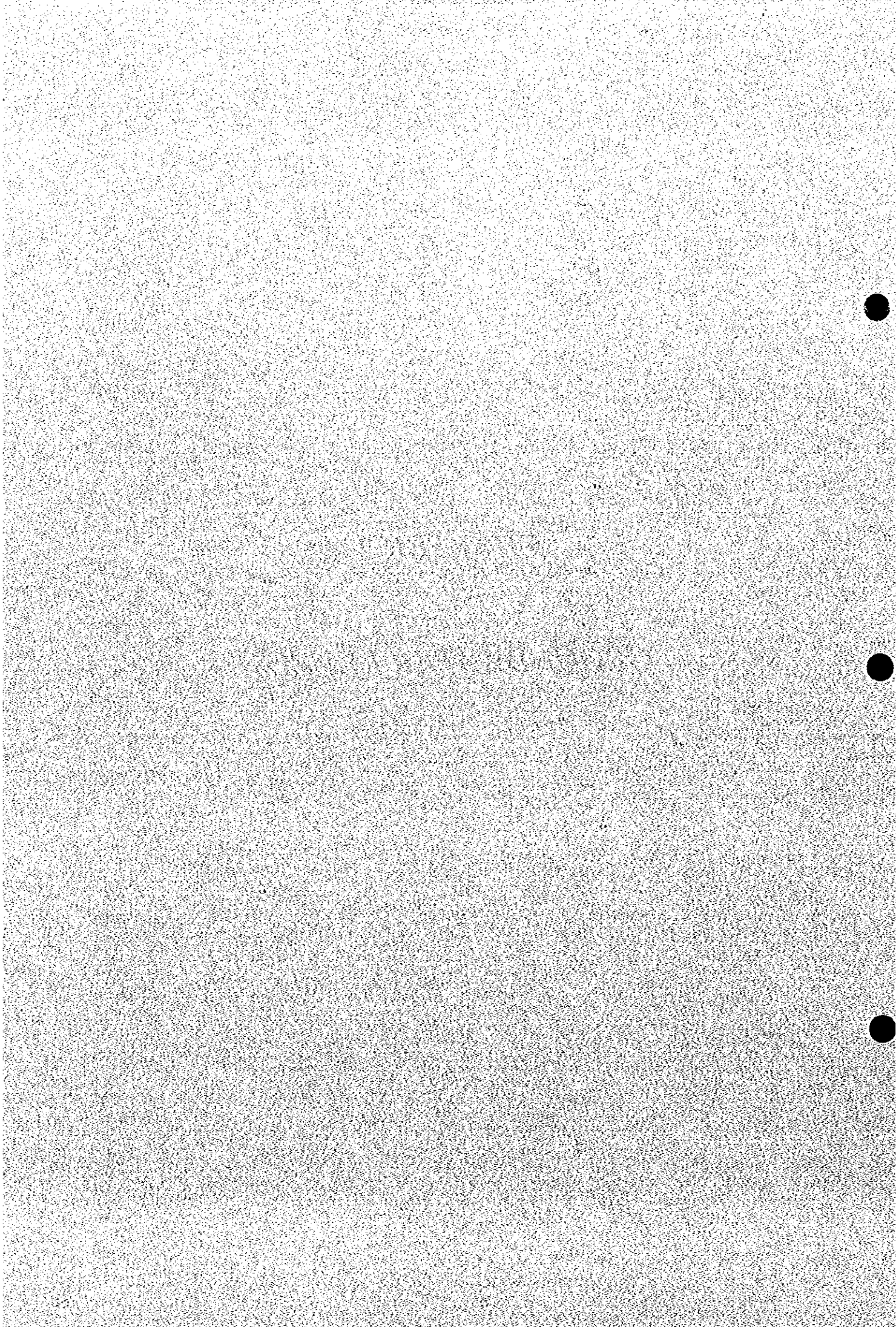


**CHAPTER 2**

**GROUNDWATER LEVELS**



## CHAPTER 2 GROUNDWATER LEVELS

### 2.1 Distribution of Groundwater Levels

#### 2.1.1 Method of Measurement

Groundwater levels of existing wells were measured in September and October 1998. Existing 200 wells were investigated with measurement of the groundwater levels as well as groundwater quality. Groundwater levels of all investigated dug wells were measured, however, the levels of most tube wells were not measured because the hand pumps could not be removed easily.

At each site, the UTM coordinate was measured by a portable GPS receiver. Then the groundwater level from the measuring point (MP) and the height of the MP from the ground surface was measured to calculate the depth to groundwater level from the ground surface. In most dug wells, the actual well depths were measured by sinking a measuring scale.

The locations of measured existing wells are shown in Figures 4.2.1 to 4.2.12 together with the locations of geophysical prospecting and test wells.

#### 2.1.2 Groundwater Levels by Province

The results of groundwater level measurement together with the results of well investigation in the target communes are presented in the Data Report. Figure 2.1.1 shows the distribution of depth to groundwater level from ground surface by province. The characteristics of the groundwater level distribution are as follows:

##### (1) Thai Nguyen

The measured twenty two (22) wells show the depth to groundwater level ranges between 2.0 and 4.0 m from the ground surface. Shallow groundwater levels within 2.0 m from the ground surface were detected at 18 wells. The groundwater levels from 4.0 to 6.0 m and from 6.0 to 8.0 m were detected at 6 wells and one well, respectively.

##### (2) Hanoi

The groundwater levels were measured at only 5 dug wells. Two dug wells in Xuan Dinh Commune show the depths to groundwater level of 9.21 m and 7.90 m. They said that the groundwater levels have been declined. The deepening of groundwater levels

has been occurred due to the groundwater extraction from the well fields of the Hanoi water supply system. Rest of the dug wells show that the depths to groundwater level are within 1.0 m from the ground surface.

**(3) Ninh Binh**

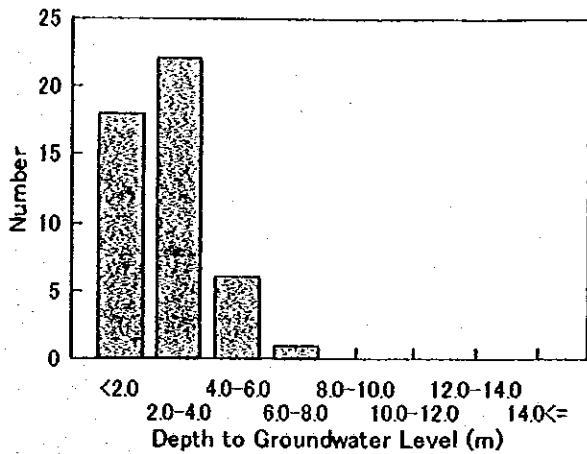
The groundwater levels in Dong Phong and Yen Thang Communes are shallow; mostly within 2.0 m from the ground surface. On the other hand, the levels in Quang Son Commune are deeper than those of Dong Phong and Yen Thang Communes. The groundwater levels deeper than 8.0 m from the ground surface were measured at 5 wells located in the western part of the commune. The deepest ground water level of 13.00 m was measured at QS-11 well.

**(4) Thanh Hoa**

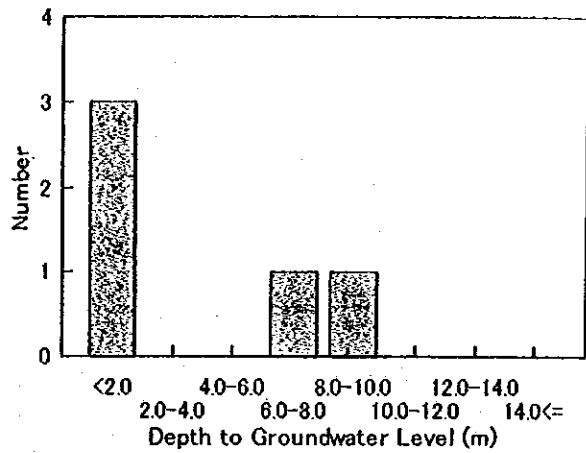
More than 6.0 m in depth to groundwater level was found in Vinh Thanh and Dinh Tuong Communes. In Vinh Thanh Commune, the deep groundwater level was found at a natural levee along the Song Ma River. The deep groundwater level in Dinh Tuong is found at the southern part of the commune where the commune is bounded by a river. The groundwater levels at the rest of the areas in Dinh Tuong Commune range from 1.56 to 3.51 m from the ground surface. The groundwater levels of Thieu Hung Commune, which is located on the north of the Song Cho River, range from 3.80 to 5.06 m except the area close to a pond. On the contrary, the groundwater levels in Thieu Do Commune, which is located on the south of the Song Cho River, show within 2.0 m from the ground surface. The groundwater levels in Van Thanh Commune and Nong Cong town are located mostly within 1.0 m from the ground surface.

