equipment
Solution tanks: 30 cum x 2 sets
Transfer pumps: Q0.2 cum/min x 5.5 kw x 2 sets (including 1 standby set)
Head tank: 4.5 cum x 1 set
Attached equipment: Same as Stage 1

Administration building
Stories: 3
Total floor area: 3,300 sqm (including pump room)

Power equipment:
Power receiving and distribution facilities for treated water pumps, wash pumps, well pumps near the plant, etc.
7.5 MVA in capacity (10 MVA in total)

Control equipment
Telemetering, remote-control and local control equipment.
Water level indicators of reservoirs and waste pond.
Flow indicators of raw water and treated water.
Alarms for water levels of the reservoir and delivery pressure of treated water pumps, etc.

Miscellaneous: Piping, fence, road, etc.

Site area; 33,000 sqm.

(4) Treated water transmission

Treated water pumps : The type of pumps are same as Stage 1.

Suction dia. (mm)	Delivery dia. (mm)	Discharge (cum/min)	Delivery head (m)	Speed (rpm)	Input power (kw)	No. of set
600	350	41.7	66	750	640	5*

* including 1 standby

Treated water main

Material: PSCP

Diameter: ϕ1,350 mm

Total length: 10 km

Summary of Facilities Alternative 2 (100,000 + 100,000 cmd)

Stage 1 (Q = 100,000 cmd)

(1) Intake Stations

Total discharge: 105,000 cmd (35 wells x 3,000 cmd/well)

Well: diameter ϕ 300 mm, depth 150 m

Screen: diameter ϕ 300 mm, length 25 m

Pump: Submersible motor pump

Delivery dia. (mm)	Discharge (cum/min)	Delivery head (m)	Speed (rpm)	Input power (kw)
150	2.1	35	3,000	22

Pump house: 3 m x 5 m = 15 sqm

Electrical equipment:

3 kV power receiving and transformation equipment from relay pumping station and 400 V low tension power distribution equipment.

Indicators of well water level and discharge.
Switch gear.

Miscellaneous: Piping, fence, road, etc.

Site area: 120 sqm

(2) Raw Water Transmission

a. Relay pumping station: 2

Aerator: 45 ~ 65 sqm x 6 stages

Relay pumps: horizontal-shaft, double-suction and volute type

	Suction dia. (mm)	Delivery dia. (mm)	Discharge head (cum/min)	Delivery head (m)	Speed (rpm)	Input power (kw)	No. of set
B block:	300	250	10.4	36	1,500	90	3*
D block:	300	250	12.5	25	1,500	75	3*

* including 1 standby set

Pump house: Total floor area: 320 sqm including pump suction well, pump room, control room electric room and office

Power equipment: 3 kV power distribution equipment
Power distribution equipment to the relay pumps and the intake pumps, etc.

Control equipment: Telemetering, remote-control and local control equipment.
Indicators of water level of pump well and flow rate.
Alarm for water level of pump well.

b. Raw water main

Collection main

Material: RCP

Diameter: ø 250 to ø 450 mm

Total length: 16.5 km

Transmission main

Material: PSCP

Diameter: ø 800 ~ 1,100 mm

Total length: 8.6 km

(3) Water treatment plant

Treating capacity: 105,000 and

Aerator: 45 sqm x 6 stages x 1 set

Lime feeding equipment:

Solution tanks: 40 cum x 2 sets

Transfer pumps: Q0.3 cum/min x 7.5 kw x 2 sets

Head tank: 6.0 cum x 1 set

Agitator, hoist, etc.

Lime feeding equipment:

Solution tanks: 40 cum x 2 sets

Transfer pumps: Q0.3 cum/min x 7.5 kw x 2 sets

Head tank: 6.0 cum x 1 set

Agitator, hoist, etc.

