

CHAPTER 4

DESCRIPTION OF THE RESEARCH AREA

4.1. Geography and Geological Setting

The research area is located in the central part of the Lower Central Plain of Thailand, expanding from 656000 UTM (Northing) to 668000 UTM (Northing) to the north and from 1556000 UTM (Easting) to 1574000 (Easting) to the east (see Figure 4.1). Based on the administration map, the research area belongs to Phra Nakhon Si Ayutthaya and Pathum Thani provinces. The length in the north-south direction is roughly 18 km and west-east direction is 12 km, comprising the entire area of 216 km². The topography is relatively flat, with gradually decreasing elevation from the north to the south. The variation of elevation ranges from 1.8 to 6 meters above mean sea level (MSL) (see Figure 4.2)

The central Plain of Thailand has been subjected to three major kinds of depositional environments namely the alluvial fan type, the flood plain or fluvial type, and deltaic-marine type of environment (Goh, 1975). According to Piancharoen & Chuamthaisong (1976), the lower central plain is a geological depression filled with alluvial and deltaic sediments with occasional shallow sea sedimentation. The depth varies probably from hundreds to thousands of meters. The basement is overlain by a thick sequence of unconsolidated, deltaic, marine and alluvial sediments of Tertiary and Quaternary origin, which in turn underlay a stratum of highly compressible soft Bangkok clay of Holocene age. The sedimentary deposits in the Lower Central Plain vary widely in the type of sediment, thickness and distribution. In the central part of the Basin, interbeds of sand, clay and gravels hundreds of meters thick occur, whereas toward the edges only thin veneers of sediments lie on top of shallow bedrock (AIT, 1981).

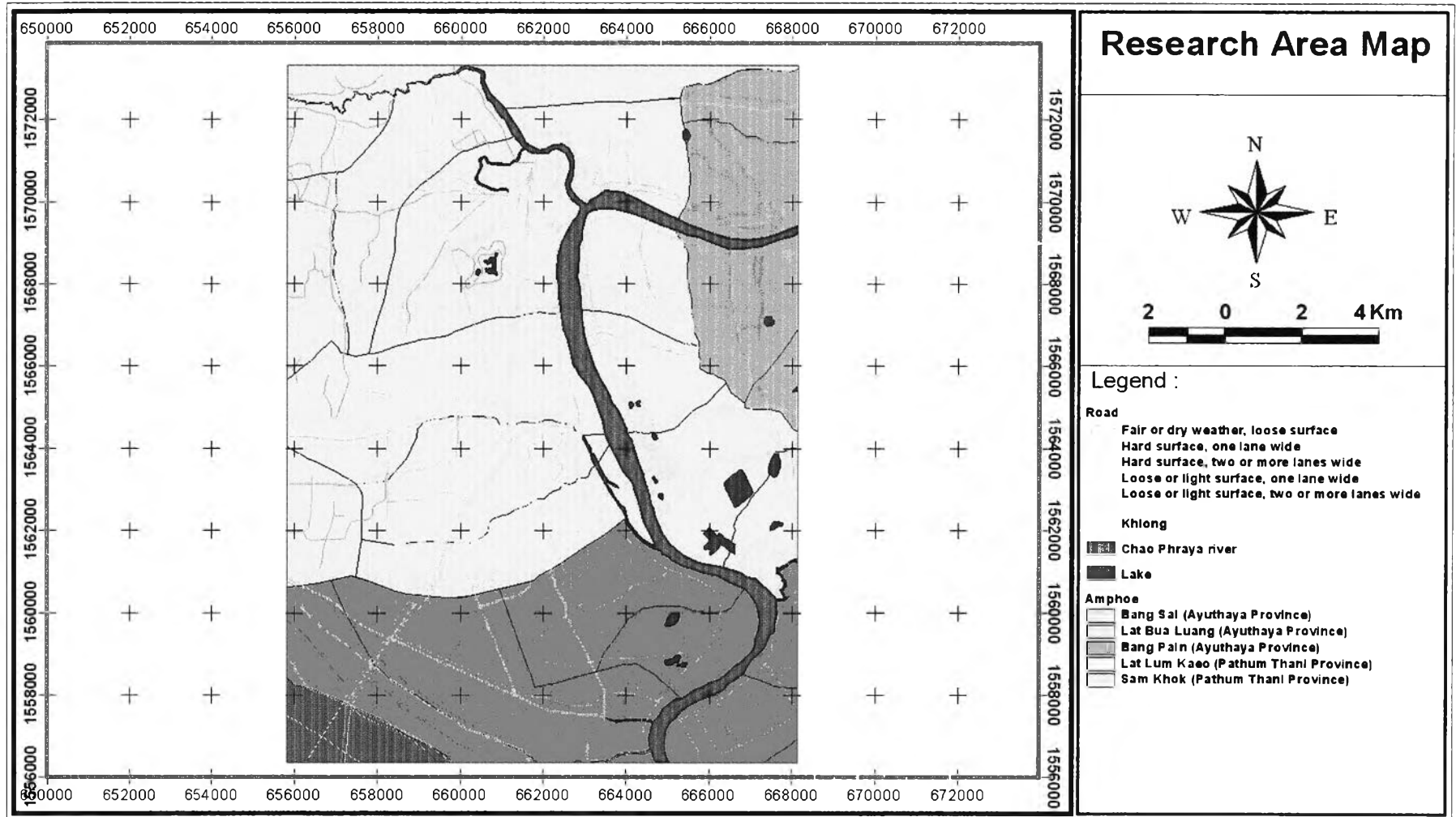


Figure 4.1. Research area map.

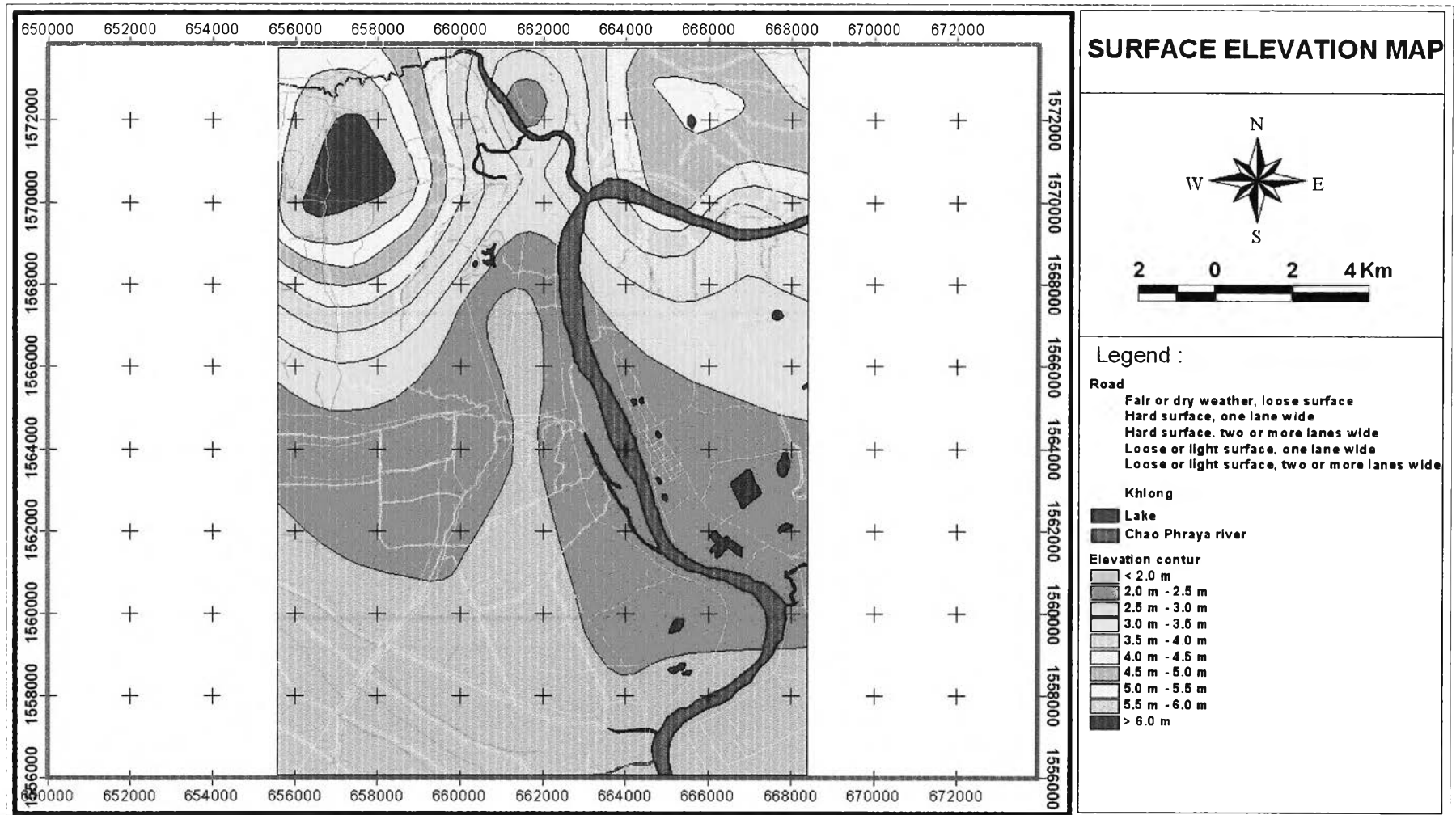


Figure 4.2. Surface elevation map.

The uppermost layers of the stratigraphic column, in the research area, are known under the term Bangkok clay, which consists of three units, i.e. weathered clay, soft clay, stiff clay (Moh, 1969). The weathered clay, of 1 or 2 meters thick, is topmost. The Bangkok soft clay can be up to an average depth of 15 meters. It is deposited on an erosion surface of stiff clay, which directly overlies the first sand layer. The most abundant clay mineral in the Bangkok soft clay is kaolinite (47 to 64%), montmorillonite (20 to 43%) and illite (to 20%).

The wells log data in the area show that the geological conditions consist of interbeds between clay, sand, gravel, sandy clay, clayey sand, gravelly sand (see Figure 3.3). Figures 3.4 and 3.5 show the cross section and fence diagram based on the available data in the research area. The details of all wells log in the research area are attached in Appendix 1.

4.2. Hydrogeology and Aquifer System

Extracted from the hydrogeologic map of Lower Central Plain of Thailand (Charoen Piancharoen and Somsak Isarangkula, 1974), the research area consists of alluvial deposit material with series of productive aquifer. Defined by the alternating sequence of clay and sand and gravel layers, the aquifer system can be divided into 8 layers at approximately 50 meters interval namely Bangkok aquifer (BK), Phra Padaeng aquifer (PD), Nakhon Luang aquifer (NL), Nonthaburi aquifer (NB), Sam Khok aquifer (SK), Phaya Thai aquifer (PT), Thon Buri aquifer (TB) and Pak Nam aquifer (PN). The piezometric head of Nakhon Luang aquifer ranges from 20 to 30 meters below sea level. The direction of groundwater flow is come from north-west direction.

The ground surface of the research area is entirely underlain by blue to gray marine clay, 15 m to 30 m thickness, known as the Bangkok clay (Muktabhant et.al., 1996). In general, the unconsolidated and semi-consolidated sediments overlying the basement have a total thickness of about 400 m to more than 1,800 m. From a detailed study of logs of groundwater wells, the Department Mineral Resources identified and named eight (8) aquifers within 550 meters depths (Table 3.1). These aquifers consist mainly of sand and gravel separated by clay beds.

In consideration of aquifer productivity, the water in the first aquifer (Bangkok aquifer (BK), 50 m zone) is not potable due to high salinity. The second aquifer (Phra Pradaeng aquifer (PD), 100 m zone), the third aquifer (Nakhon Luang aquifer (NL), 150 m zone) and fourth aquifer (Nonthaburi aquifer (NB), 200 m zone) are very productive. Most wells in Bangkok pump water from these three aquifers. The fifth aquifer (Sam Khok aquifer (SK), 300 m zone) and the sixth aquifer (Phaya Thai aquifer (PT), 350 m zone) are increasingly being developed in Pathum Thani province northwest of Bangkok. The seventh aquifer (Thon Buri aquifer (TB), 450 m zone) and the last aquifer (Pak Nam aquifer (PN), 550 m zone) are used for industrial purpose in the south and southwest areas of Bangkok where there are no alternative overlying potential aquifers. They are, however, too deep for domestic wells (Ramnarong & Buapeng, 1991).

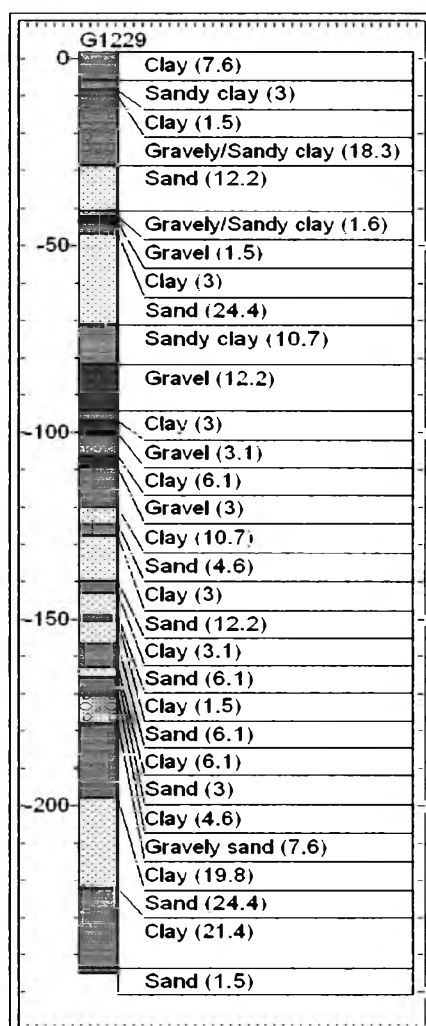


Figure 4.3. Well log of G1229.

