CHAPTER 2
HYDROGEOLOGIC ENVIRONMENT

Hydrogeologic environment is defined here as the study of the relationship between groundwater and environment, natural phenomenon and human activity that impact the quantity and quality of groundwater.

Topography, climate, hydrology, geology, land use and type of soil are used to determine hydrogeologic environment in the study area.

2.1 Topography

The topography of the study area and its adjacent is relatively flat, with gradually decreasing elevation from north to south. The variation of elevation range from 1 to 4 meters above mean sea level (MSL) (Figure 2.1). The area is dominantly formed by alluvium deposit. Bang Pakong River is the main river in the study area and its adjacent. The topography is shown by topographic map Scale 1:50,000 Sheet 5236 III (Chachoengsao).

2.2 Climate

The study area has a tropical monsoon climate that affected by an annual monsoon. There are three seasons: winter, summer, and rainy season. The winter season is from November to February when the north-east monsoon brings cooler, drier weather from China. The summer season occurs from March to May. South-easterly wind carries dry air masses from the South China Sea across the Gulf of Thailand to the area. The rainy season is from June to October when the south-west monsoon sweeps across the Indian Ocean to drench the area.

Climatological data of Chachoengsao station for the period 15 years (1989–2004) is presented in Table 2.1.

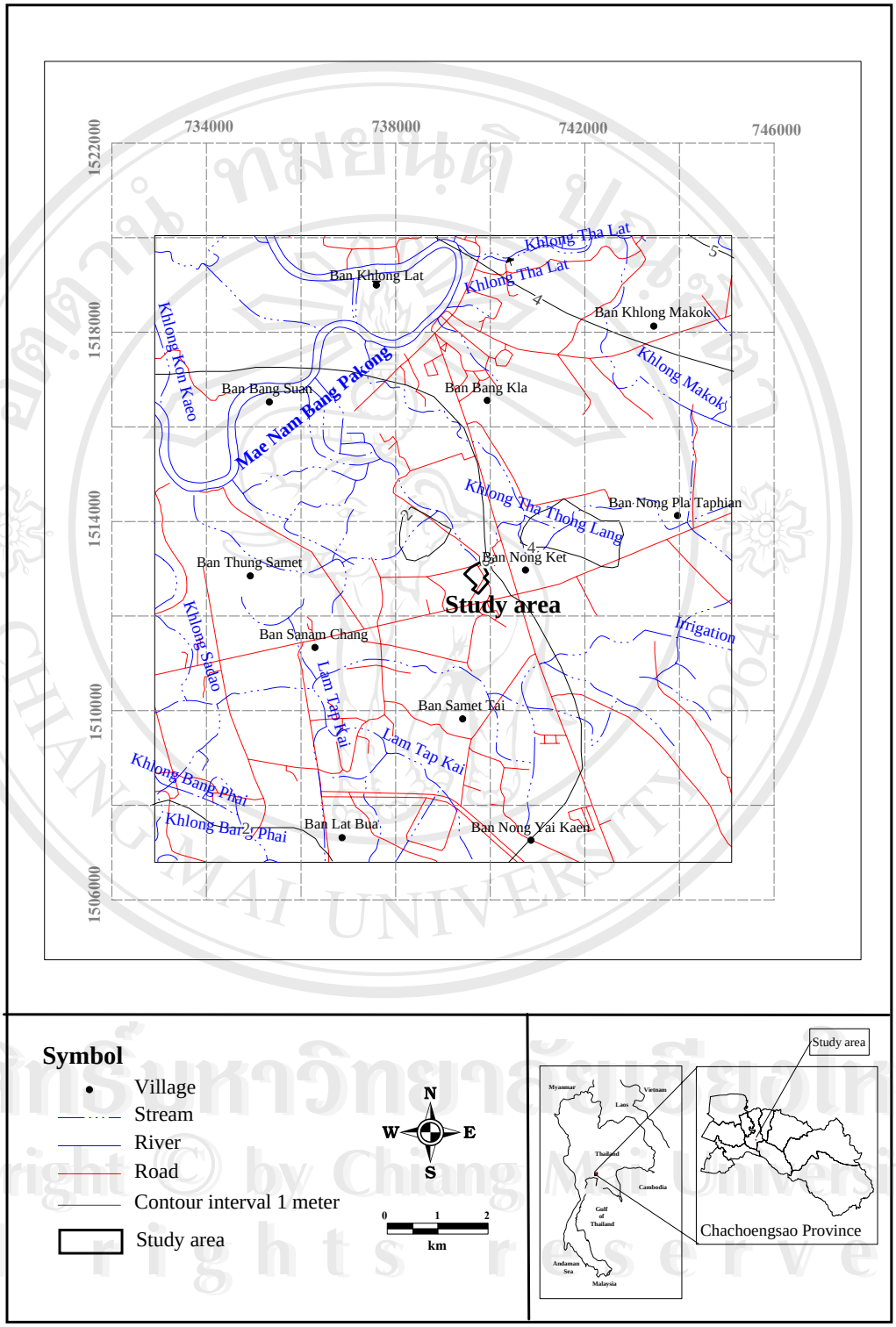

Figure 2.1 Topography in the study area and its vicinity
(modified from Royal Thai Survey Department, 1989).

Table 2.1 Climatological data of Chachoengsao period 15 years (1989-2004)
(from Climatology Division, Meteorological Department, 2004).

Station CHACHOENGSAO
Latitude 13.6 N
Longitude 101.5 E
Elevation of station above MSL 70.00 m
Height of thermometer above ground m
Height of wind vane above ground m
Height of rain gauge m

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Air temperature (celsius)													
Extreme maximum	37.5	37.7	39.1	40.2	40.2	37.5	37.0	36.0	35.1	35.1	37.1	35.9	40.2
Mean maximum	33.1	34.2	35.0	35.6	34.1	32.9	32.5	32.2	31.9	31.9	32.0	31.8	33.1
