CHAPTER 4 WATER SOURCES

CHAPTER 4
WATER SOURCES

4-1 Groundwater

4-1-1 Structure of Aquifers :

The Department of Mineral Resources (DMR) of Thailand classifies the aquifers in Bangkok city into 9 types, as shown in Table 4-1. The aquifers consist of unconsolidated or semi-consolidated tertiary to quaternary deposits distributed on rocks of quartzite and gneiss.

As it can be presumed that the aquifer in the surrounding area of Bangkok are in the same depositional environment as in Bangkok, the above classification of aquifers may also be applied to the area adjacent to Bangkok.

Probable geologic profiles were made by using the existing geologic columns and data obtained by electric prospecting and the established classification of aquifers in Bangkok was compared with the group of aquifers in the surrounding area of Bangkok in order to obtain information on the structure of the aquifers in the area of separate system. However, no more than the upper five aquifers, including the Nonthaburi aquifer, could be classified on account of inadequate depths of the existing geologic columns and the limitation of the accuracy of electric prospecting

The aquifers in the 8 Amphoes surrounding Bangkok will be discussed in detail later. This section will briefly deal with the description of the structure of the aquifers in the area adjacent to Bangkok.

Table 4-1 AQUIFER DESCRIPTION

Aquifer	Depth to Top of Aquifer (Meter)	Total Thickness (Meter)	Description
Bangkok Upper (30 meter zone)	20 to 30	<1 to 30	Fine to coarse sand with gravel. Directly underlies Bangkok clay in most pieces. Aquifer missing in some areas or to fine grained to be a source of supply.
Bangkok Lower (50 meter zone)	30 to 50	<1 to 50	Predominantly fine to coarse sand with gravel and clay layers. In many places directly interconnected with 30 meter aquifer. Both aquifers also referred to as the Bangkok aquifer.
Phra Pradaeng (100 meter zone)	60 to 100	<1 to 70	Fine to coarse white sand with gravel and clay layers. In some places directly interconnected with the 50 meter aquifer. Occasionally missing in the eastern and western parts of the area.
Nakhon Luang (150 meter zone)	110 to 160	<5 to 70	Fine to coarse sand gravel interbedded with clay layers which are locally extensive. Individual sand layers up to 30 meters thick.
Nonthaburi (200 meter zone)	180 to 200	<5 to 60	Fine to coarse sand and gravel layers interbedded with clay and silt.
Sam Khok (250 meter zone)	240 to 250	10 to 55	Sand and gravel layers interbedded with clay.
Phya Thai (350 meter zone)	295 to 320	10 to 40	Sand and gravel layers interbedded with clay.
Thonburi (400 meter zone)	350 to 435	50 to 110	Sand and gravel layers interbedded with clay. Aquifer section may contain several distinct water bearing zone.
Paknam (550 meter zone)	530	30	Variable thick layers of sand and gravel interbedded with clay. Individual and layers as little as 5 meters thick.

The aquifers in the Center of Bangkok and its surrounding area vary in thickness but are continuous. All the aquifers run thin east and west, are well developed at the center and become progressively more developed and thicker, toward south. They are structurally rugged. The Bangkok and Phra Pradaeng aquifers have an underground valley running parallel to the Chao Phraya river and a continuous underground valley which crosses it obliquely. The underground valley running parallel to the Chao Phraya river is well developed in the Nakhon Luang and Nonthaburi aquifers. As shown in Fig's. 4-1 to 4-11, strata of impermeable clay are distributed between the aquifers and are not uniform in thickness but become progressively thicker as going away from the center.

The soil distribution in Changwat Nakhon Pathum and Changwat Chachoengsao was investigated as a sample case of soil profile in the area located outside of the central plain. As a result, it was disclosed that layers of clay were developed in Changwat Chachoengsao, whereas layers of sand and gravel were developed in Changwat Nakhon Pathum. (Refer to Fig's 4-12 to 4-13.)

Fig4-1 GEOLOGIC SECTION A,B,C

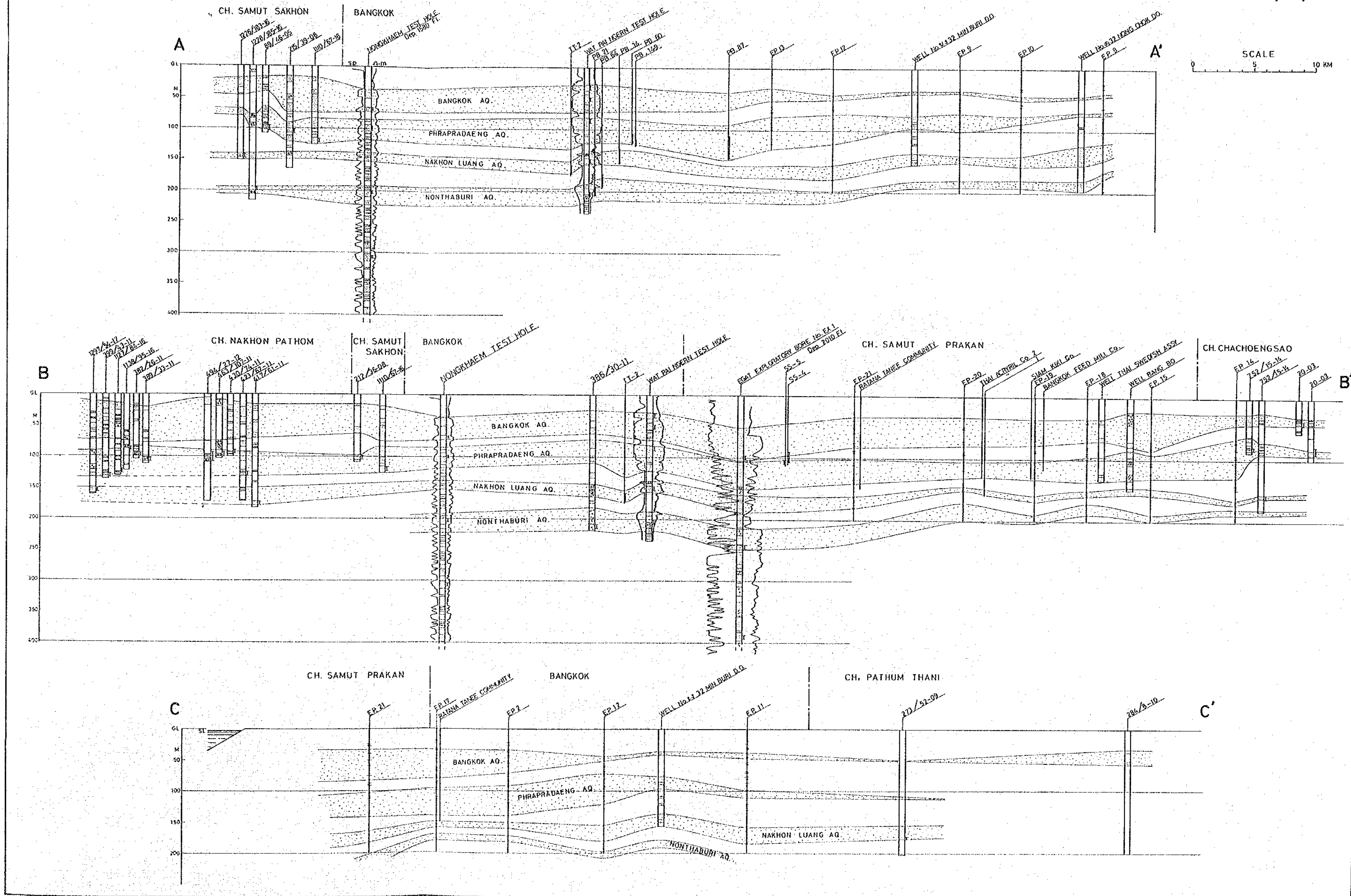


Fig4-2 GEOLOGIC SECTION D,E,F

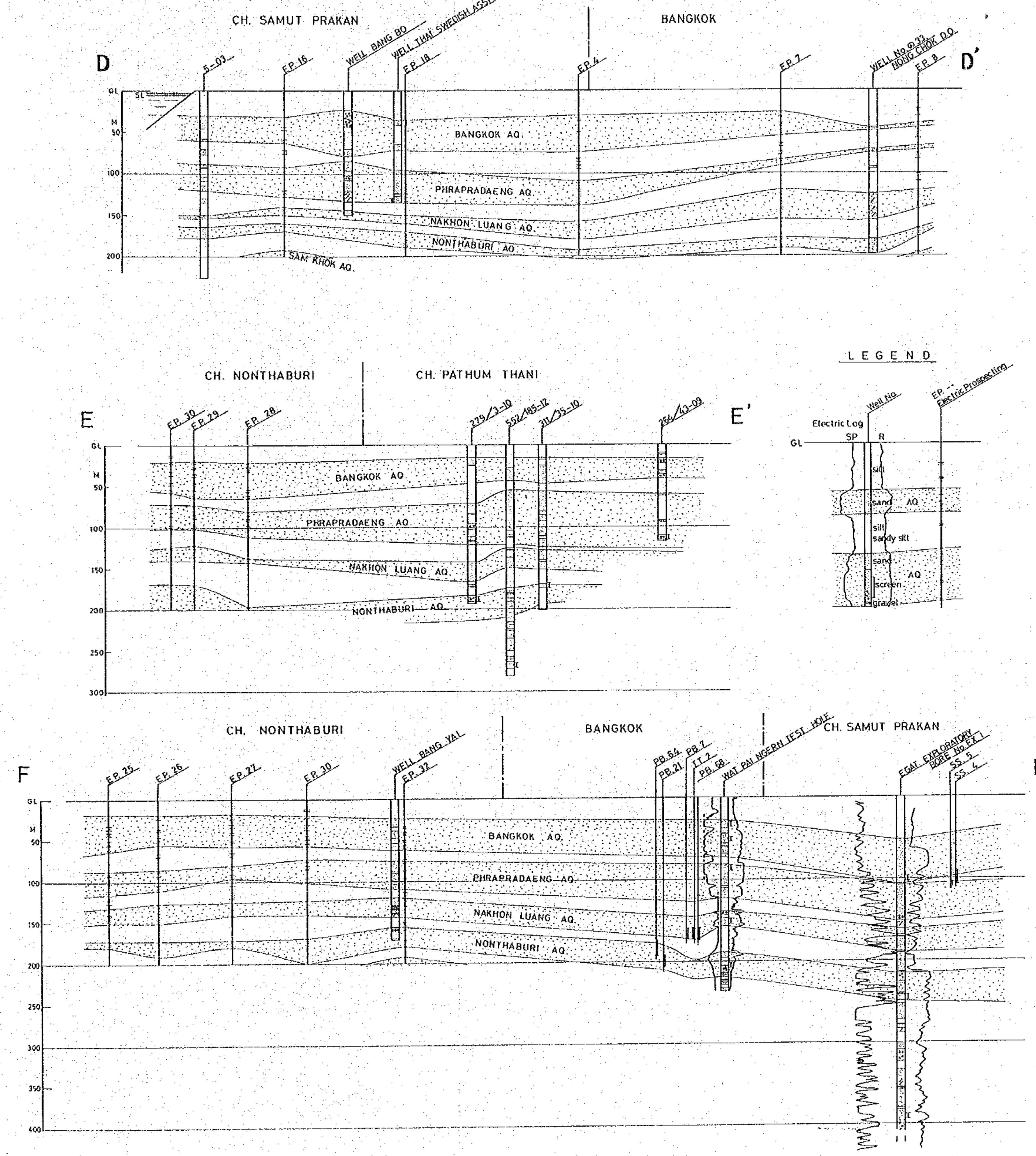
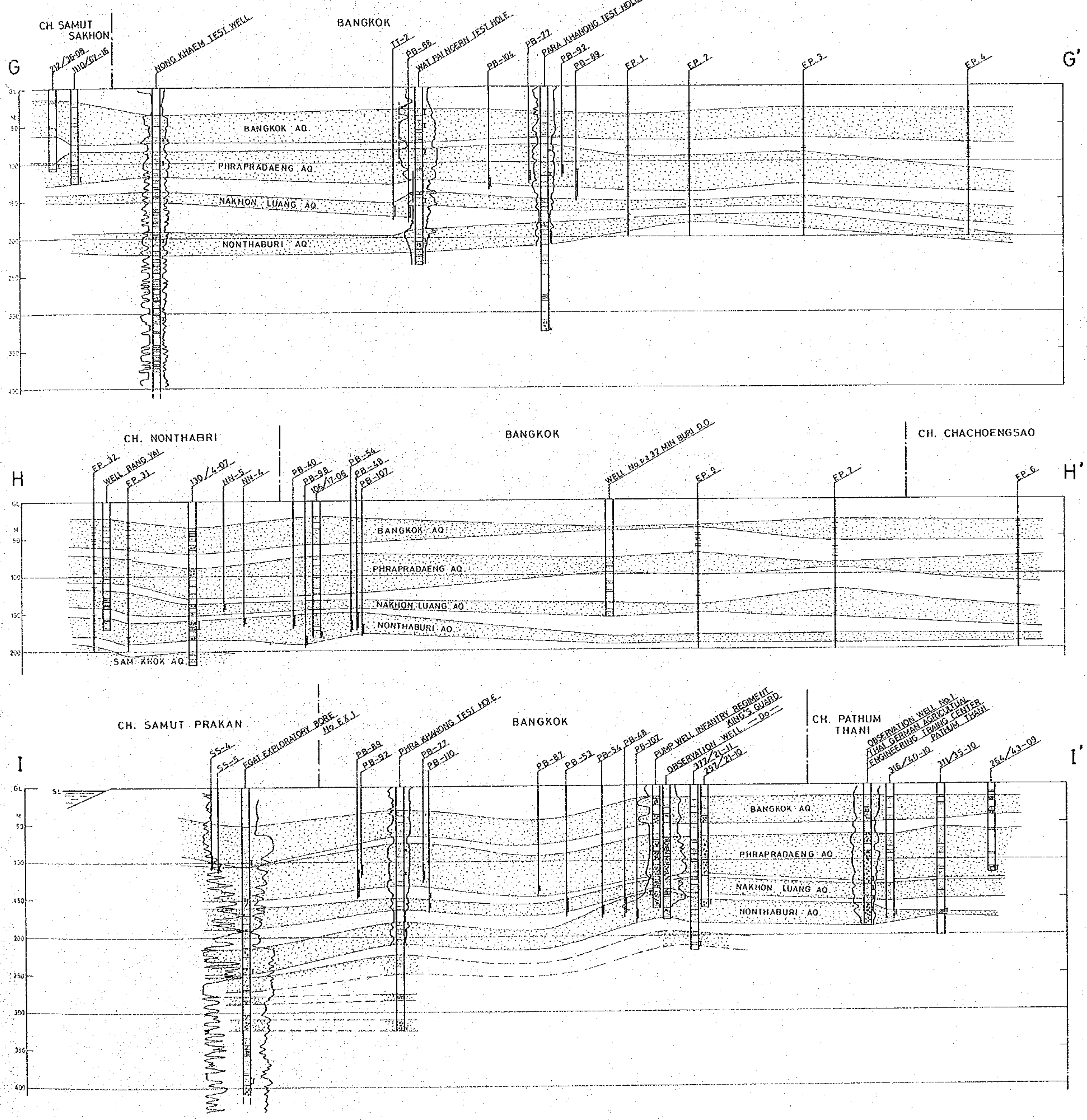