**(5) Ha Tinh**

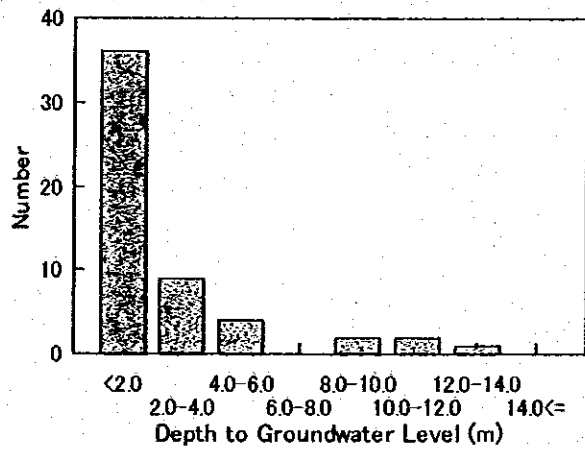
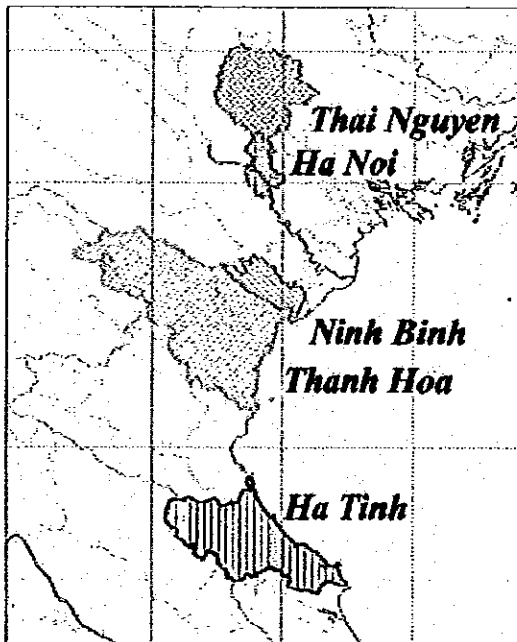
Only one well in Bui Xa Commune shows deeper than 4.0 m in groundwater level from the ground surface. Out of 38 measured wells, 21 wells fall into a range from 0.0 to 2.0 m and 16 wells fall into a range from 2.0 to 4.0 m. The depth to groundwater level varies depending on the topographic conditions of the well site.



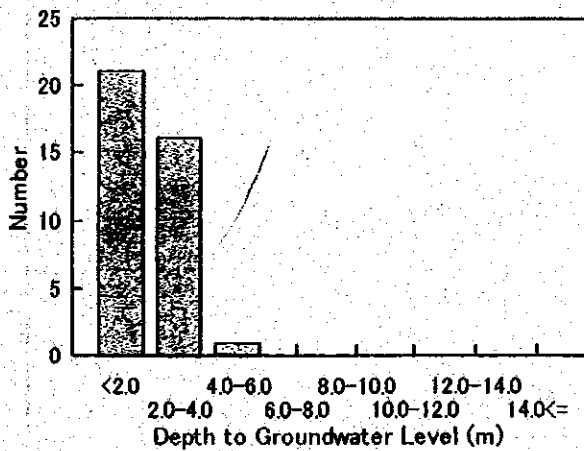
Thai Nguyen



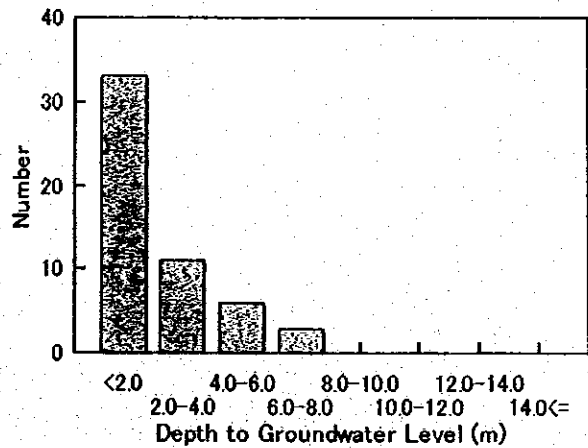
Ha Noi



Ninh Binh



Ha Tinh



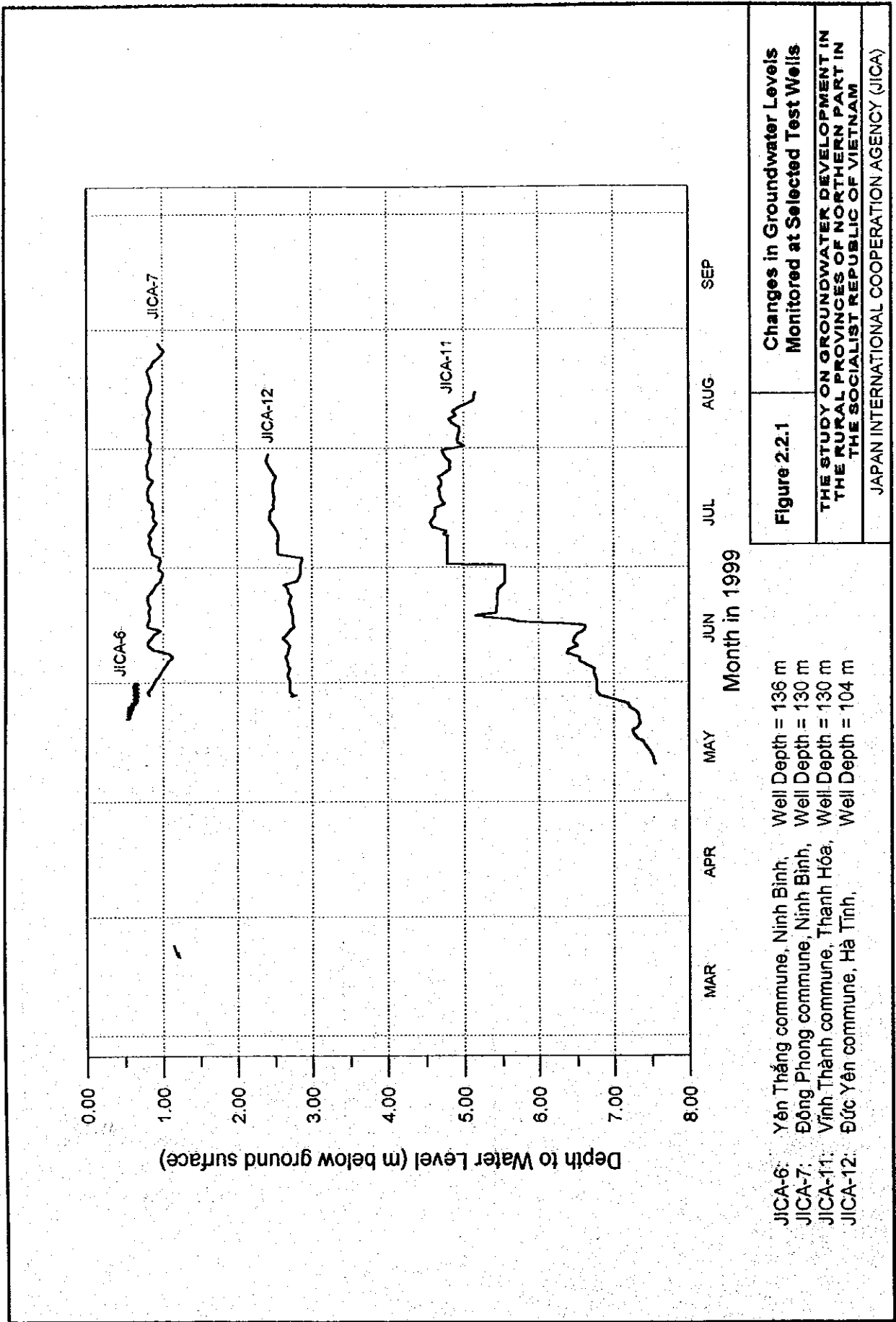
Thanh Hoa

Figure 2.1.1 Distribution of Depth to Groundwater Level from Ground Surface by Province

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(Depths to groundwater levels from ground surface were measured at existing dug wells.)



**Figure 2.2.1** Changes in Groundwater Levels Monitored at Selected Test Wells

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## 2.2 Seasonal Change of Groundwater Levels

Automatic groundwater level recorder was installed at 12 test wells after completion of the pumping test. The automatic monitoring was started in a period from March to June 1999 so that the record through one hydrological year has not been recorded yet.