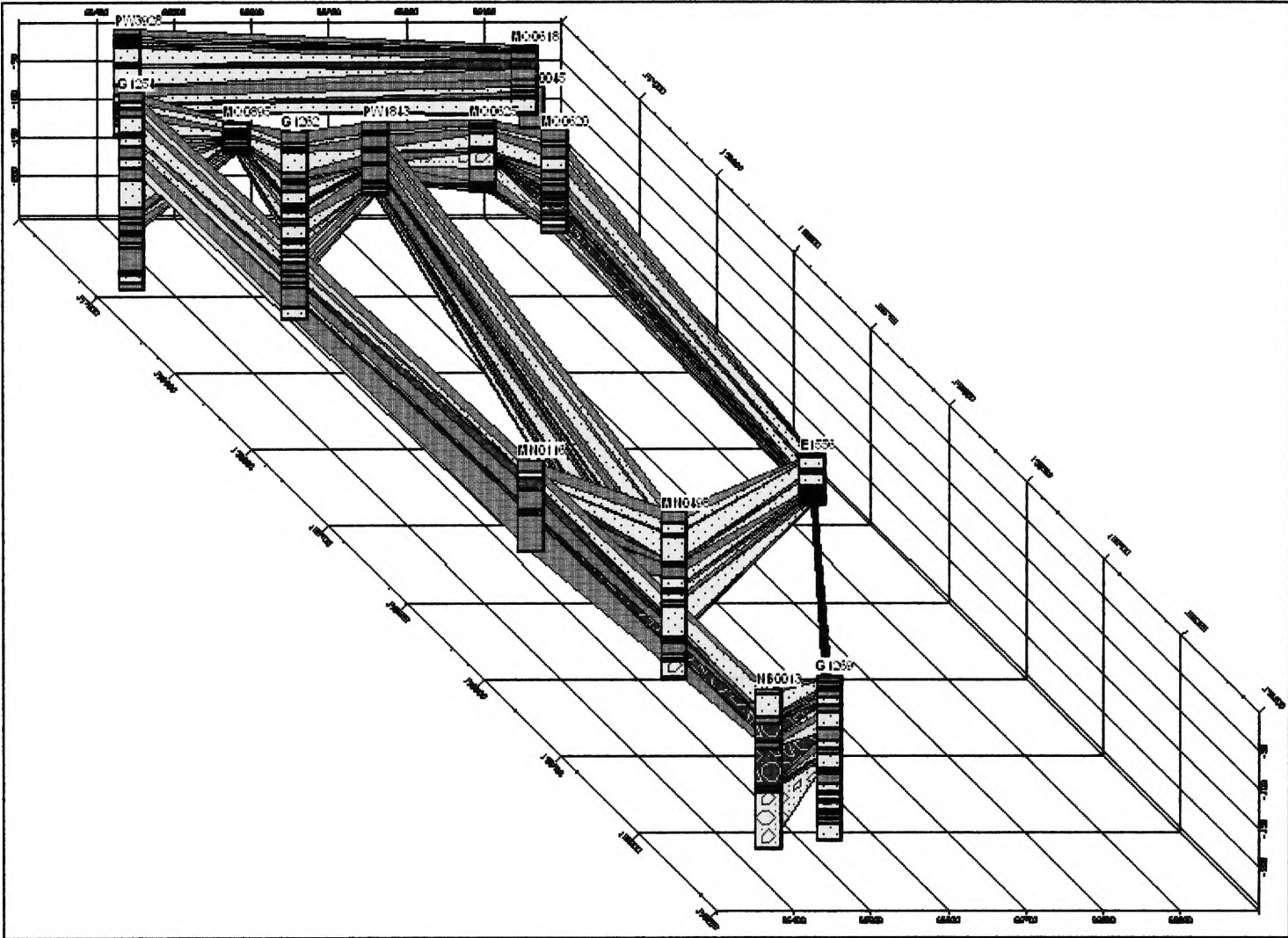


Figure 4.5. Fence diagram.

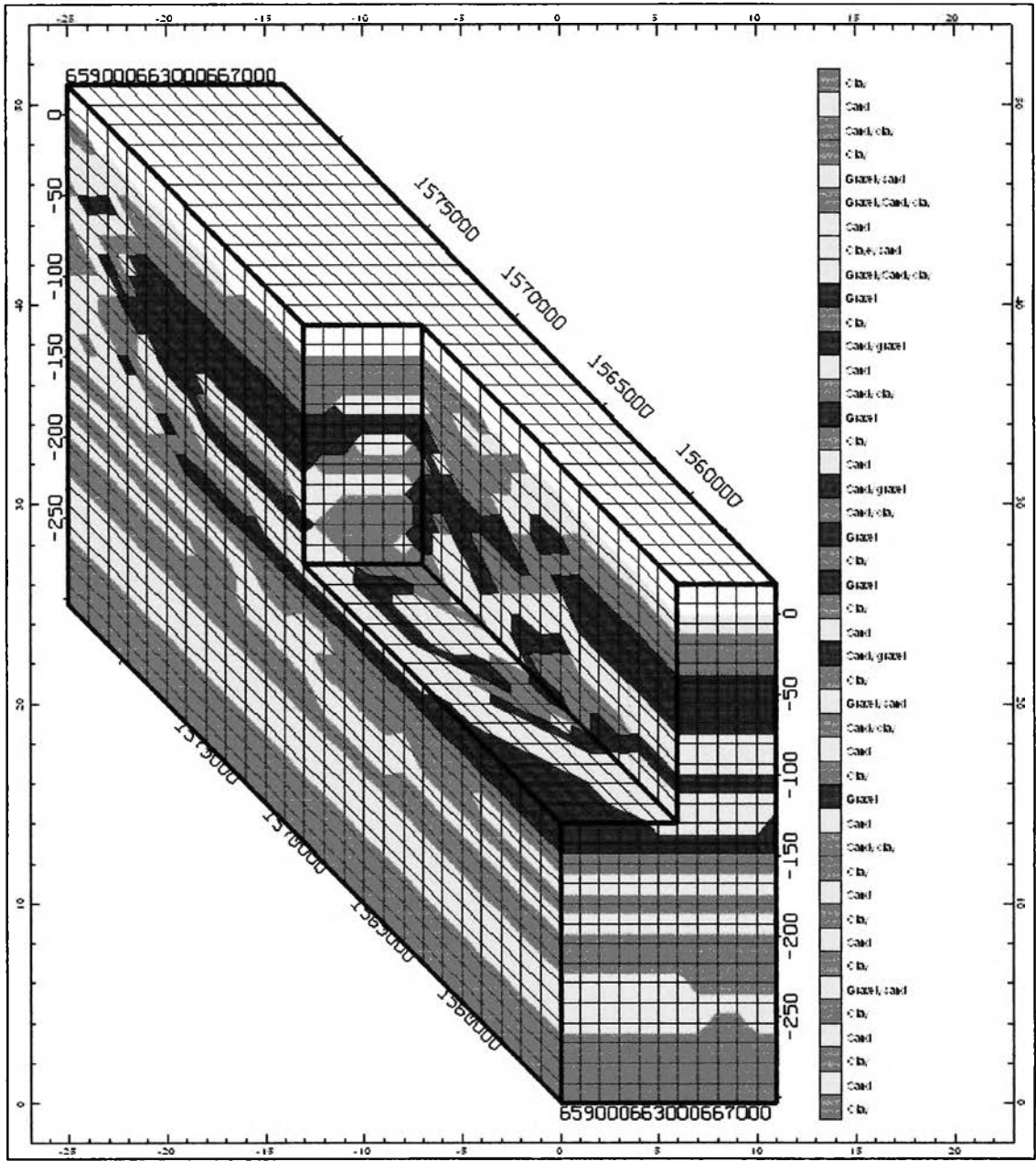


Figure 4.6. Stratigraphic modeling.

Table 4.1. Stratigraphic section of Bangkok and adjacent areas and their water-bearing properties (after Chiamthaisong, 1980).

Age	Aquifer	Thickness	Lithology	Water-bearing Properties
Late-Pleistocene to Recent	1 Bangkok (50 m zone)	± 50	Topmost clay is generally dark gray to black, limonitic lateritic in the upper portion. Coarse sand, gravel and pebble are sub angular to rounded, moderately to well sorted, composed mostly various types of fragment.	Yields considerable quantity of water of poor quality, brackish to salty and highly mineralized. Normally not developed for groundwater resource.
	2 Phra Pradaeng (100 m zone)	± 50	Separated from the Bangkok aquifer by a dark stiff clay bed. Gravel-sand is characteristically white to pale gray, sub rounded to rounded, fairly well sorted, composed mostly of quartz, chert and other rock fragment, with carbonized woods and peats at the lower part. Clay lenses interbed in places.	Yields water of good quality only in the south and southwest of Bangkok, in other areas the aquifer yields brackish to salty water.
Lower to Middle Pleistocene?	3 Nakhon Luang (150 m zone)	± 50	Over lied by thick and hard clay bed. Sand-gravel layer, which from the aquifer are rather thick (10-15 m). Fragments, mostly quartz, feldspar and quartzite; are sub angular to sub rounded, moderately to well sorted. Interbedding clays are whitish to yellowish to grayish brown, sandy and limonitic, non-plastic.	Has been heavily developed for public water supply. Yields 100 – 250 m ³ /hr of water of excellent quality. Only in the south and southwest of Bangkok wells yield salty water due to salt-water intrusion into the aquifer.
	4 Nonthaburi (200 m zone)	± 50	General characteristics of the formation are the same as the Nakhon Luang aquifer. It is consisted of rather uniform thick sands and gravels with minor sandy clay lenses. The formation can be divided into three units separated by leaky clay layers.	It is one of the most productive aquifers, which yield up to 200 m ³ /hr of water of excellent quality. The water has been extensively used for bottled drinking water and brewerage as well as domestic supplies.
	5 Sam Khok (300 m zone)	± 100	The formation is consisted of sand, gravel and clay. Sand-gravel is yellowish brown to dirty brown, but may grade to white color, medium to very coarse grained, angular to sub rounded, fairly well sorted, feldspathic, calcareous due to limestone fragment in places; with interlayering clays. Both sand-gravel and clay beds are moderately to highly compacted.	Yields slightly less than those of the Nakhon Luang and Nonthaburi aquifers. Normally penetrated by production wells in Northern Bangkok since shallower aquifer yield water of higher iron content.
	6 Phaya Thai (350 m zone)	± 50	Consisted of sand gravel and clay. Sand and gravel are dirty brown, angular, sizes ranged from medium sand to gravel size, poorly to fairly well sorted; quartz and chert being major composition. Clay is brown, compact, calcareous and lateritic.	Wells drilled in Central and Southern Bangkok yield brackish to salty water while those in Northern Bangkok produce fresh water. The aquifer is generally not popular due to its greater depth.
	7 Thon Buri (450 m zone)	± 100	Separated from the upper formation by hard and compact clay. Sand and gravel beds are usually alternated layering with clay beds. Color is generally gray to brownish gray to occasional white sand layers.	No production wells ever constructed, but the packer tests of several test holes indicate that the water is fresh to slightly brackish or mineralized in places. The aquifer is not so productive as the above aquifers due to the presence of clay in many horizons.
Pliocene?	8 Pak Nam (550-m zone)	± 100	Separated from the upper formation by leaky clay to sandy clay layer. Sand and gravel beds, generally thicker than that of Thon Buri aquifer, are white to gray and well sorted. The clay is generally very compact, olive gray to dark gray, with carbonaceous matters.	The aquifer is very permeable and yields a considerable quantity of water of good quality. Water temperature is as high as 43 °C. However, too deep to reach by domestic wells, except in areas where there is no alternative potential aquifer; i.e. the Southern Bangkok.

The vertical spreading of Bangkok aquifer is from 30 to 60 meters, and Phra Pradaeng aquifer is from 60 to 120 meters with productive aquifer at 90 to 100 meters depth. However, the Phra Pradaeng aquifer can be sub-divided into 3 to 4 layers confined by clay layers. Nakhon Luang aquifer located at 120 to 180 meters with productive aquifer at 140 to 150 meters. It can be sub-divided also into 4 to 5 layers of aquifer. Nonthaburi aquifer located at 180 to 280 meters with productive aquifer at 200 to 250 meters depth. Sam Khok Aquifer located at 280 to 360 meters depth with productive aquifer at 330 to 350 meters. Phaya Thai aquifer located at 360 to 430 meters depth (productive aquifer at 400 meters), Thon Buri aquifer located at 430 to 480 meters depth (with productive aquifer at 450 meters), Pak Nam aquifer located at 480 to 600 meters depth with productive aquifer at 550 meter (JICA, 1995).

There is a big variation of groundwater table in each aquifer. Throughout the years, not only there is a change in groundwater level, but also the flow direction as well. Each year, it has changing in the depth and also the flow direction. The groundwater level of Phra Pradaeng aquifer varied from 12 to 22 meters below SWL. Nakhon Luang aquifer has a groundwater level depth around 21 to 27.5 meters below SWL. Nonthaburi aquifer has a depth of groundwater level start from 23.6 to 27.6 meters below SWL. Basically, the flow of groundwater is come from the north-west direction in the research area, but there is a small variation among different aquifer layers (see Figure 4.7) .

The permeability of Bangkok aquifer is 3.4 m/hr with storage coefficient of 1×10^{-4} . The permeability of Phra Pradaeng aquifer ranges from 2.4 to 3.74 m/hr with storage coefficient from 1×10^{-4} to 2×10^{-4} , and the permeability of Nakhon Luang aquifer ranges from 2.2 to 3.45 m/hr with storage coefficient from 1×10^{-4} to 3.4×10^{-3} (AIT, 1981). Based on the pumping test on Nonthaburi aquifer from wells DR132 the hydraulic conductivity obtained from this method is 27.22 m/day with storage coefficient of 1.29×10^{-4} . The pumping well DR133 yielded a result slightly different from DR 132 with the hydraulic conductivity value of 21.312 m/day and storage coefficient of 1.26×10^{-4} . The detail analysis and pumping test data are attached in Appendix 2. The results of pumping test analysis are summarized in Table 4.2. Table 4.3. summaris of aquifers and clays properties from referred sources.

Table 4.2. Pumping test analysis.