Fig4-3 GEOLOGIC SECTION G,H,I



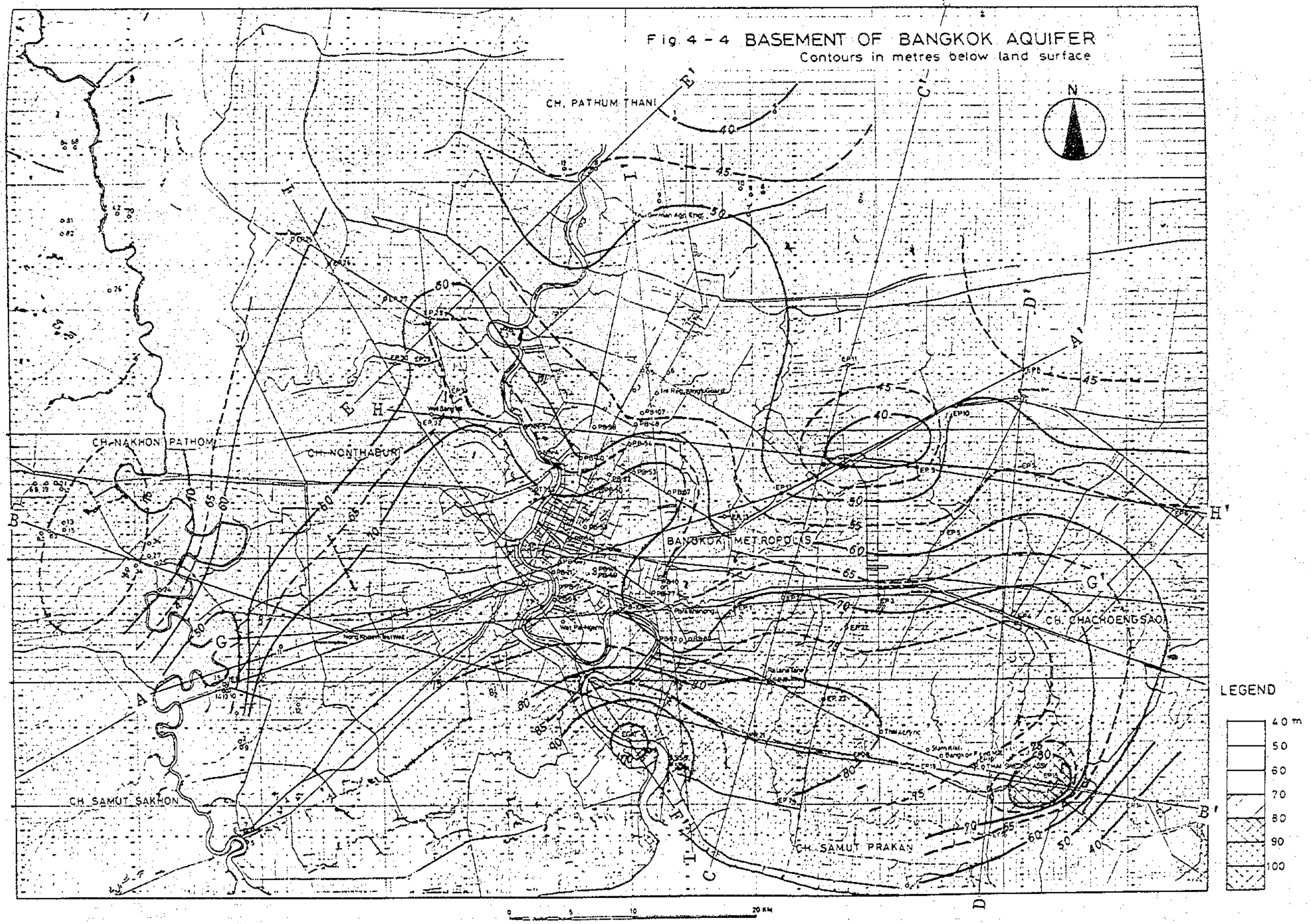


Fig. 4 - 4 BASEMENT OF BANGKOK AQUIFER
Contours in metres below land surface
N
CH. PATHUM THANI
CH. NAKHON PATHOM
CH. NONTHABURI
BANGKOK METROPOLIS
CH. CHACHOENGSAO
CH. SAMUT SAKHON
CH. SAMUT PRAKAN
LEGEND
40 m
50
60
70
80
90
100
0
5
10
20 KM

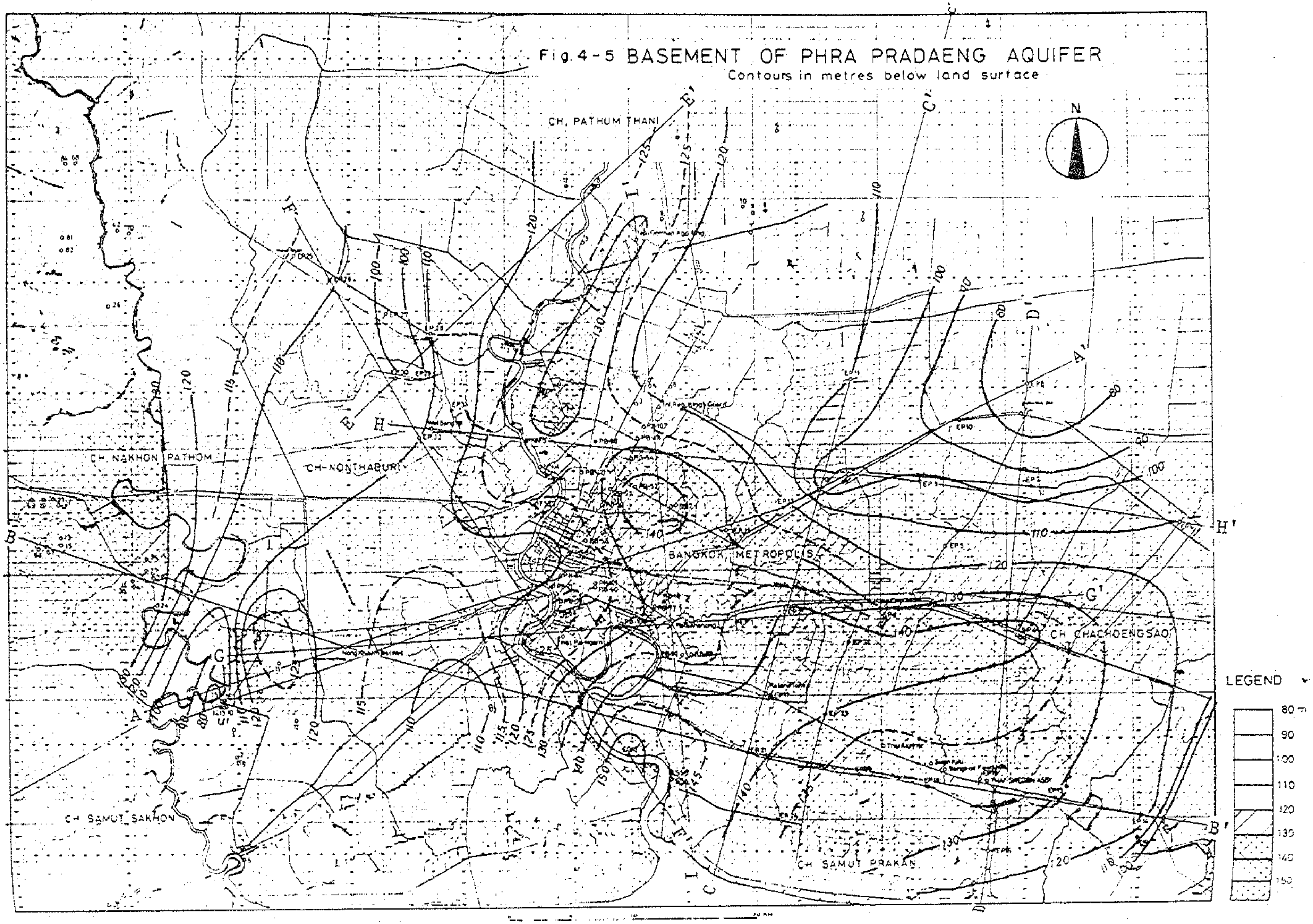


Fig. 4-5 BASEMENT OF PHRA PRADAENG AQUIFER
Contours in metres below land surface

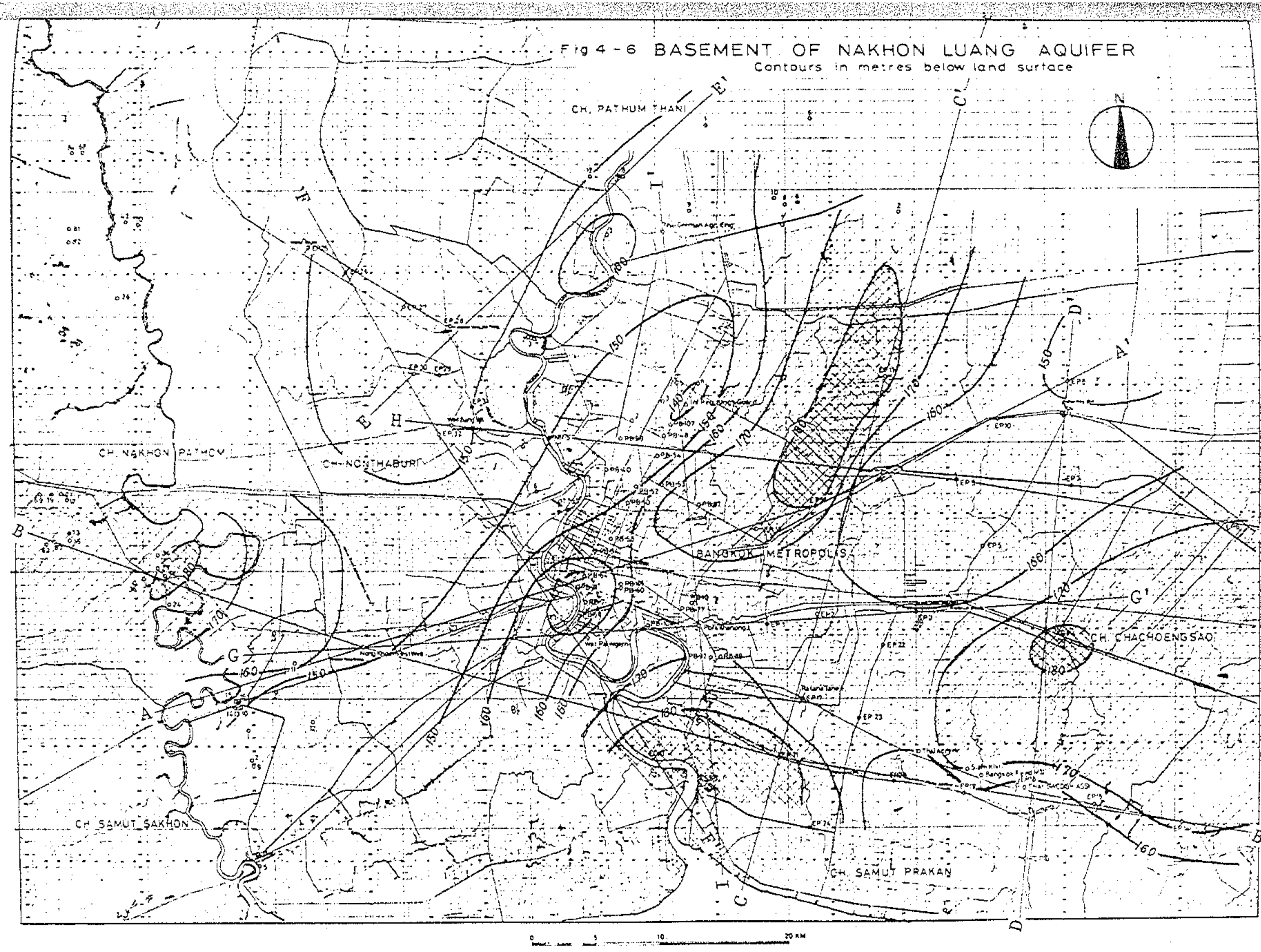


Fig 4-6 BASEMENT OF NAKHON LUANG AQUIFER
Contours in metres below land surface
N
CH. PATHUM THANI
CH. NAKHON PATHOM
CH. NONTHABURI
BANGKOK METROPOLIS
CH. CHACHOENGSAO
CH. SAMUT SAKHON
CH. SAMUT PRAKAN
LEGEND
150 m
160
170
180
0
5
10
20 KM