Mean	26.5	27.6	29.1	30.0	29.6	28.9	28.5	28.1	28.0	27.5	26.5	25.5	28.0
Mean minimum	19.8	21.3	23.2	24.6	25.0	24.7	24.5	24.1	23.9	23.2	21.1	19.1	22.9
Extreme minimum	11.5	13.0	17.8	20.1	22.3	21.8	21.6	21.4	21.3	16.7	14.0	8.8	8.8
Grass minimum temperature (celsius)													
Mean minimum	16.8	18.3	21.0	22.8	23.6	23.5	23.3	23.1	22.9	21.7	18.6	16.3	21.0
Extreme minimum	7.4	6.6	12.6	19.1	20.7	20.6	21.0	20.4	19.5	14.0	9.4	0.7	0.7
Water temperature (celcius)													
Mean maximum	30.1	31.2	33.0	34.5	34.1	32.9	32.4	32.3	32.4	32.6	30.9	29.6	32.2
Mean	24.6	25.5	27.3	28.8	28.7	28.0	27.7	27.6	27.5	27.4	25.6	23.9	26.9
Mean minimum	18.9	19.7	21.8	22.8	23.4	23.3	22.9	22.8	22.6	22.2	20.2	18.1	21.6
Relative humidity (%)													
Extreme maximum	100	100	100	100	100	100	100	100	100	100	100	100	100
Mean maximum	93	93	94	94	95	95	95	95	96	96	95	93	95
Mean	62	64	67	70	74	75	75	78	79	76	70	63	71
Mean minimum	33	34	40	43	52	56	56	59	61	57	44	35	48
Extreme minimum	9	7	7	13	24	25	35	37	26	19	11	8	7
Soil temperature (celcius)													
Mean at surface	28.7	29.8	30.9	32.2	31.0	30.5	30.0	29.4	29.3	28.5	28.1	27.2	29.6
Mean at 5 cm	29.7	30.8	32.0	33.0	31.9	31.0	30.8	30.3	29.9	29.5	29.3	28.4	30.6
Mean at 10 cm	29.8	31.0	32.3	33.2	32.0	31.2	30.9	30.3	30.0	29.7	29.6	28.8	30.7
Mean at 20 cm	29.7	31.0	32.1	33.0	31.8	30.9	30.7	30.2	29.9	29.7	29.5	29.0	30.6
Mean at 50 cm	30.2	30.8	31.7	32.6	32.0	31.2	30.9	30.6	30.4	30.2	30.1	29.8	30.9
Mean at 100 cm	32.2	32.8	33.5	34.4	34.1	33.7	33.3	32.9	32.6	32.7	32.4	32.4	33.1
Rainfall (mm)													
Total amount	10.5	27.2	86.4	101.5	149.7	135.5	146.8	175.4	243.7	172.7	21.8	5.7	1276.9
Number of rainy day	2	3	9	8	14	15	15	17	19	14	4	2	122
Greatest in 24 hr	79.7	94.9	71.4	91.4	68.1	127.2	81.5	87.8	93.0	101.0	44.7	28.0	127.2
Evaporation (mm)													
Mean	5.2	5.7	5.8	6.0	5.1	4.8	4.8	4.6	4.1	4.2	4.7	5.1	5.0
Wind													
Prevailing direction	NE	S	S	S	SW	SW	SW	SW	SW	NE	NE	NE	
Mean speed (m/s)	1.2	1.4	1.3	1.2	1.0	1.1	1.1	1.1	0.8	0.8	1.2	1.3	
Sunshine duration (hr)													
Extreme maximum	10.4	10.5	10.6	11.3	11.4	11.4	11.3	11.0	10.7	10.7	10.8	10.3	11.4
Mean	7.9	8.1	7.1	7.4	6.3	5.2	5.1	4.5	4.6	6.1	7.9	8.2	6.5