According to the results of existing well survey in the target communes, the groundwater levels in the existing wells have seasonal changes, some of the shallow wells are dried up during the dry season due to decline of groundwater levels. The groundwater levels near rivers are influenced by the changes of river water level. The range of fluctuation tends to increase with close to the river.

Figure 2.2.1 shows the changes in groundwater levels monitored at the selected test wells. The groundwater level of JICA-6 well (Yen Thang Commune, Ninh Binh) rose 0.6 m for a period from March 1999 to June 1999. The records show two cycles of daily fluctuation, that indicates the influence of the tidal fluctuations. The range of the daily fluctuation is 30 to 70 cm. The groundwater level of JICA-7 well (Dong Phong Commune, Ninh Binh) was fluctuated between 0.8 to 1.0 m below the ground surface. The fluctuation pattern does not show influences of rainfall nor changes in river water level. The groundwater level of JICA-11 well (Van Thang Commune, Thanh Hoa) gradually rose from 7.5 to 4.5 m below the ground surface during a period from the early May to the middle of July 1999, however, it declined to 5.15 m below the ground surface by the middle of August 1999. There is no clear peaks corresponding to the rainfall. The changes in groundwater level seems to be influenced by the water levels of Muc River.

## 2.3 Groundwater Levels in Hanoi Area

### 2.3.1 Groundwater and Surface Water Levels in 1990 and 1991

The Study Team has collected existing available data of observation wells and surface water observation points for years 1990 and 1991. Figure 2.3.1 shows the location of observation wells and surface water observation points. There are two (2) kind of observation wells in Hanoi area. One is pure observation wells monitoring static groundwater level or piezometric heads, whereas the other is observed production wells, that is basically groundwater production wells with monitoring dynamic groundwater level or piezometric heads. The surface water monitoring points measure the water levels of river water.

**(1) Changes in surface water level**

Figure 2.3.2 shows the monthly changes in surface water level. The water levels of the Red River show clear seasonal fluctuations. At T-2 observation point near Long Bien bridge, the highest monthly water levels were recorded in July in years 1990 and 1991. In 1990, the highest water level of 10.42 masl (m above sea level) was measured in June and the lowest water level was 2.74 masl in January. The patterns of water level changes at T-1 and T-2 are very similar to that of T-2.

On the other hand, surface water levels of small rivers in Hanoi area do not show clear seasonal changes. This indicates that the river water levels inside the city area were not affected by the Red River, in other words, rivers in the city may be controlled artificially.

**(2) Changes in groundwater level (First Aquifer)**

Groundwater levels of the Upper Semi-Confined Aquifer have been monitored at seven (7) monitoring wells as shown in Figure 2.3.3. Seasonal changes of groundwater levels can be seen at C21, C17, and C10 observation wells. These wells are located relatively close to the Red River. The groundwater levels are high in July and August, that shows a similar fluctuation patterns of the Red River water level. However, the difference between high water level and low water level of groundwater is 3.34 m at C17 well in 1990. The groundwater level at C10 well tends to decline over time.

The groundwater levels of the wells located in the central to southern part of Hanoi city do not show seasonal fluctuations. Groundwater levels over time are almost flat at C7, C12, C16, and C25 wells. However, particularly at C16 well, decline of groundwater level was observed, and the groundwater level declined at 26.16 masl in December 1991.

**(3) Changes in piezometric head (Second Aquifer)**

Figure 2.3.4 shows the changes in piezometric head of the Lower Confined Aquifer. The seasonal changes in piezometric head can be observed at A10, A17, and A14 wells. The piezometric heads are high in July and August and low in January to March. The seasonal changes in piezometric head tend to decrease with distance from the Red River. At A10 well located near Xuan Dinh commune, decline of piezometric head over time was recognized.

In the southwestern part of Hanoi city, piezometric head was almost stable but slightly declining as shown at A8 and A25 wells. For example, piezometric head at A25 well in



December 1989 was 25.51 masl, while the head in December 1991 became 26.08 masl.

**(4) Distribution of groundwater table**

Figure 2.3.5 shows the distribution of groundwater table measured at observation wells of the First Aquifer in May 1991. A depression of groundwater table can be seen at the central part of Hanoi city. The lowest groundwater table was 26.46 masl. The groundwater table near the Red River is almost same as the Red River water level.

**(5) Distribution of piezometric surface**

Figure 2.3.6 shows the distribution of piezometric surface of Lower Confined Aquifer measured at pure observation wells in May 1991. The piezometric surface was assumed to be static, without influence of nearby production wells. The deepest piezometric surface is below 210 masl in the southern part of Hanoi city. The size of depression cone is larger than that of the Upper Aquifer. The piezometric surface in most city area except along the Red River is below 0 masl. From the map, it is understood that piezometric surface of Xuan Dinh Commune is lower than Dong Ngac Commune.

### **2.3.2 Groundwater Levels and Piezometric Heads from 1988 to 1997**

The groundwater levels of the First Aquifer and the piezometric heads of the Second Aquifer in Hanoi area have been monitored by the Department of Geology and Minerals of Vietnam (DGM, 1998). Monthly average, minimum and maximum groundwater levels measured at 32 monitoring wells in 17 monitoring stations from 1988 to 1997 are presented by DGM. The location of existing groundwater monitoring wells by the DGM is shown in Figure 2.3.7.

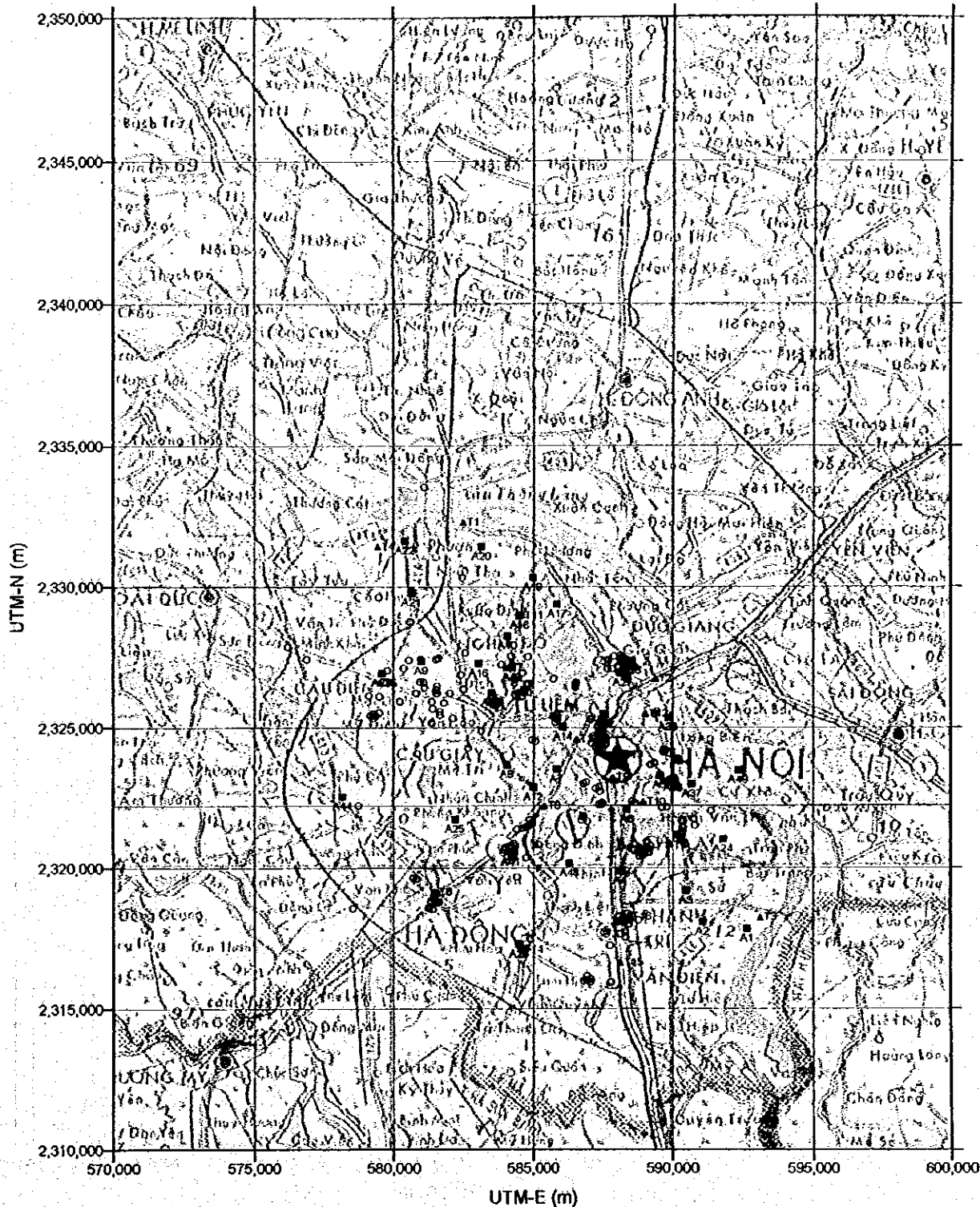
According to the data, the groundwater levels in Hanoi area differ by area and aquifer. Groundwater levels near the Red River are shallow and almost same levels as the river water level. However, groundwater levels are deeper with distance from the Red River. The groundwater levels are low in the central, southern, and southwestern part of Hanoi City. Groundwater levels of the deep aquifer (the Second Aquifer, Lower Confined Aquifer) are lower than that of the shallow aquifer (the First Aquifer, Upper Semi-Confined Aquifer).