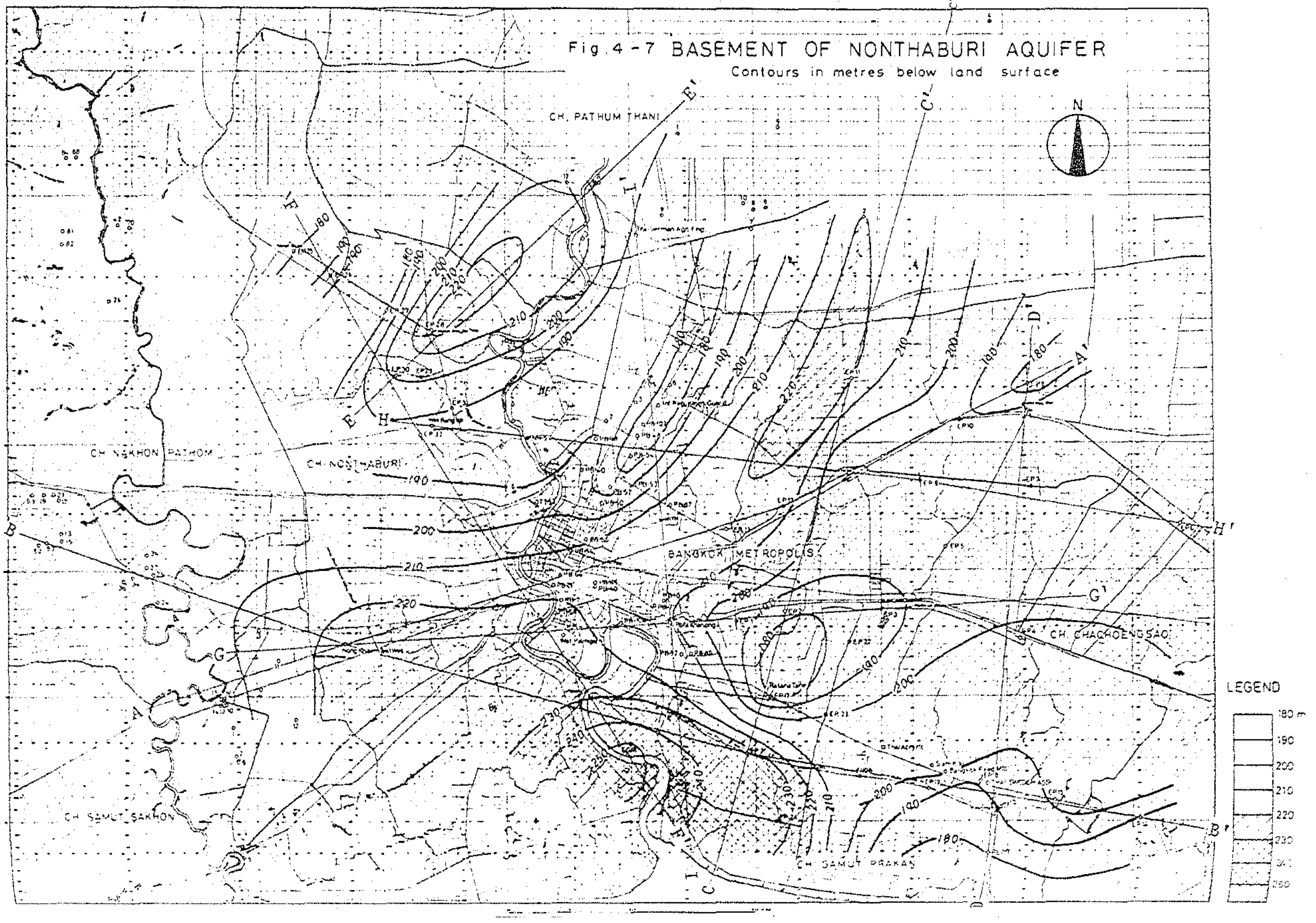


Fig. 4-7 BASEMENT OF NONTHABURI AQUIFER
Contours in metres below land surface

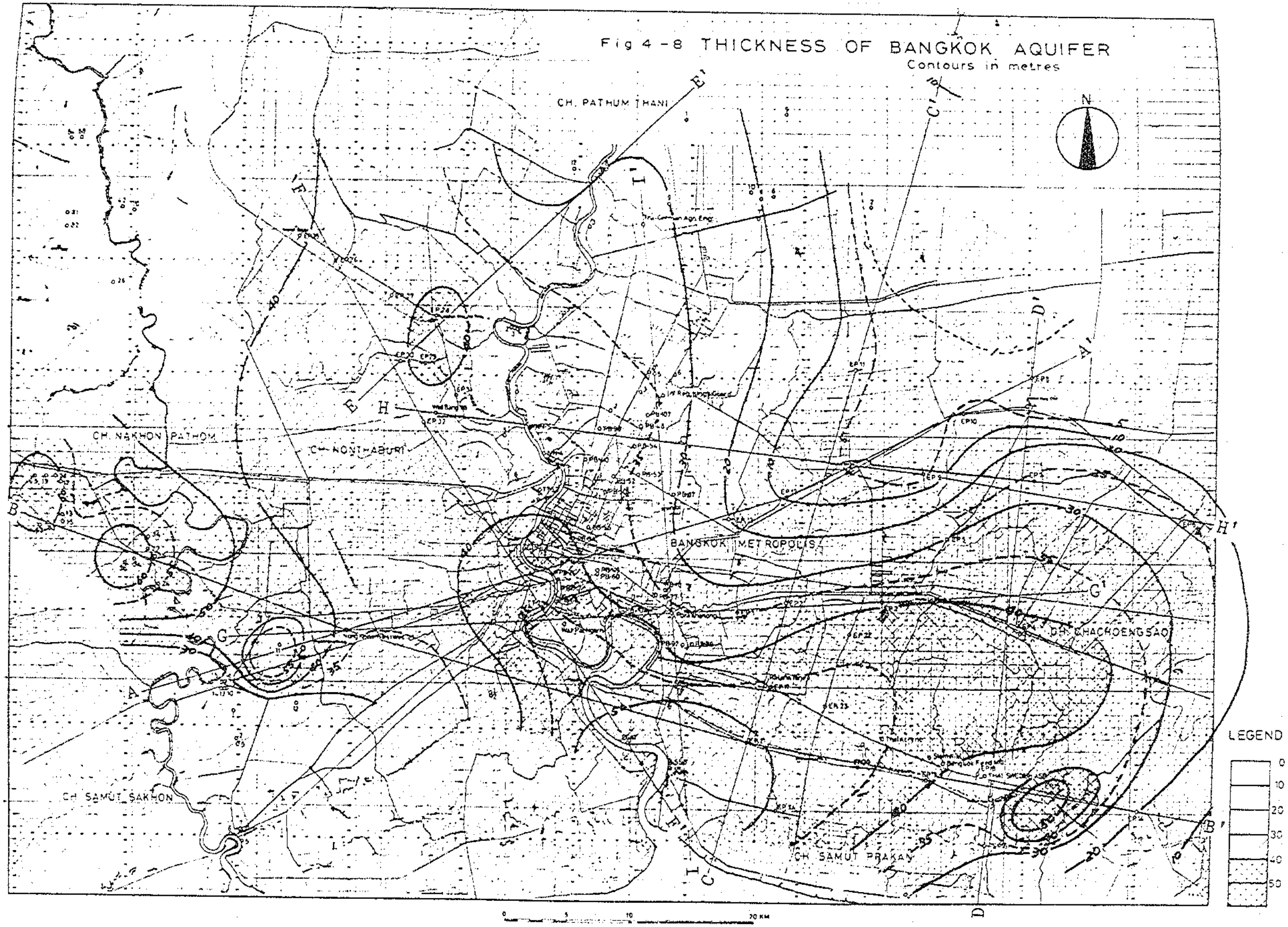


Fig 4-8 THICKNESS OF BANGKOK AQUIFER
Contours in metres

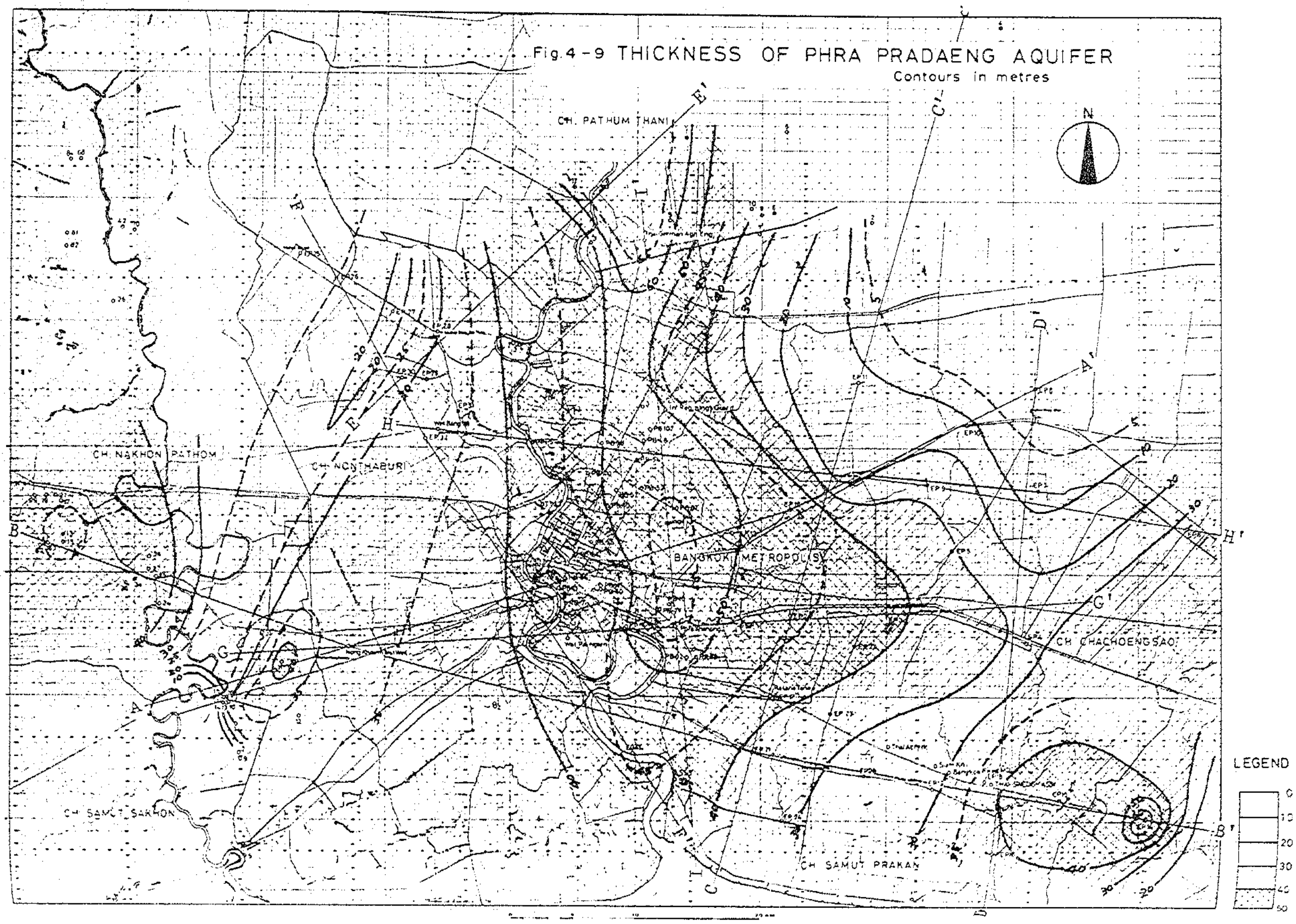


Fig.4-9 THICKNESS OF PHRA PRADAENG AQUIFER
Contours in metres
N
CH. PATHUM THANI
CH. NAKHON PATHOM
CH. NONTHABURI
BANGKOK METROPOLIS
CH. CHACHOENGSAO
CH. SAMUT SAKHON
CH. SAMUT PRAKAN
LEGEND
0 m
10
20
30
40
50