2.2.1 Rainfall

The average annual rainfall in the study area is 1,276.9 millimeters, with the mean monthly rainfall value varies from 5.7 millimeters (December) to 243.7 millimeters (September). 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 shows result from tropical storms.

2.2.2 Temperature, relative humidity, and evaporation

The mean monthly variation of temperature and relative humidity are measured at Chachoengsao station.

The annual mean temperature is 28.0 degree celcius. The average temperature range from a minimum of 25.5 degree celsius (December) to a maximum of 30.0 degree celsius (April). The coldest months are December and January, while the warmest months are March and April.

The mean relative humidity is 71 %. The minimum average relative humidity is 62 % (January). In rainy season, the relative humidity is highest, the maximum average relative humidity is 79 % (September). The months of September and October record the highest relative humidity, while the months of January, February, and December recorded the lowest relative humidity.

The mean evaporation varies from a minimum of 4.1 millimeters in September to a maximum of 6.0 millimeters in April. The monthly mean evaporation is 5.0 millimeters.

2.3 Hydrology

The drainage system in its adjacent area is a dendritic pattern (Figure 2.2). The main river of Chachoengsao is the Bang Pakong River, which flows from north to south. In the study area, there is no drainage system. Bang Pakong Diversion Dam controls flowing Bang Pakong River. Table 2.2 show hydrological data in Bang Pakong River at Bang Pakong Diversion dam areas station in 2000. The mean maximum water level at upstream is 1.23 meters and mean minimum is -0.18 meters. The mean maximum and minimum water level at downstream is 1.29 and -0.37 meters, respectively. The mean effective storage volume is $29{,}495 \times 10^3$ cubic meters.