Figure 2.3.8 shows the changes in groundwater level measured in the northern part of Hanoi Province. At Q.15 monitoring well in Soc Son District shows that the groundwater level has been fluctuated between 8.0 and 10.0 masl. The groundwater level is high in the rainy season and low in the dry season. The groundwater level at Q.23a well, which is located at Dong Anh District near the Red River, shows rhythmic seasonal fluctuations. The range of the fluctuation is between 3.5 to 9.5 masl. The changes in groundwater level is similar to that in

the Red River water level.

Groundwater levels of the First Aquifer and the Second Aquifer have been monitored at Q.62 station (Minh Khai, Tu Liem District) and Q.63 station (Dich Vong, Cau Giay District) as shown in Figure 2.3.9. The groundwater levels at Q.62, located about 2 km southwest of Dong Ngac Commune, show rhythmic seasonal fluctuations both in the First Aquifer and the Second Aquifer. However, the groundwater level of the First Aquifer gradually has declined, from a range between 2.8 and 6.7 masl in 1988 to a range between 2.0 and 4.8 masl in 1997. The piezometric head of the Second Aquifer is about 4 m lower than the groundwater level of the First Aquifer. The piezometric head was fluctuated between 21.0 and 11.0 masl in 1992, however, the head has declined to a range between 21.7 and 10.2 masl in 1997. The decline of groundwater levels has been clearly recorded at Q.63 station, located about 2 km southwest of Xuan Dinh Commune. The groundwater levels of both the First Aquifer and Second Aquifer have lowered without seasonal fluctuations. Particularly the groundwater level of the First Aquifer was situated at about 26 masl in early 1992, but it declined to 212 masl in the middle of 1995, then it suddenly dropped to 215 masl in the middle of 1996. The piezometric head of the Second Aquifer was located about 215 masl in the middle of 1992, but it is situated below 216 masl in 1997.

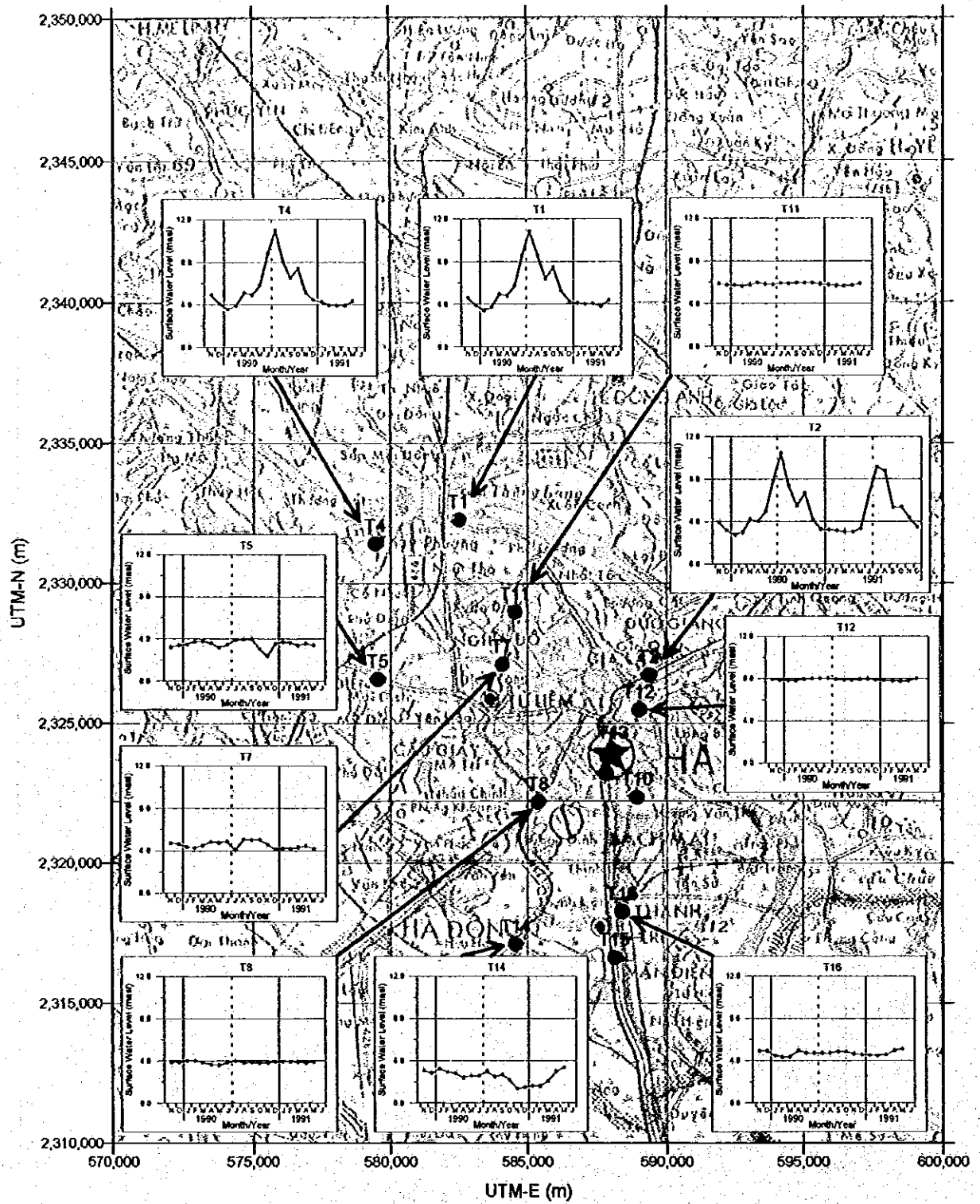
Figure 2.3.10 shows the changes of groundwater levels in the central and southern part of Hanoi city. At Q.67 station in Tay Ho District, the groundwater level of the First Aquifer is almost same as that of the Second Aquifer. The fluctuation patterns of groundwater levels of both the aquifers are similar to that of the Red River water level. Meanwhile, the groundwater levels monitored at Kim Lien in Dong Da District show that the piezometric head of the Second Aquifer is about 12 m lower than the groundwater levels of the First Aquifer. The groundwater levels of the First Aquifer range from 1.5 to 3.5 masl for a period from the middle of 1992 to the end of 1997, whereas the piezometric heads of the Second Aquifer range from 212.0 to 29.5 masl for the period.



- Observation Well with No.
- Observed Production Well
- ▲72 Surface Water Observation Point with No.