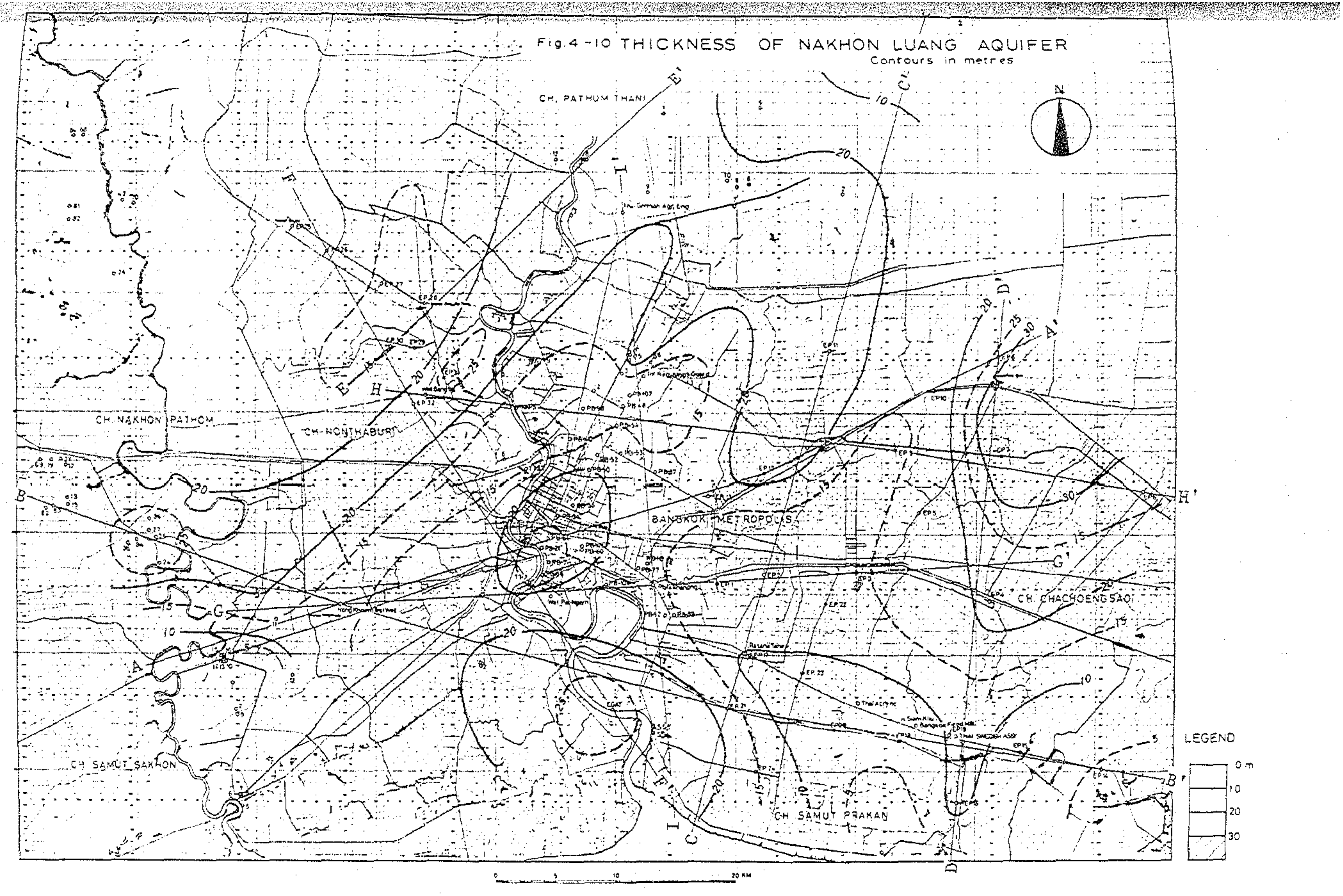


Fig.4-10 THICKNESS OF NAKHON LUANG AQUIFER
Contours in metres

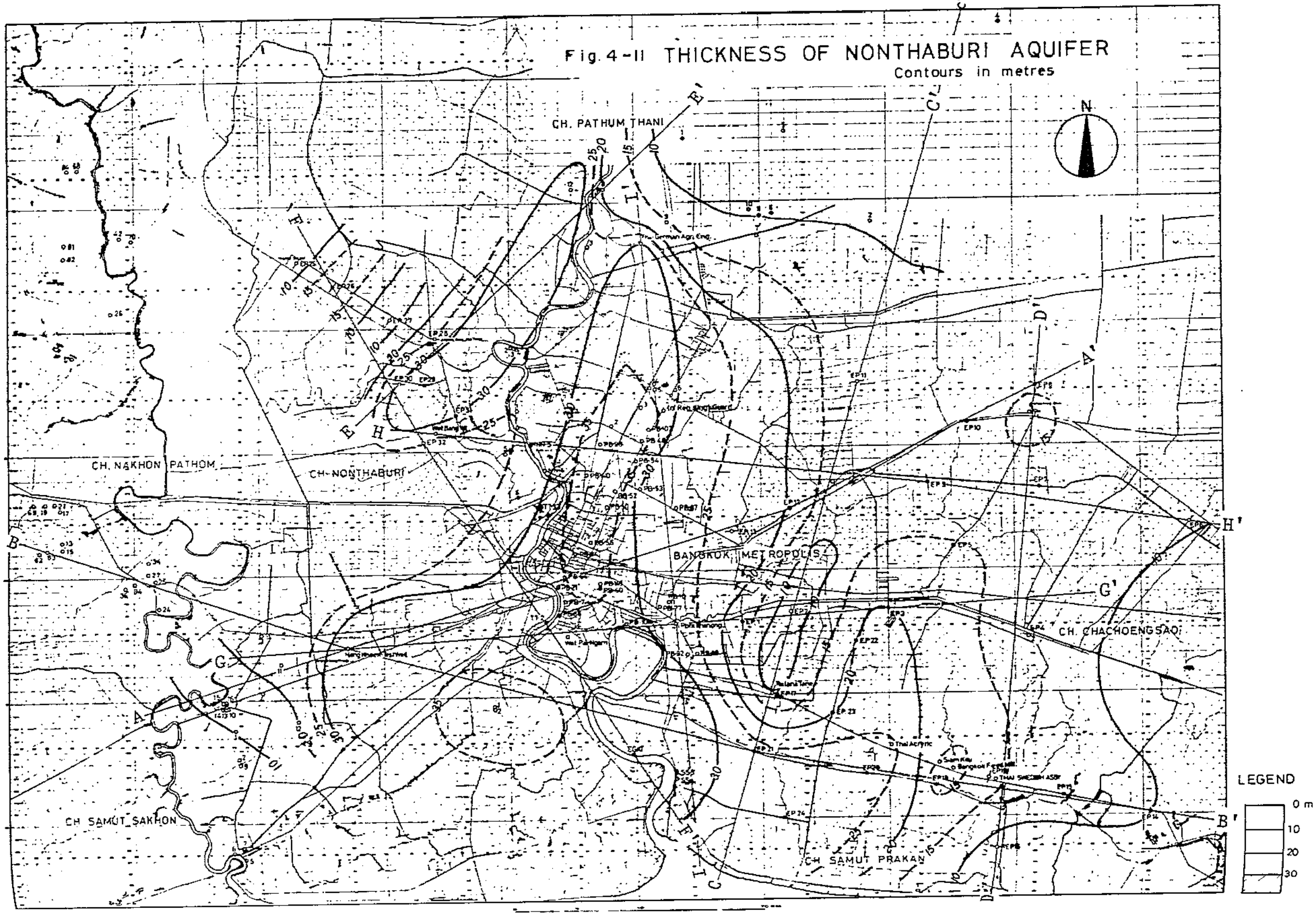


Fig. 4-11 THICKNESS OF NONTHABURI AQUIFER

Fig 4-12 LOCATION OF DEEP WELLS

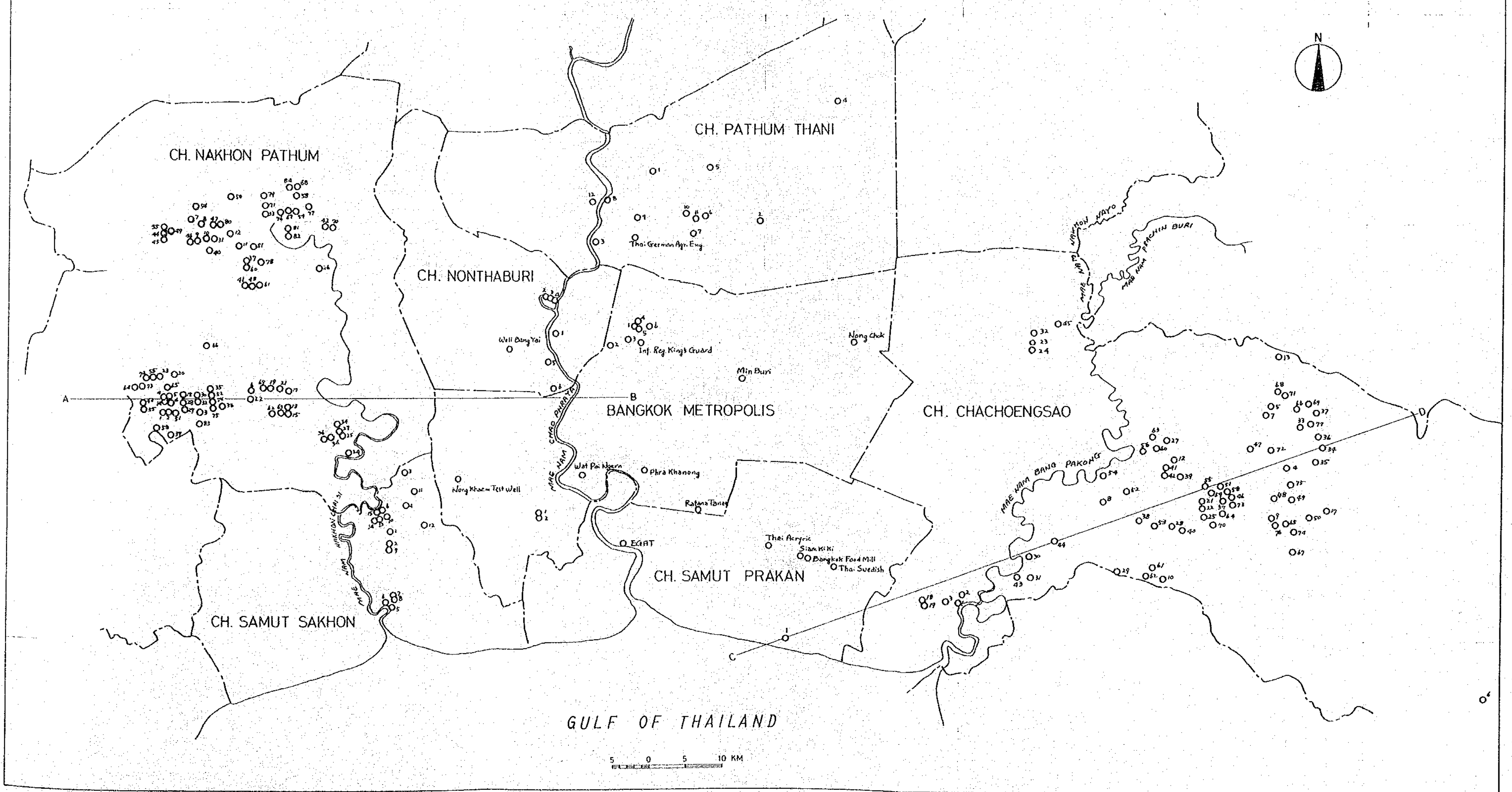
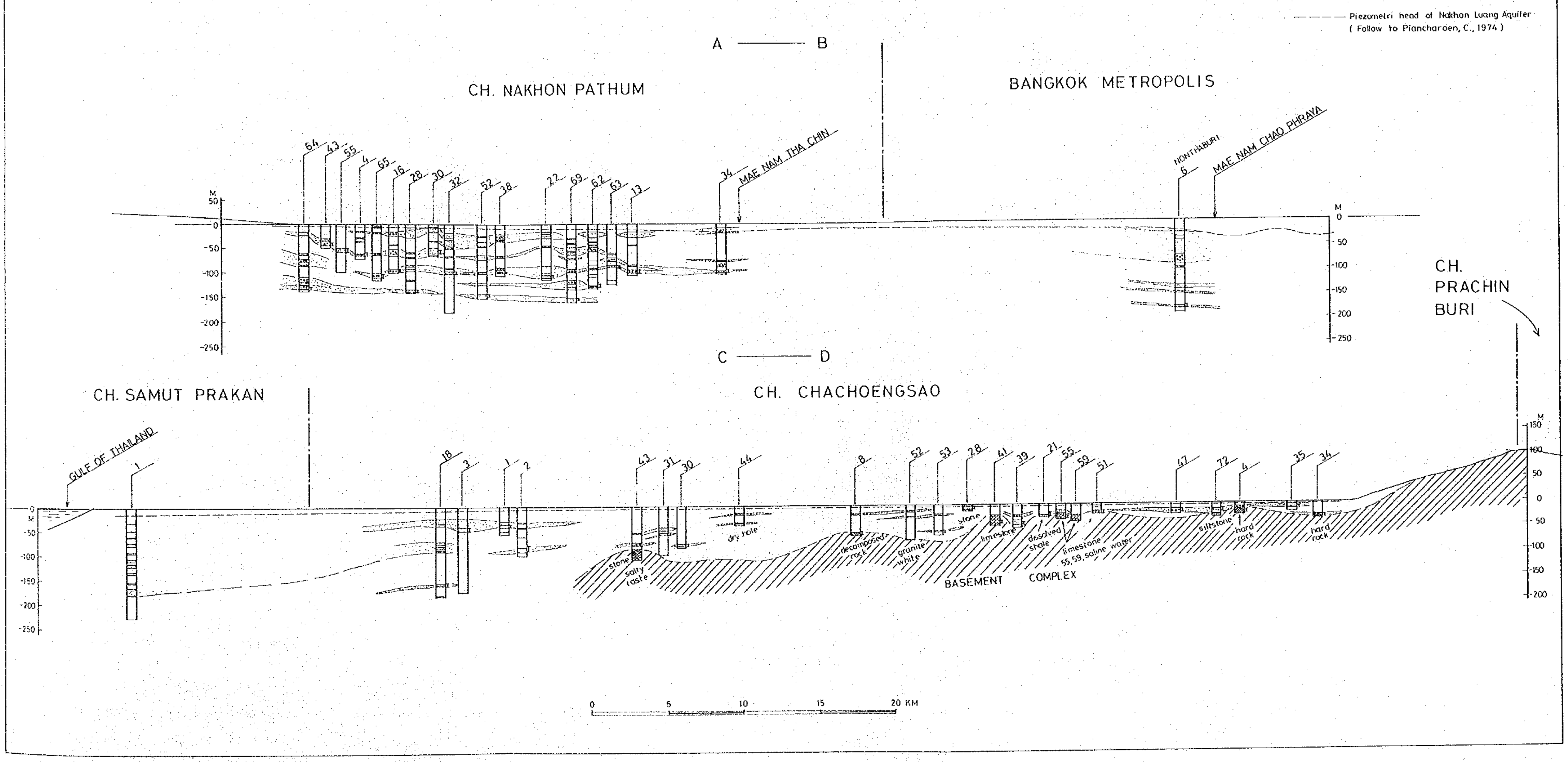


Fig 4-13 GEOLOGIC SECTION



(1) Right Bank of the Chao Phraya River :

Outlined herein are the aquifer structures in the area of Sai Noi, Bang Bua Thong and Bang Yai.

1) Bangkok Aquifer : This forms an anticline between Bang Bua Thong and Sai Noi. In Sai Noi, it inclines downward toward the north-west and joins the underground valley of Nakhom Pathom, while in Bang Bua Thong and Bang Yai the Bangkok aquifer forms a groundwater valley in the direction of the Bangkok underground valley. The bottom of the Bangkok aquifer is at a depth of 60 m in Sai Noi, 60 to 65 m in Bang Bua Thong, and 65 m in Bang Yai. The Bangkok aquifer is about 40 m thick throughout the area considered. The records of electrical prospecting show that the strata resistivity of this aquifer is 2 to 7 ohms-m, and adjudged not particularly desirable for an aquifer.

2) Phra Phradeang Aquifer : This inclines downward toward the west in Sai Noi and toward the east in Bang Bua Thong and Bang Yai. It is located over the east wing of the underground valley of Nakhom Pathom in Sai Noi, and over the west wing of the underground valley of Bangkok in Bang Bua Thong and Bang Yai. The bottom of the Phra Phradeang aquifer is at a depth of 115 m in Sai Noi, 100 to 110 m in Bang Bua Thong, and 110 m in Bang Yai. The Phra Phradeang aquifer thickness is 25 to 30 m in Sai Noi, 30 m in Bang Bua Thong, and 35 m in Bang Yai. This aquifer is thin between Sai Noi and Bang Bua Thong and becomes progressively more developed toward the west and east. The records of electric prospecting indicates that the resistivity of strata of this aquifer is in the range of 3.8 to 14.0 ohms-m; and thus this aquifer is better qualifies as a water source than the Bangkok aquifer, but its resistivity is not necessarily satisfactory.

3) Nakohn Luang Aquifer : This is nearly flat in all but the Bang Yai area where it slightly inclines downward toward the east. The bottom of the aquifer is at a depth of about 150 m from the ground surface in all the areas, but its thickness varies from one area to an other. The aquifer thickness is about 15 m in

Sai Noi and Bang Bua Thong, and 20 to 25 m in Bang Yai. The resistivity of its strata is relatively high, ranging from 12.4 to 38 ohms-m.

4) Nonthaburi Aquifer : This has a basin near Bang Bua Thong and inclines downward from Sai Noi and Bang Yai toward Bang Bua Thong. The bottom of the aquifer is at a depth of 180 to 190 m in Sai Noi, 200 to 220 m in Bang Bua Thong, and 190 m in Bang Yai; and the aquifer thickness is 10 to 15 m in Sai Noi, 25 m in Bang Bua Thong, and 25 to 30 m in Bang Yai. The strata resistivity is in the range of 12.4 to 38 ohms-m, which is about the same as that of the Nakhon Luang aquifer. A test well was bored in 1975 in the locality of Sai Noi and a series of tests were performed. As a result, the presence of good water in a stratum 190 m thick was confirmed, as the survey team was told. The past records show that well water in Sai Noi was contaminated with saline water; and, to judge from the changes in the quality of water, it appears that the well water was contaminated with water of poor quality from an other aquifer, presumably the Bangkok aquifer, due to the incomplete sealing of wells. A production well in Bang Yai which takes water from the Nakhon luang aquifer yielded water of good quality. The groundwater that is to be tapped for potable water in the area considered should be taken from the Nakhon Luang and Nonthaburi aquifers.

On the other hand, as the existing data on the groundwater of Nong Khaem district indicated that water quality was poor, the plan to tap the aquifer in Nong Khaem was discarded. According to the existing data, the basement of the Bangkok aquifer is at a depth of 70 m below ground surface, that of Phra Pradaeng aquifer from 115 to 120 m, that of Nakhon Luang aquifer 150 m, and that of Nonthaburi aquifer 220 m below ground surface. The Bangkok aquifer is presumed to be 35 to 50 m thick, the Phra Pradaeng aquifer about 35 m thick, the Nakhon Luang aquifer about 15 m thick and the Nonthaburi aquifer about 30 m thick. While aquifers are by no means poor as a water source of the right bank, the quality of groundwater in them is not qualified. Water from a deep well of a 80 m depth contains chloride ions in a concentration of 268 to 297 ppm, and iron ions in a concentration of

0.95 to 3.32 ppm. (Table 4-2).

Test boring to a depth of 500 m was performed in this area in 1971, and with results indicating that groundwater at a depth of 465 to 470 m was seemed to be available for water source of portable water but groundwater at other levels was not qualified, as shown in Table 4-3. This aquifer is presumed to belong to the Paknam aquifer at the greatest depth. As groundwater from the Phra Pradaeng, Nakhon Luang, Nonthaburi, Sam Kok and Phya Thai aquifers contained chloride ions in a concentration of 823 to 11,030 ppm, it was considered impossible to cover the demand until the target year by utilizing groundwater in this area, no matter how good the groundwater in the deepest aquifer.

Layers of sand and gravel are well developed below the ground of the east bank of the Nakhorn Chaisi river and the hydraulic conditions of groundwater in the area are relatively qualified. The analysis of water samples taken from 6 existing wells in this area showed relatively satisfactory values. That is, the water of this aquifer contained chloride ions in a concentration of 7.5 to 34 ppm, and iron ions in a concentration of 0.05 to 0.33 ppm. And, it was shown that this aquifer belonged to the Phra Pradaeng or Nakhon Luang aquifer. This aquifer, however, does not seem to have a yield sufficient to fill the demands in the area of Nong Khaem and Bang Khun Thian. If tapped, this aquifer should be exploited only as a temporary water source.

Table 4-2 WATER QUALITY OF PRODUCTION WELL AT NONG KHAEM

Item \ No.	1	2	3	4	5	WHO
Color	nil	21	20	little	little	-
Turbidity	13.0	38	46	17	30	-
pH	7.17	7.15	7.35	7.50	7.15	7.0 ~ 8.5
Methyl Orange Alkalinity	210	180	196	196	3.06	-
Phenolphthalein "	nil	nil	nil	nil	nil	-
Total Solids	-	1,737	1,607	1,489	930	100 500ppm
Dissolved Solids	660	1,250	1,150	1,100	655	-
Total Hardness	424	750	694	626	422	-
Carbonate "	210	180	196	196	306	-
Non-Carbonate "	214	570	498	430	116	-
Cℓ	293	297	268	275	277	200 ppm
SO_4	18.48	39.76	34.08	19.88	18.48	200 ppm
NO_2	nil	0.0054	0.0022	0.0086	nil	-
NO_3	nil	nil	nil	0.175	nil	40 ppm
Ca	64.6	184.2	134.6	134.6	41.6	75 ppm
Fe	0.95	3.32	2.87	1.41	1.93	0.3 ppm
Mn	0.452	0.358	0.508	0.828	0.452	0.1 ppm
Mg	42.24	68.64	66.72	69.12	38.88	50 ppm
Free Carbon Dioxide	74.0	52.0	57.0	60.0	62.0	-

Table 4-3 WATER QUALITY OF TEST WELL AT NONG KHAEM

Item \ No.	1)At 64~69m	2)At 98~102m	3)At 198~202m	4)At 300~305m	5)At 465~470m	W.H.O.
Color	less than 5	less than 5	less than 5	less than 5	less than 5	-
Odor	nil	nil	nil	nil	nil	-
Turbidity	10.2	47.0	89.5	35.0	84.0	-
pH	7.7	7.7	7.4	7.4	8.0	7.0 ~ 8.5
Total Solids	5,728	2,462	11,706	19,450	548	100~500 ppm
Dissolved Solids	5,512	2,340	11,408	18,280	434	-
Total Hardness	1,469	935	4,395	7,300	153	-
Carbonate "	142	161	165	160	153	-
Non-Carbonate "	1,327	792	4,230	7,140	nil	-
Cℓ	2,735	823	5,580	11,030	55.0	200 ppm
NO_2	0.140	nil	trace	nil	nil	-
NO_3	0.008	0.016	0.014	0.006	0.003	40 ppm
Fe	0.20	0.79	0.86	0.85	0.66	0.3 ppm
E.C.	8,500	3,000	15,000	30,000	600	-

(2) Left Bank of the Chao Phraya River :

Outlined herein are the aquifer structures in the areas of Nong Chok, Min Buri, Lat Krabang, Bang Phli, and Bang Bo.