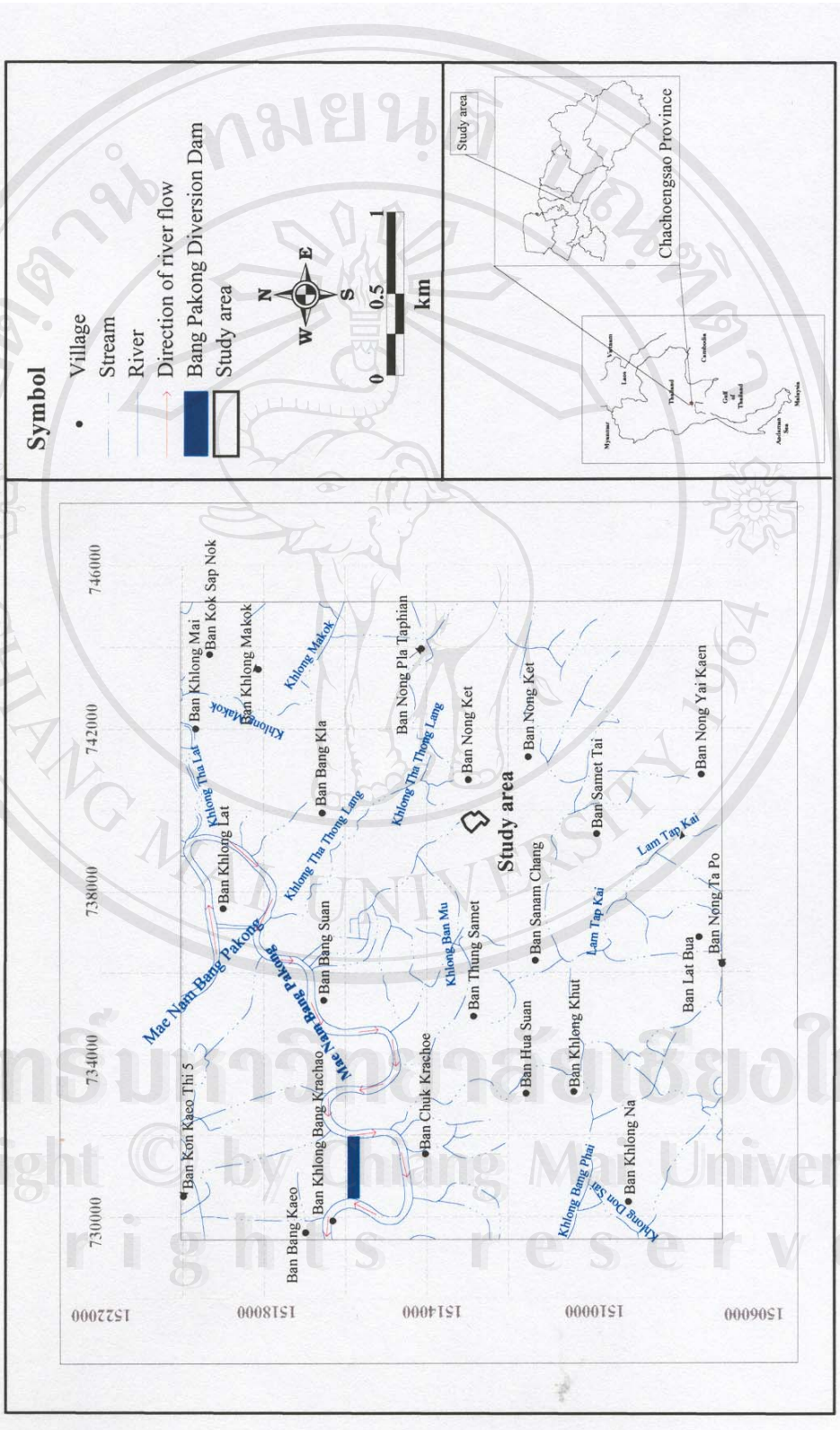

Figure 2.2 Hydrology in the vicinity of the study area.

Table 2.2 Bang Pakong hydrological data monthly report in 2000 (from Irrigation Department, 2003).