Flash mixers

Number: 2

Retention time: 1 minute

Contact basins

Number: 2

Retention time: 30 minutes

Rapid sand filters

Number: 2

Filtration rate: 180 m/day (180 cum/day/sqm)

Filter media: gravel 30 cm thick

sand 70 "

Backwash rate: 0.7 cum/min/sqm

Surfacewash rate: 0.2 "

Wash pumps:

	Suction dia. (mm)	Delivery dia. (mm)	Discharge (cum/min)	Delivery head (m)	Speed (rpm)	Input power (kw)	No. of set
Backwash	700	600	80	16	750	280	2*
Surfacewash	450	300	23	35	1,000	180	2*

Treated water reservoirs

Number: 2

Capacity: 21,000 cum (effective depth: 3.5 m)

Waste pond

Number: 1 (separated into two sections by a partition)

Capacity: 1,260 cum

Sewage pumps: 3 sets including 1 standby set.

Chlorination equipment

Chlorinator: Pre-chlorination 40 kg/hr x 2 sets
(including 1 standby set)
Post-chlorination 20 kg/hr x 2 sets
(- ditto -)

1-ton chlorine containers: 12

Pumps, hoist, etc.

Chlorine neutralization equipment

Capacity: 1 ton

Administration building

Stories: 3

Total floor area: 3,880 sqm (including pump room)

Power equipment

Extra high tension power receiving and transformation into 3 kV, 5 MVA in capacity

Power distribution equipment for treated water pumps and intake pumps, etc.

Control equipment

Telemetering, remote-control and local control equipment.

Wa er level indicators of reservoirs and waste pond.

Flow indicators of raw water and treated water.

Alarms for water levels of the reservoir and delivery pressure of treated water pumps, etc.

Miscellaneous: Piping, fence, road, etc.

Site area: 45,000 sqm in total

(4) Treated water transmission

Treated water pumps:

Horizontal-shaft, double-suction and volute type

Suction dia. (mm)	Delivery dia. (mm)	Discharge (cum/min)	Delivery head (m)	Speed (rpm)	Input power (kw)	No. of set
500	400	55.7	67	1,500	820	3*

* including 1 standby

Treated water main

Treated water main

Material: PSCP

Diameter: ϕ1,500 mm

Total length: 10 km

Stage 2 (Q = 100,000 cmd)

(1) Intake Stations

Total discharge: 105,000 cmd (35 wells x 3,000 cmd/well)

Facilities of each station are same as Stage 1.

(2) Raw water transmission

a. Relay pumping station

Number: 3

Aerator: 45 ~ 65 sqm x 6 stages

Relay pumps: The type of pumps are same as Stage 1.

	Suction dia. (mm)	Delivery dia. (mm)	Discharge (cum/min)	Delivery head (m)	Speed (rpm)	Input power (kw)	No. of set
A block	300	200	10.4	45	1,500	110	3*
C block	300	250	12.5	36	1,500	90	3*
E block	350	300	13.5	25	1,500	80	3*

* including 1 standby set

Pump house: Same as Stage 1

Electric equipment: - ditto -

Miscellaneous equipment: Same as Stage 1.

Site area: - ditto -

b. Raw water main

Collection main

Material: RCP

Diameter: Ø250 to Ø450 mm

Total length: 16.5 km

Transmission main

Material: PSCP

Diameter: Ø600 ~ Ø700 mm

Total length: 10.1 km

(3) Water treatment plant

Treating capacity: 210,000 cum including Stage 1
(plant output: 200,000 cmd)

Flash mixers

Number: 0 (2 in total)

Retention time: 1 minute

Contact basins

Number: 2 (4 in total)

Retention time: 30 minutes

Rapid sand filters

Number: 6 beds (12 in total)

Treated water reservoirs

Number: 2 (4 in total)

Capacity: 21,000 cum (effective depth: 3.5 m)
42,000 cum in total

Power equipment

Extra high tension transformation into 3 kV, 5 MVA in capacity (10 MVA in total) and power distribution facilities for treated water pumps, wash pumps, pumps near the plant, etc. etc.

Control equipment

Telemetering, remote-control and local control equipment.
Water level indicators of reservoirs and waste pond.
Flow indicators of raw water and treated water.
Alarms for water levels of the reservoir and delivery pressure of treated water pumps, etc.