Pump. Test	Well Function	Well Code	Method of Analysis	Hydraulic conductivity (m/day)	Storage coefficient (1/m)
1	Pumping well	DR 132 PSA 54	Recovery	25.92	
1	Observation well	DR 133 PSA 55	Theis	27.22	1.29×10^{-4}
1	Observation well	DR 133 PSA 55	Recovery	56.016	
2	Pumping well	DR 133 PSA 55	Recovery	20.16	
2	Observation well	DR 132 PSA 54	Theis	21.312	1.26×10^{-4}
2	Observation well	DR 132 PSA 54	Recovery	34.416	

Source: Primary Analysis, 2004

Table 4.3. Summary of the aquifers and clays properties.

	Layer	Source	AIT, 1981		JICA, 1995		Researcher, 2003	
			K (m/hour)	Ss	K (m/day)	Ss	K (m/day)	Ss
1	Bangkok Clay				$3.6e^{-6} - 4.6e^{-4}$	$6.75e^{-3}$		
2	Bangkok Aquifer		3.4	$1e^{-4}$	1 - 98.2			
3	Phra Padaeng Clay				$1.5e^{-7} - 2.1e^{-5}$	$2.12e^{-4}$		
4	Phra Padaeng Aquifer		2.4 - 3.74	$1e^{-4} - 2e^{-4}$	0.5 - 183.6			
5	Nakhon Luang Clay				$2.1e^{-7} - 3.9e^{-6}$	$1.67e^{-4}$		
6	Nakhon Luang Aquifer		2.2 - 3.45	$1e^{-4} - 3.4e^{-3}$	0.3 - 147.4			
7	Nonthaburi Clay				$4.9e^{-8} - 1.0e^{-5}$	$1.15e^{-4}$		
8	Nonthaburi Aquifer				1 - 161.6		20.16- 56.016	$1.26e^{-4} - 1.29e^{-4}$
9	Sam Khok Clay				$1.1e^{-7} - 9.7e^{-7}$	$7.72e^{-5}$		

Source: Compilation Data, 2004

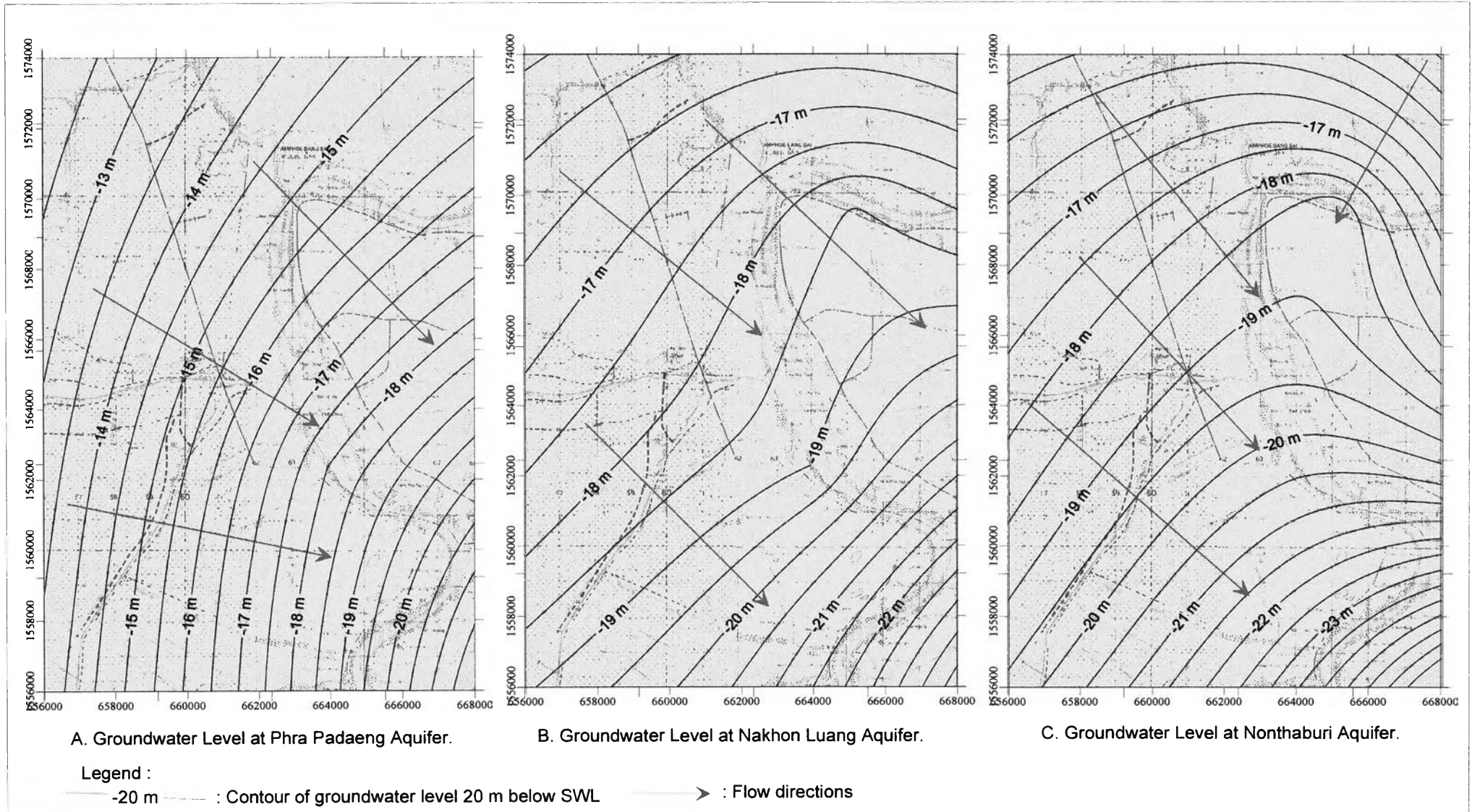


Figure 4.7. Groundwater Level in The Research Area.

4.3. Hydrology

The Chao Phraya river basin occupies most of the northern region and the Central Plain of Thailand. The total drainage area of the Chao Phraya river basin is about 160,000 km². The whole drainage area is generally divided into the Upper Chao Phraya river basin and The Lower Chao Phraya river basin. The outlet of the Upper Basin is located at Nakhon Sawan at which the rivers of the northern region Ping, Wang, Yom and Nan emerge to become the Chao Phraya river. The drainage areas of the Upper and Lower Chao Phraya river basins are 105,929 and 53,417 km², respectively (AIT, 1982)

As shown Figure 3.6, the average discharge of the Chao Phraya river downstream of the confluence of the Ping and Nan rivers at station C.2 in Nakhon Sawan is 683.62 m³/sec. The drainage area above this station is 111,435 km². About 100 km downstream from Nakhon Sawan near Chai Nat province. The Chao Phraya dam was constructed to divert the river flow to irrigate an area of about 97.9 km² located downstream along both sides of the Chao Phraya river. From a drainage area of 120,693 km², the flow of the Chao Phraya river downstream of this dam at station C.13 has decreased to 336.10 m³/sec.

On downstream of Chai Nat province, many effluent branches off from the main river such as Suphan, Noi and Lop Buri rivers. The discharge of the Chao Phraya river before it reaches the city of Ayuthaya as observed at station C.7A is averages at 358.02 m³/sec.

At the city of Ayuthaya, where the Chao Phraya river joins with fifth tributary on the east, the Pasak river. From there, the river enters the research area and meander as a single channel southwards until it meets the Gulf of Thailand. The study area is located on west side of the Chao Phraya river.

The lower stretch of the Chao Phraya river is affected by ocean tides, by which extends up to Bang Sai district and Rama IV Dam in the Pasak river (JICA, 1987).

As shown in Figure 3.6 river flow fluctuates sharply according to the season changed. For instance, the discharge of the Chao Phraya river at station C.7A varies from 495.8 to 835.3. m³/sec in the period from January to August with a minimum of 354.1 m³/sec in February, while the discharge in the period of September to December

exceeds 1,000 m³/sec with a maximum of 2,789.7 m³/sec in October. The capacity of the river is only 1,500 m³/sec near Ayuthaya and the excess water will overflow and flood the low-lying area including the research area from September to November. As mentioned above, the gradient of the river ranges only from 1/10,000 to 1/50,000 for its lower course.

Tables 4.4 and 4.5 show the groundwater level head in the Chao Phraya river at Bang Sai (Ayuthaya) and Muang (Pathum Thani) stations. The highest of level occurs in the October and November, and the lowest level in the February and March.

Not only the a Chao Phraya river serves as a main river in the research area, but also there are many canals that called Khlong criss-cross the study area. Some khlongs are intermittent but almost all of them are perennial with mouth in the Chao Phraya river. They also have five lakes in the research area. The biggest lake located in the middle of research area with covering area of 0.09 km².

Table 4.4. Water level of Chao Phraya river in Bang Sai station.

Station Code : C.29

River System : Chao Phraya

Station Name : Bang Khaek, Bang Sai, Ayuthaya

Northing : 14°-11'-33"

River : Chao Phraya

Easting : 100°-30'-23"

No.	Year	Monthly Average head (m-SWL)											
		Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar
1	1990	0.36	0.4	0.66	0.3	0.34	0.43	1.69	0.79	0.81	0.35	0.41	0.4
2	1991	0.38	-0.2	-0.6	-0.1	0.54	1.17	1.04	-0.04	0.83	0.51	0.41	0.39
3	1992	1.3	1.64			2.56			1.58	1.8	1.48	1.36	1.41
4	1993	-1.2	-0.9	0.26	0.2	0.22		0.56	0.51				
5	1994	0.32	0.24	0.75	0.7	0.59	1.53	1.64	0.54	0.71	0.52	0.54	0.45
6	1995	0.47	0.41	0.33	0.4	1.22	2.31	2.62	2.34	1.22	0.58	0.63	0.48
7	1996	0.55	0.78	0.84	0.5	0.59	1.33	2.72	2.55	1.38	0.62	0.58	0.54
8	1997					0.5							
		0.31	0.34	0.37	0.3	0.82	1.35	1.71	1.18	1.13	0.68	0.66	0.61

Source: Irrigation Department, 2003

Table 4.5. Water level of Chao Phraya river in Muang station.

Station Code : C.31

River System : Chao Phraya

Station Name : Ban Prok, Muang, Pathum Thani Northing : 14°-01'-12"

River : Chao Phraya Easting : 100°-32'-22"

No.	Year	Monthly Average head (m-SWL)											
		Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar
1	1984						1.1	1.4	1.33	1.35	1.17	1.23	0.82
2	1985		1.04	0.84	0.83	1.09	1.62	1.79	1.9	1.72	1.34	1.05	1.22
3	1986							1.31	1.35	0.96	1.06	0.99	1.17
4	1987	1.23	0.99	0.78	0.58	0.72	1.29	1.86	1.27	1.62	1.25	1.3	1.35
5	1988	1.07	1.03	0.93	0.91	1.02	1.39	1.02	2.03	1.57	1.34	1.21	1.19
6	1989	0.98	0.81	0.85	0.68	0.57	0.85	1.25	1.26	1.47	1.28	1.16	1.13
7	1990	1	0.89	1.01	0.57	0.59	0.78	1.98	1.36	1.47	1.31	1.19	1.16
8	1980	1.06	0.75	0.62	0.56	0.71	1.42	1.45	1.23	1.47	1.22	1.1	1.03
9	1981	0.94	0.78	0.62	0.53	0.72	0.74	1.43	1.31	1.38	1.29	1.32	1.2
10	1982	0.97	0.8	0.62	0.54	0.58	0.97	1.1	1.07	1.2	1.21	1.21	1.16
11	1983	0.91	0.75	1.14	1.13	0.97	1.9	2.03	1.2	1.36	1.24	1.21	1.15
12	1984	1.07	0.96	0.84	0.81	1.5	2.74	3.56	3.18	1.79	1.24	1.25	
13	1985	1.17	1.29	1.26	0.93	1.14		2.95	2.97	1.98	1.28	0.79	1.15
Average		1.04	0.917	0.86	0.73	0.874	1.35	1.779	1.651	1.49	1.25	1.15	1.144

Source: Irrigation Department, 2003

Water qualities in Chao Phraya river are showed in Table 4.6, BOD values from the upstream, middle and downstream are higher than Water Quality Standard values of class 2, class 3, and class 4, respectively, while most parameters were still in the range of Water Quality Standard class 3 (Monchan Maketon at all, 2003). The calculated Water Quality Index (WQI) is shown in Table 4.7, it is relatively high because Fecal-coliform bacteria (FCB) value is not included in the calculation. The indices indicate that the water qualities in the upstream and the middle are very good to fair instead of fair to poor, but the downstream qualities are poor at all sites.