Month	**Dam water level**				**Effective storage volume at 24.00 (10^3 m^3)**	**Inflow (10^3 m^3)**	**Outflow (10^3 m^3)**	**River outflow (10^3 m^3)**
	Upstream		**Downstream**					
	Max (m)	**Min (m)**	**Max (m)**	**Min (m)**				
Jan	1.04	0.04	1.32	-1.04	25,239	11,331	10,305	10,305
Feb	0.94	0.09	1.35	-1.06	26,866	13,569	13,465	13,465
Mar	1.06	-0.49	1.13	-0.54	23,027	117,295	118,013	118,013
Apr	1.07	-0.55	1.07	-0.55	25,405	***	***	***
May	1.16	-0.54	1.16	-0.54	28,795	***	***	***
Jun	1.36	-0.25	1.35	-0.25	34,878	***	***	***
Jul	1.44	-0.09	1.43	-0.09	38,100	***	***	***
Aug	1.22	-0.36	1.22	-0.36	34,737	***	***	***
Sep	1.56	0.40	1.55	0.28	37,765	***	***	***
Oct	1.51	0.34	1.51	0.34	33,721	***	***	***
Nov	1.32	-0.10	1.31	-0.10	26,185	***	***	***
Dec	1.14	-0.65	1.13	-0.65	19,229	***	***	***
Mean	1.23	-0.18	1.29	-0.37	29,495	47,398	47,261	47,261

Remark: *** Invalid

The highest effective storage volume is 38,100x103 cubic meters in July and lowest effective storage volume is 19,229x10^3 cubic meters in December.

2.4 Geology

The study area and its adjacent have no distinctive geological feature. The area consists entirely of alluvial deposits, which accumulates during the Pleistocene period until the present day (Figure 2.3). It consists of clay, clayey sand and some gravel presented in place. The land is somewhat flatten with the elevation averaging around 1-4 meters above MSL. The deposition took place somewhere around 25 million years and was part of the Lower Central Plain in Thailand (Department of Mineral Resources, 1996).

2.5 Land use

The study area covers about 0.2 square kilometers. Ditches and bar were constructed throughout the area in order to protect flooding. The objective of the Bang Khla Royal Development Project is mainly to study the New Theory of Agriculture Project. The land use in the study area is divided into 30:30:30:10 which include water resources 30 %, horticulture 30 %, paddy field 30 %, and village 10 % (Figure 2.4). The project is being carried out successfully and also served as Training Centers for both farmers and students.

2.6 Type of soil

Base on type of soil map Scale 1:100,000, the study area and its adjacent can be divided into 6 group of soil series that is shown in Figure 2.5 and Table 2.3. The type of soil in the study area is Bangnamprew (Bp). The characteristic of Bangnamprew is clay that has gray in upper soil and gray mottled brown and yellow or red in subsoil, poor drainage, and pH range from 4.5 to 5.5.