Miscellaneous: Piping, fence, road, etc.

(4) Treated water transmission

Treated water pumps: The type of pumps are same as Stage 1.

Suction dia. (mm)	Delivery dia. (mm)	Discharge (cum/min)	Delivery head. (m)	Speed (rpm)	Input power (kw)	No. of set
500	400	55.7	67	1,500	820	2*

* 5 sets in total

II-3-3 PROJECT COST AND TIME SCHEDULE

Proposal

The project cost as estimated consists of the costs for all the items of facilities described in II-3-2. Table 2.3.1 is the cost estimates for 1st Stage 50,000 cmd production project, requring some US$2,110,000 local currency component and some US$4,190,000 foreign currency component totaling US$6,300,000. Table 2.3.2 is the cost estimates for 2nd Stage 150,000 cmd production with some US$6,080,000 local currency component and some US$12,220,000 foreign currency component totaling US$18,300,000. Thus, US$24,600,000 will be the grand total of the project cost for the ultimate production of 200,000 cmd.

As an alternative, cost estimates for 100,000 cmd program to be followed by another 100,000 cmd project are provided in Tables 2.3.3 and 2.3.4. In case the bigger initial work is preferred for some reason, this alternative may be considered for implementation.

Since the project as proposed starts with collection of groundwater at the area and ends by the transmission of treated water to the existing distribution trunk mains at Cholon, the cost estimates do not include the cost for distribution pipe lines. It is expected that the improvement project on distribution system will be undertaken separately.

Contingencies of some 20 percent are provided in the contents of the project cost taking into account of price escalation within the next two years or so. Further escalation shall be considered when the initiation of the project is delayed.

Schedule of the Project

Since the purpose of the project as proposed is to provide additional supply of water to the existing service area urgently in order to improve the service of SMWO, the schedule of implementation should carefully be considered.

As recommended earlier, the initial work should be for implementation of smaller portion of the project, with its necessary engineering including soil borings and the construction program which the project will follow. The advantage of this undertaking will be the relatively short time required in producing additional supply and the small amount of funds needed which will be easier for negotiation for loans. The proposed time schedule, assuming that actions shall be taken immediately, is shown in Fig. 2.3.8 attached herewith.

It should be kept in mind that the improvement and extention of the distribution system should be undertaken urgently in order to 1) rectify the leakage condition of the pipelines to prevent the wastage of water, 2) expand the service area as much as possible for presently unserved people, 3) effectively utilize the additional supply from the Thu Duc plant which is expected by the improvement of the Dong Nai system and 4) use groundwater as the implementation program proceeds according to the proposed plan.

Table 2.3.1 Summary of Project Cost (Alternative 1, Stage I)

Q = 50,000 cmd

Particular		Q'ty	Local	Foreign	Total
				(US$1,000)	
A.	Intake				
1	Wells	18	165.0	289.6	454.6
2	Pumps	18	12.3	249.2	261.5
	" (Standby)	2	-	25.7	25.7
3	Pump houses	18	24.9	-	24.9
4	Electrical equipment	LS	9.3	177.5	186.8
5	Miscellaneous	LS	12.4	31.2	43.6
	Sub-total		223.9	773.2	997.1
B.	Raw water transmission				
1	Collection main	9.0 km	150.0	154.8	304.8
2	Transmission main	3.8 "	127.6	128.7	256.3
3	Aeration	LS	24.2	-	24.2
4	Pumps	3	3.1	54.1	57.2
5	Pump houses	1	17.2	20.3	37.5
6	Electrical equipment	LS	8.4	150.8	159.2
7	Miscellaneous	LS	11.1	16.6	27.7
	Sub-total		341.6	525.3	866.9
C.	Water treatment plant				
1	Flash mixers	-	-	-	-
2	Contact basins	-	-	-	-
3	Filters	-	-	-	-
4	Mechanical equipment	-	-	-	-
5	Waste pond	-	-	-	-
6	Chemical feeders etc.	LS	1.4	26.4	27.8
7	Electrical equipment	LS	22.2	405.1	427.3
8	Administration Bldg.	LS	40.2	46.5	86.7
9	Miscellaneous	LS	50.5	84.3	134.8
	Sub-total		114.3	562.3	676.6
D.	Treated water transmission				
1	Treated water reservoir	LS	235.6	155.7	391.3
2	Treated water pumps	3	16.6	315.4	332.0
3	Treated water main	10 km	626.1	633.6	1,259.7
	Sub-total:		878.3	1,104.7	1,983.0
	Construction cost total:		1,558.1	2,965.5	4,523.6
E.	Engineering	LS	226.2	538.4	764.6
F.	Contingencies	LS	326.8	685.0	1,011.8
Total project cost (Stage I)			2,111.1	4,188.9	6,300.0

