CHAPTER I

INTRODUCTION

1.1 General

Bangkok Metropolis is one of the most rapid growing capitals of the world that has population of approximately four and a half millions in 1980. It is situated about 25 kilometers north of the Gulf of Thailand and occupies both sides of the Chao Phraya River. Due to slow and inefficient development of surface water resources so extraction of the groundwater takes place to fulfill its ever increasing demand of water. In 1980, approximately 500 groundwater wells in Bangkok area have been drilled by four main groups, Metropolitan Water Work Authority (MWWA), Private Drilling Contractors, Electricity Generating Authority and Department of Mineral Resources. Almost all of them have the depth of penetration less than 300 meters below the ground surface.

Depletion of water, deterioration of water quality and general land subsidence will be some of irrecoverable losses caused by uncontrolled groundwater extraction. Even today Bangkok Metropolis is badly affected by general land subsidence as well as depletion of water and deterioration of groundwater quality.

Now, there are several interpretations regarding Bangkok subsurface strata. Although in the Lower Central Plain has still many questions on geology and geohydrology, Piyasena (1979) conclude that:

1) The stratigraphy of the Lower Central Plain sedimentary deposits has not been established.

2) The geological history of the Central Plain (especially the ages of the sediments and the effects of the Pleistocene sea level changes on the nature and the distribution of sediments) is not known.

3) The thickness, lateral extension and the distribution of the sedimentary units have not been defined.

4) The knowledge of the lateral extension of these sedimentary units into the Gulf is virtually nil.

5) The information on properties of aquifers such as recharge area, rate of recharge, transmissibility, etc., are very limited and are often not reliable.

6) The depositional environment of these sedimentary units have not been studied, thus the extent of the connate brine trapped in aquifers connot be delineated.

1.2 Study area.

The study area has been defined to include the Changwats of Nonthaburi, Pathum Thani, Bangkok and Samut Prakan. Total area is 1,500 squre kilometers, from lattitude 13°33'N to 13°59'N and longitude 100° 25'E to 100°41'E (Figure 1; Plates 1,2 and 3). Essentially, the study area extends easterly from Amphoe Taling Chan to Amphoe Bang Krapi. The southern and northern limits are approximately the Gulf of Thailand and Amphoe Muang Pathum Thani respectively.

1.2.1 Topography and drainage.

The topography of study area is typical of a flood plain and delta of the Chao Phraya River (Metcalf & Eddy Inc., 1977). So it is extremely flat and land elevations generally range from 1 to 1.5 meters above the mean sea level, with a maximum elevation of about 2 meters. The Chao Phraya River is the principal drainage in the area and it drains from North to South, which does not conform with groundwater flows (Figure 2)

1.2.2 Climate and land-use.

Generally there are three seasons in Bangkok area (Table 1)

Table 1 : The Climatological data of Bangkok Area, 1951-1975 (Climatology Division, Meteorological Department)

Month	Season	Average Precipitation (millimeters)	Average Temperature (celcius)
October - January	Cold Season	301.1	26.2
February - May	Hot Season	312.2	28.6
June - September	Rainy Season	930.6	27.9