1) Bangkok Aquifer : The bottom of this area is dome shaped near Min Buri, with the axis of an anticline stretching south-west, and develops into a large underground valley toward the east of this anticline and stretches south-west. The underground valley is about 15 km wide, forming a basin beginning at a point about 10 km east of Lat Krabang to Bang Phli.

The bottom of the Bangkok aquifer is at a depth of 50 m in Nong Chok, 40 to 45 m in Min Buri, 65 to 70 m in Lat Krabang, 80 to 85 m in Bang Phli, and 70 to 75 m in Bang Bo. The thickness of the aquifer progressively increases toward the center of the underground valley (Chachoeng Sao)and is as great as 40 to 50 m at its center . while the aquifer is as thin as 5 to 10 m in Nong Chok and Min Buri, 35 to 40 m thick in Lat Krabang, 35 to 40 m thick in Bang Phli, and about 35 m thick in Bang Bo. The underground water of this aquifer contains chloride and iron ions in such high concentrations that it is not used for potable water.

2) Phra Phradeang Aquifer : Structurally, this is much like the Bangkok aquifer. Its basement forms a dome near Nong Chok, and its anticline extends to Min Buri where it is intercepted by an extension of the Bangkok underground valley and thus changes its direction toward the south-east. The Bangkok underground valley extends to Bang Phli where it joins the underground valley that extends south-east from the eastern part of Lat Krabang. The bottom of the Phra Phradeang aquifer is at a depth of 80 m in Nong Chok, 100 m in Min Buri, 130 m in Lat Krabang, 140 m in Bang Phli, and 130 to 135 m in Bang Bo.

The thickness of this aquifer is about 5 m in Nong Chok, 20 m in Min Buri, 30 to 40 m in Lat Krabang, 40 m in Bang Phli, and 30 to 35 m in Bang Bo. This aquifer is well developed in Lat Krabang, Bang Phli, and Bang Bo and yields water which is used in the community for drinking and industrial purposes. In some parts of the area, however, the water contains iron ions in high concentrations.

3) Nakhon Luang Aquifer : This differs in structure from the aforementioned Bangkok and Phra Phradeang aquifers. The Bangkok underground valley that runs parallel to the Chao Phraya river changes its direction of flow here toward the east and extends from a point 5 km west of Min Buri to a point 5 km west of Bang Phli. The underground valley which is developed at Chachoeng Sao changes here into a wide basin.

The dome of the Nakhon Luang aquifer continues to the east of Nong Chok, and its base extends toward Min Buri and Lat Krabang.

The bottom of the Nakhon Luang aquifer is at a depth of 150 m in Nong Chok, 160 m in Min Buri and Lat Krabang, and 170 m in Bang Phli and Bang Bo. The thickness of the aquifer is 25 to 30 m in Nong Chok, 20 m in Min Buri, 15 m in Lat Krabang, and 10 to 15 m in Bang Phli and Bang Bo.

4) Nonthaburi Aquifer : The geological structure of this aquifer bears some resemblance to that of the Nakhon Luang. Its underground valley extends south-west in the area west of Min Buri and changes toward the south direction in the area of Wat Paingern. The underground valley forms a dome in the areas of Nong Chok and in the northwesterly part of Bang Phli, and the two domes are connected by a ridge.

The bottom of the Nanthaburi aquifer is at a depth of 190 m in Nong Chok, 200 m in Min Buri, 190 m in Lat Krabang, 210 m in Bang Phli, and 200 m in Bang Bo. The thickness of this aquifer is 15 m in Nong Chok, Min Buri, Lat Krabang, and Bang Bo, and 20 to 25 m in Bang Phli.

It is presumed that the time of deposition of the middle and upper strata of the aquifers of five Amphers on the left bank of the Chao Phraya river nearly coincided with that of the Bangkok and Phra Phradeang aquifers, whereas the place and conditions of deposition seem to differ from the Nakhon Luang aquifer to the Nonthaburi aquifer. The electrical prospecting shows that the resistivity of the Bangkok aquifer is in the range of 3.9 to 5.0 ohms-m in Nong Chok, 1.4 to 6.9 ohms-m in Min Buri, 2.0 to 9.8 ohms-m in Lat Krabang, 5.0 to 7.8 ohms-m in Bang Phli, and 2.5 to 23.0 ohms-m in Bang Bo. The resistivity of the Bangkok aquifer is low over much of its length. The fact that the resistivity of its strata is low in spite of a considerable thickness except in Nong Chock and Min Buri suggests a poor quality of the water of this aquifer.

On the other hand, the resistivity of the Phra Phradeang aquifer is relatively high, ranging from 4.2 to 13.2 ohms-m in Nong Chok, 4.6 to 12.9 ohms-m in Min Buri, 4.0 to 9.8 ohms-m in Lat Krabang, 3.4 to 40.0 ohms-m in Bang Phli, and 12.0 to 15.0 ohms-m in Bang Bo. The resistivity of strata of this aquifer is rather high in Bang Phli and Bang Bo, as shown above, but is, on the whole, near the average value of the Bangkok aquifer. This means that the Phra Phradeang aquifer does not necessarily make a good water source for human use.

The Nakhon Luang and Nonthaburi aquifers show much the same level of resistivity of strata, which ranges from 8.4 to 13.2 ohms-m in Nong Chok, 4.6 to 12.9 ohms-m in Min Buri, 9.2 to 22.0 ohms-m in Lat Krabang, 7.2 to 40.0 ohms-m in Bang Phli, and 12.0 to 23.0 ohms-m in Bang Bo. The average resistivity of the two aquifers is much higher than that of the Bangkok and Phra Phradeang aquifers. High resistivities of strata are nothing but an indication that the aquifers contain evaporation residues and clay soil in relatively low percentages.

On the basis of the structural features, and the resistivity of aquifers resulting from electrical prospecting, the Bangkok and Phra Phradeang aquifers and the Nakhon Luang and Nonthaburi aquifers may be categorized into two groups; and the two groups, the Nakhon Luang and Nonthaburi aquifer group should be chosen as the water source for the water supply project, as suggested by the past data and the information obtained by the latest survey.

The aquifers planned to be tapped in this feasibility study are shown according to district and as shown in Table 4-4.

Table 4-4 ADOPTED AQUIFERS FOR SEPARATE SYSTEM

	Aquifer	Right Bank			Left Bank				
		Sai Noi	Bang Bua Thong	Bang Yai	Nong Chok	Min Buri	Lat Krabang	Bang Phli	Bang Bo
Depth of Bottom	Bangkok	60 m	60 - 65 m	65 m	50 m	40 - 45 m	65 - 70 m	80 - 85 m	70 - 75 m
	Phra Pradaeng	115	100 - 110	110	80	100	130	140	130 - 135
	Nakhon Luang	150	150	150	150	**160**	**160**	170	170
	Nonthaburi	**180 - 190**	**200 - 220**	**190**	**190**	200	190	**210**	**200**
Thick-ness	Bangkok	40 m	40 m	40 m	5 - 10 m	5 - 10 m	35 - 40 m	35 - 40 m	35 m
	Phra Pradaeng	25 - 30	30	35	5	20	30 - 40	40	30 - 35
	Nakhon Luang	15	15	20 - 25	25 - 30	20	15	10 - 15	10 - 15
	Nonthaburi	10 - 15	25	25 - 30	15	15	15	20 - 25	15
Specific Resist-ance	Bangkok	2.0 - 7.0 Ω-m			3.9 - 5.0 Ω-m	1.4 - 6.9 Ω-m	2.0 - 9.8 Ω-m	5.0 - 7.8 Ω-m	2.5 - 23.0 Ω-m
	Phra Pradaeng	3.8 - 14.0			4.2 - 13.2	4.6 - 12.9	4.0 - 9.8	3.4 - 40.0	12.0 - 15.0
	Nakhon Luang & Nonthaburi	12.4 - 38.0			8.4 - 13.2	4.6 - 12.9	9.2 - 22.0	7.2 - 40.0	12.0 - 23.0

NOTE : Shows adopted Aquifer for Separate System

4-1-2 Electric Prospecting:

Electric prospecting is widely employed one of the method in the investigation of groundwater, and the most common of all its methods is the resistivity method. The resistivity method of electric prospecting utilizes the phenomenon that there is a considerable difference in resistivity between the aquifer and the impermeable layer. Another reason for its popular use is the fact that the soil investigated has a stratified structure in most instances.

The electric resistivity of the soil layers is generally influenced by the following factors:

1) Mineral composition of the layer.

2) Crystallinity of minerals.

3) Consolidation of the composite material of the layer.

4) Porosity of the layer.

5) Amount of groundwater in the layer and its resistivity.

Judging from the results of electric prospecting to an average depth of 200 m in the area surrounding Bangkok, there does not appear to be any significant difference in mineral composition and crystallinity from one place to the other. In this area, therefore, the consolidation of the composite material of the layer, porosity of the layer, amount of water in the layer and its resistivity can be considered the factors which govern the resistivity of the layer of interest.

The results of measurements taken in electric prospecting are analyzed by the standard curve method and direct identification method. The former method is employed in the determination of the resistivity of the layer from the observed apparent resistivity. When this method is employed, the boundary of layers is detected according to the difference in electric nature between the two layers unlike the boundary of aquifers. On the other hand, when the direct identification method is employed, the depth distribution of layers is expressed by a curve and the boundary of layers is determined by expressing the layer of sand and gravel in case of a rising curve and the layer of clay in case of a falling curve.

The location of electric prospecting and results of them performed in surrounding area of Bangkok can be represented by the columns of resistivity as shown in Fig's. 4-14 and 4-15. The notable finding obtained in the electric prospecting in this area is the fact that the upper bed shows a low value of layer resistivity, while the lower bed is high in layer resistivity. The boundary of the upper and lower layers is at a depth of about 50 m in some parts and at a depth of about 100 m in others. It appeared that the boundary at a depth of 50 m was that of the Bangkok and Phra Pradaeng aquifers, and that the boundary at a depth of 100 m was that of the Phra Pradaeng and Nakhon Luang aquifers.

The distribution of layer resistivity to a depth of 100 m to 200 m is as shown in Fig. 4-14. As is clear from this figure, the soil of the northern area on both the right and left banks of the Chao Phraya river shows a low value of resistivity.

The southern coastal area on the left bank of the Chao Phraya river also shows a low value of resistivity. The area in which a high value of resistivity was shown extends from Sai Noi to Bang Yai, and an other similar area extends along National Highway No. 34 from Bang Phli to Bang Bo.

The specific electric conductivity and resistivity of ground water are influenced by the degree in a concentration of ions in the groundwater such that the better quality the water has, thus the lower its specific electric conductivity and the higher its resistivity. (Refer to Figs. 4-16, 4-17 and 4-18).

It can therefore be said that the groundwater is satisfactory, both qualitatively and quantitatively, in the district where the soil shows a higher value of resistivity. If the value of layer resistivity is low, the pumpage must be planned to have an extra margin of safety and the well must be designed to have a sufficient depth to reach the aquifer showing a high value of resistivity.