Table 2.3.2 Summary of Project Cost (Alternative 1, Stage II)

Q = 150,000 cmd Total 200,000 cmd

Particular		Q'ty	Local	Foreign (US$1,000)	Total
A.	Intake				
1	Wells	52	477.0	837.1	1,314.1
2	Pumps	52	36.3	719.9	756.2
	" (Standby)	4	-	51.2	51.2
3	Pump houses	52	71.9	-	71.9
4	Electrical equipment	LS	27.0	513.0	540.0
5	Miscellaneous	LS	36.0	90.0	126.0
	Sub-total		648.2	2,211.2	2,859.4
B.	Raw water transmission				
1	Collection main	26.0 km	237.6	245.4	483.0
2	Transmission main	15.5 "	970.9	982.6	1,953.5
3	Aeration	LS	71.9	-	71.9
4	Pumps	12	16.6	315.6	332.2
5	Pump houses	4	75.3	87.7	163.0
6	Electrical equipment	LS	33.8	603.2	637.0
7	Miscellaneous	LS	44.3	66.5	110.8
	Sub-total		1,450.4	2,301.0	3,751.4
C.	Water treatment plant				
1	Flash mixer	2	18.1	33.4	51.5
2	Contact basins	4	128.3	109.8	238.1
3	Filters	12	237.8	608.4	846.2
4	Mechanical equipment	LS	11.1	210.5	221.6
5	Waste pond	1	23.3	40.2	63.5
6	Chemical feeders etc.	LS	10.6	201.6	212.2
7	Electrical equipment	LS	43.8	1,141.3	1,185.1
8	Administration Bldg.	LS	358.9	421.3	780.2
9	Miscellaneous	LS	143.3	254.7	398.0
	Sub-total		975.2	3,021.2	3,996.4
D	Treated water transmission				
1	Treated water reservoir	LS	704.5	469.6	1,174.1
2	Treated water pumps	5	33.2	631.7	664.9
3	Treated water main	10 km	1,239.8	1,249.7	2,489.5
	Sub-total		1,977.5	2,351.0	4,328.5
	Construction cost total		5,051.3	9,884.4	14,935.7
E.	Engineering	LS	-	268.5	268.5
F	Contingencies	LS	1,027.8	2,068.0	3,095.8
Total project cost (Stage II)			6,079.1	12,220.9	18,300.0
Grand Total (Stage I + II)			8,190.2	16,409.8	24,600.0

Table 2.3.3 Summary of Project Cost (Alternative 2, Stage I)