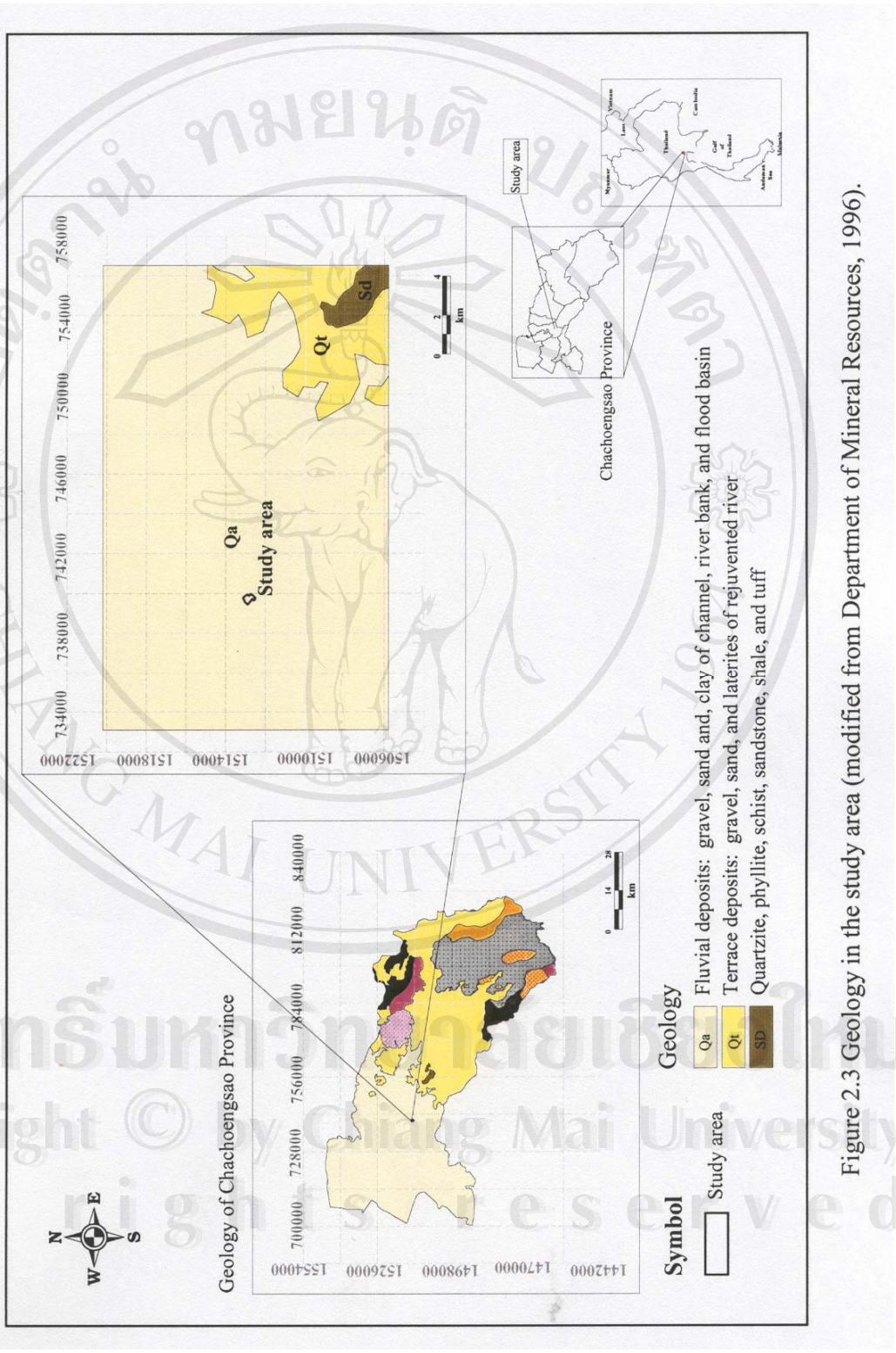

Figure 2.3 Geology in the study area (modified from Department of Mineral Resources, 1996).