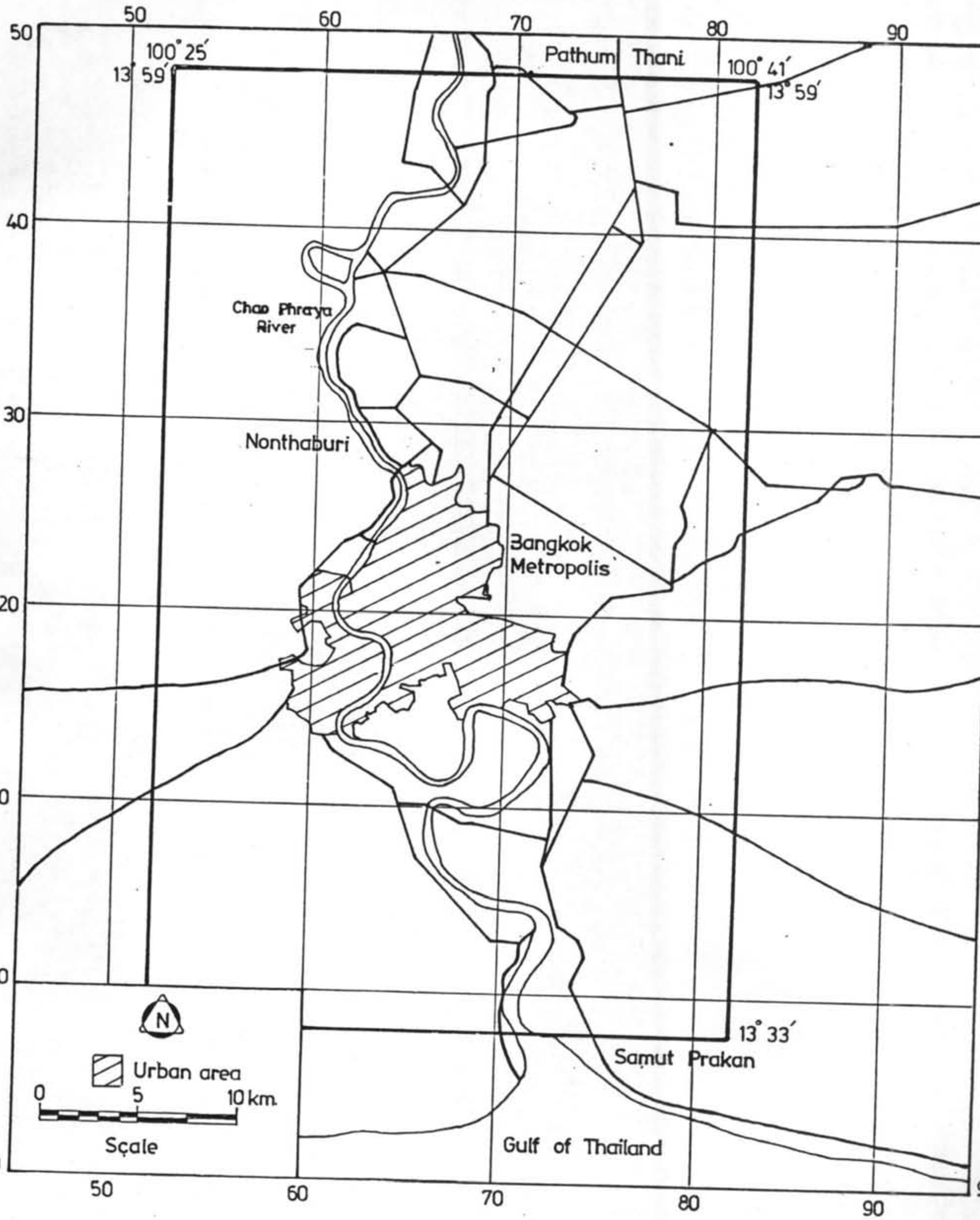

Figure 1 MAP OF THE STUDY AREA

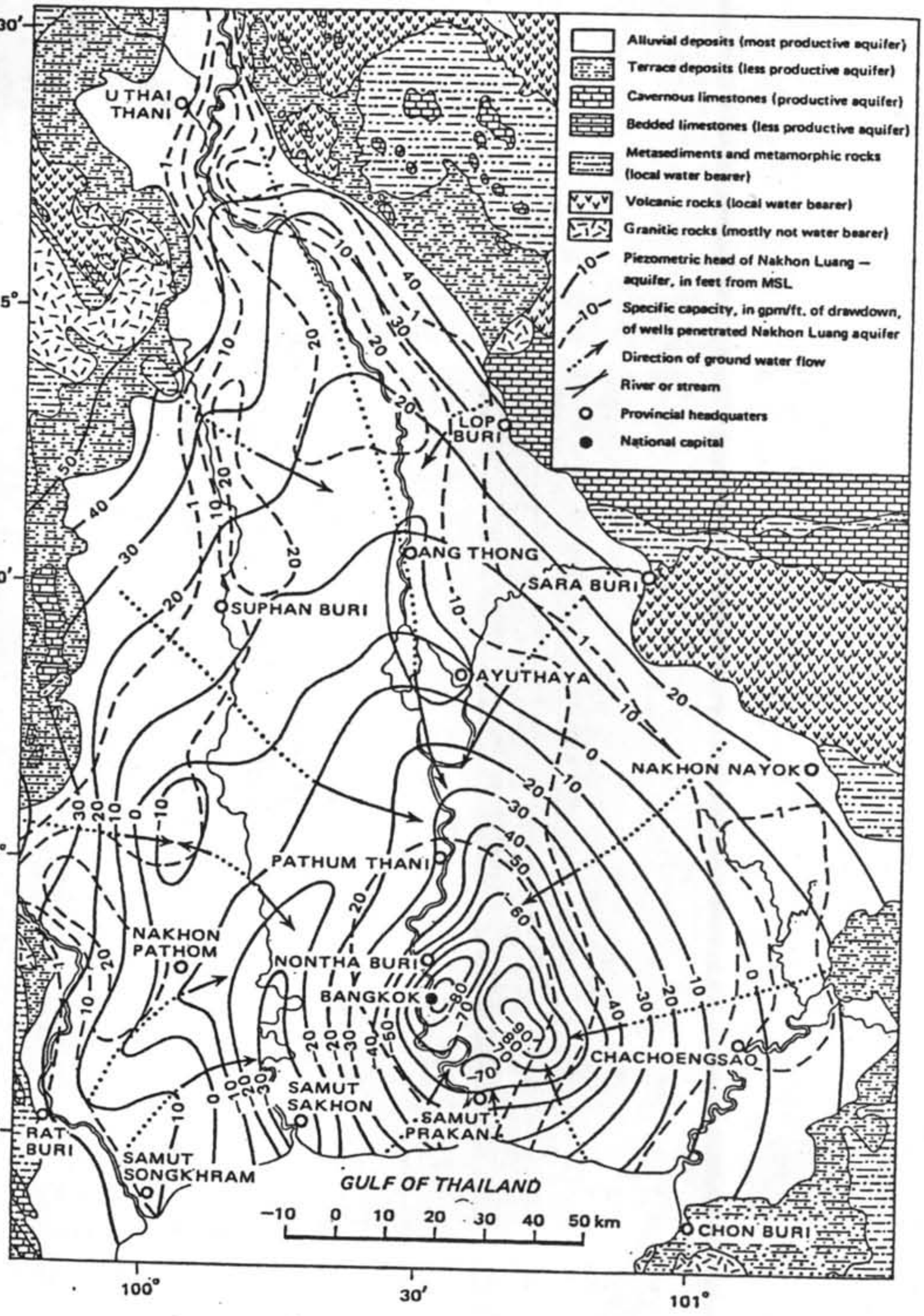

Figure 2 Hydrogeologic map of the Lower Central Plain

(Pianchareen and Chuamthaisong, 1976)

The average cold season, hot season and rainy season temperatures are about 26.2, 28.6 and 27.9 degree celcius respectively. Table 2 shows selected temperature data. Bangkok area receives about 1,543.9 millimeters of rain per year. Based on long-term means, about 19.5 percent of the annual precipitation occurs during the cold season. Precipitation during the hot season is about 20.2 percent of the annual amount. Table 3 shows selected precipitation data.

Area of Bangkok Metropolis and adjoining towns have been used for housing and industrial about 200 square kilometers, the rest have been used for agriculture that cousists of paddy, orchards and vegetables.

1.2.3 Distribution of groundwater wells.

The ratio between number of groundwater well and study area in square kilometers is 1:3, but in the central part of the study area, ratio increase to 2:1. Besides, on the West bank side of Chao Phraya River there are many more groundwater wells as compared with the east bank side and their distributions are concentrated along the Chao Phraya River or in the urban districts (Plates 1,2 and 3)

1.3 Geology of the Lower Central Plain of Thailand.

1.3.1 Geographic setting

The Lower Central Plain occupies the central part of Thailand. It is located within lattitudes $13^{o}33'$N to $15^{o}45'$N and longitudes

Table 2 : Selected data on temperature at Bangkok Metropolis from 1977-1979 (Climatology Division, Meteorological Department).