Q = 100,000 cmd

Particular		Q'ty	Local	Foreign	Total
				(US$1,000)	
A.	Intake				
1	Wells	35	318.4	566.0	884.4
2	Pumps	35	25.5	483.4	508.9
	" (Standby)	3	-	38.5	38.5
3	Pump houses	35	48.4	-	48.4
4	Electrical equipment	LS	18.2	345.2	363.4
5	Miscellaneous	LS	24.6	60.2	84.8
	Sub-total		435.1	1,493.3	1,928.4
B.	Raw water transmission				
1	Collection main	16.5 km	181.9	189.4	371.3
2	Transmission main	8.6 "	652.4	652.5	1,304.9
3	Aeration	LS	30.4	-	30.4
4	Pumps	6	6.1	116.3	122.4
5	Pump houses	2	35.6	41.7	77.3
6	Electrical equipment	LS	15.9	302.6	318.5
7	Miscellaneous	LS	22.2	33.2	55.4
	Sub-total		944.5	1,335.7	2,280.2
C.	Water treatment plant				
1	Flash mixers	2	18.1	33.4	51.5
2	Contact basins	2	64.3	54.8	119.1
3	Filters	6	118.5	304.6	423.1
4	Mechanical equipment	LS	11.1	210.5	221.6
5	Waste pond	1	23.3	40.2	63.5
6	Chemical feeders etc.	LS	9.0	170.9	1,179.9
7	Electrical equipment	LS	41.1	781.5	822.6
8	Administration Bldg.	LS	368.3	432.4	800.7
9	Miscellaneous	LS	153.1	272.2	425.3
	Sub-total		806.8	2,300.5	3,107.3
D.	Treated water transmission				
1	Treated water reservoir	LS	469.6	313.1	782.7
2	Treated water pumps	3	25.0	475.5	500.5
3	Treated water main	10 km	1,534.2	1,546.5	3,080.7
	Sub-total		2,028.8	2,335.1	4,363.9
	Construction cost total		4,215.2	7,464.6	11,679.8
E.	Engineering	LS	226.2	538.4	764.6
F	Contingencies	LS	782.1	1,573.5	2,355.6
Total project cost			5,223.5	9,576.5	14,800.0

Table 2.3.4 Summary of Project Cost (Alternative 2, Stage II)

Q = 100,000 cmd Total 200,000 cmd

Particular		Q'ty	Local	Foreign (US$1,000)	Total
A.	Intake				
1	Wells	35	318.3	566.0	884.3
2	Pumps	35	25.4	483.4	508.8
	" (Standby)	3	-	38.4	38.4
3	Pump houses	35	48.4	-	48.4
4	Electrical equipment	LS	18.1	345.3	363.4
5	Miscellaneous	LS	24.6	60.2	84.8
	Sub-total		434.8	1,493.3	1,928.1
B.	Raw water transmission				
1	Collection main	16.5 km	181.9	189.3	371.2
2	Transmission main	10.1 "	399.9	399.8	799.7
3	Aeration	LS	48.4	-	48.4
4	Pumps	9	11.1	210.2	221.3
5	Pump houses	3	54.5	64.0	118.5
6	Electrical equipment	LS	23.9	453.8	477.7
7	Miscellaneous	LS	33.2	49.9	83.1
	Sub-total		752.9	1,367.0	2,119.9
C.	Water treatment plant				
1	Flash mixers	-	-	-	-
2	Contact basins	2	64.3	54.7	119.0
3	Filters	6	118.4	304.7	423.1
4	Mechanical equipment	-	-	-	-
5	Waste pond	-	-	-	-
6	Chemical feeders etc.	LS	1.6	30.7	32.3
7	Electrical equipment	LS	30.0	570.5	600.5
8	Administration Bldg.	-	-	-	-
9	Miscellaneous	LS	37.6	66.7	104.3
	Sub-total		251.9	1,027.3	1,279.2
D.	Treated water transmission				
1	Treated water reservoir	LS	469.6	313.1	782.7
2	Treated water pumps	2	16.7	317.0	333.7
3	Treated water main	-	-	-	-
	Sub-total		486.3	630.1	1,116.4
	Construction cost total		1,925.9	4,517.7	6,443.6
E.	Engineering	LS	-	268.5	268.5
F.	Contingencies	LS	427.5	860.4	1,287.9
Total project cost			2,353.4	5,646.6	8,000.0
Grand Total	(Stage I + II)		7,576.9	15,223.1	22,800.0