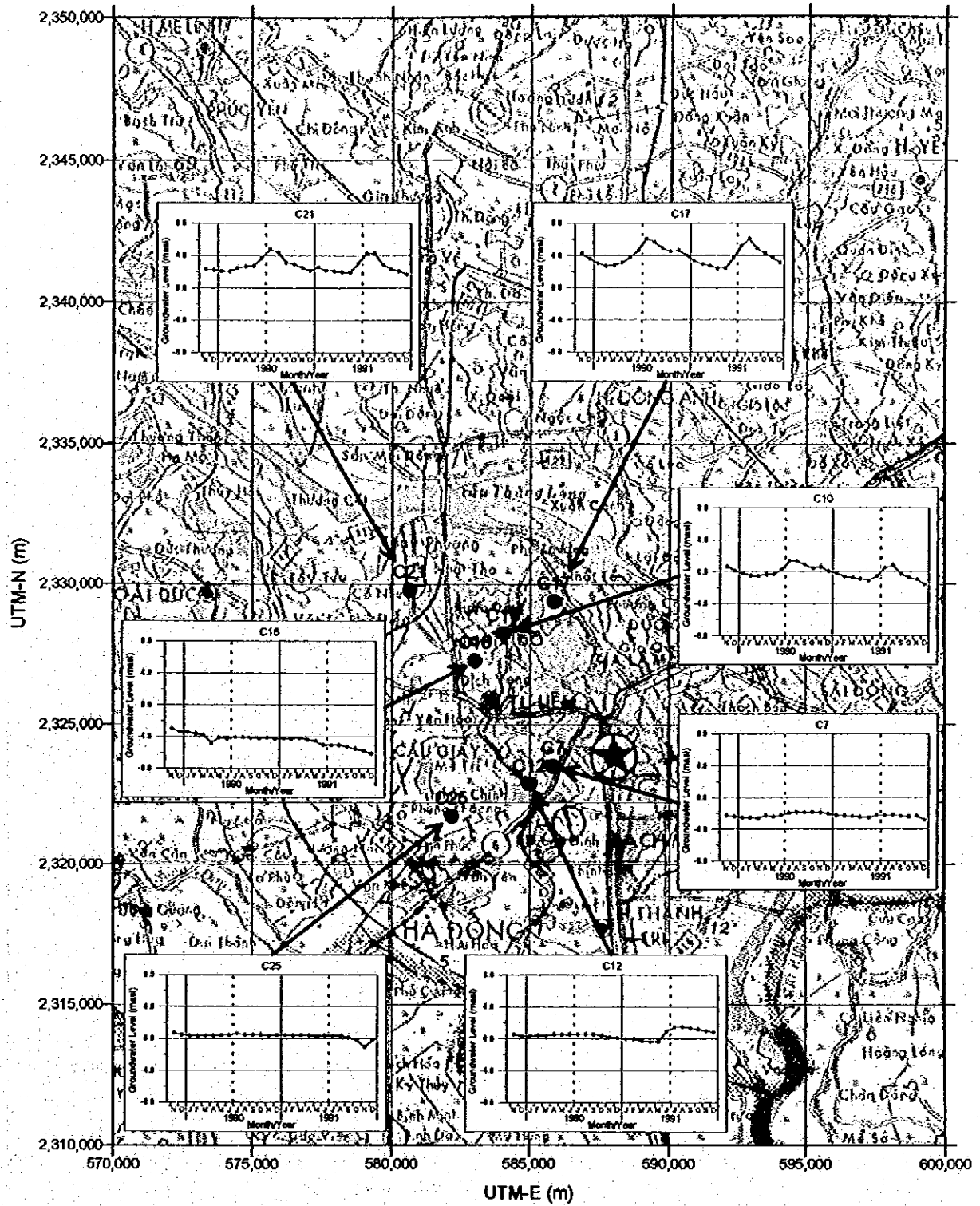
Figure 2.3.1 Location of Observation Wells in Hà Nội Area

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T16 ● Surface Water Observation Point with No.

Figure 2.3.2	Monthly Changes in Surface Water Levels of Hà Nội Area
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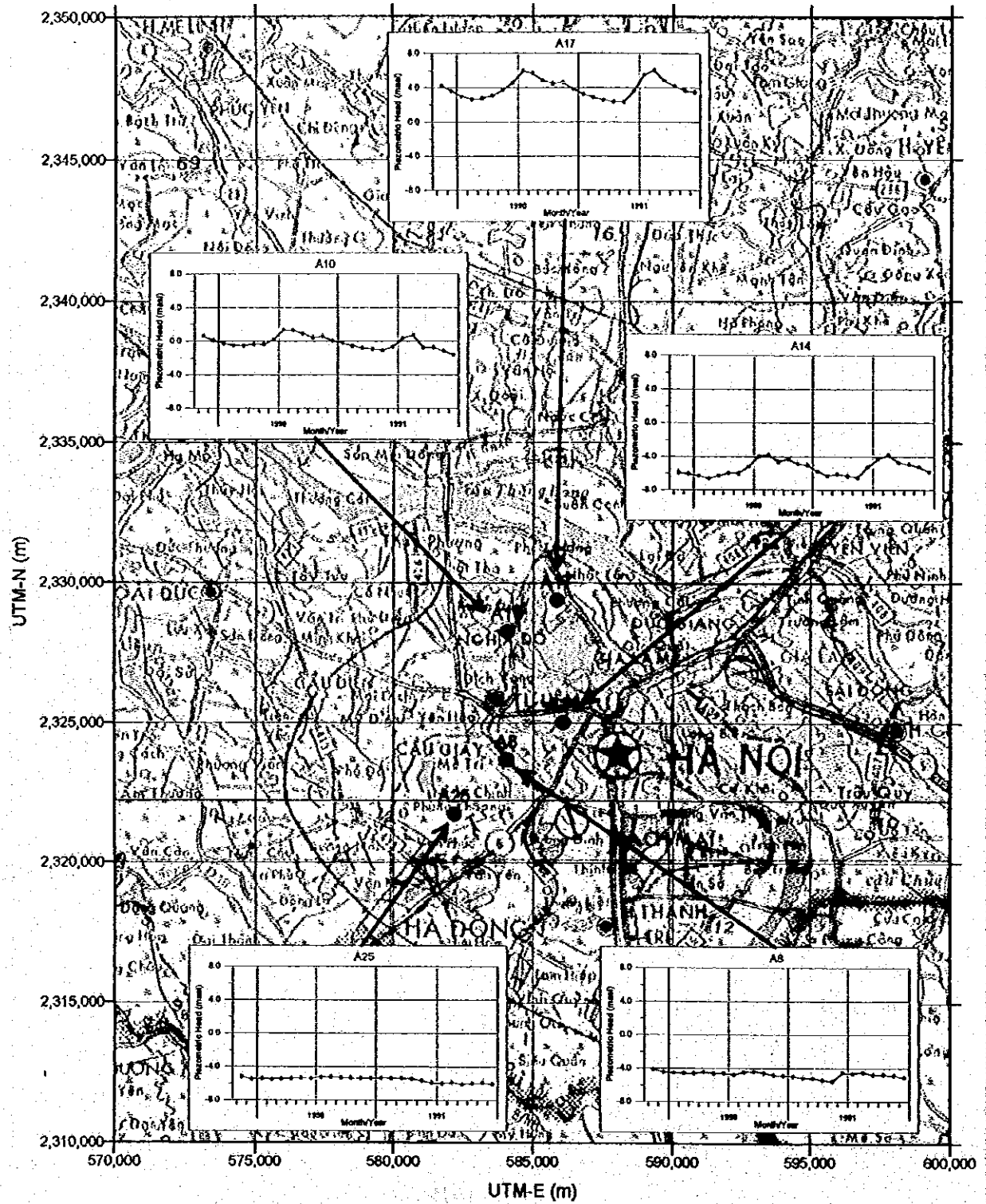
● C10 Observation Well of Unconfined Aquifer with No.

