CHARPTER 5

DATA UNCERTAINTY

Data uncertainty is inherent in all methods of assessing groundwater vulnerability. Many errors arise from different sources of input data, lack of appropriate data, and differing methods of computerization. A large degree of uncertainty is also results from existing vulnerability methods. The process of assessing vulnerability is dynamic and interactive and requires careful handling of available data and its appropriate distribution.

5.1 Uncertainty from input data

Data collection is another major cause of uncertainty, for example, measurements of depth to groundwater level. Due to groundwater fluctuation both seasonally and annually in the rainy season, groundwater level rises after a period of time and in the dry season groundwater levels drop. Thus, differing periods of time of groundwater measurements result in uncertainty in regard to vulerability. To overcome this uncertainty, the same period of time for collecting groundwater levels (In the year 2004) was used for the entire study area.

Different data sources and scales, such as the groundwater map of DGR created in 1:100,000 map scale; the soil map of DLD created in 1:50,000 map scale; and the topographic map of Royal Thai Survey Department, RTSD, created in 1:50,000 map scale; also cause uncertainty. The distribution of data points also plays an important role in uncertainty; some areas may be too dense while in other areas there is no data available. In order to get information for areas from which there is no data, extrapolation and interpolation methods were used. This extrapolation and interpolation introduced uncertainty to cells without hard data. The data resulting from interpolation may or may not reflect actual conditions. Hence, this uncertainy increases the importance of selecting appropriate methods and parameters for calculation and assessment in vulnerability mapping.

Given to the advances made possible by the computer, more data can be computed faster and stored in larger amounts, and overlay and index methods can now be widely used. The advantages of using the computer are ease of data processing retrieval, and correction. The software used in assessment of vulnerability methods was the ArcView® program, which was used in the calculation of the grid cell basis. Two methods were used for interpolating the grid used in ArcView® program: the inverse distance weighting method and the Spline method, both of which are suitable for uniform data sampling points but not for random sampling point, interpolation and extrapolation. There is some uncertainty for values in the cell beyond the existing sampling data points.

5.2 Uncertainty analysis

As mentioned above, uncertainty is involved in the analysis of the result of various parameters that were employed in order to delineate the vulnerability index map. Each parameter was taken into account with the goal of determining which parameter was the most sensitive to input data uncertainty. Parameters such as net recharge from the wet season and net recharge from annual rainfall were used to calibrate the data uncertainty; depth to groundwater level at depths of less than 100 meters and all other depths were used to get the effect of groundwater levels; and groundwater quality, as total dissolved solids at different times (previous and present) were also used to calculation in the model.

5.2.1 Net recharge

Net recharge from the wet season, defined as May to October. The rest of the year was defined as the dry season. The two periods of rainfall, wet and annual rainfall, were used in order to calculate the net recharge in the DRASTIC assessment method. By applying Inverse Distance Weighting methods at the power of 2, the nearest Neighbor of 12 and cell size of 100 by 100 meters, map of net recharge, and wet periods and annual rainfall were delineated and the results were compared. (Figures 5.1 and 5.2)

According to the map of net recharge, the wet period ranged from 664 to 1,669 mm/y and the net recharge from annual rainfall ranged from 585 to 1,444 mm/y. The map shows that at the middle of the high index value of net recharge of both maps were in the same area. There was only a small variation in area dimension of net recharge. Therefore, the effect of net recharge from the wet period and annual rainfall period did not have much influence in vulnerable index mapping.