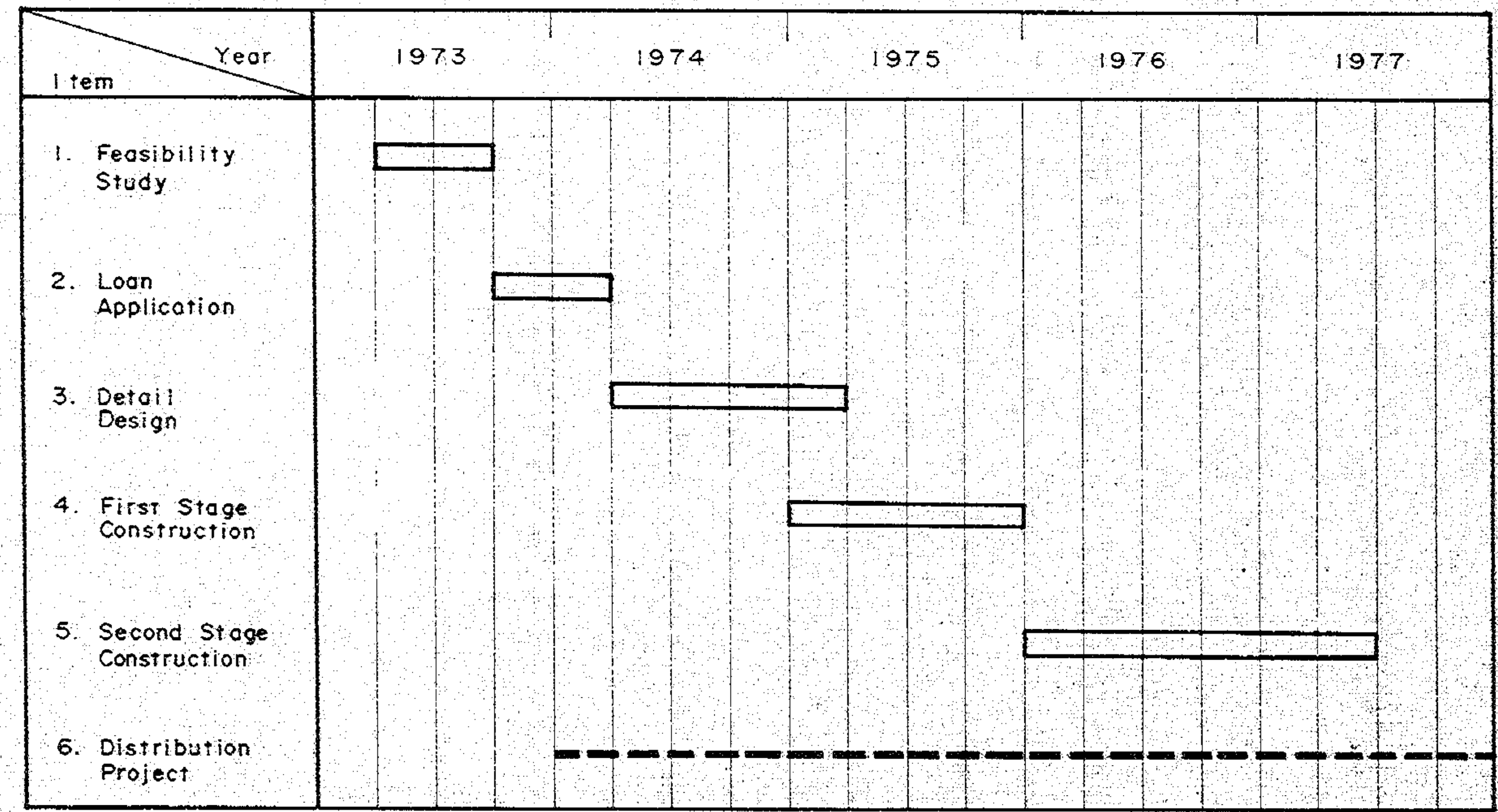


Fig. 2.3.8.a SCHEDULE OF GROUNDWATER SUPPLY PROJECT ALTERNATIVE I