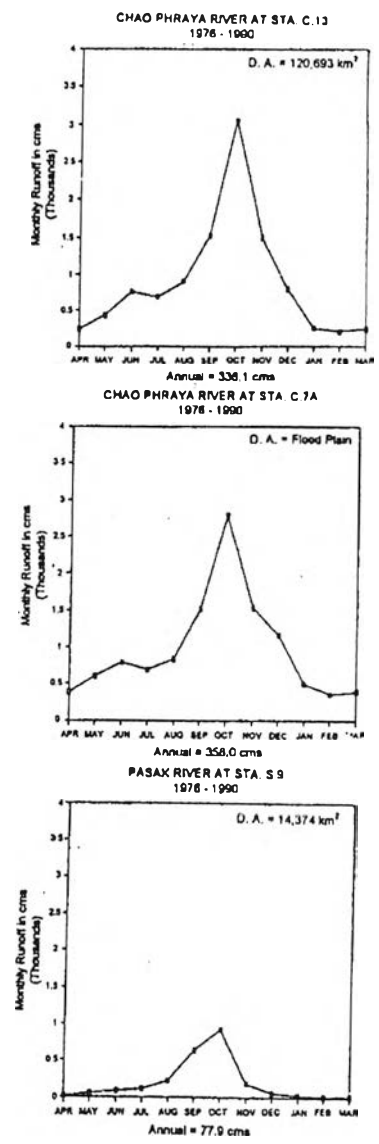
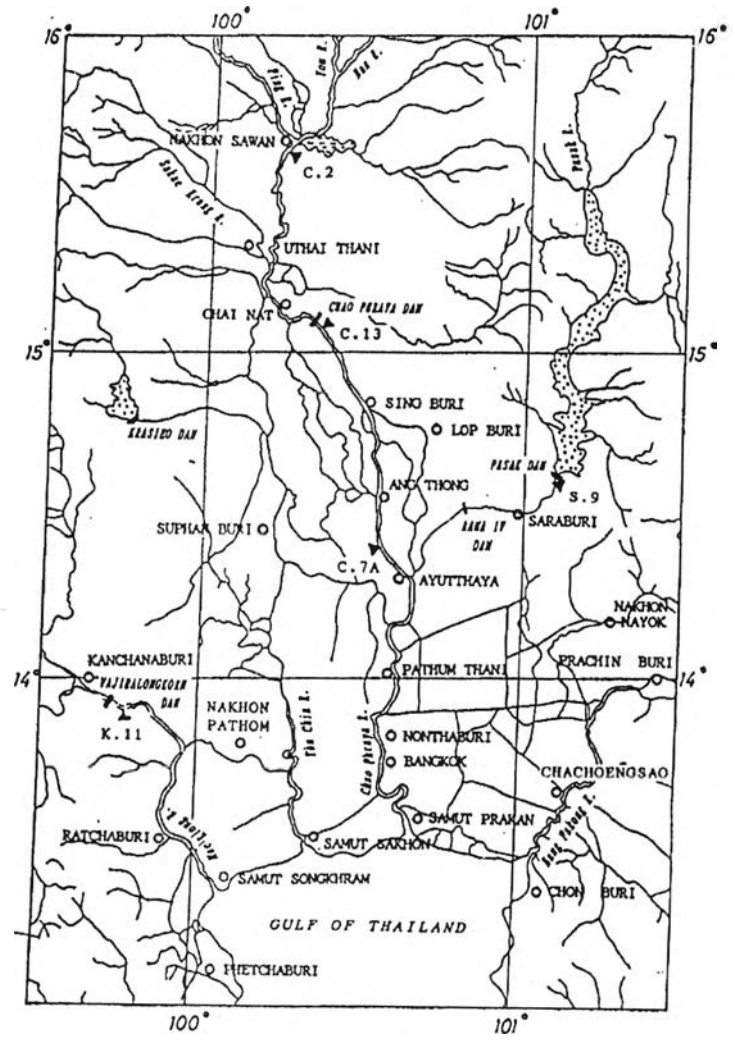
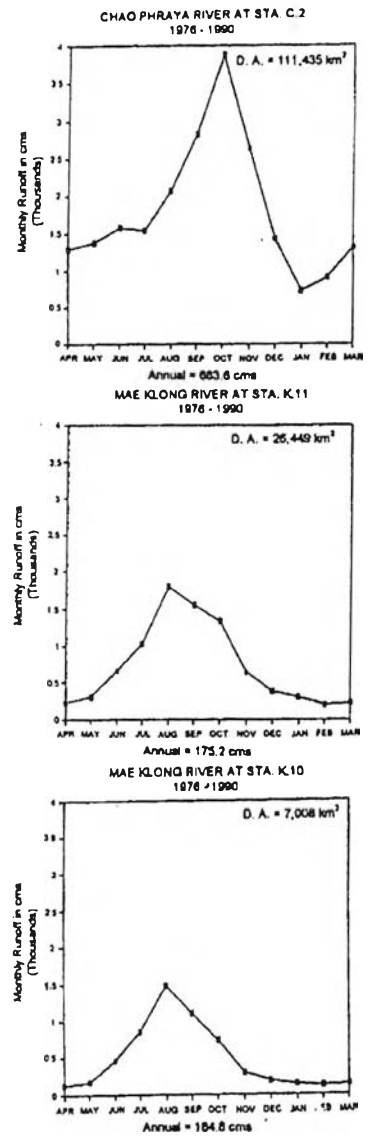


Figure 4.8. Mean monthly distribution of runoff of the Chao Phraya, Pasak and Mae Klong rivers.

Table 4.6. Average parameters of water qualities from 14 sites in the Chao Phraya river.
from January to December, 1997.

Site \ Parameters	Ambient Temp. (°C)	Water Temp.(°C)	pH	Transparency (cm)	Salinity (ppt.)	TSS (mg/L)	DO (mg/L)	BOD (mg/L)	NO ₃ ⁻ (mg/L)	PO ₄ ³⁻ (mg/L)
1. Nakhon Sawan	32.3	29.8	7.43	23.3	0.00	81.17	7.46	2.55	0.16	0.40
2. Chai Nat	32.5	30.0	7.47	32.5	0.00	31.50	8.15	2.70	0.09	0.38
3. Singburi	31.8	30.1	7.63	28.8	0.00	42.17	8.08	2.88	0.15	0.38
4. Ayuthaya	32.4	29.9	7.48	36.7	0.00	34.17	7.05	2.98	0.18	0.37
5. Bangpain	32.8	30.1	7.37	32.5	0.00	56.50	6.07	2.76	0.23	0.40
6. Pathum Thani	32.9	30.0	7.35	27.3	0.00	62.83	5.79	2.49	0.18	0.39
7. Pakkret	30.7	29.5	7.29	33.3	0.03	57.08	3.82	2.73	0.38	0.40
8. Piboon Songkram	30.4	29.7	7.30	45.2	0.05	62.67	2.41	2.45	0.50	0.60
9. Taevej	31.3	29.5	7.25	55.8	0.06	59.00	2.14	3.45	0.50	0.60
10. Budha Yodfa Bridge	32.1	29.4	7.18	51.0	0.18	44.50	2.28	4.60	0.42	0.57
11. Bangkok Bridge	31.5	29.4	7.27	54.6	0.47	53.50	2.23	4.84	0.42	0.65
12. Phrakanong	32.7	29.6	7.30	43.6	3.18	58.83	1.46	5.23	0.40	0.77
13. Phrapdang	33.1	29.8	7.34	49.8	5.98	73.75	1.88	4.35	0.53	0.72
14. The estuary of the river	32.6	30.4	7.51	45.3	12.87	180.17	3.18	4.03	0.47	0.67

Source: Monchan Maketon et al, 2003

Table 4.7. Water Quality Index (WQI) from 14 sites in the Chao Phraya river from January to December, 1997.

Site	Parameters	WQI (Score)							Remark	
	WQI Total	WQI min	pH	TS	BOD	DO	Nitrate	Phosphate	DO saturate (mg/L)	Saturate (%)
1. Nakhon Sawan	80	45	93	85	76	99	97	45	7.6	98.2
2. Chai Nat	79	47	91	83	73	96	99	47	7.6	107.6
3. Singburi	79	47	90	85	72	97	97	47	7.6	106.3
4. Phra Nakhon Si Ayuthaya	79	49	91	84	71	97	97	49	7.6	92.8
5. Bangpain	78	45	93	86	73	87	97	45	7.6	79.9
6. Pathum Thani	78	46	93	86	77	82	97	46	7.6	76.2
7. Pakkret	69	42	94	86	73	22	94	28	7.6	50.3
8. Piboon Songkram	57	22	94	86	73	22	94	28	7.6	31.7
9. Taevej	54	19	94	86	67	19	94	27	7.6	28.2
10. Budha Yodfa Bridge	53	19	93	85	57	19	95	24	7.8	28.6
11. Bangkok Bridge	52	19	94	86	55	19	95	24	7.8	28.6
12. Phrakanong	47	13	94	86	54	13	95	20	7.6	19.2
13. Phrapdang	49	15	94	85	60	15	94	21	7.6	24.7
14. The estuary of the river	56	24	91	75	62	33	94	24	7.6	41.8

Source: Monchan Maketon at all, 2003

4.4. Climate

4.4.1. Rainfall

The research area is located in the monsoonal region, which has a distinct dry season and a flood season caused by monsoonal rains. Over the Lower Central Plain, most of the rain is caused by the regular south-west monsoon winds but a smaller portion falls in the form of very intense torrential showers resulting from tropical storms. The average frequency of tropical storms entering Thailand is approximately two storms per year, which generally occur during the months of May through December.

With its flat topography, very little variation exists in the rainfall regime within the research area, therefore, the monthly and annual rainfall data for Phra Nakhon Si Ayuthaya province be considered representative for the entire research area. Based on 10 years recorded data from 1993 to 2002 in the Tha Ruat station, the average monthly rainfall in the research area can be calculated. The average of annual rainfall is 1066.64 mm, with the highest rainfall occurs in 1999 (1,420.30 mm) and lowest in the 1997 (741.10 mm). The mean monthly rainfall value varies from 8.33 mm (January) to 223.70 mm (September). About 86 % of the rainfall occurs from May to October, with September generally as the month of highest rainfall. The period from November to March is distinctively dry. The details of mean monthly rainfall in the research area are summarized in Table 4.8.

4.4.2. Temperature, relative humidity, evaporation and evapotranpiration

The mean monthly variation of temperature and relative humidity are measured at Ayuthaya Agromet station. The station is located in Tha Rua, Bang Pain, Ayuthaya outside the study area in the north around 25 km. The mean monthly temperature varies from 20.8 °C (March) to 38.88 °C (April). The data indicates that, on the average, monthly temperature ranges from a minimum of 26.04 °C (December) to a maximum of 30.79 °C (April). The coldest months are December and January while the warmest months are March and April.

The monthly average relative humidity ranges from a maximum of 97.7% to a minimum of 16.3%. The months of April, May and November record the highest relative

humidity readings, while the months of January, February and March record the lowest. Mean annual relative humidity is recorded at 64.25%.

In Ayuthaya, mean monthly evaporation varies from a minimum of 112.52 mm in September to a maximum of 180.07 mm in April. The maximum evaporation in ten years period is 2,000.51 mm occurred in 1993 and the minimum is 1,661.21 mm occurred in 1999. Estimated annual mean is set at 1,776.91 mm. With the above temperature and humidity conditions, evaporation is considered high in the study area.

The evapotranspiration data is calculated using Reference Evapotranspiration Calculator (REF-ET) software. The input data are latitude, elevation, air temperature, humidity, wind speed, sunshine hour and solar radiation. The monthly average data in ten years (1993-2002) from the measurement in the field is used as an input into the REF-ET software. REF-ET software calculates the daily evapotranspiration, by which total evaporation in month is equal to daily evapotranspiration multiply by amount of day in that month. The result shows the maximum evapotranspiration of 194.80 mm (see Table 4.9.) occurred in April and minimum of 136.25 mm. occurred in September. The comparison graph of rainfall, evaporation and evapotranspiration is showed in Figure. 4.9.

Table 4.8. Rainfall data in the research area.

Station Code	: 415301	Elevation	: 4 m (MSL)
Station Name	: Ayuttaya Agromet	Latitude	: 14.32.00
Amphoe	: Tha Rua	Longitude	: 100.43.40
Changwat	: Phra Nakhon Si Ayuthaya		

No.	Year	Monthly Rainfall (mm)												Total
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
1	1993	0.00	3.50	21.50	50.50	224.80	45.20	63.50	244.70	172.90	97.80	0.00	3.50	927.90
2	1994	1.90	10.40	26.60	117.60	143.90	352.80	73.10	180.70	252.40	106.40	0.20	0.40	1266.40
3	1995	0.00	0.00	21.00	55.40	99.90	69.10	118.20	285.20	463.40	108.10	26.50	0.00	1246.80
4	1996	0.00	5.90	14.60	75.90	181.20	200.60	86.20	67.10	280.90	125.80	19.00	0.00	1057.20
5	1997	0.10	0.00	18.00	38.20	67.00	77.30	41.50	183.80	192.50	104.00	18.70	0.00	741.10
6	1998	0.00	0.00	0.00	12.70	182.80	167.60	279.00	246.10	121.90	160.80	39.80	0.00	1210.70
7	1999	29.80	8.50	7.20	168.30	287.90	121.50	190.30	189.60	206.70	188.80	21.70	0.00	1420.30
8	2000	0.00	18.60	21.20	154.40	96.40	102.50	78.90	164.20	157.40	97.00	8.60	0.00	899.20
9	2001	2.10	4.50	171.10	1.40	230.80	87.20	84.60	112.80	84.50	87.50	3.30	10.80	880.60
10	2002	49.40	5.00	13.70	9.80	95.80	52.20	36.60	195.80	304.40	54.30	94.70	104.50	1016.20
Average		8.33	5.64	31.49	68.42	161.05	127.60	105.19	187.00	223.70	113.05	23.25	11.92	1066.64

Source: Computer Sub Division, Climatology Division Meteorological Department, 2003.

Table 4.9. Monthly evaporation data.

Station Code	: 415301	Elevation	: 4 (MSL)
Station Name	: Ayuttaya Agromet	Northing	: 14.32.00
Amphoe	: Tha Rua	Easting	: 100.43.40
Changwat	: Phra Nakhon Si Ayuthaya		

No.	Year	Monthly Evaporation (mm)												Total
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
1	1993	147.21	159.50	196.20	205.60	195.00	190.60	192.60	139.80	133.00	129.90	143.80	167.30	2000.51
2	1994	146.11	164.30	190.60	201.50	163.40	117.20	139.50	132.70	116.30	138.00	164.20	156.20	1830.01
3	1995	148.21	169.50	199.50	209.90	174.20	163.30	164.10	116.20	71.70	95.10	159.00	186.60	1857.31
4	1996	148.71	185.50	191.40	172.20	160.50	121.00	125.20	127.60	96.60	119.60	125.80	161.50	1735.61
5	1997	131.91	145.10	180.60	198.70	205.80	194.70	160.30	152.90	115.40	120.30	127.10	148.90	1881.71
6	1998	133.31	146.40	192.20	186.30	197.40	144.20	125.10	128.30	115.40	106.90	117.70	151.50	1744.71
7	1999	150.21	145.40	177.30	134.90	127.70	123.80	143.00	135.70	116.10	110.60	115.80	180.70	1661.21
8	2000	159.11	142.50	167.60	133.30	149.80	130.80	131.40	145.80	109.10	119.30	146.70	162.80	1698.21
9	2001	129.61	134.90	124.30	176.00	141.10	137.70	149.30	146.10	133.80	109.50	142.80	153.80	1678.91
10	2002	154.31	123.70	162.00	182.30	146.00	143.90	153.30	125.40	117.80	117.00	137.90	117.30	1680.91
Average		144.87	151.68	178.17	180.07	166.09	146.72	148.38	135.05	112.52	116.62	138.08	158.66	1776.91

Source: Computer Sub Division, Climatology Division Meteorological Department, 2003

Table 4.10. Monthly evapotranspiration in the research area.

