CHAPTER IV

DATA COLLECTION AND ANALYSIS

4.1 Temperature measurement

The experimental sites for this study are 20 observation wells located within Chiang Mai Basin. The wells belong to the Department of Groundwater Resources (DGR). These wells were selected based on the following criteria: they are spatially distributed throughout the study area; the depths are from 44 to 300 meters and screen through different geologic formations. The geologic logs or driller's logs on record; the observation wells are not equipped with pumps and can be accessed fairly easy. The locations of the selected wells are displayed in Figure 2.3.

Temperature-depth profiles were observed in the 20 observation wells during 26 February 2007 to 2 March 2007. Firstly, the depth of water table was recorded (Figure 4.1). Then groundwater temperature was measured by lowering a thermistor down into the observation wells. Precautions were taken to ensure that the recorded temperature was representative of water in the aquifer and not influenced by movement of water in the observation well. When the groundwater temperatures in the well were in equilibrium with the surrounding aquifer or aquitard, the temperatures were measured at every 2 m depth interval. The system used for temperature measurement consists of a quartz oscillator probe, an external reference oscillator, a line amplifier, a frequency counter, and a recording device made by Takara Thermistor, Model TXW-46 and cable length of 300 m. (Figure 4.2). The quartz probe and the reference oscillator were put in a stainless-steel vessel and placed at the strainer position of a well from which fresh groundwater can flow. To achieve prompt response to changes in water temperature, the tip of the probe was directly exposed to groundwater. The signals from the probe were transmitted through a cable to the counting system on the ground and were amplified, counted and recorded. The equipment can measure temperatures in the wells to within ± 0.01°C.

Figure 4.1 Measurement of water level.

Figure 4.2 Equipment used in groundwater temperature measurement; thermometer (grey), sensor or thermistor (green) and cable (black wire).

Groundwater temperature data were collected with a thermistor. In general, temperatures in each well were measured at depths below the water table. The general steps used for collecting groundwater temperature profile data are as follows:

1. Depth to water below measuring point for the well was measured using a water level meter. No correction factor was applied to the measurement. The depth to water was then rounded to the nearest and recorded as the rounded depth to water below measuring point show in Figure 4.1

2. The thermistor was lowered down in 2m depth interval and then temperature was recorded when the measurement was stable (Figure 4.3).

Figure.4.3 Measuring of groundwater temperature from water level to well bottom at every 2 m interval.

4.2 Data analysis

After obtaining the temperature depth profiles of all the wells, the depth of 'surficial zone', in which the temperature gradient might be influenced by the surface seasonal temperature (Parsons, 1970), was identified and discarded from the measured temperature-depth profile. The temperature data between the surficial zone and geothermal zone were used for further refined investigation.

The next step is to carry out detailed investigation for the β values and vertical groundwater flow (recharge or discharge) directions and rates in those wells. As such, in each of those wells, hydrogeological units were firstly selected based on lithologic and electric Logs (SP and R Logs) reported by DGR. Of each geological unit, a set of β values was calculated from the equation (11) by using the iterative methods of Microsoft Excel Solver outlined by Arriaga and Leap (2006). Then the best average β value of each geological unit in all the wells can be obtained. To validate the calculated β values, the temperature-depth data of some hydrogeological units that were used for calculation of the β values by the Solver were superimposed at exactly the same scale on the set of type curves of function f(β, z/L) or $(T_z-T_o)/(T_L-T_o)$ vs z/L of Bredehoeft and Papadopulos (1965). It appears that the calculated β values are agree quite well with the β values obtained from the curve matching on the type curves.

It is important to mention here that under isotropic and steady-state conditions where vertical groundwater flow does not occur (β value ≈ 0), the thermal gradient is linear with depth. However, when the vertical groundwater movement occurs depending on the direction of its movement; if the thermal profile curves and the plot of the ratios $(T_z-T_o)/(T_L-T_o)$ against z/L in the type curve is concave upward (positive β value), it represents the downward leakage of groundwater or recharge zone; if it is convex upward (negative β value), it indicates the upward movement of groundwater or discharge zone.

After obtaining β values of each geological unit of all the wells, the vertical groundwater flow velocities were estimated by computing from the relation equation (9)

If the rest of the parameters in this equation are known, the v_z can provides the vertical groundwater velocity from the equation (9). The thermal properties of the hydrogeological unit used in our calculation are as follows. The typical value for the thermal conductivity (k) of water-saturated clay is 2×10^{-3} cal/cm sec °C (Birch et al., 1942).The average value for the thermal conductivity of water-saturated sand and gravel aquifers is 4×10^{-3} cal/cm sec °C, and that of water-saturated silt is 2×10^{-3}cal/cm sec °C (Wade, 1994). The value of specific heat of groundwater (c_o) is assumed to be 1 cal/g °C and density of fluid (ρ_o) is 1 g/cm^3.