Month	Long term means (celcius)	Average temp.			Average Max.Temp.			Average Min.Temp.		
		1977	1978	1979	1977	1978	1979	1977	1978	1979
January	25.5	26.6	27.0	27.7	32.5	32.6	33.5	22.0	22.9	23.6
February	27.1	26.2	26.9	28.5	32.1	31.5	33.7	21.1	23.4	24.5
March	28.6	27.6	29.5	29.8	32.8	33.9	35.0	24.8	26.2	25.9
April	29.5	29.6	30.4	30.3	34.7	35.3	35.8	26.0	26.8	26.4
May	29.0	29.3	29.0	30.0	34.1	34.2	35.5	25.1	25.3	25.9
June	28.5	29.8	28.8	28.7	35.1	33.3	32.1	25.9	25.4	25.0
July	28.0	28.8	28.4	28.9	33.7	32.9	33.5	25.2	25.3	25.6
August	27.8	28.5	28.3	28.6	33.4	32.2	32.8	25.1	25.3	25.5
September	27.5	27.9	27.6	28.5	32.2	32.2	33.2	24.7	24.5	25.1
October	27.4	28.4	28.0	28.1	33.4	32.4	33.1	24.9	24.3	23.6
November	26.6	26.6	27.4	26.7	31.8	32.4	32.5	22.5	23.2	21.9
December	25.3	26.4	26.4	26.0	32.4	32.4	32.3	21.5	21.3	20.7

Table 3 : Selected precipitation data at Bangkok Metropolis from 1977-1979 (Climatology Division, Meteorological Department)

Month	Long term means	Monthly Precipitation (millimeters)		
		1977	1978	1979
January	8.9	27.1	23.5	36.7
February	29.1	25.7	103.6	6.8
March	28.0	3.8	1.0	0.0
April	70.0	28.8	13.0	10.7
May	185.1	101.3	245.0	141.6
June	150.4	66.3	255.2	373.8
July	171.3	113.3	135.1	101.7
August	206.8	120.7	81.9	126.8
September	402.1	358.5	271.5	295.9
October	234.2	135.9	105.7	22.3
November	47.6	59.8	0.6	13.3
December	10.4	3.9	0.0	0.2
Annual	1,543.9	1,045.1	1,236.1	1,129.8

$99^{o}30'E$ to $101^{o}45'E$. (Figure 3). The plain is bounded in the south by the Gulf of Thailand, in the north by the Nakhon Sawan Depression, in the west by the Thanaosri Range; and in the east by the Khorat Plateau and the Chantaburi Region. Approximate area of the entire plain is 53,400 square kilometers. The length from north to south is approximately 250 kilometers and east to west is approximately 200 kilometers. The elevation of the central part (Chao Phraya River Course) of the plain varies from 25 meters above the mean sea level at Nakhon Sawan in the North, to less than 4 meters at Ayutthaya, and to about 2 meters at Bangkok Metropolis.

The plain is characterized by a flat, low-lying broad depositional surface, which some authors have refered to as a matured deltaic plain (Brown et al, 1951). The major drainage system of the Lower Central Plain consists of Chao Phraya River and its distributaries, Tha Chin Rivers. Besides, the plain also receives waters from three rivers, the Mae Klong in the west, the Bang Pakong in the east and the Pa Sak in the northeast. The mean annual flow of the Chao Phraya River is about 917 cubic meters per second. The central plain recieves a mean annual rainfall of 1,050 millimeters and it looses 1,000 millimeters through evaporation (Khan, 1976).