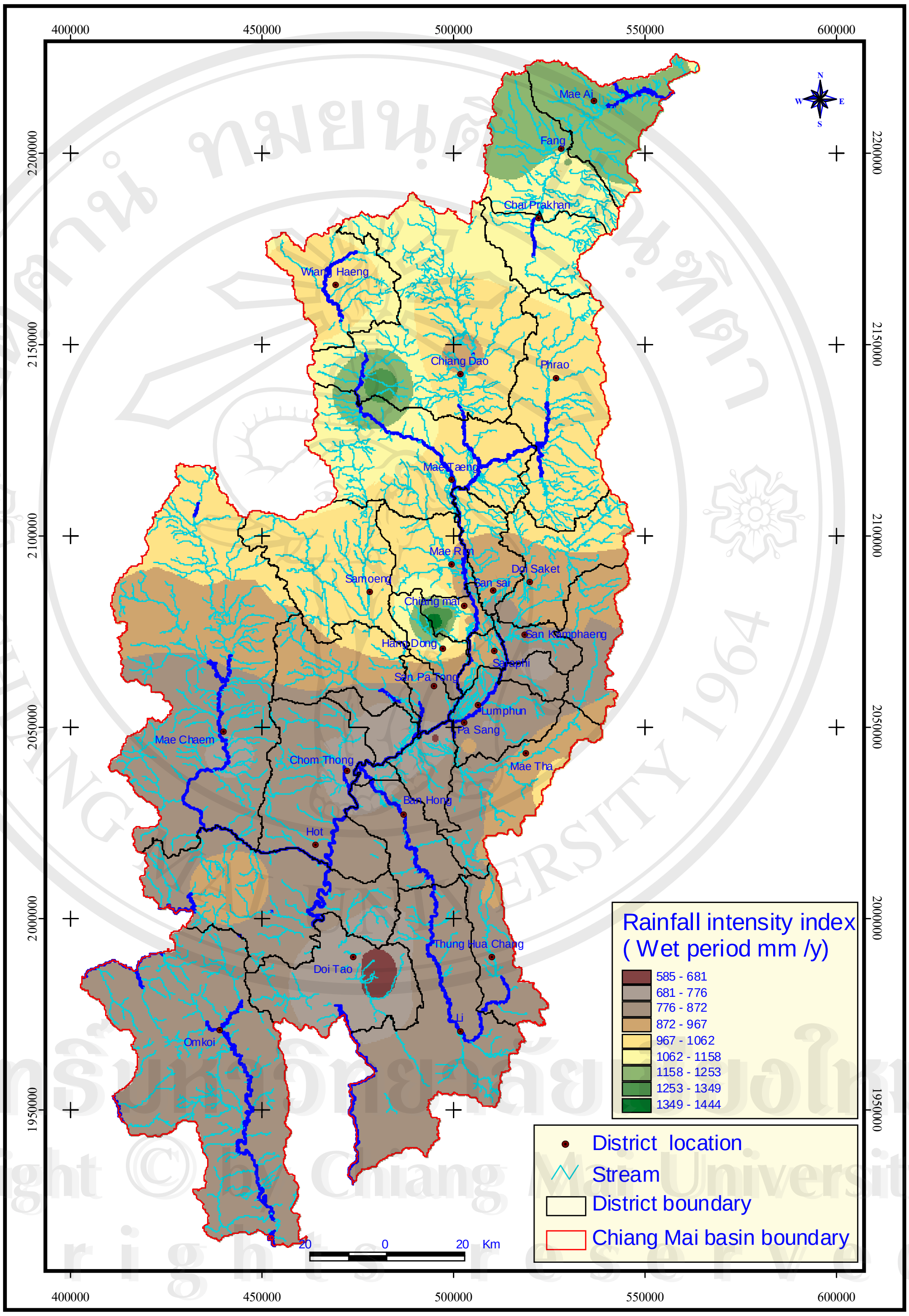

Figure 5.1 Net recharge of the wet period.