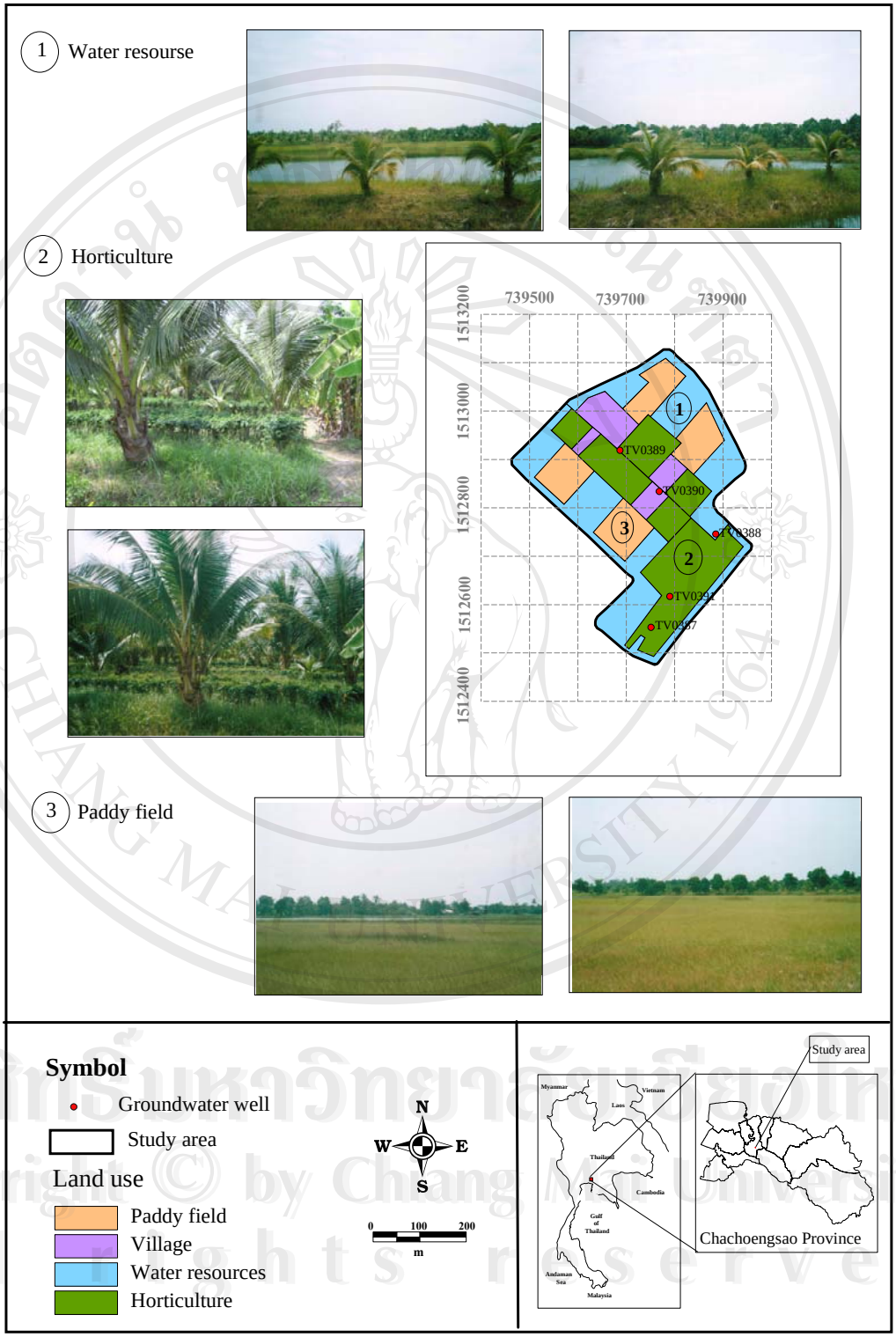

Figure 2.4 Land use in the study area in accordance with the New Theory of Agriculture Project (modified from Royal Development Project, 2002).