1.3.2 Geological setting

The central plain is located within a north-south trending structural depression that resulted from the block-fault tectonics during the Tertiary time. The depression, bounded in the west by

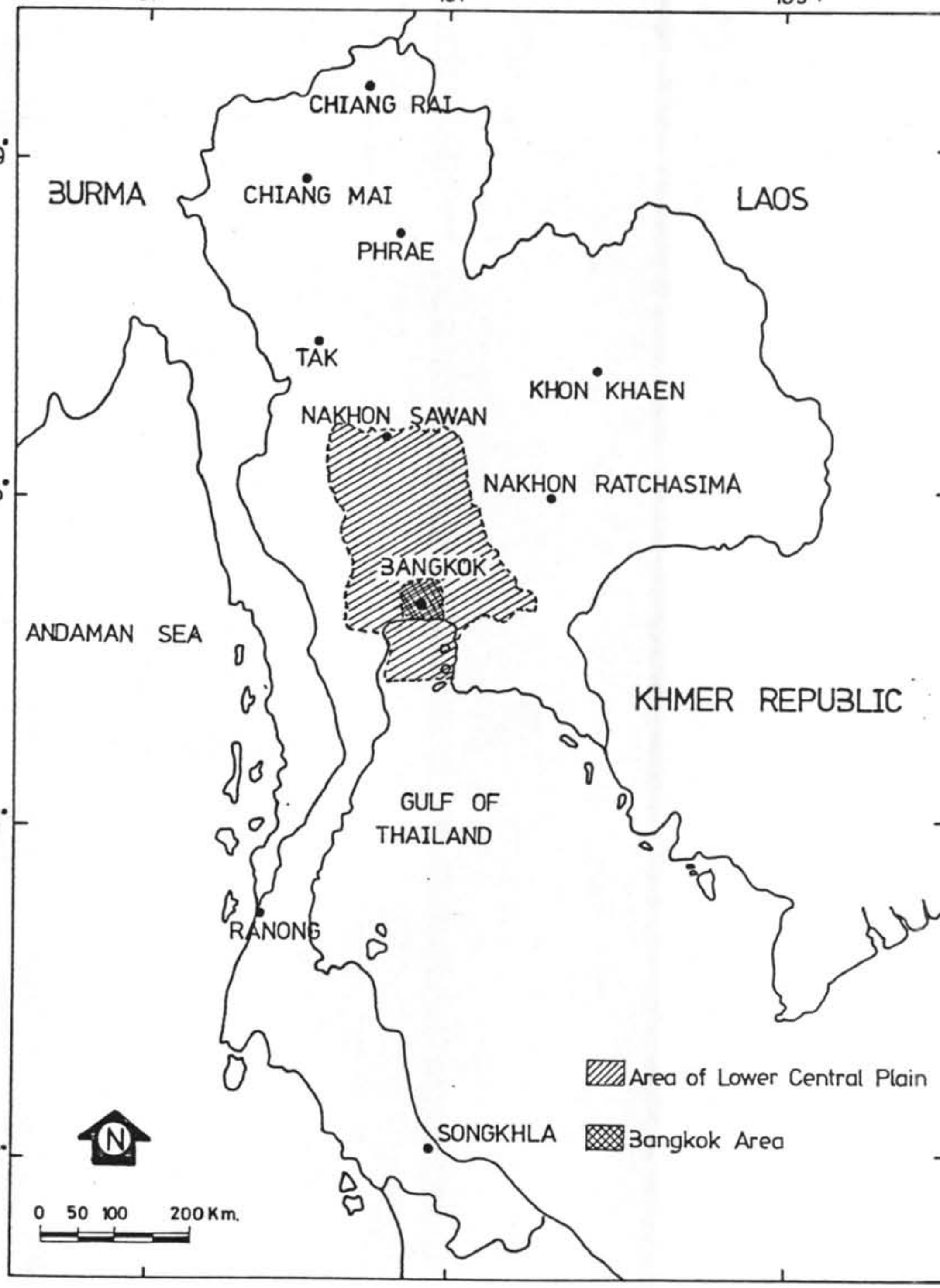

Figure 3 Lower Central Plain of Thailand

north-south trending Paleozoic fold belts of the Thai-Malay Peninsula, in the east by the Khorat Plateau, in the north by Krok Phra Arch at Nakhon Sawan and in the south, the depression extends into the Gulf of Thailand. Aeromagnetic data indicates that the Lower Central Plain is floored by basement arches and plutons in association with a diverse assemblage of faults or flexure zones (Achalabhuti, 1974). The exact configuration of the basin floor is unknown. A few wells which were drilled to bed rock reveal several basement rock types at various depths (Table 4)