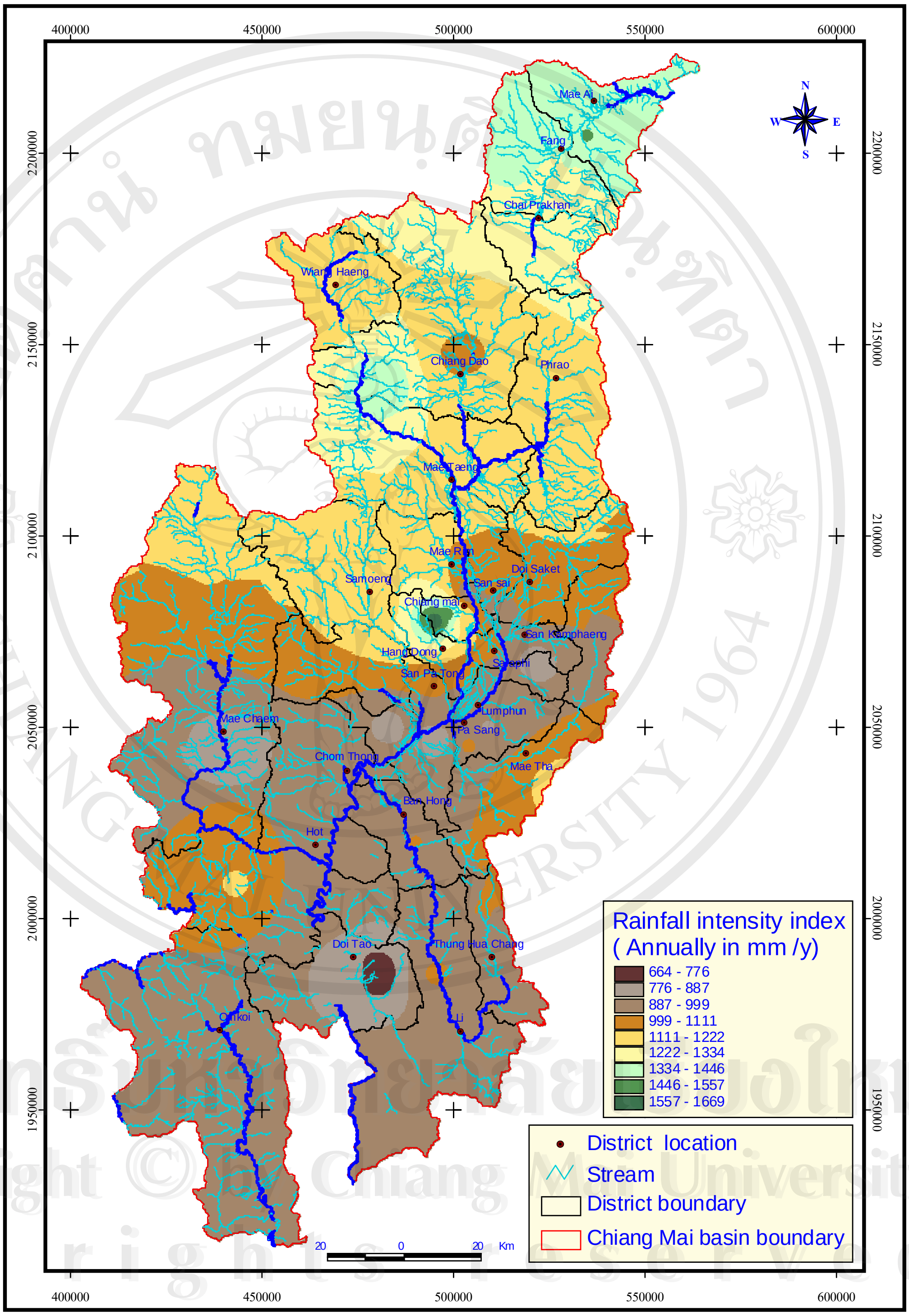

Figure 5.2 Net recharges of annual rainfall.

5.2.2 Depth to groundwater level

Groundwater levels of different drilled depths, less than 100 meters and all drilled depths, were used to calibrate uncertainty. The depths of the wells of less than 100 meters indicated static water levels varying from a few centimeters to 62 meters; the average water table was about 8.2 meters. To compare the result, groundwater levels according to vulnerability were rated and ranged and were applied to both depths at less than 100 meters and all depths as well (Figures 5.3 and 5.4).