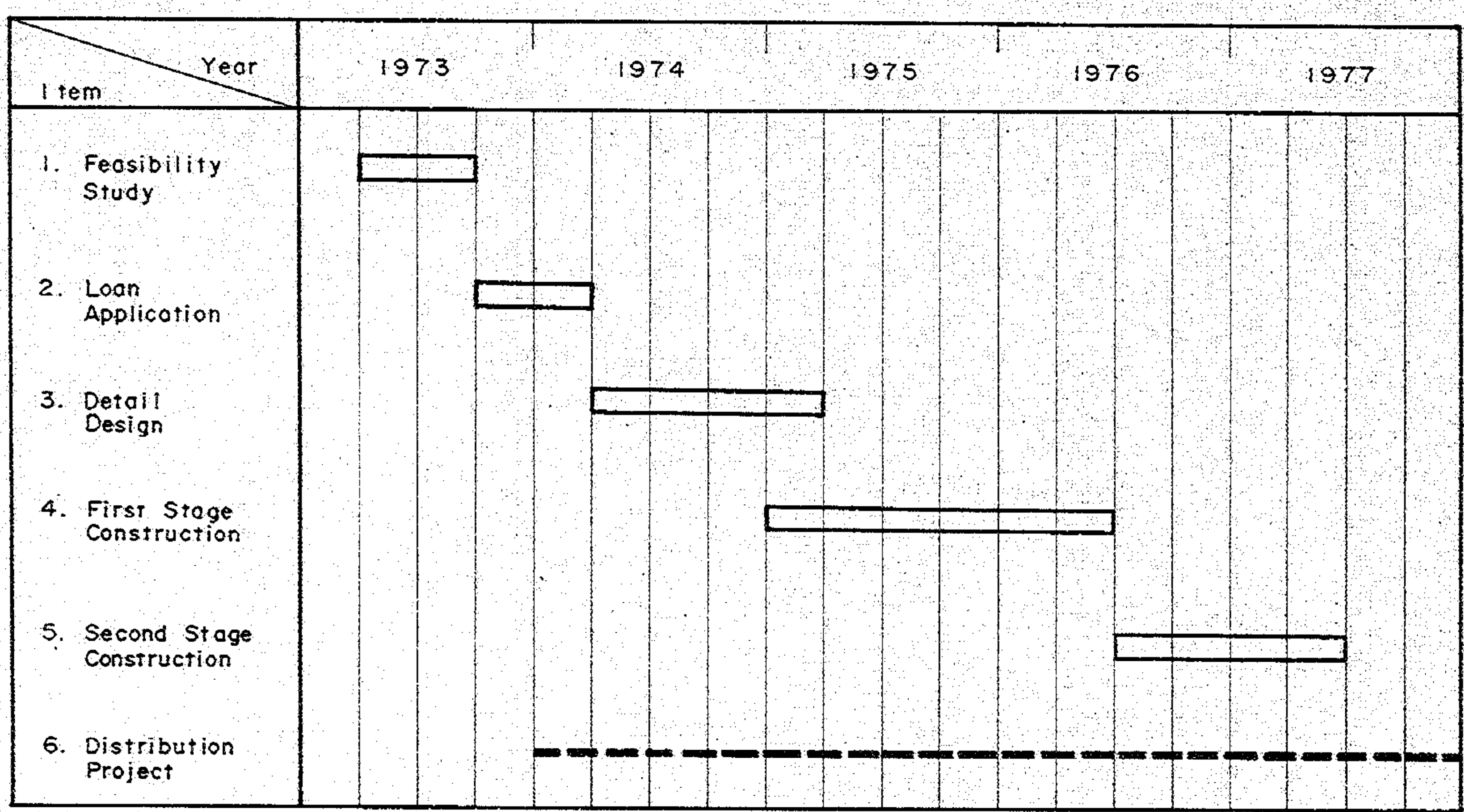


Fig. 2.3.8.b SCHEDULE OF GROUNDWATER SUPPLY PROJECT ALTERNATIVE 2