Month	Day	Year	Tmax (°C)	Tmin (°C)	n/N dec	Wind M/s	DewP (°C)	PM ETo	stPM ETo	56PM ETo	Kpen Eto	Pen ETo	Harg ETo	Average Eto	Monthly Eto
1	1	94-02	35.9	14.9	0.7	2.6	23.2	4.1	4.12	4.12	4.01	4.24	5.78	4.40	136.40
2	1	94-02	37	17.1	0.7	4.8	23.2	5.7	5.71	5.71	5.26	5.82	6.42	5.77	161.65
3	1	94-02	38.2	20.1	0.6	2.5	23.2	5.6	5.61	5.61	5.25	5.82	6.93	5.81	180.06
4	1	94-02	38.9	22.6	0.6	2.8	23.2	6.5	6.45	6.45	5.98	6.55	7.06	6.49	194.80
5	1	94-02	38	22.7	0.6	2	23.2	5.7	5.65	5.65	5.55	5.81	6.78	5.85	181.45
6	1	94-02	36.2	23.1	0.5	2.2	23.2	5.2	5.17	5.17	5.47	5.36	6.14	5.42	162.50
7	1	94-02	36.3	23	0.4	2.6	23.2	5.1	5.12	5.12	5.67	5.14	6.17	5.39	167.19
8	1	94-02	35.4	22.4	0.4	2	23.2	4.5	4.5	4.5	5.02	4.72	5.99	4.87	151.07
9	1	94-02	34.4	22.3	0.4	1.6	23.2	4.2	4.19	4.19	4.57	4.52	5.58	4.54	136.25
10	1	94-02	34.8	20.6	0.6	2.6	23.2	4.6	4.57	4.57	4.8	4.91	5.57	4.83	149.83
11	1	94-02	34.8	18.6	0.7	3.6	23.2	4.6	4.62	4.62	4.62	4.73	5.24	4.74	142.25
12	1	94-02	35.1	15.2	0.7	4.4	23.2	4.3	4.34	4.34	4.29	4.35	5.37	4.51	139.66

Source: Primary Analysis, 2004

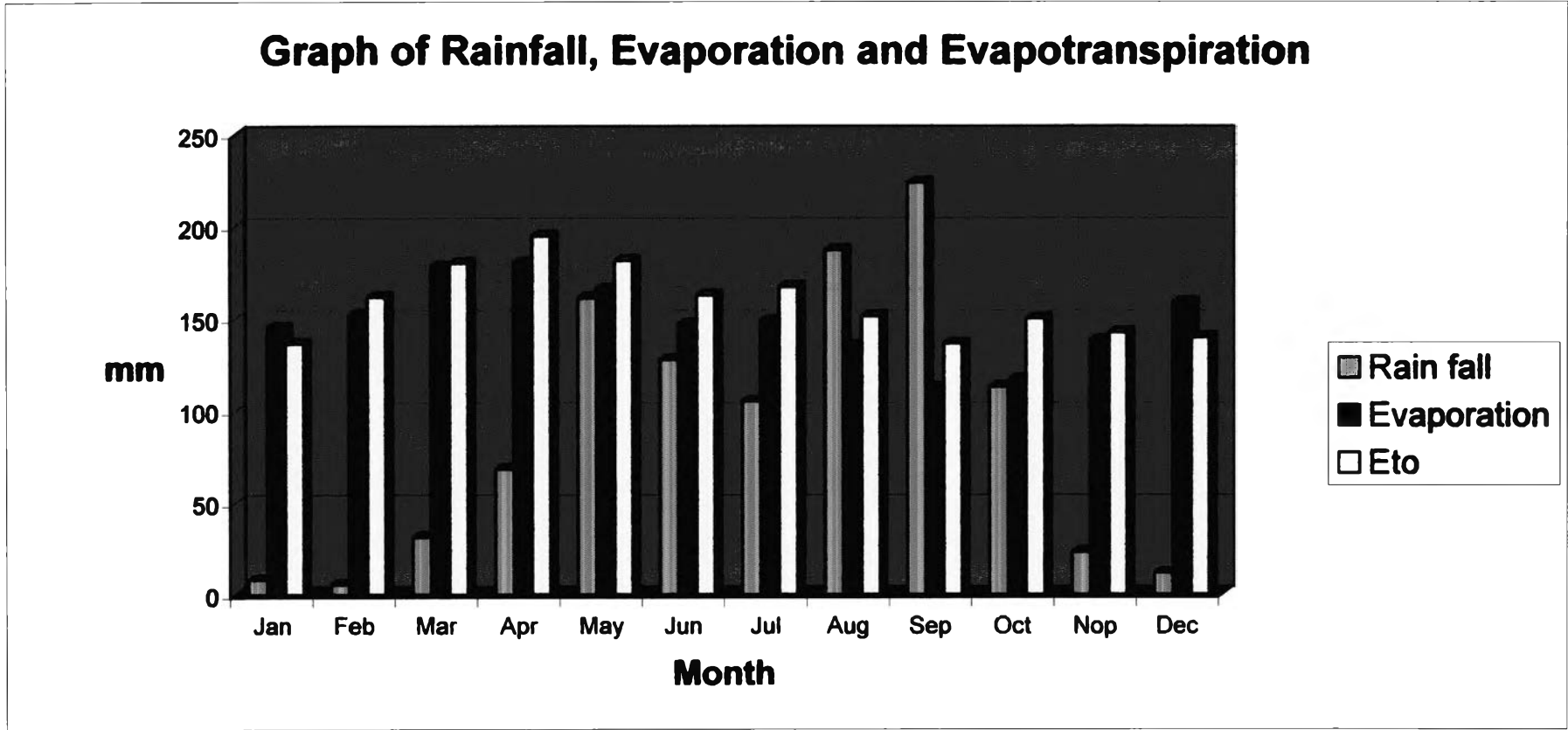


Figure 4.9. Comparison graph of rainfall, evaporation and evapotranspiration from 1993 to 2003.

4.5. Land Use and Soils

The newest 1: 1,000,000 scale land use map is produced by Land Development Department in 1998 (see Figure 4.10). The units are broadcasted paddy field 80%, field crops 3 %, orchard 4 %, horticulture 5%, swidden cultivation 2 %, pasture and farm house 2 %, lowland and village 2%, allocated land project 1%, industrial estate 0.5%, water body 2% and others 1.5% of the land area.

Basically, land quality in the research area is good and belongs to Class I category (according to The soil resources of Thailand, 1996). These are prime land highly productive soil, with few management-related constraints. Soil temperature and moisture conditions are ideal for annual crops. Soil management consists largely of sensible conservation practices to minimize erosion, appropriate fertilization, and use of the best available plant materials. Risk to sustainable grain crop production is generally less than 20%.

Based on the Soil Survey Division 1972 and 1976, the research area consists of alluvial soil type (National 1 Classification). Using the USDA-1970 classification of soil, it can be divided into typic tropaquepts, sulfic tropaquepts, typic haplaquolls, aeric tropaquepts and suffice tropaquepts. The spreading of soil type is dominated by typic tropaquepts around 40% from the total area. Suffice tropoquepts type can be found around Chao Phraya river and in southern part of the research area. The details of soil type in the research area are shown in Figure 4.10 and Table 4.11.

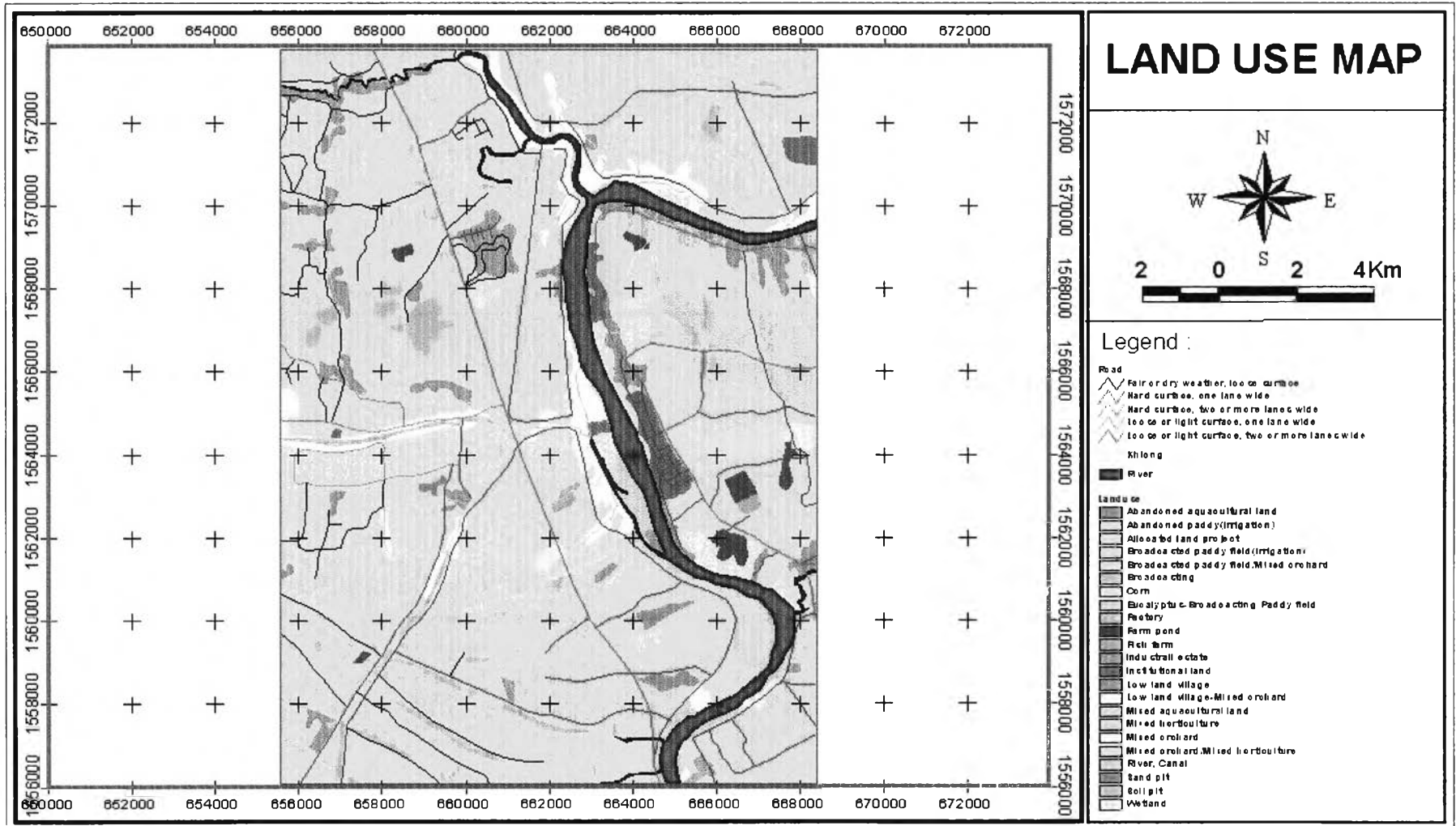


Figure 4.10. Land use map.

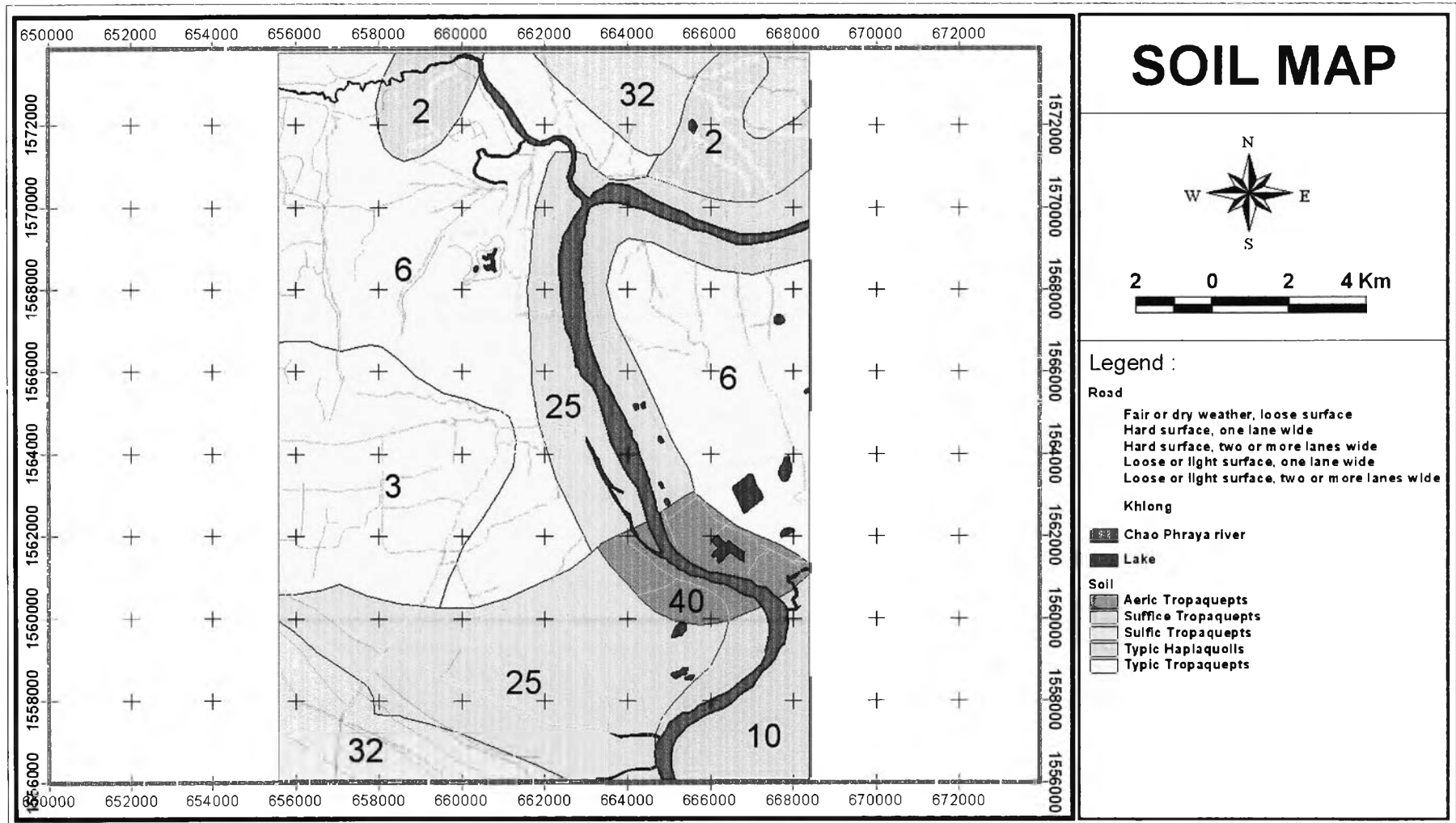


Figure 4.11. Soil type map.