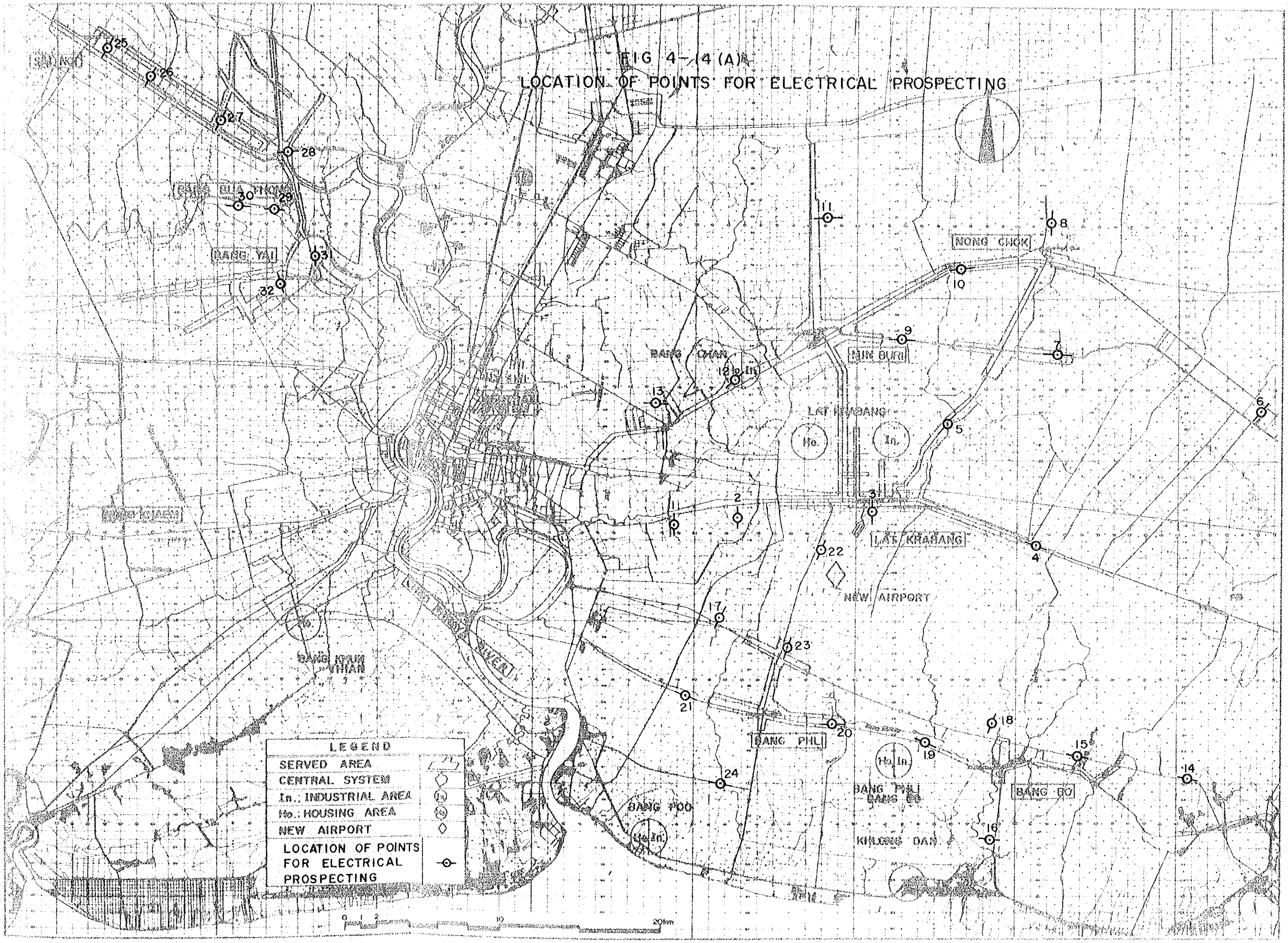


FIG 4-14 (A)
LOCATION OF POINTS FOR ELECTRICAL PROSPECTING

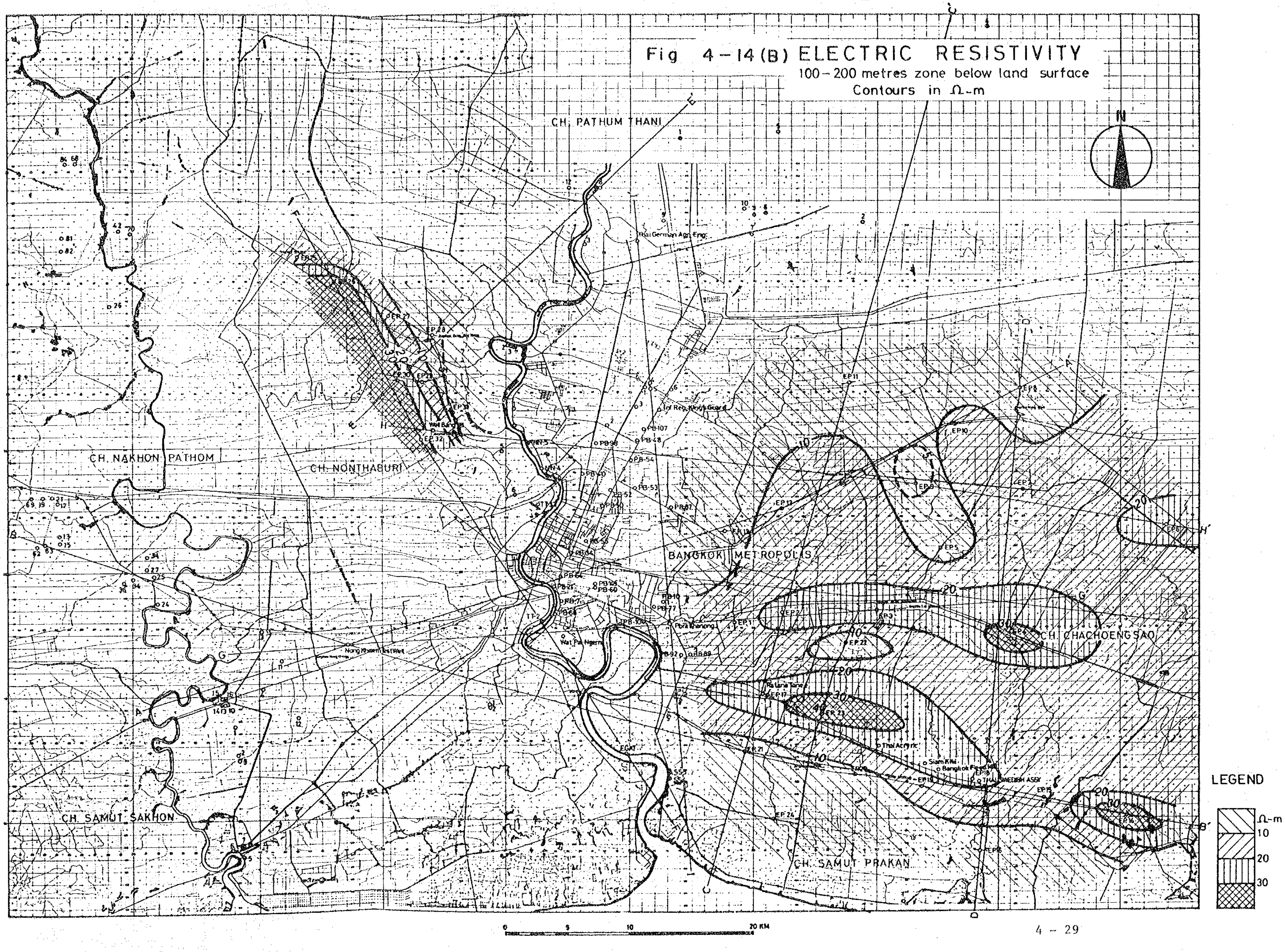
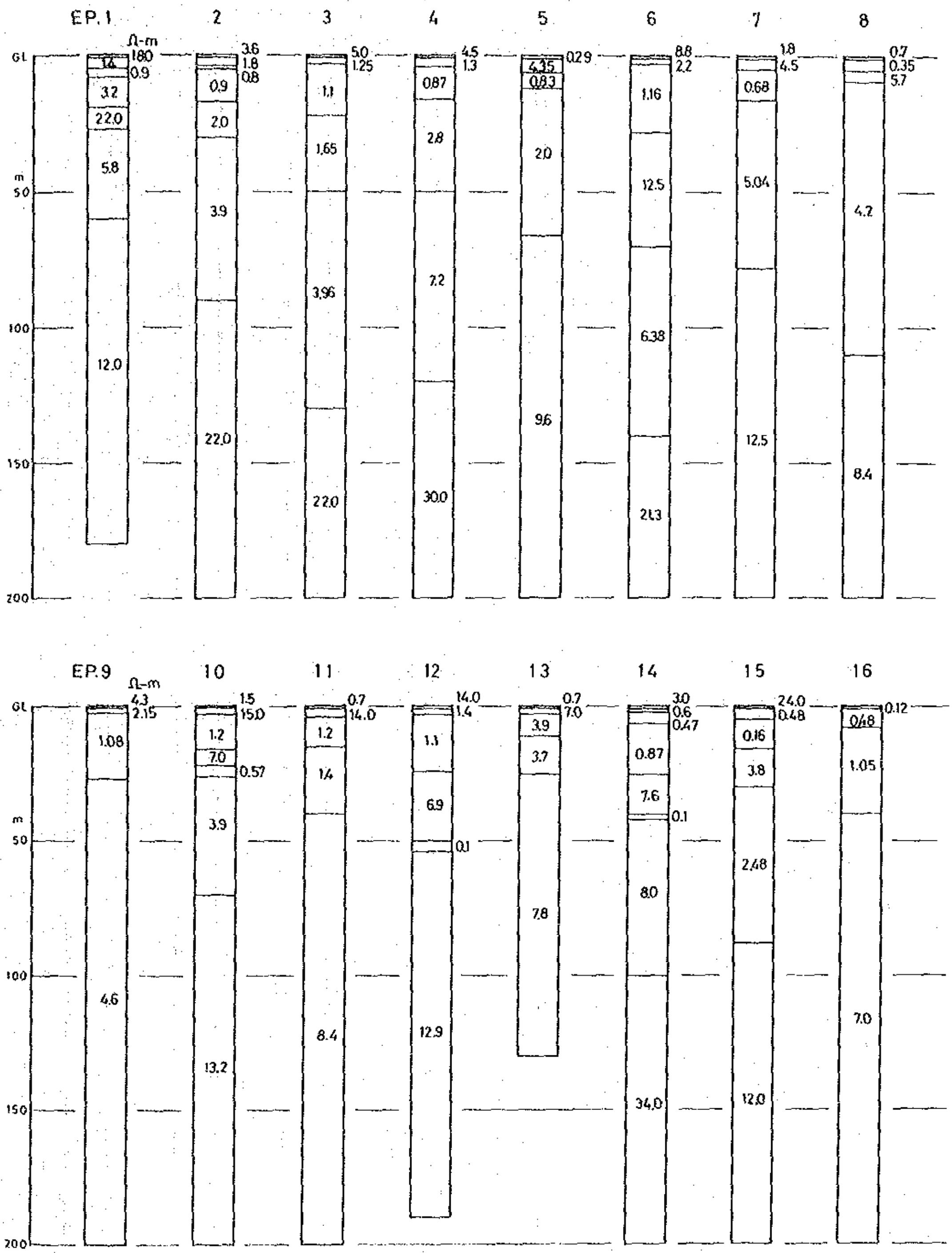


Fig 4-14(B) ELECTRIC RESISTIVITY
100-200 metres zone below land surface
Contours in Ω-m
N
CH. PATHUM THANI
CH. NAKHON PATHOM
CH. NONTHABURI
BANGKOK METROPOLIS
CH. CHACHOENGSAO
CH. SAMUT SAKHON
CH. SAMUT PRAKAN
LEGEND
Ω-m
10
20
30
0 5 10 20 KM