The maps show vulnerability index values, medium to high vulnerability (score 7-10) of drilled depths less than 100 meters, were present in a larger area than the entire drilled depths, especially in the central and south of the basin. The low rated vulnerability (Figure 5.4 light green to olive green color, score 2-3) areas in the north of Chiang Dao district disappear when applied to drilled depths less than 100 meters, while shallow aquifers (Figure 5.3) show high ratings (score 5-7) of vulnerability in the same area, and much more in the others area. It can be inferred that the wells at different depths and situated in the same area, or near the area, resulted in penetration by multiple aquifers, both shallow, and deep, which had different groundwater levels. Therefore it seems that deep groundwater wells are less vulnerable than shallow wells. The method of interpolation and extrapolation used average groundwater levels for all wells in the assigned search radius value instead of using groundwater levels of the same aquifer or the same depth. For these reason, shallow aquifers will be more vulnerable to contaminants than deep aquifers.

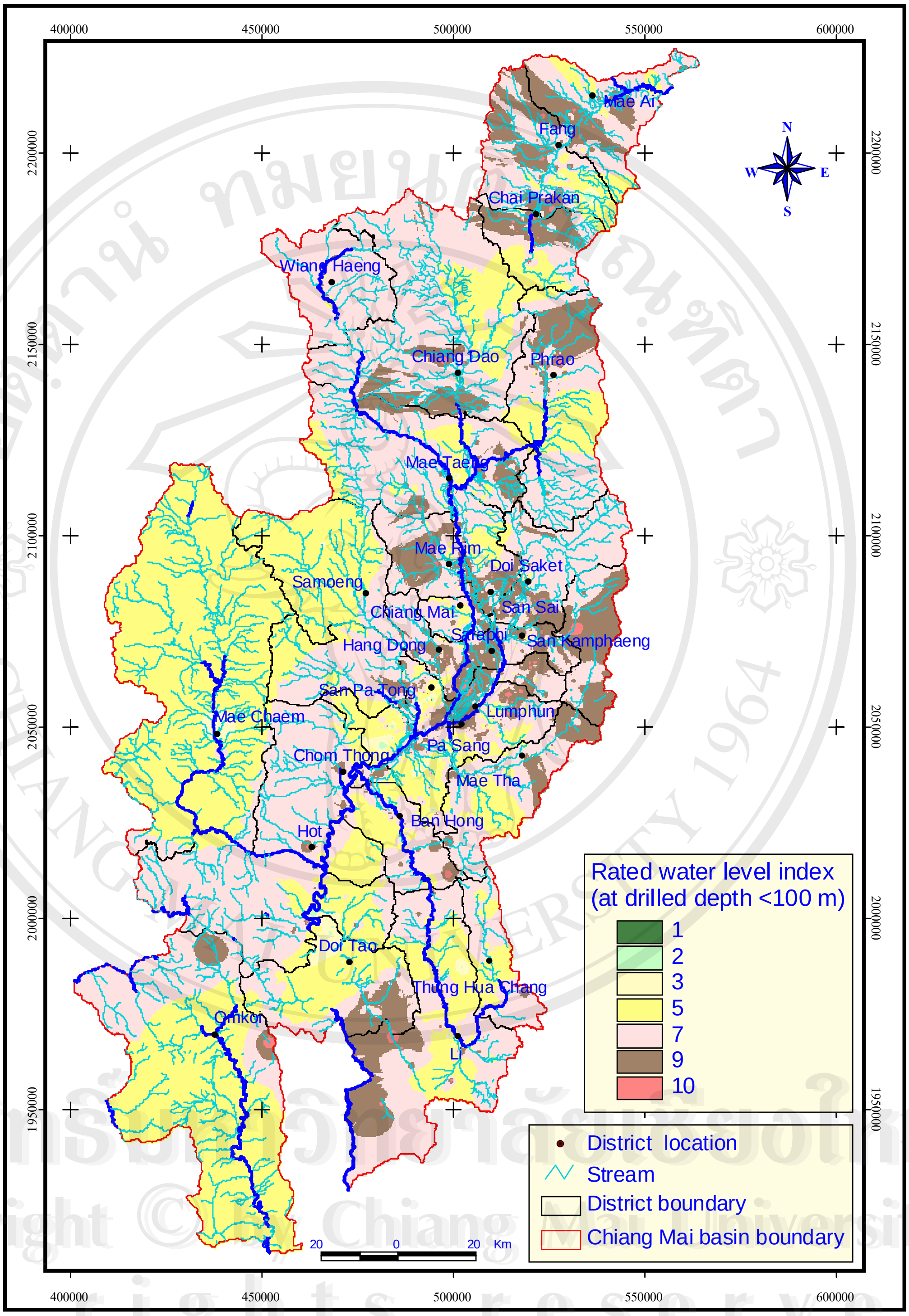

Figure 5.3 Rating of groundwater levels at drilled depth less than 100 meters.