Table 4.11. Soil classification in the research area.

Code	Classification 1. USDA 1970 2. National I	Slope (%)	Effective Soil Depth (cm)	Textural Profile	Structure - Upper A Horizon - Subsoil	- Drain - Permeability - Surface run off	Period of water star rake -surface -sub surface
6	1.Typic Tropaquepts 2.Alluvial Soils	< 1	> 150	Clay throughout	- weak to moderate coarse blocky - weak coarse prismatic breaking to blocky over structure less massive	- poor - K < 0.5 cm/hr - slow	- 7 – 8 months - 10 – 11 months
32	1.Sulfic Tropaquepts 2.Alluvial Soils	< 1	> 150	Clay throughout	- weak medium & coarse blocky - weak medium & coarse prismatic breaking to blocky	- poor - K < 0.5 cm/hr - slow	- 6 – 7 months - 10 – 11 months gwl 100 cm for 1-2 months
10	1.Typic Haplaquolls 2.Alluvial soils	1 or less	> 150	Clay throughout	- weak blocky to massive - moderate fine blocky	- poor - K < 0.5 cm/hr - slow	- 6-7 months - 8-10 months
40	1.Aeric Tropaquepts 2.Alluvial soils	1 or less	> 150	Clay or silty Clay throughout	- weak to moderate fine & medium blocky with some scrumb - moderate fine & medium blocky	- somewhat poorly - K < 0.5 cm/hr - slow	- 5-6 months - 8-10 months
21	1.Typic Tropaquepts 2.Alluvial soils	1 or less	> 150	Clay or silty clay Over clay	- moderate blocky - prismatic breaking to blocky	- poor - K < 0.5 cm/hr - slow	- 5-6 months - 8-10 months, gwl 150 cm for 1-2 months
25	1.Suffice Tropaquepts 2.Alluvial soils	< 1	> 150	Clay or silty clay Over clay	- weak granular to blocky - weak prismatic breaking to moderate or strong fine blocky	- poor - K < 0.5 cm/hr - slow	- 6-7 months - 10-11 months, gwl 100 cm for 1-2 months
2	1.Typic haplaquolls 2.Alluvial soils	0 - 1	> 150	Clay throughout	- weak blocky to massive - moderate fine blocky	- poor - K < 0.5 cm/hr - slow	- 6-7 months - 8 – 10 months
3	1.Typic Tropaquepts 2.Alluvial soils	0 - 1	> 150	Clay or silty clay Over clay	- moderate blocky - prismatic breaking to blocky	- poor - K < 0.5 cm/hr - Slow	- 5 – 6 months - 8 – 10 months, gwl 150 cm for 1-3 months

Source: Land Development Department of Thailand, 1998.

4.6. Groundwater Use

The groundwater use from the research area is estimated from the DMR recorded data. Private wells are those well registered with DMR for water rights, while Public Wells are those wells constructed or managed (or both) by Department of Mineral Resources, Metropolitan Waterworks Authority (MWA), Provincial Waterworks Authority (PWA), Accelerated Rural Development Office (ARDO) and Industrial Estates Authority Thailand (IEAT). Public wells are usually not registered with DMR for water rights.

The groundwater pumpage estimations basically relies on the Groundwater Database System, especially on the well inventory database system which stores all the different well inventories collected from the mentioned agencies. These well inventories contain 118 private wells, 14 public wells and 6 groundwater observation wells.

Table 4.12 and Figure 4.10 show the distribution of the inventoried private wells, public wells and observation wells by Changwat, by aquifer and by type of user. About 54 of the private wells are located in Pathum Thani province and 84 wells in Phra Nakhon Si Ayuthaya province, with more than 35% are extracted water from Nakhon Luang aquifer. Most of the public wells are located in Phra Nakhon Si Ayuthay province and are close to the Chao Phraya river. Note that the well screen position or the well depth is used to determine the aquifer from which a well is withdrawing groundwater. In circumstance that these is no recorded of screen position of groundwater wells, the produced aquifer is assumed from the closest wells and depth of drilling. Aquifers are identified using isopach of the three aquifers units. Nonthaburi aquifer is the most productive aquifer in the research area and the second is Nakhon Luang aquifer.

Based on the analysis of elements from samples of groundwater in the research area and its vicinity, they reveal that the water quality is still acceptable for drinking purpose, but some of them have content values higher than the standard for drinking water requirements. Therefore, the pumped groundwater must be treated before use it. The details of chemical analysis of groundwater are summarized in Table 3.13.

Table 4.12. List of wells in the research area and it's vicinity.

Well Numb.	UTME	UTMN	Address	Elevation (mSWL)	DrillDate	Depth (m)	GWL (m)	Welltype	PumpDat	Wellog	Screen (m)	Screen-Position (m)	Discharge (m ³ /day)
00299	667994	1569659	Phra Nakhon Si Ayuthaya			90		Production	No	No	6.00	80-86	
00362	668882	1553945	Pathum Thani					Production	No	No			
00493	656966	1556366	Pathum Thani			300		Production	No	No			
00537	657970	1554572	Pathum Thani			300		Production	No	No			
00852	664256	1561913	Pathum Thani					Production	No	No			
00853	665874	1560664	Pathum Thani					Production	No	No			
00854	656597	1558687	Pathum Thani			300		Production	No	No			
01169	656690	1562620	Phra Nakhon Si Ayuthaya			217	6.00	Production	No	No			
01287	656775	1569962	Phra Nakhon Si Ayuthaya					Production	No	No			
02540	665515	1562965	Phra Nakhon Si Ayuthaya			263	22.00	Production	No	No	6.00	254-260	
02700	658922	1555086	Pathum Thani			367		Production	No	No			
02710	666597	1557967	Pathum Thani					Production	No	No			
02712	666381	1554508	Pathum Thani					Production	No	No			
05454	658717	1568052	Phra Nakhon Si Ayuthaya			212	17.00	Production	No	No	6.00	201-207	
07725	664313	1570776	Phra Nakhon Si Ayuthaya			151		Production	No	No			
09047	658204	1559255	Pathum Thani		6/27/95	300	30.00	Production	No	No	6.00	28-286	
09963	656917	1556403	Pathum Thani		2/25/96	318	30.00	Production	No	No	6.00	291-297	
10196	662535	1557771	Pathum Thani			300		Production	No	No			
10197	661370	1557832	Pathum Thani		4/13/96	294	36.00	Production	No	No	6.00	269-275	
10404	667685	1554187	Pathum Thani		5/13/96	319	53.00	Production	No	No	12.00	282-294	
10405	668189	1560170	Pathum Thani		5/27/96	307	51.00	Production	No	No			
10407	667100	1554736	Pathum Thani		5/24/96	303	45.00	Production	No	No			
10445	658711	1567998	Phra Nakhon Si Ayuthaya			241	22.00	Production	No	No	6.00	232-238	
10758	667207	1558451	Pathum Thani		8/13/96	320	41.00	Production	No	No			
10759	666232	1556208	Pathum Thani		8/23/96	313	45.00	Production	No	No			
10795	669436	1554363	Pathum Thani		8/17/96	386	32.00	Production	No	No			
10818	657548	1558506	Pathum Thani		9/14/96	315	32.00	Production	No	No			

Well Numb.	UTME	UTMN	Address	Elevation (mSWL)	DrillDate	Depth (m)	GWL (m)	Welltype	PumpDat	Welllog	Screen (m)	Screen-Position (m)	Discharge (m ³ /day)
13934	664710	1556052	Pathum Thani		10/26/87	292	23.00	Production	No	No	6.00	82-88	
16327	657389	1556137	Pathum Thani			265		Production	No	No			
16578	656779	1569944	Phra Nakhon Si Ayuthaya					Production	No	No			
16579	655361	1553951	Pathum Thani					Production	No	No			
16581	656379	1554075	Pathum Thani					Production	No	No			
16582	656041	1555204	Pathum Thani					Production	No	No			
16582	662460	1562200	Phra Nakhon Si Ayuthaya			170		Production	No	No	6.00	162-168	
16583	656004	1555615	Pathum Thani					Production	No	No			
16585	660106	1555727	Pathum Thani					Production	No	No			
16594	656990	1557423	Pathum Thani					Production	No	No			
16609	663088	1558056	Pathum Thani			243		Production	No	No			
16725	657009	1557456	Pathum Thani			300		Production	No	No			
16880	655107	1558335	Pathum Thani			300		Production	No	No			
17411	663735	1565832	Phra Nakhon Si Ayuthaya			215		Production	No	No			
17413	669091	1561829	Phra Nakhon Si Ayuthaya			350		Production	No	No			
17414	668575	1561787	Phra Nakhon Si Ayuthaya			250		Production	No	No			
17417	663040	1570751	Phra Nakhon Si Ayuthaya			215		Production	No	No			
17418	665341	1570518	Phra Nakhon Si Ayuthaya			220		Production	No	No			
10612	666600	1557900	Pathum Thani	2.00	6/15/87	212	18	Production	No	No	6.00		11.00
107-2239	664050	1569950	Phra Nakhon Si Ayuthaya	3.00				Production	No	No	6.00		41.00
109-1021	663850	1565450	Phra Nakhon Si Ayuthaya	3.00				Production	No	No			31.00
12982	657550	1565350	Phra Nakhon Si Ayuthaya	2.00	7/19/88	217	6	Production	No	No			11.00
14863	666550	1554400	Pathum Thani	2.00	5/20/89	302	28	Production	No	No	6.00		11.00
301-146	664800	1569700	Phra Nakhon Si Ayuthaya	3.00	5/24/80	120	30	Production	No	No	6.00		11.00
3082	665800	1569550	Phra Nakhon Si Ayuthaya	3.00	8/24/80	138		Production	No	No			11.00
3101-0005	666100	1558250	Pathum Thani	2.00	1/11/89	243	28	Production	No	No	6.00		11.00
3101-0105	665600	1556500	Pathum Thani	2.00	2/22/89	222	30	Production	No	No	6.00		11.00
3104-0091	661150	1571550	Phra Nakhon Si Ayuthaya	5.00	10/19/89	160	14	Production	No	No	6.00		52.00
3201-0065	665550	1557850	Pathum Thani	2.00	9/15/89	254	36	Production	No	No	6.00		11.00
3201-0120	664300	1561550	Pathum Thani	2.00	9/28/90	242	28	Production	No	No	6.00		11.00
3201-0139	656850	1554850	Pathum Thani	2.00	10/28/90	262	29	Production	No	No			31.00

Well Numb.	UTME	UTMN	Address	Elevation (mSWL)	DrillDate	Depth (m)	GWL (m)	Welltype	PumpDat	Wellog	Screen (m)	Screen-Position (m)	Discharge (m ³ /day)
3203-0056	656300	1554400	Pathum Thani	2.00	1/19/90	320	30	Production	No	No			53.00
3203-0069	662650	1564900	Phra Nakhon Si Ayuthaya	3.00	10/15/89	210	24	Production	No	No	6.00		63.00
3301-0188	662850	1563350	Phra Nakhon Si Ayuthaya	2.00	11/29/90	240	24	Production	No	No	6.00		11.00
3303-0206	664950	1561300	Pathum Thani	2.00	3/21/91	258	28	Production	No	No			55.00
3305-0005	664550	1557250	Pathum Thani	2.00	5/15/90	270	36	Production	No	No	6.00		59.00
3401-0219	662200	1568300	Phra Nakhon Si Ayuthaya	3.00	4/26/92	240	17	Production	No	No	6.00		21.00
3403-0002	661250	1564550	Phra Nakhon Si Ayuthaya	2.00	3/28/91	216	20	Production	No	No	6.00		11.00
3403-0081	661250	1566100	Phra Nakhon Si Ayuthaya	2.00	5/18/91	240	21	Production	No	No	9.00		63.00
3406-0003	668400	1558800	Pathum Thani	2.00	6/11/91	210	24	Production	No	No	6.00		59.00
3906	661450	1572200	Phra Nakhon Si Ayuthaya	2.00	4/9/82	104		Production	No	No			11.00
3928	661450	1572200	Phra Nakhon Si Ayuthaya	2.00	5/6/82	151		Production	No	No			11.00
401-327	663300	1567100	Phra Nakhon Si Ayuthaya	3.00	2/4/82	212	18	Production	No	No	12.00		31.00
5066	655300	1554500	Pathum Thani	2.00	7/28/83	232		Production	No	No	6.00		11.00
5700	666300	1555700	Pathum Thani	2.00	3/22/84	272		Production	No	No	6.00		11.00
601-051	663050	1567600	Phra Nakhon Si Ayuthaya	3.00	3/30/83	219	36	Production	No	No	6.00		31.00
604-038	664550	1569750	Phra Nakhon Si Ayuthaya	3.00	8/15/83	223	16	Production	No	No	6.00		31.00
702-022	660950	1563950	Phra Nakhon Si Ayuthaya	2.00	8/6/84	267	20	Production	No	No	6.00		21.00
702-023	660050	1573800	Phra Nakhon Si Ayuthaya	4.00	7/22/84	132	35	Production	No	No	6.00		21.00
802-026	659900	1573700	Phra Nakhon Si Ayuthaya	4.00	10/13/86	132	35	Production	No	No	6.00		21.00
8269	664150	1554600	Pathum Thani	2.00	12/18/86	326	16	Production	No	No	6.00		11.00
9530	664200	1555050	Pathum Thani	2.00	10/26/87	292	23	Production	No	No	6.00		11.00
ARD-008	661650	1564800	Phra Nakhon Si Ayuthaya	2.00	7/20/92	262	8	Production	No	No	3.00		11.00
ARD-016	663200	1563600	Phra Nakhon Si Ayuthaya	2.00	8/19/92	323	6	Production	No	No	3.00		11.00
AY 25040	655200	1564300	Phra Nakhon Si Ayuthaya	2.00	10/1/90	122	17	Production	No	No	3.00		11.00
AY 25050	662500	1570800	Phra Nakhon Si Ayuthaya	3.00	10/31/90	137	23	Production	No	No	6.00		11.00
DR0044	668560	1570387	Phra Nakhon Si Ayuthaya	4.20		240	36.00	Production	No	No	12.00	228-240	
DR0045	668760	1570145	Phra Nakhon Si Ayuthaya	4.10		174	27.00	Production	No	No	12.00	156-168	
G1169	664975	1561270	Pathum Thani		1/20/92	285	25.50	Production	No	No	12.00	246-252,264-270	
G1186	666150	1555050	Pathum Thani	2.00	8/10/92	288	42.73	Production	No	No	12.00	246-258,246-258	48.00
G1213	653300	1569800	Phra Nakhon Si Ayuthaya	3.00	5/21/93	232	18	Production	No	No	6.00		21.00
G1214	657700	1563900	Phra Nakhon Si Ayuthaya	2.00	5/31/93	241	18	Production	No	No	6.00		21.00