Fig 4 -15 COLUMNS OF ELECTRIC LOG - 1
after ρ-a curves



COLUMNS OF ELECTRIC LOG — 2
after ρ-a curves

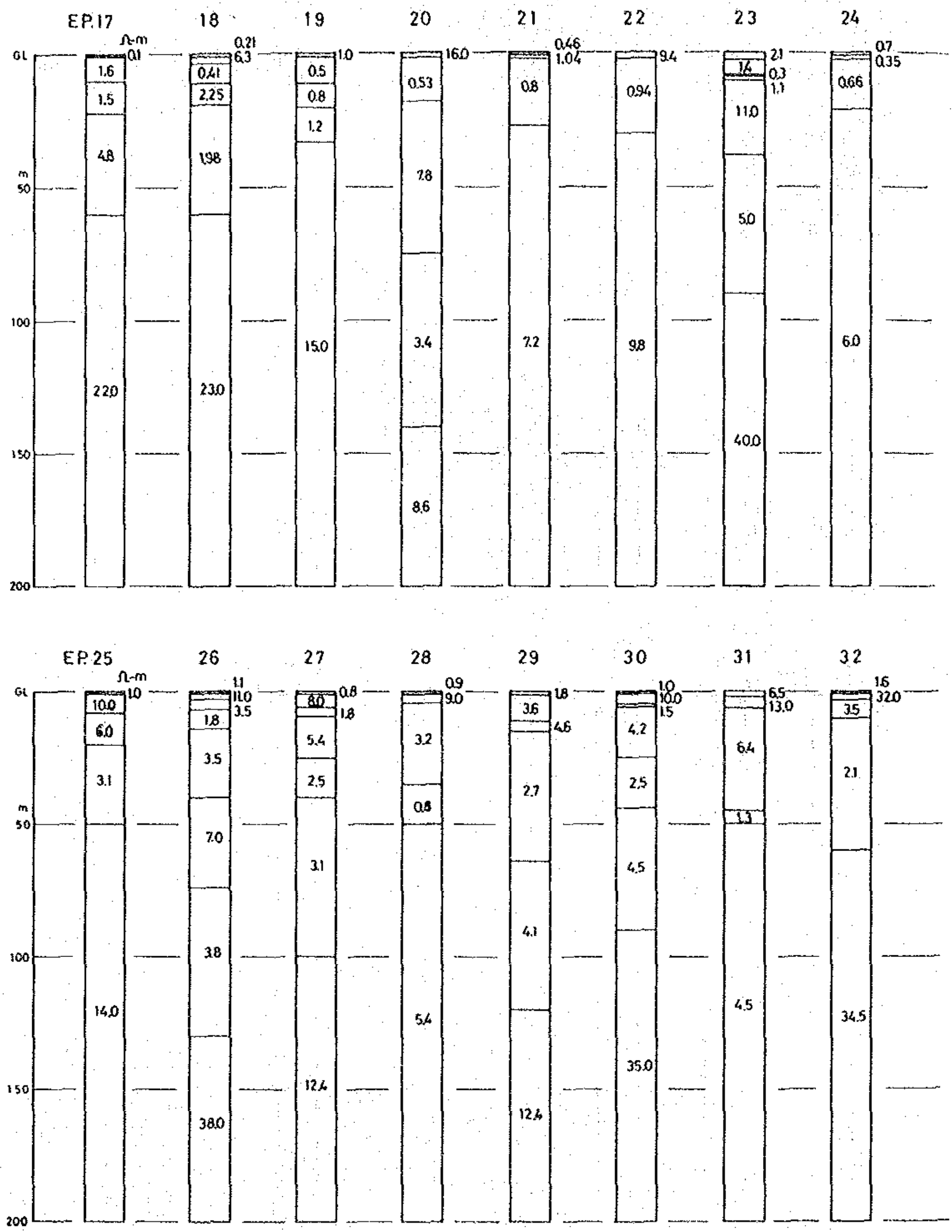


Fig. 4-16 RELATIONSHIP OF ELECTRIC CONDUCTIVITY AND Cl^{-1} CONTENTS OF GROUND WATER IN BANGKOK

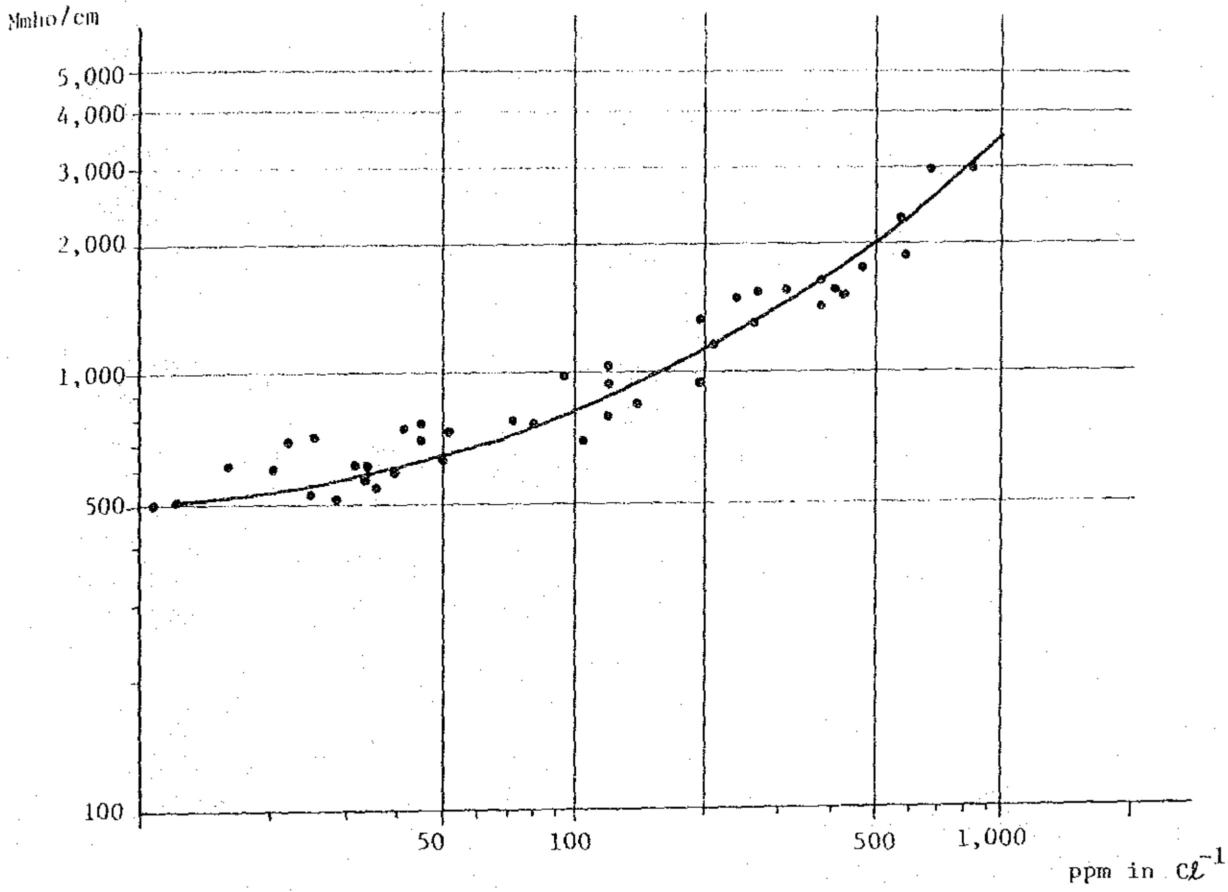


Fig. 4-17 RELATIONSHIP OF ELECTRIC CONDUCTIVITY AND EVAPORATION RESIDUE IN GROUND WATER IN BANGKOK

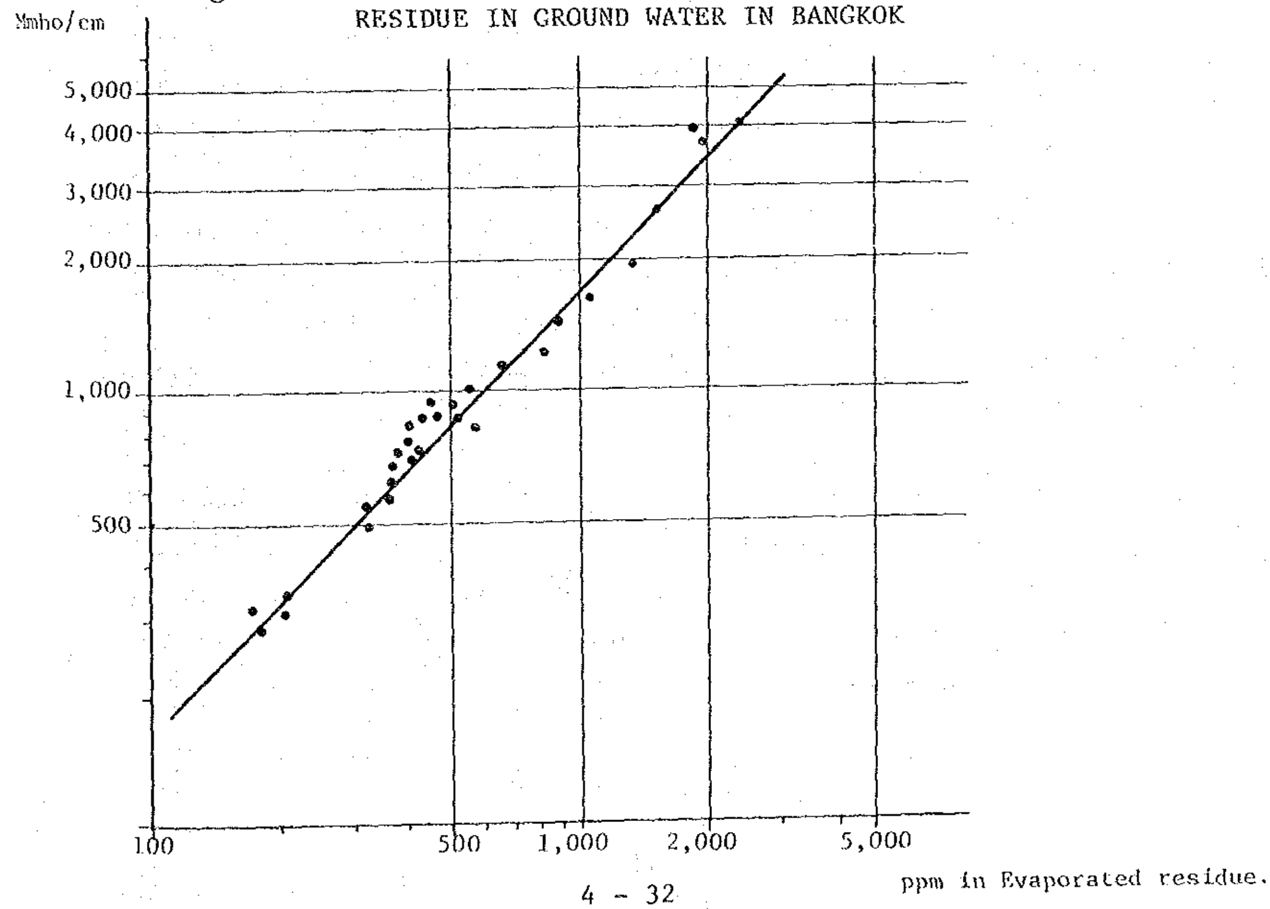
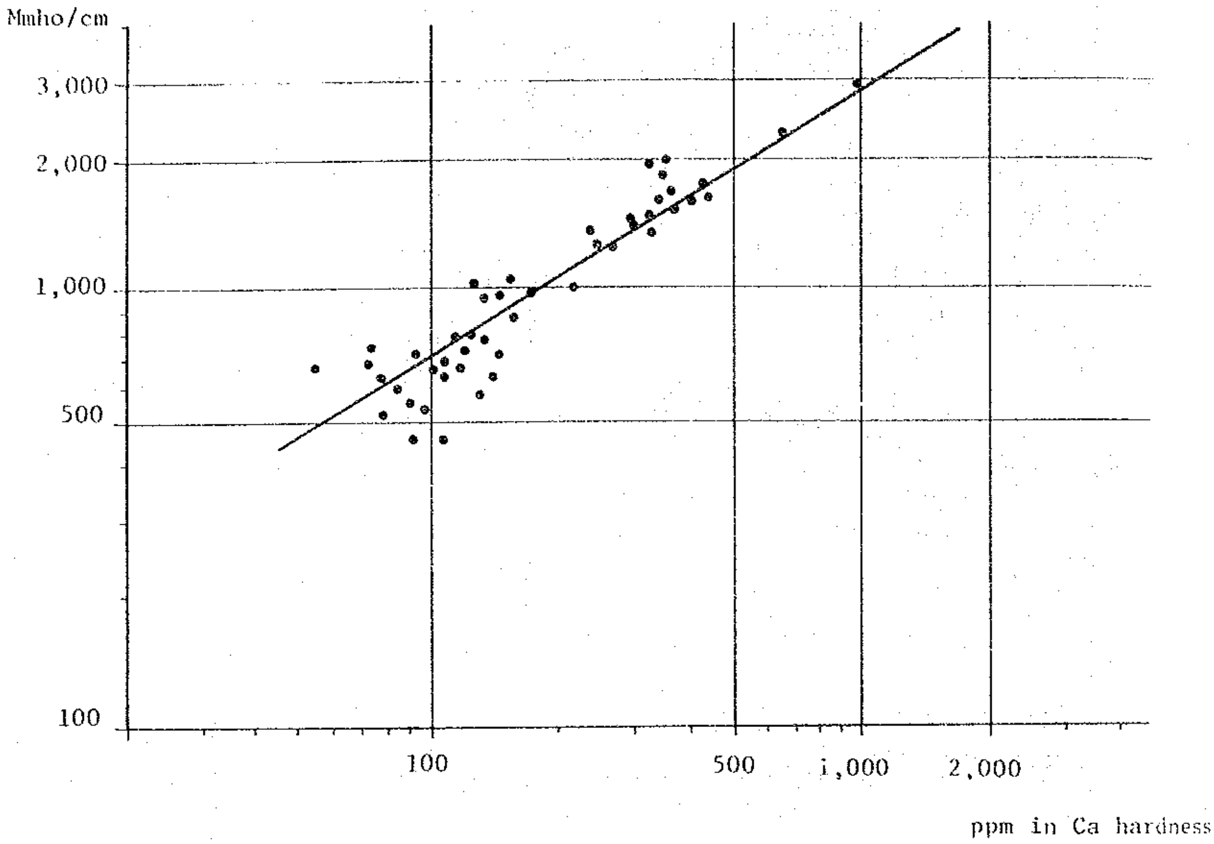


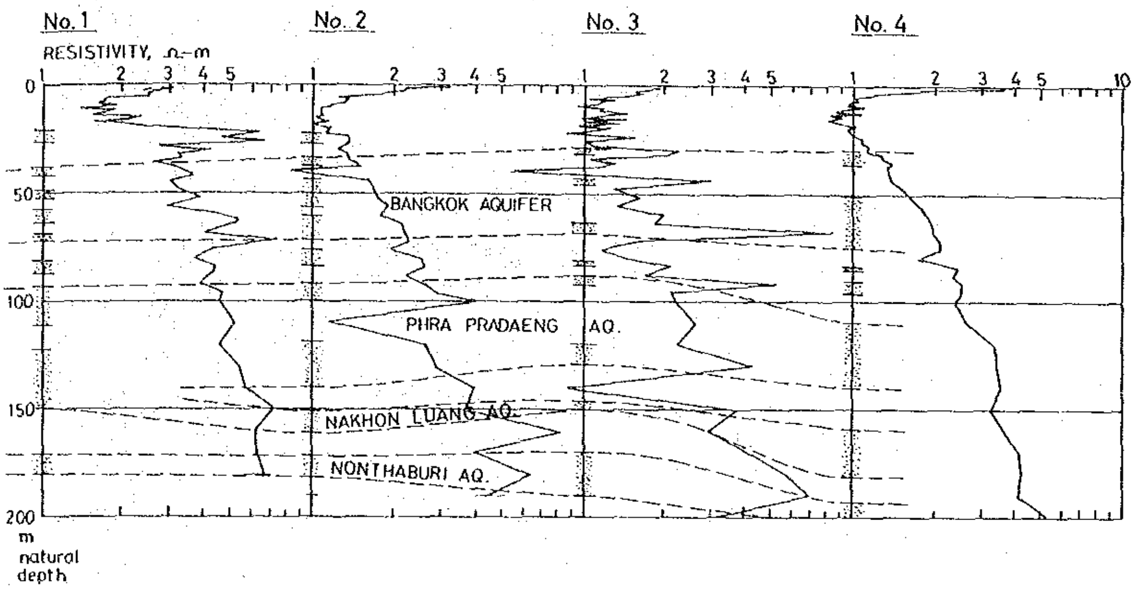
Fig. 4-18 RELATIONSHIP OF ELECTRIC CONDUCTIVITY AND Ca HARDNESS OF GROUND WATER IN BANGKOK

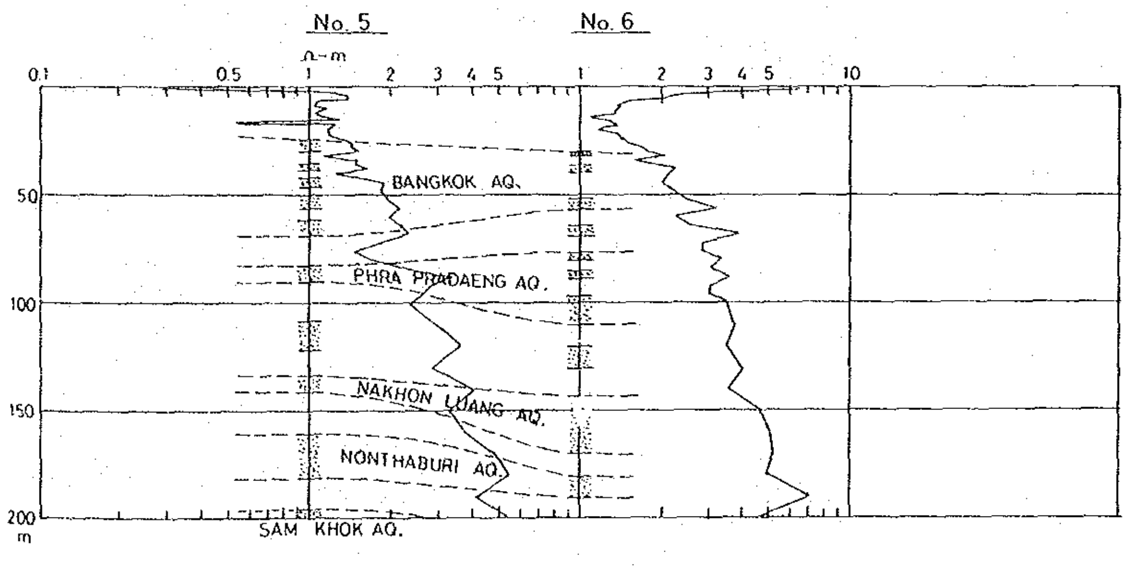


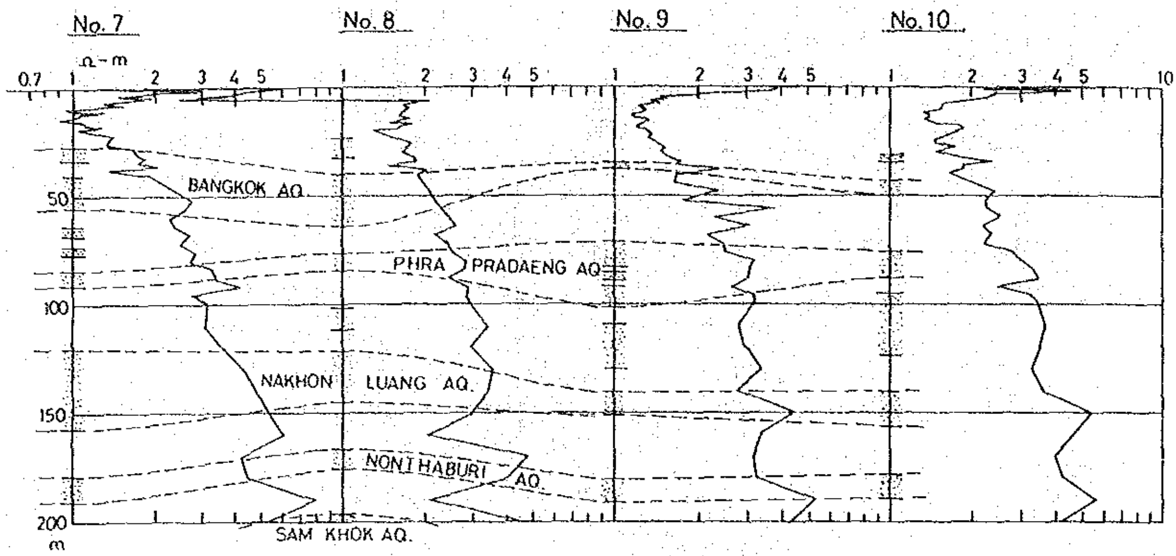
For the districts where no boring data were available it was necessary to estimate the soil structual profile from the results of electric porspecting. The results of electric prospecting were analyzed by the direct identification method, as shown in Fig. 4-19. Since the layer distinction by this method is made on the basis of a change in apparent resistivity, it must be compared with the soil data obtained by boring in the neighboring site. In the surveyed area there was good agreement between the results of electric prospecting and the soil data of the neighboring site, so that the direct identification method was employed.

However, the data obtained by electric prospecting should be used as a only guide for the estimation of the soil nature, since all such data are obtained on the ground surface. In the stage of detail design, therefore, exploratory boring must be carried out without fail to obtain the soil conditions and determine the thickness of the aquifer.