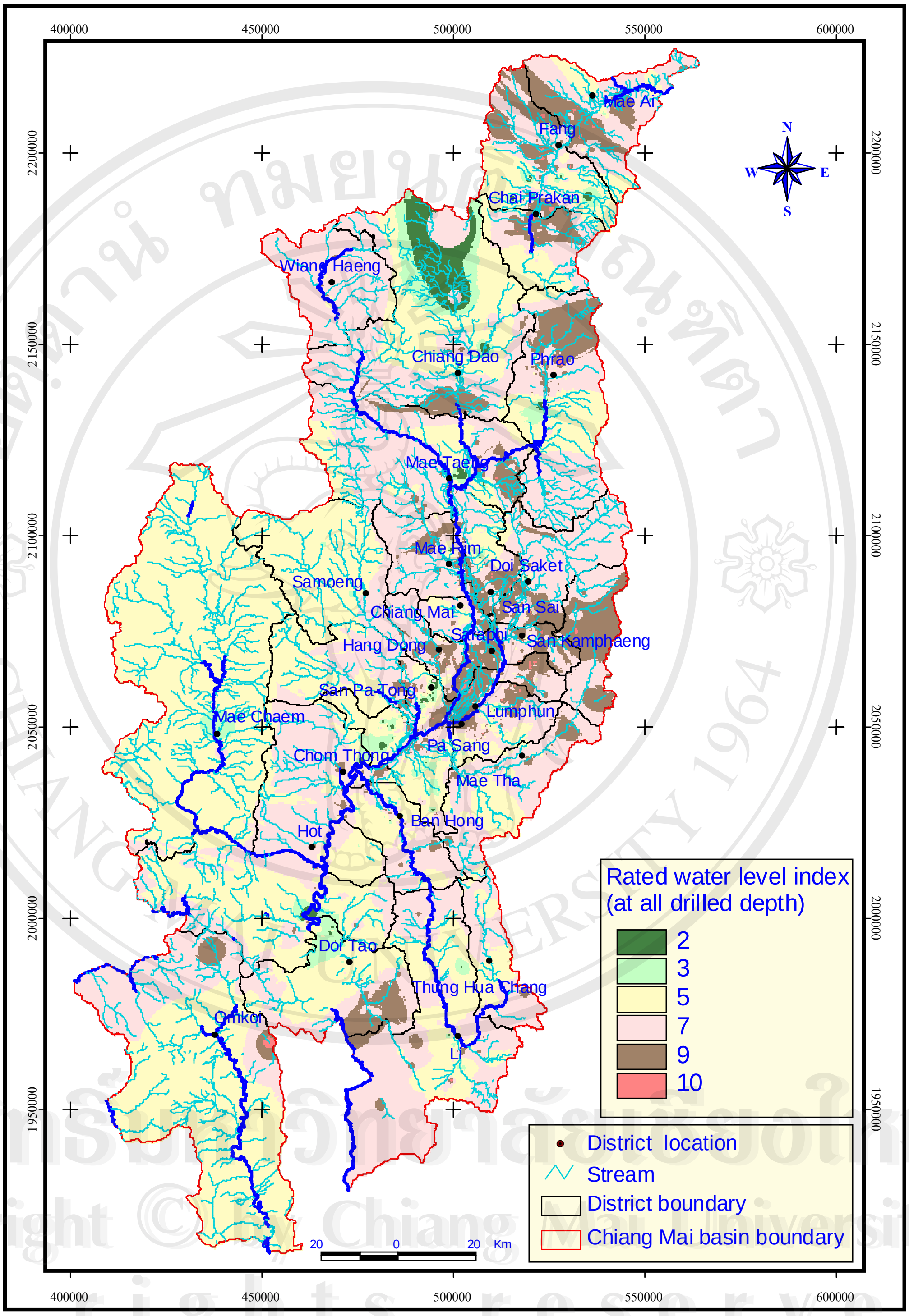

Figure 5.4 Rating groundwater levels at all drilled depths.

5.2.3 Groundwater quality

Groundwater inventories have been conducted since the year 2004 and groundwater levels and groundwater quality, obtained by means of EC measurement, were included in the survey. By using conductivity meters, groundwater samples were taken from the wells and were measured in-situ. The results from the field survey of conductivity of groundwater were presented in micro semen (µs) per centimeter; and subsequently converted to Total Dissolved Solids, TDS (ppm.), by multiplying by 0.65. The TDS of wells was calculated using the ArcView®program by the same parameters; 100*100 grid cell sizes, Inverse Distance Weighting method and the power 2. Then the grid maps were re-classified into 4 groups according to groundwater classification: (DGR groundwater availability map), 0-250 ppm. (fresh water), 250-500 ppm (medium water), 500-750 ppm (saline water), and 750-1,500 ppm (poor water), respectively. Four wells had a high TDS concentration, ranging from 1,626 ppm to 2,648 ppm with shallow aquifer depth about 21 m. to 51 m. (Table 5.1); these were far more than in the high vulnerable area and high chloride concentrations were also found, ranging from 548 ppm to 1,036 ppm. High chloride concentration is an indicator of leakage of contaminated surface water (may be leachate water) through the groundwater wells. The influence of locally contaminated wells did not have much of an effect in vulnerability index mapping.

Table 5.1 Groundwater quality (Total Dissolved Solids and Chloride in ppm).

Well No	Village name	Depth	SWL	Yield	Fe	Cl	TH	TDS
MW0420	Kinder garden Developing center	51	2	2	4	734	904	1890
MW0097	Mae Chong temple	36	21	2	28	705	330	1862
G0514	Nong Keow school	33	9	1	0	1036	644	2648
G0606	Ban Sop Tia	21	6	1	1	548	600	1626

TDS distribution measured from well depths< 100 meters and all depths are shown in Figures 5.5 and 5.6, respectively. Both maps showed distribution of the medium to high TDS values, from the north of Doi Saket district to the south of Ban Hong district of the basin, and were scattered along low terraces and the edge of central of Chiang Mai basin, but the values for the innermost flood plain of the Mae Ping River TDS were relatively low. This may be due to high water recharge or direct recharge water from the rivers. The other high TDS areas (west and south of basin) may be caused by error in the methods of extrapolation where data is not available. TDS distribution maps of shallow aquifers will behave in the same way. Hence, the TDS distribution map at drilled depths less than 100 meters (shallow aquifers) was used overlayed with other parameters of vulnerability index maps.