1.3.3 Distribution and characteristics of the Lower Central Plain sediments

Major depositional environment of the Lower Central Plain are alluvial fan type, flood plain or fluviatile type, and the deltaic type (Goh, 1975). According to Piancharoen and Chuamthaisong (1976), since Tertiary time, the Lower Central Plain has been filled with sediments that occured under a fluviatile and deltaic environment with occasional shallow sea sedimentation. The soils of the Lower Central Plain have been differentiated into :

a) Soft marine clay,

b) Brackish water soils, and

c) Fresh water soils

Table 4 : Depths to Bed Rock and Bed Rock Types of the Lower Central Plain Basin

Well Location	Depth to Bed Rock	Rock Type	Reference
Ayutthaya	6,027 ft.	Permian(?) shale and limestone	KOBAYASHI, 1964
Ayutthaya	1,158 ft.	Leucogranite	ACHALABHUTI, 1974
Wat Sala Daeng, Phasi Charoen	6,098 ft.	Upper Cretaceous biotite granite	ACHALABHUTI, 1974
Rangsit	1,640 ft.	Quartzite	RAMNARONG, 1976
Sam Phran, Nakhon Pathom	1,434 ft.	Gneiss, quartzite	RAMNARONG, 1976
Bang Poo, Samut Prakan	1,350 ft.	Quartzite	RAMNARONG, 1976

The marine clay and brackish water soils which are clayey in composition occur within the proximity of lower half of the plain. They are derived from clayey sediments which were deposited under a marine and deltaic environments associated with an inland transgression of the sea water during post-Glacial times.

The fresh water soils are derived from flood-plain and river terrace deposits. First, soils associated with the flood plain deposits are mostly made up of sandy clay and are found throughout the northerly half of the plain. Second, soils derived from river terrace deposits are sandy and gravelly in composition and are located along the eastern and western extremities of the plain.

After Selvakumar (1977), the alluvial fan deposits can be found surrounding the western and the eastern boundaries of the plain. Some of these larger fans are the Don Chedi and Kanchanaburi alluvial fans in the west, the Tak Fa alluvial fans in the northeast and the alluvial fans surrounding the base of the Khorat Plateau in the east. (Table 5)

1.4 Objectives of the study.

The present investigation primarily aims at reconstructing the various depositional environments of sediments within a depth range of 0 to less than 300 meters below the ground surface of Bangkok Metropolis. Besides, an attempt has been made to correlate the sedimentary facies of different depositional environments to the groundwater potential in terms of the groundwater quality and the hydraulic characteristics.

Table 5 : Landforms of the Central Plain of Thailand (after SELVAKUMAR, 1977)