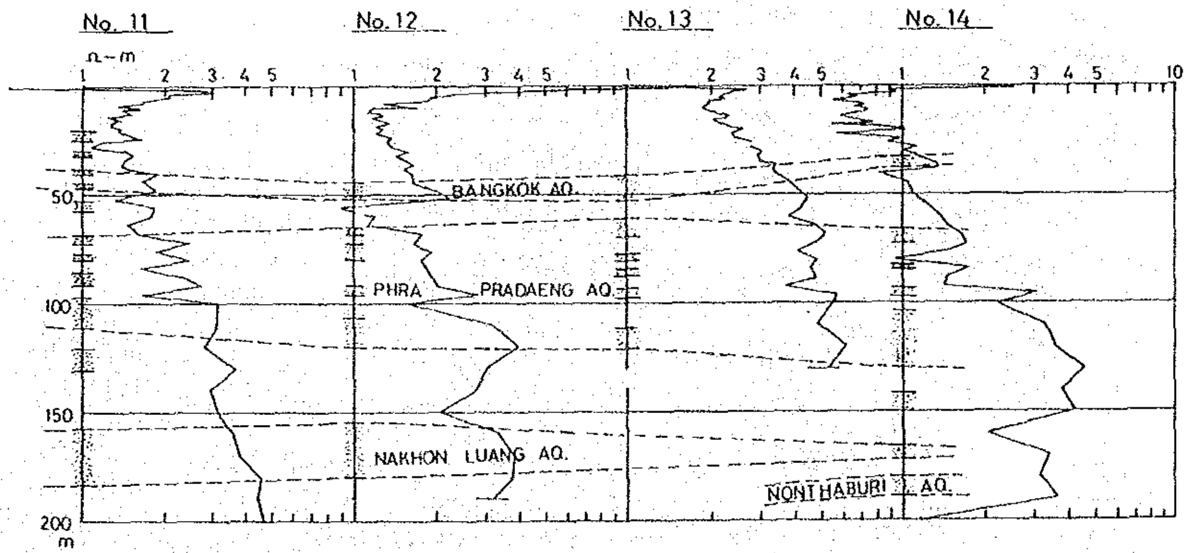
Fig. 4-19 ELECTRIC LOG ρ-NATURAL DEPTH



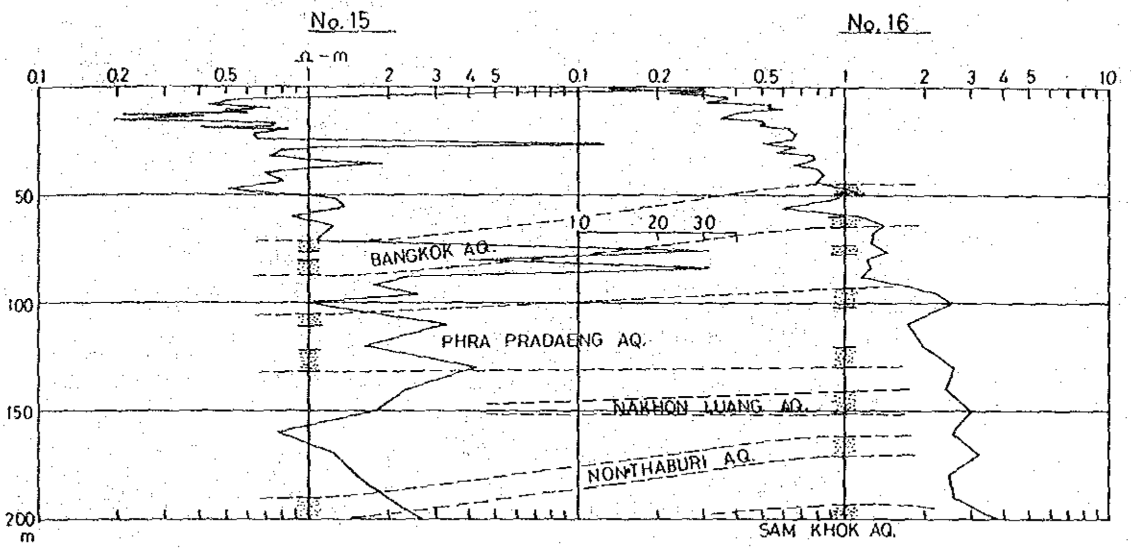


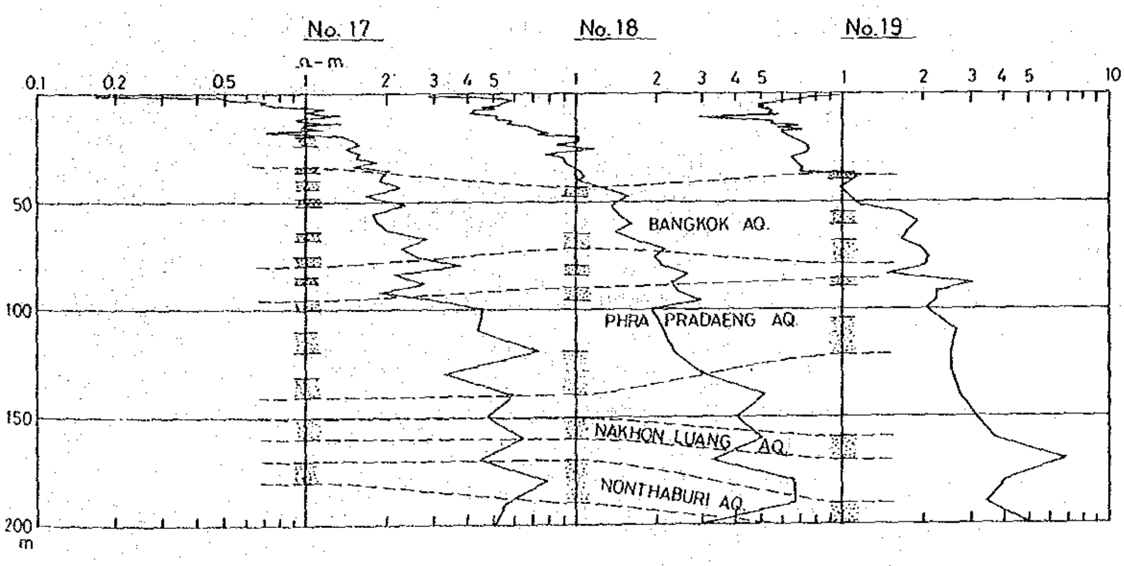


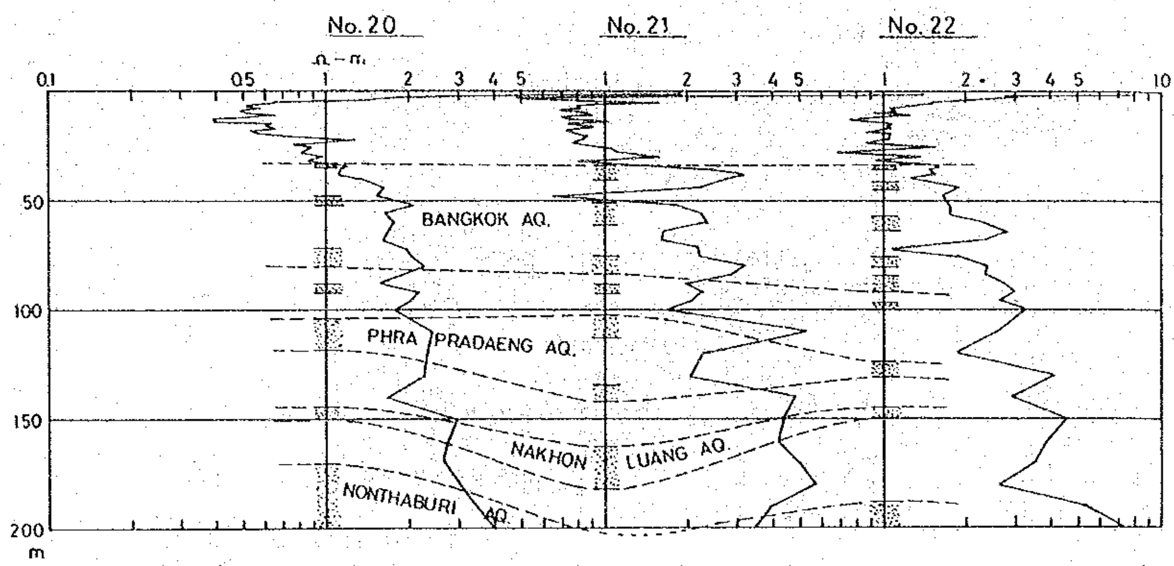
No. 7
No. 8
No. 9
No. 10
Ω-m
0.7
1
2
3
4
5
10
50
100
150
200
m
BANGKOK AQ.
PHRA PRADAENG AQ.
NAKHON LUANG AQ.
NONTHABURI AQ.
SAM KHOK AQ.

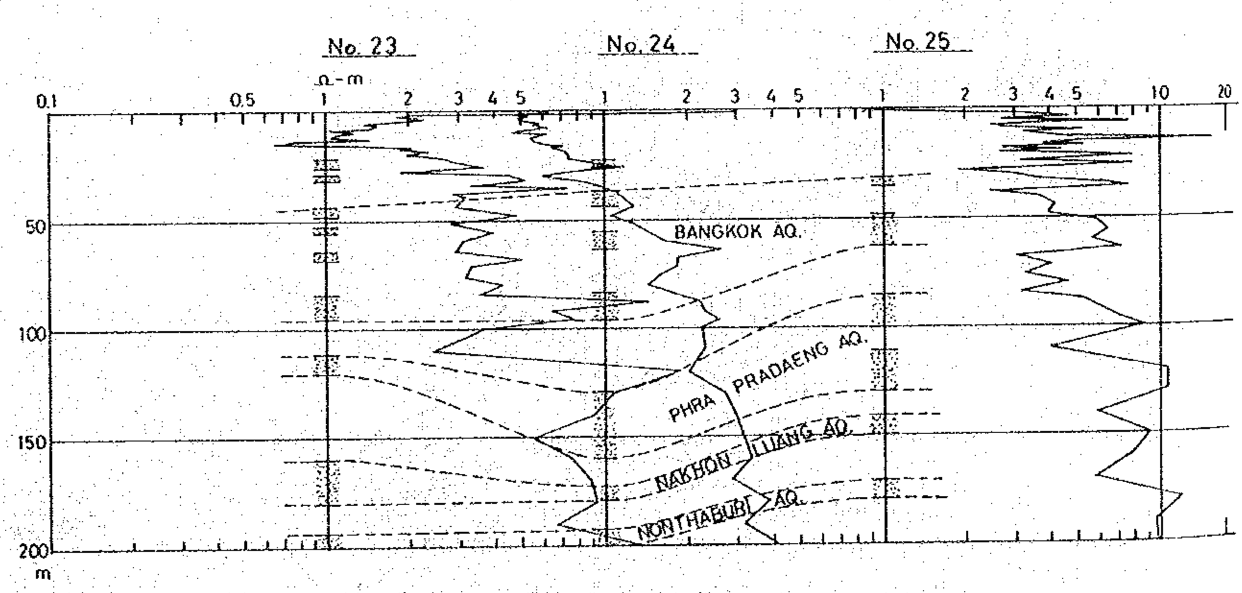


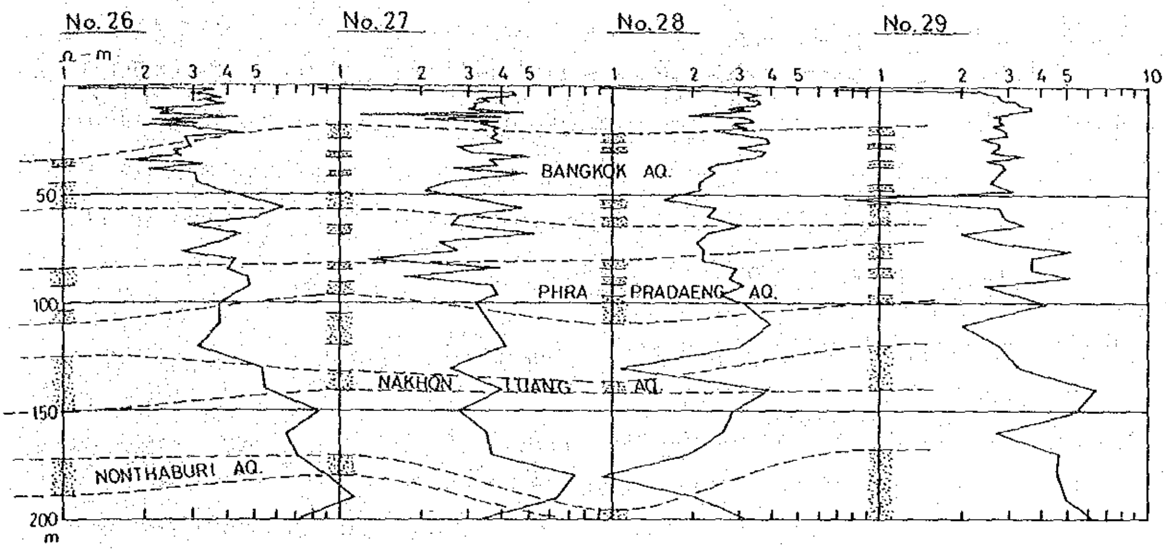
No. 11
No. 12
No. 13
No. 14
Ω-m
1
2
3
4
5
10
50
100
150
200
m
BANGKOK AQ.
PHRA PRADAENG AQ.
NAKHON LUANG AQ.
NONTHABURI AQ.

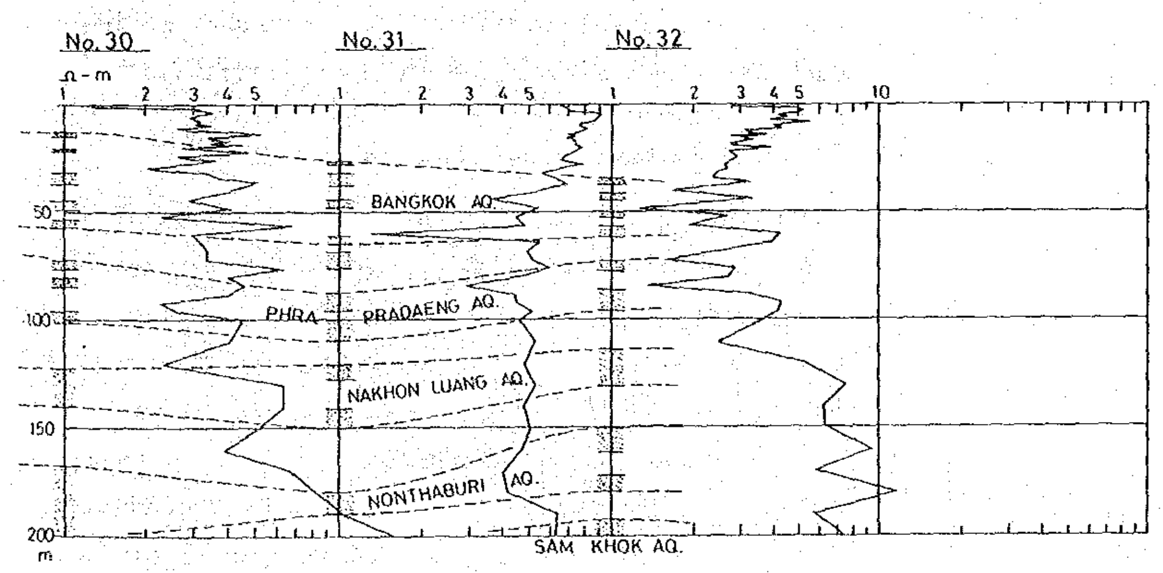

No. 15
No. 16
Ω - m
0.1
0.2
0.5
1
2
3
4
5
0.1
0.2
0.5
1
2
3
4
5
10
50
100
150
200
m
10
20
30
BANGKOK AQ.
PHRA PRADAENG AQ.
NAKHON LUANG AQ.
NONTHABURI AQ.
SAM KHOK AQ.


No. 17
No. 18
No. 19
Ω - m
0.1
0.2
0.5
1
2
3
4
5
1
2
3
4
5
1
2
3
4
5
10
50
100
150
200
m
BANGKOK AQ.
PHRA PRADAENG AQ.
NAKHON LUANG AQ.
NONTHABURI AQ.


No. 20
No. 21
No. 22
Ω - m
0.1
0.5
1
2
3
4
5
10
50
100
150
200
m
BANGKOK AQ.
PHRA PRADAENG AQ.
NAKHON LUANG AQ.
NONTHABURI AQ.


No. 23
No. 24
No. 25
Ω - m
0.1
0.5
1
2
3
4
5
10
20
50
100
150
200
m
BANGKOK AQ.
PHRA PRADAENG AQ.
NAKHON LUANG AQ.
NONTHABURI AQ.


No. 26
No. 27
No. 28
No. 29
Ω - m
1
2
3
4
5
10
50
100
150
200
m
BANGKOK AQ.
PHRA PRADAENG AQ.
NAKHON LUANG AQ.
NONTHABURI AQ.


No. 30
No. 31
No. 32
Ω - m
1
2
3
4
5
10
50
100
150
200
m
BANGKOK AQ.
PHRA PRADAENG AQ.
NAKHON LUANG AQ.
NONTHABURI AQ.
SAM KHOK AQ.