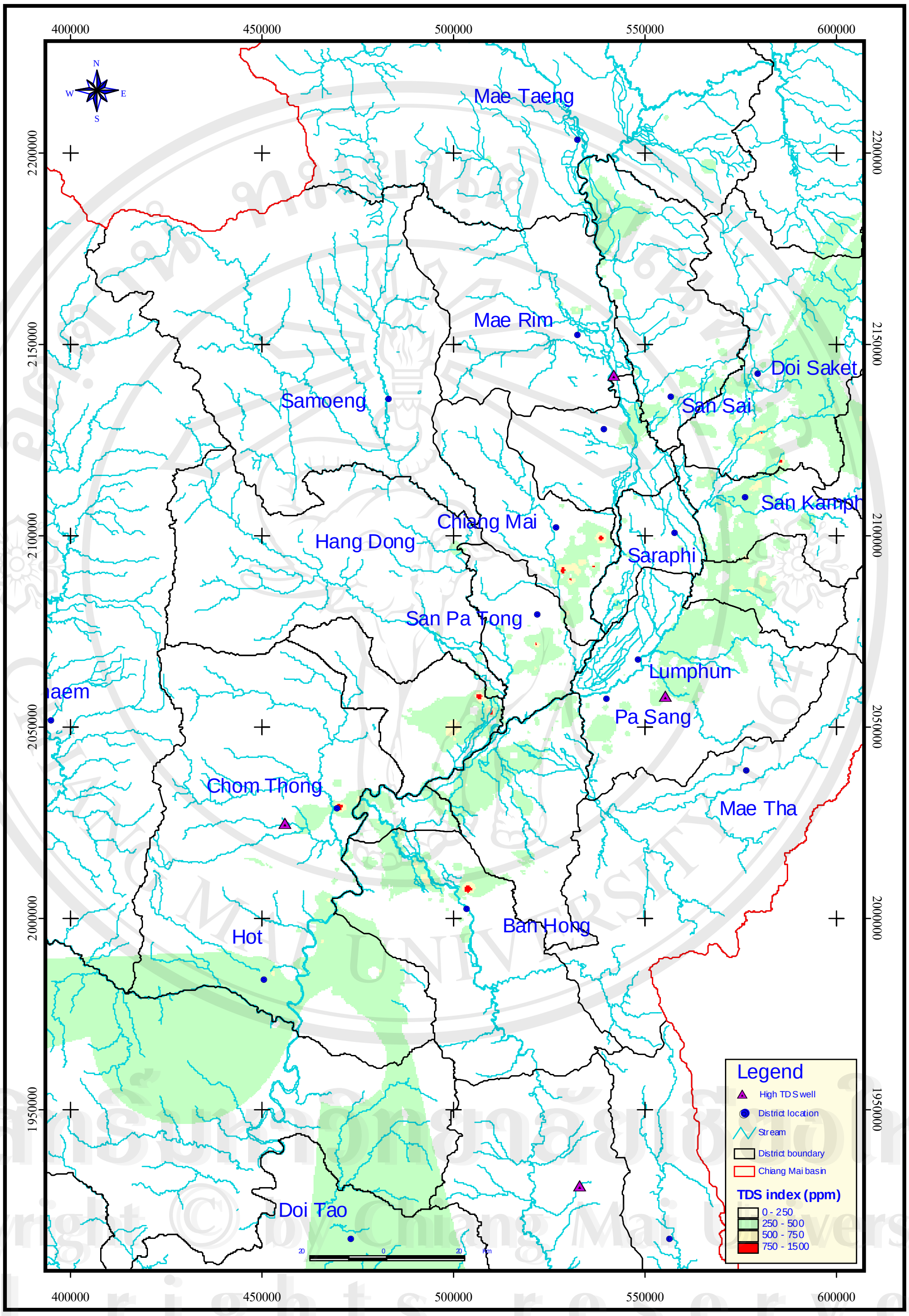

Figure 5.5 Distribution map of Total Dissolved Solids at drilled depth less than 100 meters.