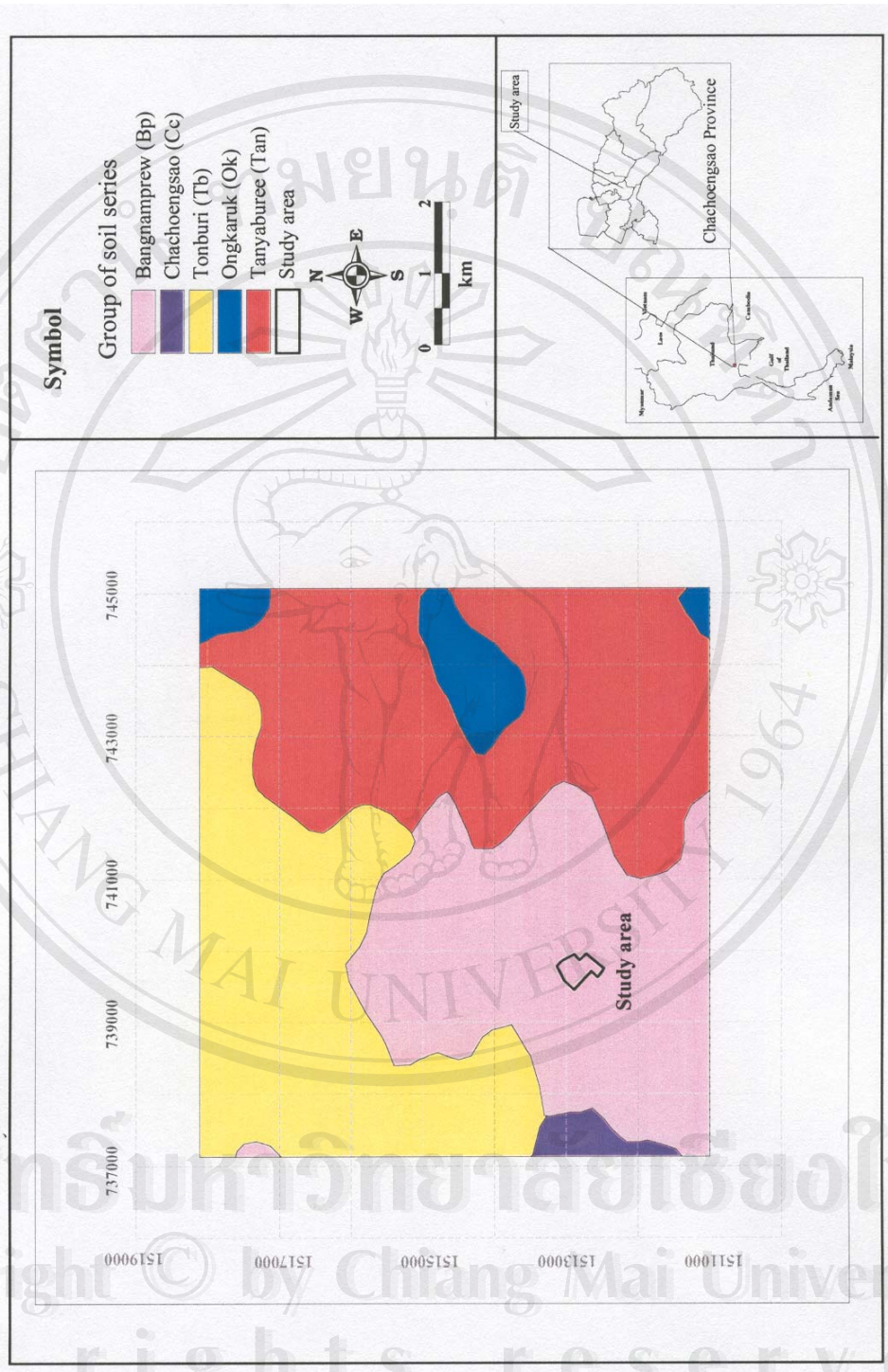

Figure 2.5 Type of soil in the study area and its vicinity (modified from Land Development Department, 1996).

Table 2.3 Soil classification in the study area and its adjacent (modified from Land Development Department, 1996).

Soil unit	**Group of soil series**	**Texture profile**	**pH**	**Drain**	**Slope (%)**	**Effective soil depth (m)**
2	Bangnamprew (Bp)	Clay	4.5 – 5.5	Poor	<1	>150
3	Chachoengsao (Cc)	Over clay	- Upper A horizon 5.5 – 6.5 - Subsoil 7.5 – 8.0	Poor	<1	
8	Tonburi (Tb)	Clay	6.0 – 7.0		<1	
10	Ongkarak (Ok)	Clay	- Depth <50 m <4.5	Poor	<1	<50
11	Tanyaburee (Tan)	Clay	4.5 – 5.0	Poor	<1	50 - 100