Figure 2.3.3

Monthly Changes in Groundwater Levels of Hà Nội Area

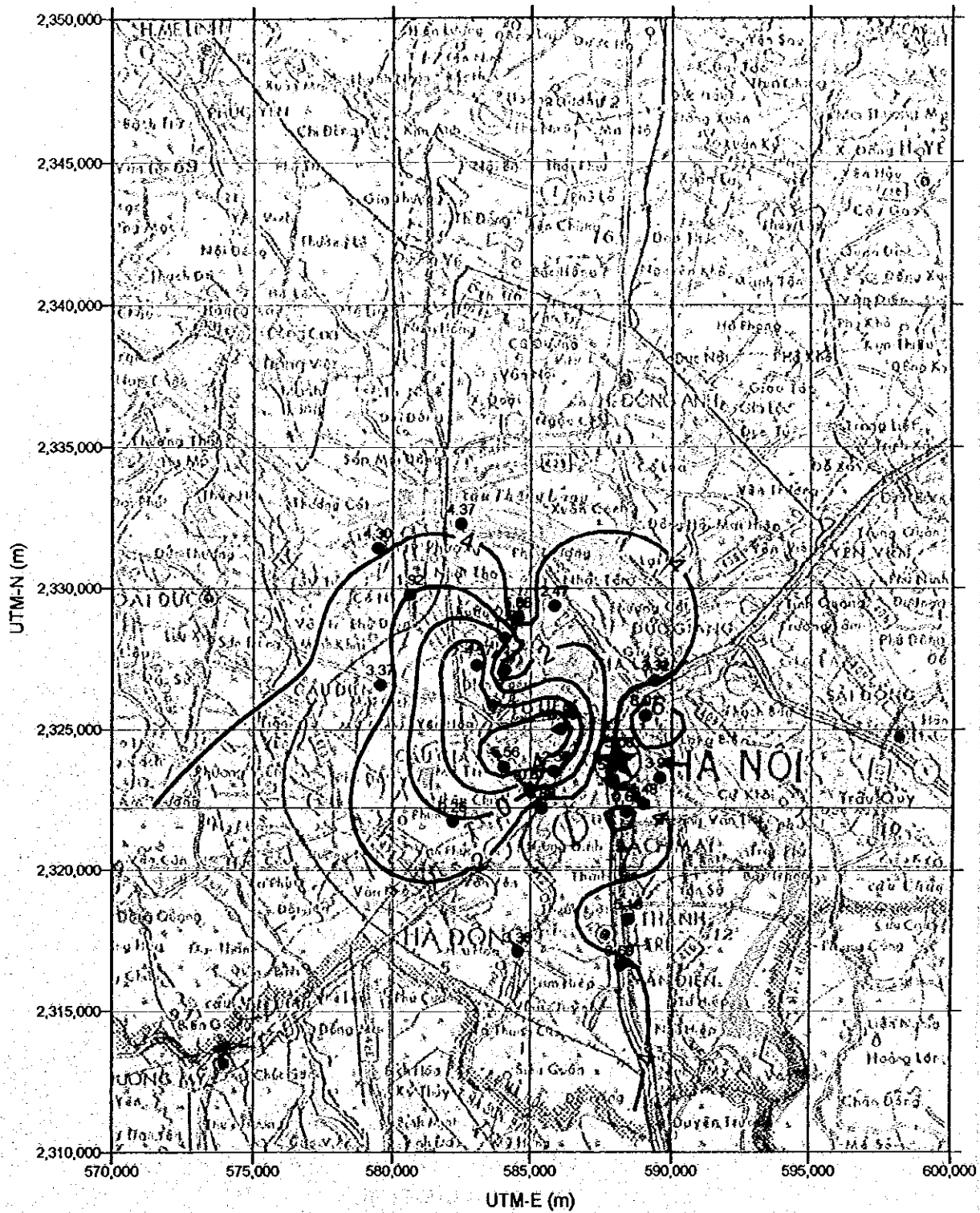
THE STUDY ON GROUNDWATER DEVELOPMENT IN THE RURAL PROVINCES OF NORTHERN PART IN THE SOCIALIST REPUBLIC OF VIETNAM

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A17 ● Observation Well of Confined Aquifer with No.

Figure 2.3.4	Monthly Changes in Piezometric Heads of Hà Nội Area
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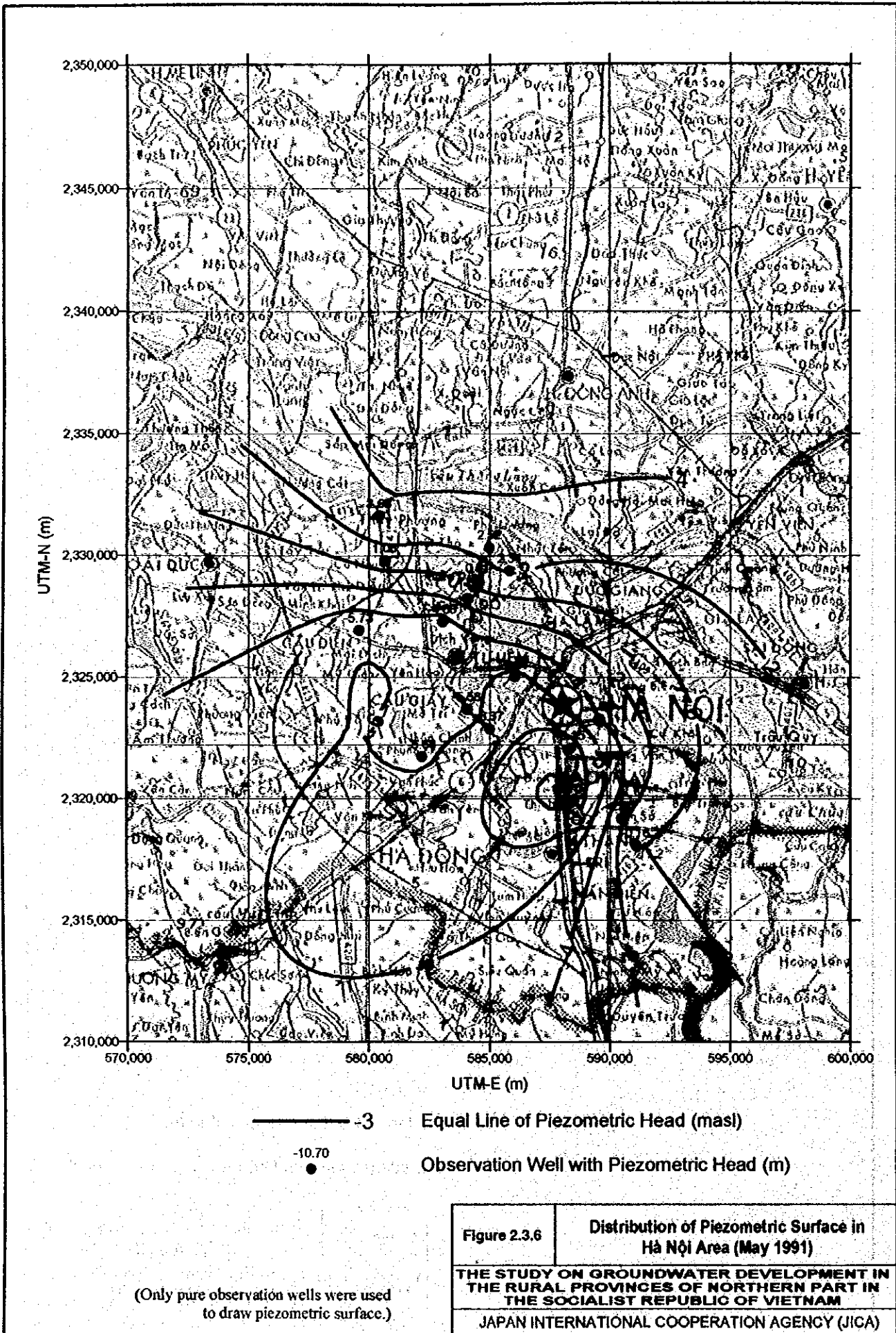


-2 Equal Line of Groundwater Table (masl)  
 -6.46 Observation Well with Groundwater Level (masl)

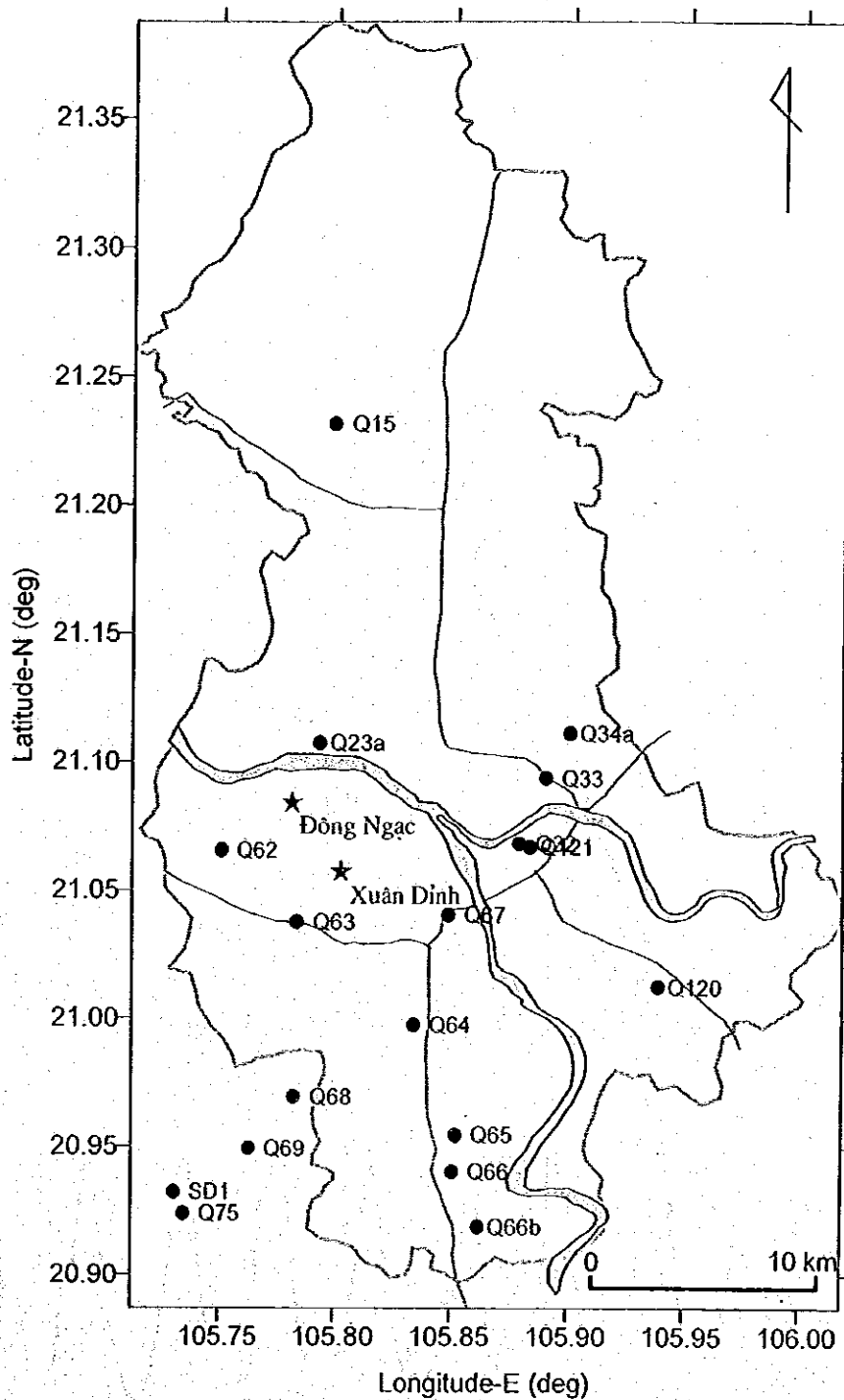
Figure 2.3.5	<b>Distribution of Groundwater Table in Hanoi Area (May 1991)</b>
<b>THE STUDY ON GROUNDWATER DEVELOPMENT IN THE RURAL PROVINCES OF NORTHERN PART IN THE SOCIALIST REPUBLIC OF VIETNAM</b>	
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(Only pure observation wells were used to draw piezometric surface.)