Well Numb.	UTME	UTMN	Address	Elevation (mSWL)	DrillDate	Depth (m)	GWL (m)	Welltype	PumpDat	Wellog	Screen (m)	Screen-Position (m)	Discharge (m ³ /day)
G1223	668483	1570062	Phra Nakhon Si Ayuthaya			144	19.80	Production	No	No	6.00	132-138	
G1229	666675	1555058	Pathum Thani	1.80	9/25/93	264	36.30	Production	No	Yes	12.00	249-261	
G1252	665152	1556615	Pathum Thani		6/19/94	280	41.48	Production	No	No	12.00	240-252	
G1253	665930	1557265	Pathum Thani		7/9/94	261	41.28	Production	No	No	12.00	240-252	
G1254	663529	1570079	Phra Nakhon Si Ayuthaya	3.60		252	90.74	Production	No	Yes	12.00	231-243	
G1262	665131	1569574	Phra Nakhon Si Ayuthaya	4.20		243	23.00	Production	No	Yes	6.00	192-198	
G1269	664944	1562480	Phra Nakhon Si Ayuthaya	2.10	5/20/95	240	23.62	Production	No	Yes	6.00	204-210	29.52
GWA0011	668550	1570391	Phra Nakhon Si Ayuthaya	5.00	1/10/97	288		Production	No	No	12.00	258-264	
GWA0012	668550	1570391	Phra Nakhon Si Ayuthaya	5.00	11/3/97	240	36.02	Production	No	No	6.00	231-237	
GWA0013	668550	1570391	Phra Nakhon Si Ayuthaya	5.00	2/3/97	88		Production	No	No	6.00	34-40	
GWA0014	668550	1570391	Phra Nakhon Si Ayuthaya	5.00	2/8/97	115	25.59	Production	No	No	6.00	106-112	
GWA0015	668550	1570391	Phra Nakhon Si Ayuthaya	5.00	2/11/97	176	24.60	Production	No	No	12.00	157-163,166-172	
GWA0016	668550	1570391	Phra Nakhon Si Ayuthaya	5.00	3/1/97	176	25.81	Production	No	No	12.00	157-163,166-172	
MN0116	663900	1565300	Phra Nakhon Si Ayuthaya	3.00	7/14/83	210	17.12	Production	Yes	Yes	6.00	201-207	21.00
MN0139	655200	1564500	Phra Nakhon Si Ayuthaya		5/18/84	162	12	Production	No	No	6.00		21.00
MN0165	663900	1565300	Phra Nakhon Si Ayuthaya	3.00	12/4/84	213	15.35	Production	No	No	6.00	201-207	21.00
MN0259	663900	1565300	Phra Nakhon Si Ayuthaya	3.00	3/4/87	213	15.33	Production	No	No	6.00	201-207	21.00
MN0498	665068	1564615	Phra Nakhon Si Ayuthaya	3.00	9/15/91	215	19.34	Production	No	Yes	6.00	204-210	21.00
MQ0546	670321	1559914	Pathum Thani		4/18/90	143	19.50	Production	No	No	12.00	102-108,111-117	
MQ0569	664347	1556683	Pathum Thani		11/30/90	210	24.00	Production	No	No	12.00	189-201	
MQ0570	664983	1561277	Pathum Thani		1/14/91	225	12.00	Production	No	No	18.00	126-132,138-150	
MQ0587	657750	1572500	Phra Nakhon Si Ayuthaya	6.00	6/8/91	168	14	Production	No	No	12.00		21.00
MQ0588	658150	1573850	Phra Nakhon Si Ayuthaya	4.00	6/15/91	163	13	Production	No	No	12.00		21.00
MQ0590	654300	1573950	Phra Nakhon Si Ayuthaya	6.00	6/30/91	163	14	Production	No	No	12.00		21.00
MQ0617	663700	1570300	Phra Nakhon Si Ayuthaya	3.00	2/29/92	185	15.29	Production	No	No	12.00	168-180	30.00
MQ0618	669200	1570690	Phra Nakhon Si Ayuthaya	3.00	3/7/92	90	16.50	Production	No	Yes	6.00	81-87	
MQ0620	668500	1569590	Phra Nakhon Si Ayuthaya	3.00	3/23/92	132	19.50	Production	No	Yes	6.00	102-108	24.00
MQ0625	667690	1569712	Phra Nakhon Si Ayuthaya	3.00	4/30/92	90	15.00	Production	No	Yes	6.00	81-87	21.00
MQ0895	664500	1569700	Phra Nakhon Si Ayuthaya	3.00	10/31/98	132	18.00	Production	Yes	Yes	8.00	116-124	
MW0074	663900	1565300	Phra Nakhon Si Ayuthaya	3.00	1/16/81	239	7.50	Production	No	Yes	18.00	186-192,204-210,216-222	21.00
NB0013	663979	1562311	Phra Nakhon Si Ayuthaya	2.00	10/10/79	204	15.00	Monitoring	No	Yes	6.00	177-180,186-189	

Well Numb.	UTME	UTMN	Address	Elevation (mSWL)	DrillDate	Depth (m)	GWL (m)	Welltype	PumpDat	Wellog	Screen (m)	Screen-Position (m)	Discharge (m ³ /day)
NB0069	665126	1569478	Phra Nakhon Si Ayuthaya	3.00	9/17/90	232	20.00	Monitoring	No	Yes	6.00	217-223	
NL0012	665126	1569478	Phra Nakhon Si Ayuthaya	3.00	9/6/79	162	11.00	Monitoring	No	Yes	6.00	143-149	
NL0078	663979	1562311	Phra Nakhon Si Ayuthaya	2.00	10/2/90	226	17.00	Monitoring	No	Yes	6.00	164-170	
PD0068	665126	1569478	Phra Nakhon Si Ayuthaya	3.00	9/22/90	102	15.00	Monitoring	No	Yes	6.00	89-95	
PD0074	663979	1562311	Phra Nakhon Si Ayuthaya	2.00	3/4/90	120	16.00	Monitoring	No	Yes	6.00	109-115	
PW1843	666300	1569700	Phra Nakhon Si Ayuthaya	3.40	4/12/76	95	4.70	Production	No	Yes			
PW3062	663500	1570000	Phra Nakhon Si Ayuthaya	3.60	8/24/80	138		Production	No	Yes			
PW3097	667800	1569200	Phra Nakhon Si Ayuthaya	3.90	11/28/80	111	11.40	Production	No	Yes			
PW3928	664300	1570900	Phra Nakhon Si Ayuthaya	4.40	4/9/82	137	11.00	Production	No	Yes			
MQ0749	657079	1583113	Phra Nakhon Si Ayuthaya					Production	No	No			
TE0207	661450	1572200	Phra Nakhon Si Ayuthaya					Production	No	No			
DR 132	663258	1564938	Phra Nakhon Si Ayuthaya			318	39.5	Production	Yes	Yes	12.00	260-272	
DR 133	662815	1564904	Phra Nakhon Si Ayuthaya			292	38.5	Production	Yes	Yes	12.00	258-270	
DR 134	663071	1565235	Phra Nakhon Si Ayuthaya			252		Production	No	Yes	12.00	234-246	
Mon 3	662986	1564984	Phra Nakhon Si Ayuthaya			142		Monitoring	No	Yes	8.00	132-140	
Mon 4	662986	1564984	Phra Nakhon Si Ayuthaya			140		Monitoring	No	Yes	8.00	32-40	

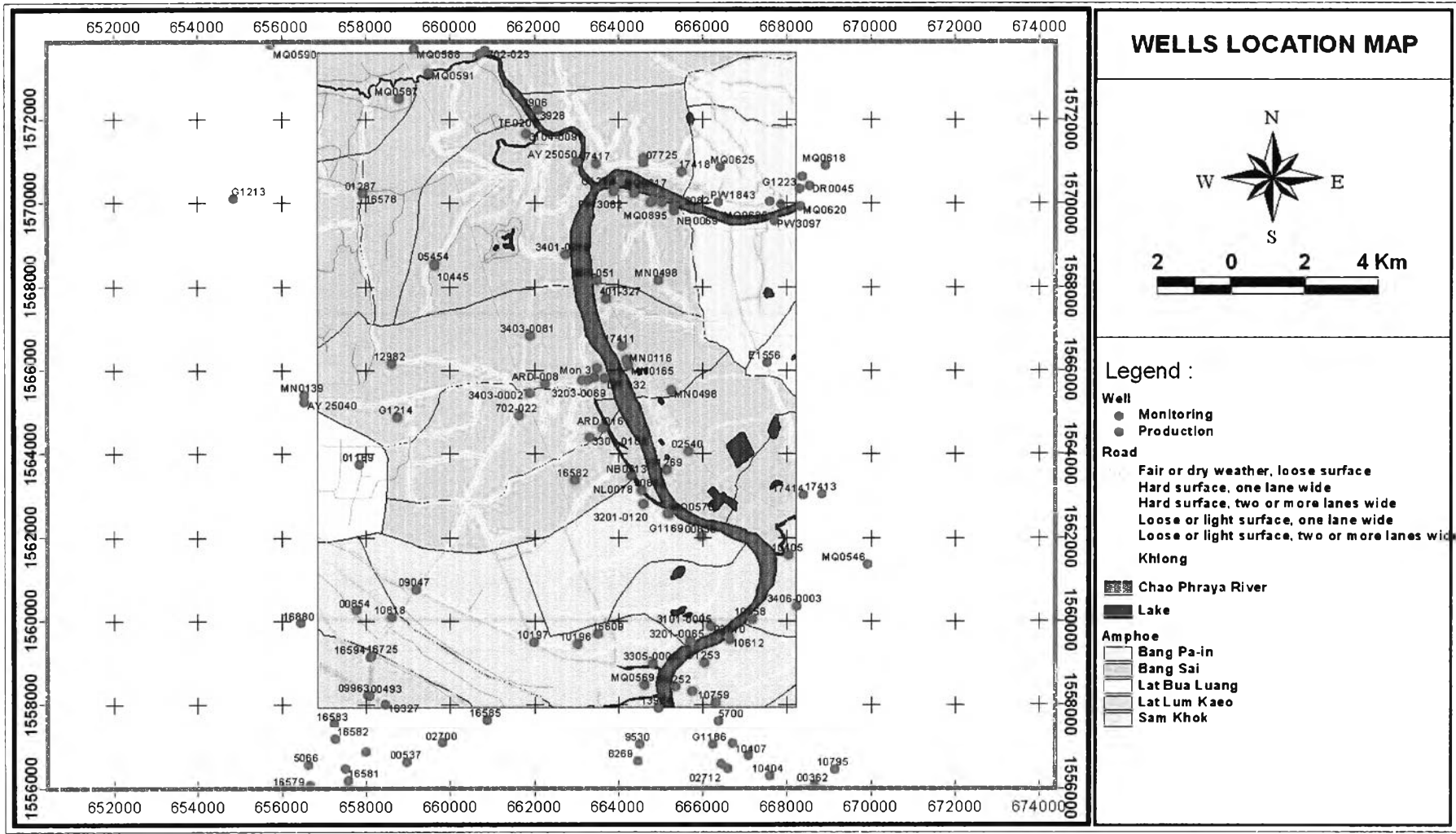


Figure 4.12. Wells location map.

Table 4.13. Quality of groundwater in the research area and its vicinity.