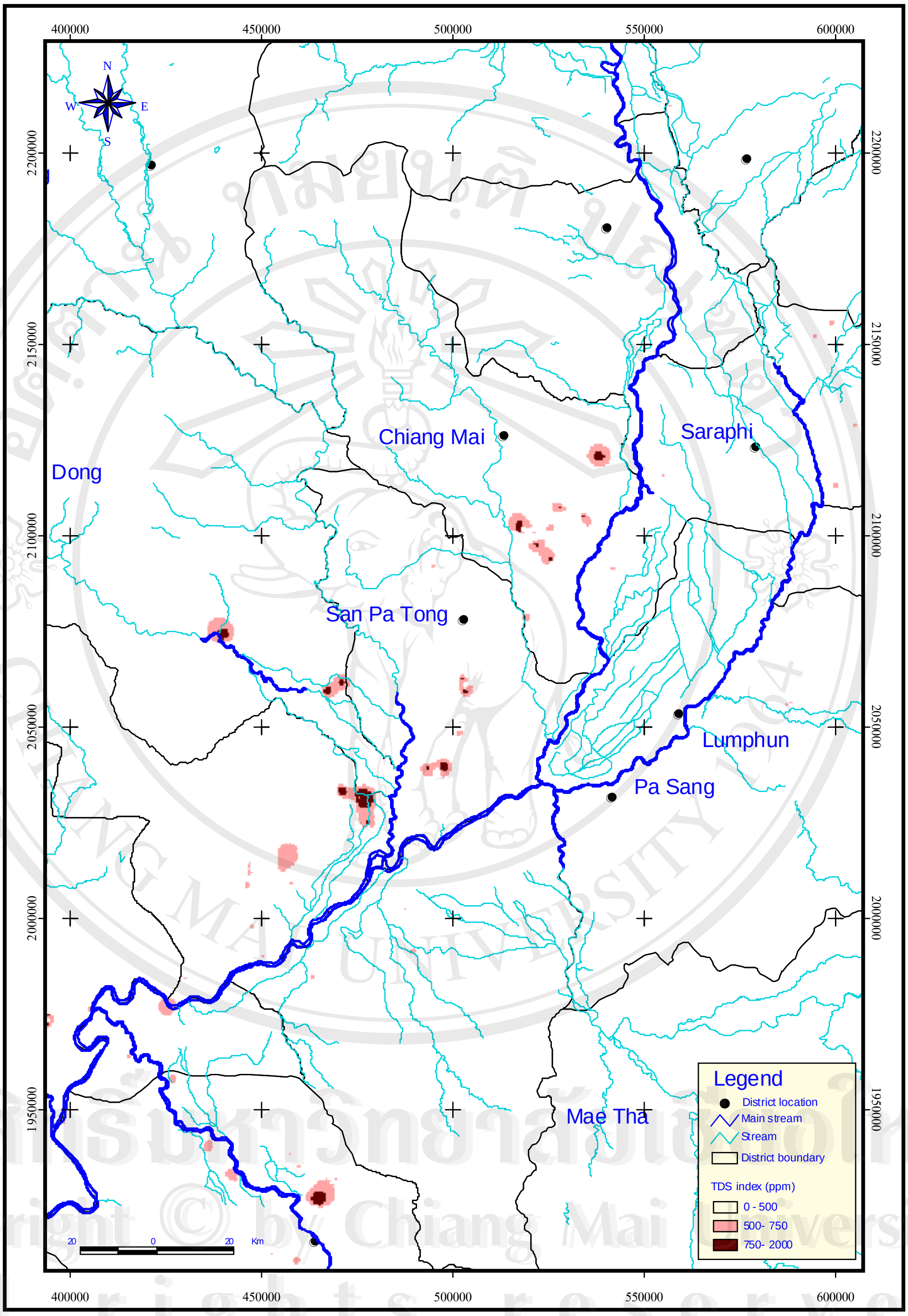

Figure 5.6 Distribution maps of Total Dissolved Solids at all drilled depths.