		Unit	Elevation in m. above m.s.l.	Trend	
				Slope m/km	Direction
Tanao Sri Piedmont	Pediplain	Upper Lat Yao Lat Yao Nong Khayang	120-100 60-40 60-30	1.29 1.74 1.67	N83°E N82°E S85°E
Tanao Sri Piedmont	Alluvial Fan	Don Chedi Kanchana Buri	35-5 25-5	0.75 0.50	S70°E N80°E
Khorat Apron	Tak Fa Bahada	4 Coalescing Alluvial Fans	100-30	4.00	-
Khorat Apron	Bahada	Khok Samrong Alluvial Fans Lop Buri Alluvial Fan Saraburi Alluvial Fan	55-30 35-10	2.5 2.5	N45°W S45°W
Khorat Apron	Alluvial Fan	Paisali Nakhon Nayok Prachantakham	 80-30 25-15	 2.0 1.3	 S60°W S45°W
Khorat Apron	Terrace	(Pa Sak) Sara Buri Left (Pa Sak) Sara Buri Right (Hanuman) Kabin Buri	20-10 20.10 30-20	0.53 0.80 0.80	S52°W S36°W S38°W
Chao Phraya Plain	Terrace	Uthai Thani Chainat Pak Hai Khok Phip	20-16 20-17 8-6 20-10	0.08 0.09 0.16 0.56	S24°E S15°W N 3°E S25°W
Chao Phraya Plain	Flood Plain	Bangkok	4-2	-	-
Marine	Terrace	In Buri-Sam Chuk Lower Chainat Rat Buri Prachin Buri Left Prachin Buri Right Chachoeng Sao Upper Chacheong Sao	12-8 14-7 9-6 10-8 10-7 30-27 50-35	0.10 0.13 0.14 0.21 0.17 0.23 0.64	S29°E S23°E S67°E N 5°W S30°W N18°W N13°W
Structurally Controlled Landforms	Gulf Coastal Plain		3-2	-	-
Structurally Controlled Landforms	Troughs	Krok Phra Ridge Nakhon Sawan Ban Phraek Embayment Suphan Buri Mae Klong	60-30 30-23 5-2 20-2 50-20	- - - - -	- - NW-SE NE-SW NW-SE
Structurally Controlled Landforms	Swell	Bang Sai Bangkok	6-3 5-3	- -	EW EW

With respect to the determination of sedimentary facies related to different depositional environments, the conclusion are drawn from the following factual information :

a) Geological data obtained from the bore-hole regarding sedimentary properties, namely, colour, grain size, composition, sorting, roundness & sphericity, and

b) Geophysical well loggings.

The subsurface geological map of the area concerned are prepared and the reconstruction of sedimentary environment of depositions are accordingly interpreted. In order to illustrate the data and information concerned, fence diagrams, geological cross-sections, structural contour maps, etc. are prepared.

The outputs of sedimentary analyses are then furnished into the groundwater potential study within this area. The various aquifers are delineated and aquifer characteristics are determined. In addition, the groundwater quality and hydraulic characteristics are determined for each aquifer.

1.5 Methods of approach.

In order to fulfill the objectives of the present investigation, 3 steps of approach have been formulated. They are as follows :

A) Nature of sedimentary facies will be analysed for each aquifer and the depositional environments concerned will accordingly be interpreted. Several steps of detailed work-plan are :

(a) All data of ground water wells in Bangkok Metropolis and nearest area are collected.

(b) Groundwater well data (from:a) are divided into 3 groups

1) Raw data that are cuttings of groundwater well are analysed for their physical properties. These wells are used for primary reference wells.

2) Groundwater well data that are already identified are used in the analysis in two ways :

2.1) For complete groundwater well data will be used as primary wells, complete groundwater well data should be consisted of lithology, color, thickness, depth, screen interval.

2.2) For non-complete groundwater well data will be used as secondary wells.

3) Geophysical log data from groundwater wells that consist of Self Potential log (SP.) and Resistivity log (R) are used for depositional environment interpretation. These wells are also called primary reference wells.

(c) Cuttings from groundwater wells are identified for lithology in each interval and physical properties as grain size, roundness, sphericity and sorting. Besides, depositional environment are interpreted from the shape of self potential log.

(d) All groundwater wells location (from a) are compiled and presented as the well location map.

(e) Primary wells are correlated as a close system in each part of study area and then join them together for cheeking purpose of larger scale correlation program.

(f) Subsurface map are prepared from correlated information in (e) that presented as the fence diagram, cross sections and structural contour top of each aquifer. These maps will show the distribution and extention of all aquifers and all depositional environments.

(g) Relationships between depositional environment of each aquifer is identified by means of the subsurface map in (f)

(h) Analysis of sedimentary facies are concluded.

B) Groundwater Potential will be studied in two ways; hydraulic characteristics and groundwater quality from previous identified data.

(a) Hydraulic characteristics data and groundwater quality data are collected from each aquifer.

(b) Groundwater potential will be identified especially groundwater quality in each aquifer.

(c) Identification of groundwater potential.

C) Sedimentary Facies and Groundwater Potentials in each aquifer are concluded and synthesize together in an integrated manner.