Well Numb.	UTME	UTMN	Address	Aquifer	pH	Fe (mg/L)	Cl (mg/L)	TDS	TH (mg/L) CaCO ₃	NO ₃ (mg/L) NO ³ -N
	Maximum allowance for Drinking purpose				5.0 - 9.2	1	600	2000	500	45
00362	668882	1553945	Pathum Thani		7.60					
00493	656966	1556366	Pathum Thani	NB		0.02	2.40	351	139.00	0.50
00537	657970	1554572	Pathum Thani	NB	7.70	0.07	1.20	366	122.00	0.20
00852 (*)	664256	1561913	Pathum Thani		7.80	0.18	6.00	321	137.00	0.00
00853 (*)	665874	1560664	Pathum Thani		7.60	0.01	6.00	372	129.00	0.80
00854 (*)	656597	1558687	Pathum Thani	NB	7.50					
02700	658922	1555086	Pathum Thani	NB						
02710	666597	1557967	Pathum Thani		7.50		23.08	830	174.23	0.11
02712	666381	1554508	Pathum Thani							
09047 (*)	658204	1559255	Pathum Thani	NB	7.70	0.06	2.00	348	134.00	0.30
09963	656917	1556403	Pathum Thani	NB		0.09	3.20	321	138.00	0.20
10196 (*)	662535	1557771	Pathum Thani		6.70					
10197 (*)	661370	1557832	Pathum Thani	NB		0.03	46.16	391	181.80	
10404	667685	1554187	Pathum Thani	NB	7.70					
10405	668189	1560170	Pathum Thani	NB	7.80					
10407	667100	1554736	Pathum Thani	NB	8.00					
10758 (*)	667207	1558451	Pathum Thani	NB	7.80					
10759 (*)	666232	1556208	Pathum Thani	NB						
10795	669436	1554363	Pathum Thani	NB	7.80					
10818 (*)	657548	1558506	Pathum Thani	NB						
13934	664710	1556052	Pathum Thani	NB						
16327	657389	1556137	Pathum Thani	NL		0.04	1.60	402	125.00	0.90
16579	655361	1553951	Pathum Thani							
16581	656379	1554075	Pathum Thani							
16582 (*)	656041	1555204	Pathum Thani			0.64	5.00	393	100.00	

Well Numb.	UTME	UTMN	Address	Aquifer	pH	Fe (mg/L)	Cl (mg/L)	TDS	TH (mg/L) CaCO ₃	NO ₃ (mg/L) NO ³ -N	
	Maximum allowance for Drinking purpose					5.0 - 9.2	1	600	2000	500	45
16583	656004	1555615	Pathum Thani			0.01	8.79	386	97.10		
16585	660106	1555727	Pathum Thani			0.71	331.88	958	313.15	0.24	
16594	656990	1557423	Pathum Thani			0.04	345.99	1104	378.69	0.27	
16609 (*)	663088	1558056	Pathum Thani	NL	7.60	0.08	5.71	318	145.65	0.02	
16725 (*)	657009	1557456	Pathum Thani	NB		0.40	306.00	853	362.00	0.20	
16880	655107	1558335	Pathum Thani	NB		0.05	0.80	374	99.00	0.20	
10612 (*)	666600	1557900	Pathum Thani	NL		0.32	190.00	708	226.00	0.30	
14863	666550	1554400	Pathum Thani	NB		0.02	42.00	370	120.00	0.30	
3101-0005 (*)	666100	1558250	Pathum Thani	NL		0.00	27.47	498	131.09	0.10	
3101-0105 (*)	665600	1556500	Pathum Thani	NL		0.00	775.03	2104	699.10	0.31	
3201-0065 (*)	665550	1557850	Pathum Thani	NL		0.04	598.66	1748	640.86	0.37	
3201-0120 (*)	664300	1561550	Pathum Thani	NL		2.00	250.00	592		2.10	
3201-0139	656850	1554850	Pathum Thani	NL		0.60	98.00	380		2.10	
3203-0056	656300	1554400	Pathum Thani	NB		0.23	460.00	1030	420.00	2.30	
3303-0206 (*)	664950	1561300	Pathum Thani	NL		0.40	1200.00	1940	730.00	2.10	
3305-0005 (*)	664550	1557250	Pathum Thani	NB		1.10	153.00	712	223.00	0.40	
3406-0003	668400	1558800	Pathum Thani	NL		0.01	6.20	310	122.50	0.10	
5066	655300	1554500	Pathum Thani	NL			1.60	370	120.05	0.15	
5700	666300	1555700	Pathum Thani	NB		0.16	260.00	868	260.00	0.00	
8269	664150	1554600	Pathum Thani	NB		0.34	130.00	432	7.00		
9530	664200	1555050	Pathum Thani	NB		0.52	370.00	904	240.00		
G1169 (*)	664975	1561270	Pathum Thani	NB							
G1186	666150	1555050	Pathum Thani	NB							
G1229	666675	1555058	Pathum Thani	NL	7.80						
G1252 (*)	665152	1556615	Pathum Thani	NB	9.70						
G1253 (*)	665930	1557265	Pathum Thani	NL	8.30						

Well Numb.	UTME	UTMN	Address	Aquifer	pH	Fe (mg/L)	Cl (mg/L)	TDS	TH (mg/L) CaCO ₃	NO ₃ (mg/L) NO ³ -N
	Maximum allowance for Drinking purpose				5.0 - 9.2	1	600	2000	500	45
MQ0546	670321	1559914	Pathum Thani	PD	7.60					
MQ0569 (*)	664347	1556683	Pathum Thani	NL	7.70					
MQ0570 (*)	664983	1561277	Pathum Thani	NL	7.91					
00299	667994	1569659	Phra Nakhon Si Ayuthaya	BK	7.00	0.10	126.00	630	152.00	0.10
01169	656690	1562620	Phra Nakhon Si Ayuthaya	NL	7.70	0.08	4.00	324	156.00	0.20
01287	656775	1569962	Phra Nakhon Si Ayuthaya		7.70					
02540	665515	1562965	Phra Nakhon Si Ayuthaya	NL	7.70		2.20	400	138.88	0.09
05454	658717	1568052	Phra Nakhon Si Ayuthaya	NL	7.60		3.30	360	148.98	
07725	664313	1570776	Phra Nakhon Si Ayuthaya	PD	7.40	0.03	11.00	354	126.00	
10445	658711	1567998	Phra Nakhon Si Ayuthaya	NL	7.70					
16578	656779	1569944	Phra Nakhon Si Ayuthaya		7.60					
16582	662460	1562200	Phra Nakhon Si Ayuthaya	NL	8.00	0.04	4.40	355	32.00	0.10
17411 (*)	663735	1565832	Phra Nakhon Si Ayuthaya	NL	7.70	0.18	1.20	388	93.00	0.30
17413	669091	1561829	Phra Nakhon Si Ayuthaya	NB	7.60	0.06	48.00	576	118.00	0.30
17414	668575	1561787	Phra Nakhon Si Ayuthaya	NL	7.90	0.13	1.60	429	96.00	0.60
17417 (*)	663040	1570751	Phra Nakhon Si Ayuthaya	NL	7.80	0.01	10.00	417	118.00	0.70
17418	665341	1570518	Phra Nakhon Si Ayuthaya	NL	8.10	0.13	4.00	401	104.00	0.00
107-2239	664050	1569950	Phra Nakhon Si Ayuthaya				337.22	1212	443.45	0.46
109-1021	663850	1565450	Phra Nakhon Si Ayuthaya			0.16	5.20	354	121.00	0.40
12982	657550	1565350	Phra Nakhon Si Ayuthaya	NL		0.07	10.00	364	135.00	0.40
301-146 (*)	664800	1569700	Phra Nakhon Si Ayuthaya	PD		0.03	7.20	414	127.00	0.50
3082 (*)	665800	1569550	Phra Nakhon Si Ayuthaya	PD		0.03	38.00	406	127.00	0.30
3104-0091	661150	1571550	Phra Nakhon Si Ayuthaya	PD		6.50	33.00	433	110.00	0.10
3203-0069 (*)	662650	1564900	Phra Nakhon Si Ayuthaya	NL		0.40	26.00	388	100.00	2.10
3301-0188 (*)	662850	1563350	Phra Nakhon Si Ayuthaya	NL		1.10	69.00	500	180.00	2.10
3401-0219 (*)	662200	1568300	Phra Nakhon Si Ayuthaya	NL		1.40	14.00		50.00	

Well Numb.	UTME	UTMN	Address	Aquifer	pH	Fe (mg/L)	Cl (mg/L)	TDS	TH (mg/L) CaCO ₃	NO ₃ (mg/L) NO ³ -N	
	Maximum allowance for Drinking purpose					5.0 - 9.2	1	600	2000	500	45
3403-0002 (*)	661250	1564550	Phra Nakhon Si Ayuthaya	NL		0.38	98.00	540	97.00	0.10	
3403-0081 (*)	661250	1566100	Phra Nakhon Si Ayuthaya	NL		0.02	12.00	415	122.00	0.20	
3906	661450	1572200	Phra Nakhon Si Ayuthaya	BK		0.05	11.96	384	110.25	0.28	
3928	661450	1572200	Phra Nakhon Si Ayuthaya	PD							
401-327 (*)	663300	1567100	Phra Nakhon Si Ayuthaya	NL		9.60	1556.00	3518	770.00	0.00	
601-051(*)	663050	1567600	Phra Nakhon Si Ayuthaya	NL		0.16	600.00	1560	600.00	0.20	
604-038	664550	1569750	Phra Nakhon Si Ayuthaya	NL		0.40	736.00	1620	636.00	0.50	
702-022 (*)	660950	1563950	Phra Nakhon Si Ayuthaya	NL		1.60	3000.00	5020	2700.00	2.10	
702-023	660050	1573800	Phra Nakhon Si Ayuthaya	PD		0.66	92.00	566	86.00		
802-026	659900	1573700	Phra Nakhon Si Ayuthaya	PD		9.20	3000.00	5730	1800.00		
ARD-008 (*)	661650	1564800	Phra Nakhon Si Ayuthaya	NL		9.90	4900.00	9300	3500.00		
ARD-016 (*)	663200	1563600	Phra Nakhon Si Ayuthaya	NB		0.56	470.00	1200	520.00		
AY 25040	655200	1564300	Phra Nakhon Si Ayuthaya	BK		43.00	2100.00	4190	1800.00		
AY 25050 (*)	662500	1570800	Phra Nakhon Si Ayuthaya	PD							
DR0044	668560	1570387	Phra Nakhon Si Ayuthaya	NL	8.20						
DR0045	668760	1570145	Phra Nakhon Si Ayuthaya	NL	7.70						
E1556 (*)	667602	1565369	Phra Nakhon Si Ayuthaya	NL	0.00						
G1213	653300	1569800	Phra Nakhon Si Ayuthaya	NL							
G1214	657700	1563900	Phra Nakhon Si Ayuthaya	NL							
G1223	668483	1570062	Phra Nakhon Si Ayuthaya	PD	7.40						
G1254	663529	1570079	Phra Nakhon Si Ayuthaya	NL	7.60						
G1262 (*)	665131	1569574	Phra Nakhon Si Ayuthaya	NL	7.80						
G1269 (*)	664944	1562480	Phra Nakhon Si Ayuthaya	NL	0.00						
GWA0011	668550	1570391	Phra Nakhon Si Ayuthaya	NB	10.00						
GWA0012	668550	1570391	Phra Nakhon Si Ayuthaya	NL	9.40						
GWA0013	668550	1570391	Phra Nakhon Si Ayuthaya	BK	7.60						

Well Numb.	UTME	UTMN	Address	Aquifer	pH	Fe (mg/L)	Cl (mg/L)	TDS	TH (mg/L) CaCO ₃	NO ₃ (mg/L) NO ³ -N
	Maximum allowance for Drinking purpose				5.0 - 9.2	1	600	2000	500	45
GWA0014	668550	1570391	Phra Nakhon Si Ayuthaya	BK	8.00					
GWA0015	668550	1570391	Phra Nakhon Si Ayuthaya	PD	8.10					
GWA0016	668550	1570391	Phra Nakhon Si Ayuthaya	PD	7.80					
MN0116	663900	1565300	Phra Nakhon Si Ayuthaya	NL	6.90					
MN0139	655200	1564500	Phra Nakhon Si Ayuthaya	PD						
MN0165	663900	1565300	Phra Nakhon Si Ayuthaya	NL	7.50					
MN0259	663900	1565300	Phra Nakhon Si Ayuthaya	NL	8.30					
MN0498 (*)	665068	1564615	Phra Nakhon Si Ayuthaya	NL	7.80					
MQ0587	657750	1572500	Phra Nakhon Si Ayuthaya	PD						
MQ0588	658150	1573850	Phra Nakhon Si Ayuthaya	PD						
MQ0590	654300	1573950	Phra Nakhon Si Ayuthaya	PD						
MQ0591	658550	1573200	Phra Nakhon Si Ayuthaya	PD						
MQ0617 (*)	663700	1570300	Phra Nakhon Si Ayuthaya	PD	8.20					
MQ0618	669200	1570690	Phra Nakhon Si Ayuthaya	BK	7.60					
MQ0620	668500	1569590	Phra Nakhon Si Ayuthaya	PD	8.20					
MQ0625	667690	1569712	Phra Nakhon Si Ayuthaya	BK	7.00					
MQ0895 (*)	664500	1569700	Phra Nakhon Si Ayuthaya	PD	7.20					
MW0074 (*)	663900	1565300	Phra Nakhon Si Ayuthaya	NL	7.80					
NB0013 (*)	663979	1562311	Phra Nakhon Si Ayuthaya	NL	7.80					
NB0069 (*)	665126	1569478	Phra Nakhon Si Ayuthaya	NL	10.20					
NL0012 (*)	665126	1569478	Phra Nakhon Si Ayuthaya	PD	7.80					
NL0078 (*)	663979	1562311	Phra Nakhon Si Ayuthaya	NL	7.10					
PD0068 (*)	665126	1569478	Phra Nakhon Si Ayuthaya	BK	8.20					
PD0074 (*)	663979	1562311	Phra Nakhon Si Ayuthaya	PD	6.80					
PW1843 (*)	666300	1569700	Phra Nakhon Si Ayuthaya	BK						
PW3062 (*)	663500	1570000	Phra Nakhon Si Ayuthaya	PD						

Well Numb.	UTME	UTMN	Address	Aquifer	pH	Fe (mg/L)	Cl (mg/L)	TDS	TH (mg/L) CaCO ₃	NO ₃ (mg/L) NO ³ -N
	Maximum allowance for Drinking purpose				5.0 - 9.2	1	600	2000	500	45
PW3097 (*)	667800	1569200	Phra Nakhon Si Ayuthaya	BK						
PW3928	664300	1570900	Phra Nakhon Si Ayuthaya	PD						
MQ0749	657079	1583113	Phra Nakhon Si Ayuthaya							
TE0207	661450	1572200	Phra Nakhon Si Ayuthaya							
DR 132 (*)	663258	1564938	Phra Nakhon Si Ayuthaya	NB	7.2	0.8	65	553	160	< 2
DR 133 (*)	662815	1564904	Phra Nakhon Si Ayuthaya	NB	7.8	1	110	670	220	< 2
DR 134 (*)	663071	1565235	Phra Nakhon Si Ayuthaya	NL	8.6	0.4	10	459	110	< 2
Mon 3 (*)	662986	1564984	Phra Nakhon Si Ayuthaya	PD	7	2.3	1500	3340	1400	< 2
Mon 4 (*)	662986	1564984	Phra Nakhon Si Ayuthaya	PD	8.6	0.8	440	1380	130	< 2

Note : (*) : Well inside the model area