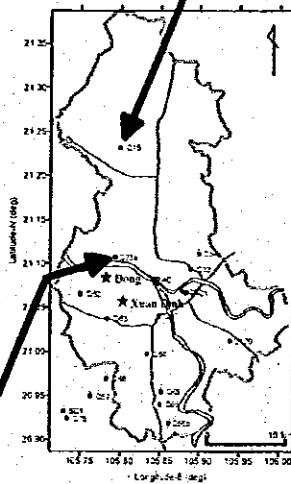
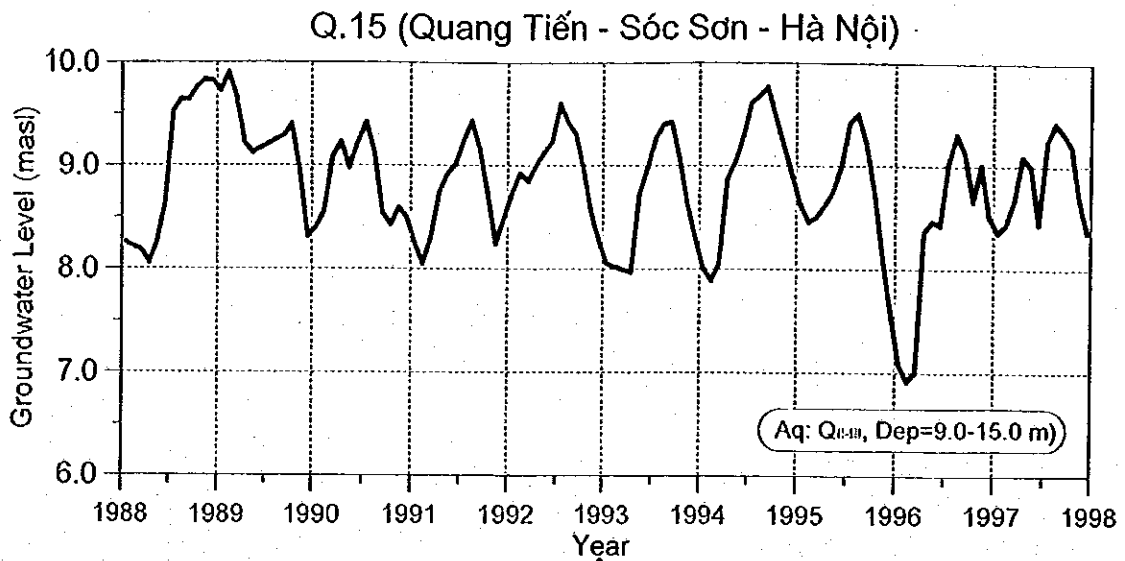




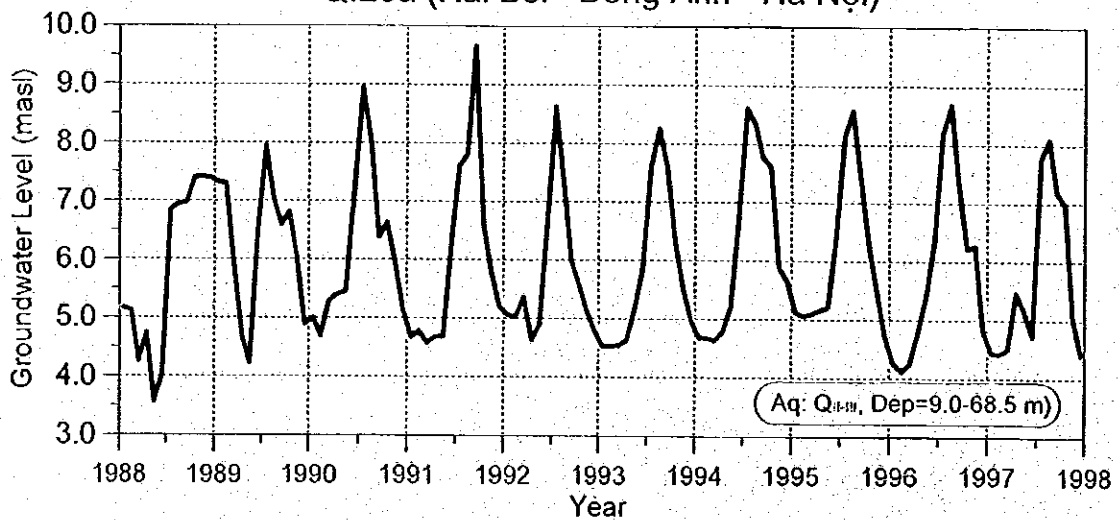


[Data Source: ĐẶC TRƯNG / ĐỘNG THÁI NƯỚC DƯỚI ĐẤT VÙNG ĐỒNG BẰNG BẮC BỘ (1988-1997)]

<b>Figure 2.3.7</b>	<b>Location of Existing Groundwater Monitoring Wells in Hà Nội Area</b>
<b>THE STUDY ON GROUNDWATER DEVELOPMENT IN THE RURAL PROVINCES OF NORTHERN PART IN THE SOCIALIST REPUBLIC OF VIETNAM</b>	
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**Q.23a (Hải Bối - Đông Anh - Hà Nội)**



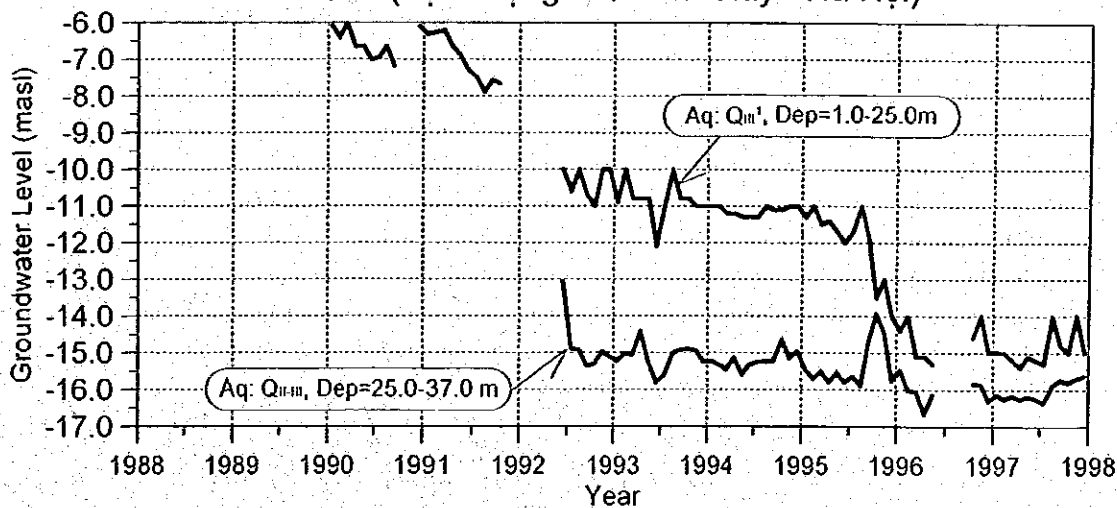
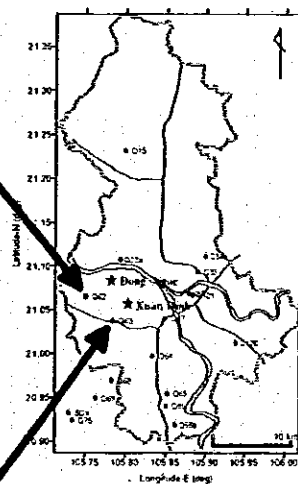
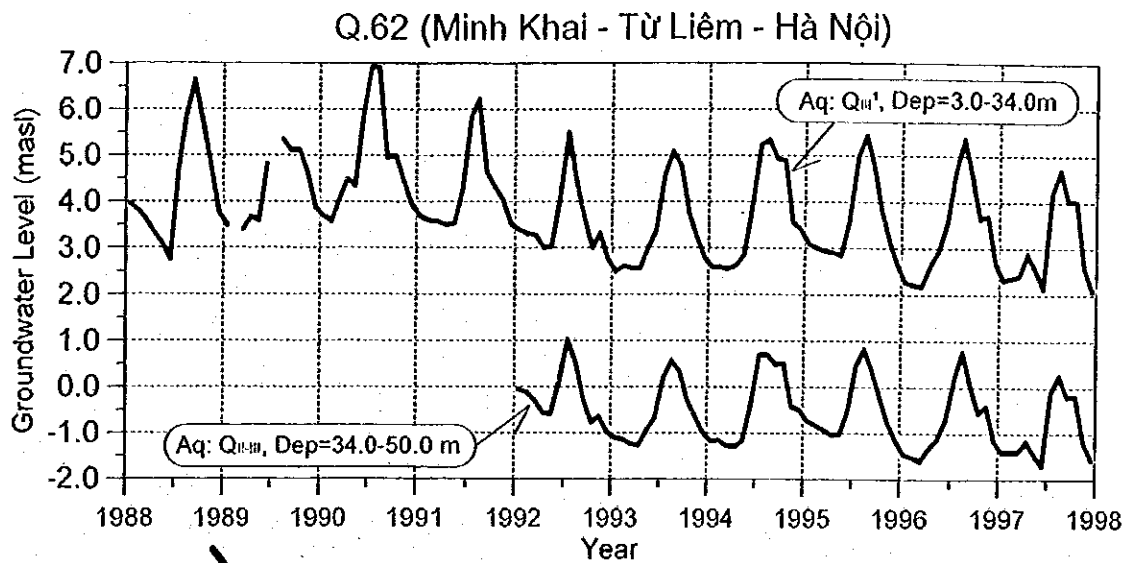
**Figure 2.3.8**

**Changes in Groundwater Level  
in Hà Nội Area (1)**

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[Data Source: ĐẶC TRUNG / ĐỘNG THÁI NƯỚC DƯỚI  
ĐẤT VÙNG ĐỒNG BẰNG BẮC BỘ (1988-1997)]



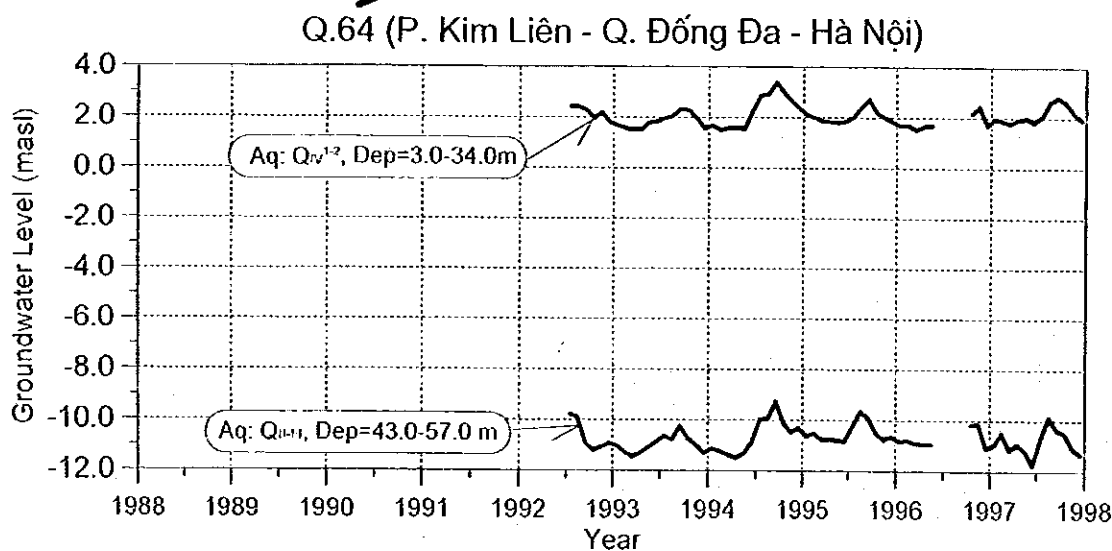
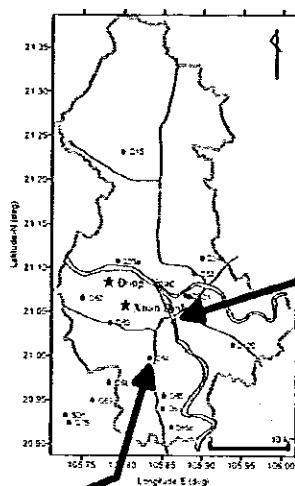
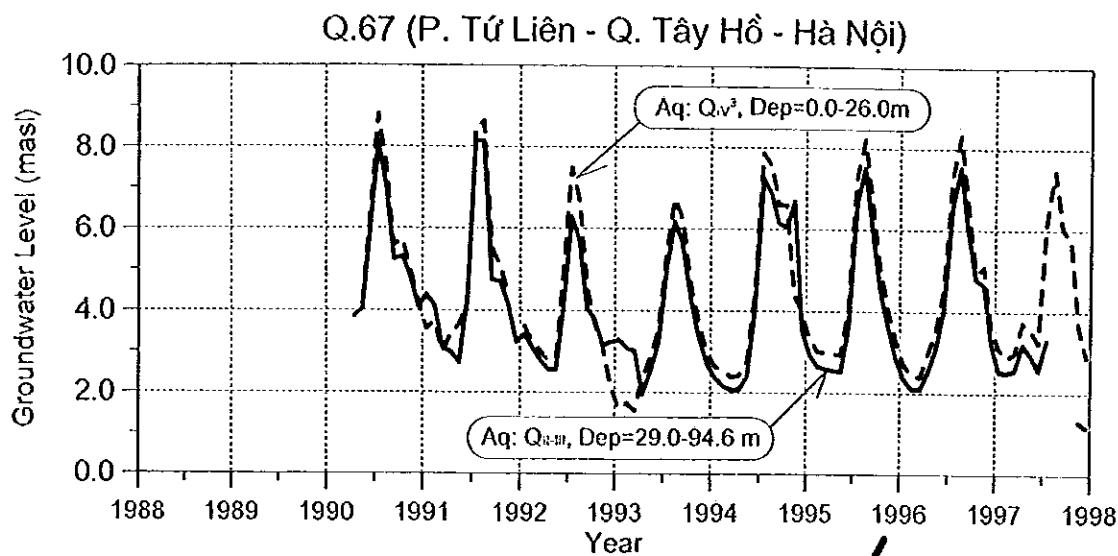
**Figure 2.3.9**

Changes in Groundwater Level  
in Hà Nội Area (2)

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[Data Source: ĐẶC TRƯNG / ĐỒNG THÁI NƯỚC DƯỚI  
ĐẤT VÙNG ĐỒNG BẰNG BẮC BỘ (1988-1997)]



<b>Figure 23.10</b>	<b>Changes in Groundwater Level in Hà Nội Area (3)</b>
<b>THE STUDY ON GROUNDWATER DEVELOPMENT IN THE RURAL PROVINCES OF NORTHERN PART IN THE SOCIALIST REPUBLIC OF VIETNAM</b>	
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[Data Source: ĐẶC TRƯNG / ĐỘNG THÁI NƯỚC DƯỚI ĐẤT VÙNG ĐỒNG BẰNG BẮC BỘ (1988-1997)]